A COMPARISON OF THE DISTRIBUTION OF *AEDES CANADENSIS* LARVAE WITHIN WOODLAND POOLS USING THE CYLINDRICAL SAMPLER AND THE STANDARD PINT DIPPER [1]

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ABSTRACT. *Aedes canadensis* (Theobald) were sampled in New Jersey woodland pools over a 3-week period during the spring of 1976 to determine larval distribution. Replicate pools were divided into 3 concentric zones based on depth, and collections were taken with a cylindrical sampler and a standard pint dipper in each zone up to 14" deep. An analysis of variance on the data showed significant differences in distribution of larvae between the 2 sampling techniques. The cylindrical sampler data showed that *Ae. canadensis* larvae were equally distributed throughout the pools. Dipping collected the most larvae from the shallower zones of the pool and did not adequately sample the larval population in the deeper zones.

INTRODUCTION

The accuracy of dipping as a larval sampling technique for quantitative purposes has long been argued. The dipper has been evaluated in previous studies for sampling larvae of *Culex* and *Culiseta* (Hagstrum 1971, Knight 1964), but no such evaluation has been performed for flood water or woodland pool *Aedes* species. *Aedes canadensis* (Theobald) was selected for this study because of its importance in New Jersey as a ubiquitous early season species now considered both a nuisance and a suspected vector for dog heartworm (Bergen County MEC 1975, Crans and Feldlaufer 1974, Headlee 1945). The objectives of the study were to determine the spatial distribution and abundance of *Ae. canadensis* larvae in woodland pools using the cylindrical larval sampler (Scanlon and Roberts 1974), and to compare to the results that were obtained by the dipper.

MATERIALS AND METHODS

Three woodland pools in Central New Jersey were selected for uniformity in size, general water quality, composition of benthic litter, and *Ae. canadensis* larval density. All 3 pools were saucer shaped averaging 7.5 ft (7.3–7.8 ft) in diameter and .92 ft (.67–1.17 ft) in depth at the center. The pools were divided into concentric zones 1, 2, and 3, which segregated each pool into shallow ($\bar{X}$ depth=.56 ft), intermediate ($\bar{X}$ depth=.80 ft), and deep ($\bar{X}$ depth=.92 ft) zones respectively. When sampling was initiated, only 2nd instar *Ae. canadensis* larvae were present in all pools. Sampling was conducted on 4 different occasions between March 24 and April 9, 1976.

The sampling tools consisted of the enamel coated pint dipper with a 4ft dowel handle, and a cylindrical larval sampler following the concept of the Belleville sampler (Welch and James, 1960) and more recently the model of Roberts and Scanlon (1974). The cylindrical samplers consisted of a plastic outer, open-ended sleeve graduated in inches on one side and a plastic inner cylinder, with a galvanized funnel plastic inner cylinder, with a galvanized funnel inverted and attached to the base with a dowel handle at the top (Fig. 1).

A laboratory experiment was designed to determine the length of time necessary

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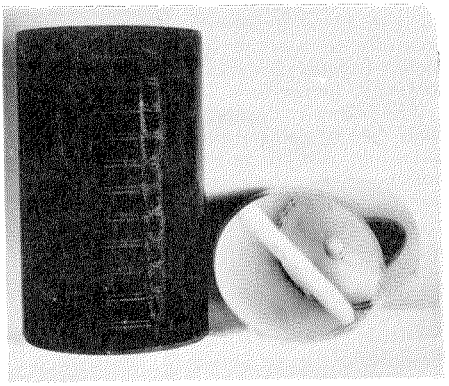

Figure 1. The cylindrical larval sampler showing outer sleeve, and inner sleeve with funnel.

to capture a constant percentage of a known number of *Ae. canadensis* larvae in the cylindrical sampler at woodland pool temperatures. A 5 gal. plastic bucket was filled to a depth of 8 in. with 55–60°F water. The outer sleeve of the cylindrical sampler was placed in the bucket and 20 instar II and III *Ae. canandensis* larvae were placed within the sleeve. The inner sleeve was then inserted in the sampler forcing larvae to rise through the funnel as they surfaced to breathe. Each larva that surfaced above the funnel was removed to prevent it from accidentally diving back down through the funnel. The elapsed time was recorded when each larva emerged over a 20 min. period, and the procedure was repeated 8 times.

In the field the outer sleeve of the cylindrical sampler was placed in the woodland pool trapping larvae inside and then the inner sleeve was slid down until the funnel apex was an inch or so below the water surface. Six samplers were placed in each pool, 2 per zone, in a transect across the diameter of the pool, and left for the appropriate length of time (Fig. 2). A rubber stopper was then placed in the funnel opening to prevent the loss of trapped larvae. The inner sleeve was pulled out and the contents emptied into a white enamel pan. The number of larvae were recorded by instar and a subsample was saved for identification. The depth of the water was recorded by instar and a subsample was saved for identification. The depth of the water was recorded as well as the zone in which the sample was taken.

Figure 2. Cylindrical larval samplers set in woodland pool sampling site.

The dipper was used to sample randomly from the same 3 zones as those using the cylindrical sampler. Two dips per zone were taken for each pool to allow a direct comparison with the cylindrical samplers. Larvae from each dip were emptied into a white enamel pan, recorded by instar, and a subsample was saved for identification.

The experiment followed the split-plot randomized complete block design (Steel and Torrie 1960) where factor A was depth zones and factor B was number of larvae by instar. Data from the dipper samples and the absolute samples were subjected to a 2 factor analysis of variance (ANOVA) and the Student-Newman-Kuels (SNK) multiple range test (Zar 1974).

RESULTS AND DISCUSSION

SAMPLING TIME FOR THE CYLINDRICAL SAMPLER. The results of the laboratory experiment indicated that 15 min. were required for 50% of the known number of *Ae. canadensis* larvae to become trapped in the cylindrical sampler at ambient woodland pool temperature. A regression analysis of the data from 8 trials indicated a linear relationship (Fig. 3). The 50%

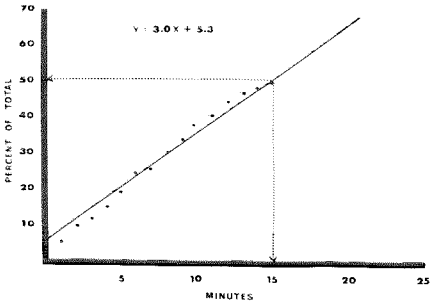

Figure 3. Regression line for percent of total larvae trapped in the cylindrical sampler per unit time.

fraction was an acceptable estimate and 15 min. was established as the sampling time of the cylindrical samplers in the woodland pool. All absolute samples are estimates of half the actual number of larvae per sample unit.

DISTRIBUTION OF LARVAE BY AREA AND VOLUME USING THE CYLINDRICAL SAMPLER. The area of the water surface samples by the cylindrical sampler used in this study was 18 in.^{2}. There were no differences in numbers of larvae collected per 18 in.^{2} between zones according to the ANOVA (F=0.8). There were highly significant differences (F=7.8**) between the numbers of larvae of different instars sampled. There were no differences due to interaction between instars and zones.

The SNK multiple range test showed that instars I and IV were statistically equal in number and instars II and III were equal in number but were more abundant than I and IV at the P=.05 level (Table 1). These differences were most likely due to mortality of larvae as they aged from II to III and IV stage during the study, and secondly to a small hatch which introduced I instars into the population while the other larvae were late instars.

Table 1. SNK * test for differences (P=.05) between instar densities in larvae per 18 in.^{2}

Instar	I	IV	II	II
Ave no. larvae per 18 in.^{2}	.61	1.07	2.22	3.11

* Underlined values are not statistically different.

The sample depth was recorded for each cylindrical sampler collection, and the number of larvae per unit volume was calculated. For the purposes of analysis, a standard unit of larvae per 100 in.^{3} was used. No differences existed in numbers of larvae collected per 100 in.^{3} between zones according to the ANOVA. As with the area samples, there were differences between the densities of the various instars per unit volume (F=7.0**), and no interaction occurred between instars of larvae collected and collection zones. The SNK multiple range test showed that the densities of instars collected per unit volume differed similarly to the larvae per unit area data (Table 2).

Table 2. SNK test for differences (P=.05) between instar densities in larvae per 100 in.^{3}

Instar	I	IV	II	II
Ave no. larvae per 100 in.^{3}	.37	.63	1.73	2.18

DISTRIBUTION OF LARVAE FROM DIPPER SAMPLES. Significant differences occurred in the numbers of larvae per dip between zones (F=7.3**) and between densities of different instars (F=13.7**) according to the ANOVA. There was also a highly significant interaction between the number of larvae of the same instar collected between zones (F=5.2**).

The SNK multiple range test indicated that most of the larvae were dipped from zone 1 by a statistically significant margin (Table 3). The number of larvae collected

Table 3. SNK test for differences (P=.01) between zones in number of larve sampled by dipper.

Zone	2	3	1
Ave no. larvae per dip	.68	.79	1.63

from zones 2 and 3 did not differ from each other, but were both significantly less (P=.01) than that of zone 1.

The abundance of the various instars differed statistically during the course of the study based on dipper samples. Instars I and IV were collected in equal numbers and instars II and III were collected in equal but statistically higher numbers than instars I and IV (Table 4). In this respect, the dipper samples agreed with the absolute samples and corroborate Hagstrum's (1971) findings.

Table 4. SNK test for differences (P=.01) between instar densities in larvae per dip.

Instar	I	IV	II	II
Ave no. larvae per dip	.20	.54	1.39	2.00

Larvae of different instars were collected in unequal proportions in the 3 zones. Instar I larvae were dipped in equal numbers in all zones. Instars II and III were collected in greatest numbers from zone 1. Instar IV larvae were collected in statistically equal numbers throughout the zones (Fig. 4). The proportions of different instars from the dipper samples in the shallower sampling zones 1 and 2 agreed with the larvae per unit volume samples (Fig. 5). The dipper collected instars II in greatest proportion from the shallowest zone. However in the deepest zone, instars IV were collected in the greatest proportion in spite of their lower absolute abundance. Had instars IV been more plentiful in the total population, the shift in relative abundance would have been much greater.

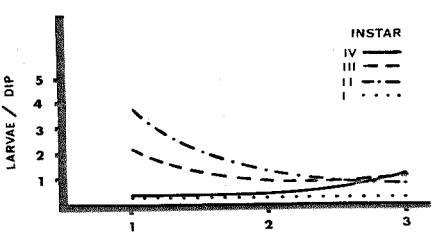

Figure 4. Distribution of larval instars per dip across the sampling zones.

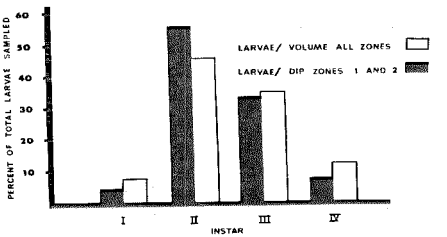

Figure 5. Proportion by instar of the dipper collections in zones 1 and 2 and of larvae per volume throughout the pool.

Since older instars apparently spend more time at the surface breathing than early instars (Thomas 1950), the chance of collecting older instars is greater with the dipper. In the deeper parts of the pool, the increased depth allows the earlier instars, which spend less time at the surface and are more easily disturbed, to better escape the dipper. In shallower water, it is possible to collect all instars even though they may dive because the dipper comes closer to the pool bottom. When the dipper is used in deeper water, the collection is biased towards older instars.

The observed distribution of larvae of all instars sampled by area, by volume, and

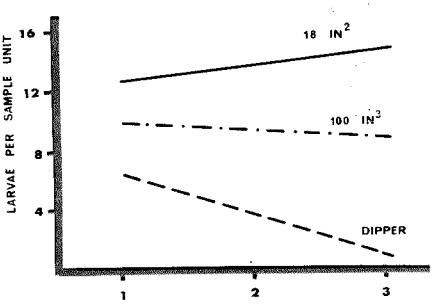

Figure 6. Observed performance of the three sampling techniques over different pool depths.

by dip is shown in Figure 6. Larvae per unit area showed a slightly positive slope; larvae per unit volume, which is the best estimate, showed a neutral slope for randomness; and larvae per dip showed a strongly negative slope where the the difference between zone 1 and zones 2 and 3 was significant. The total number of larvae per dip in zone 1 was roughly 3/5 of the estimated larvae per 100 in.^{3} throughout the pool by extrapolation from Figure 6.

CONCLUSIONS

The spatial distribution of *Ae. canadensis* larvae in woodland pools up to 14 in. deep appears to be statistically uniform throughout the pool when measured as larvae per unit surface area or larvae per unit volume. All instars were randomly dispersed in the pool and showed no significant indication of aggregation at any specific pool depth. The dipper was only efficient at collecting larvae from the shallower parts of woodland pools. Its performance decreased rapidly as pool depth increased beyond 7 in. resulting in an underestimate of total larval density and a bias towards late instars. Therefore when using the dipper for sampling *Ae. canadensis* larvae, dipping should be confined to the portions of the pool less than 7 in. deep.

An estimate of the actual number of larvae per 100 in.^{3} of pool volume is roughly equal to 5/3 the number of larvae per dip from depths less than 7in. Using this relationship as a conversion factor, comprehensive larval density data can be obtained using a dipper.

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