BACKYARD MOSQUITO LARVAL HABITAT AVAILABILITY AND USE AS INFLUENCED BY CENSUS TRACT DETERMINED RESIDENT INCOME LEVELS

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ABSTRACT. One hundred and eighty premises in each of three distinct economic income levels within the urbanized area of East Baton Rouge Parish, Louisiana were inspected for artificial containers producing mosquitoes. Census tracts, and their accompanying descriptive statistics were used to objectively quantify each of the income levels studied. Differences, presumably due to living conditions associated with income level, were found for the amount, type and condition of the containers encountered in each area, as well as between species composition and the extent of production. Overall, low income areas produced more mosquitoes than either of the other two areas, mainly as a result of the types of containers present.

INTRODUCTION

Within the last few years, both the mosquito research community and mosquito abatement personnel have experienced a renewed interest in the biology, ecology and control of mosquitoes produced from artificial containers, particularly *Aedes aegypti* (Linn.), *Ae. triseriatus* (Say), *Ae. albopictus* (Skuse), and *Culex quinquefasciatus* Say. Recent literature in this area detailed aspects of the relationship of dengue transmission and the presence of *Ae. aegypti* which were using a variety of manufactured containers for their larval habitat (Giglioli 1979, Moody et al. 1979). Hedberg et al. (1985) examined the relationships between *Ae. triseriatus* which emerged from tires and the potential of this mosquito for transmitting LaCrosse virus. Others reported that discarded, water-filled tires were one of the preferred larval habitats of *Ae. aegypti* (Prock and Eatherly 1944, Moore et al. 1978, Focks et al. 1981, Frank 1981, Ritchie 1982).

Tinker (1964), conducted a key study on *Ae. aegypti* ovipositional preference for a variety of manufactured containers found discarded in backyards in different locales throughout the southeastern United States. He reported that containers in neighborhoods with dwellings having inadequate sanitation were often areas of high *Ae. aegypti* production. Such areas, described as "substandard," consistently produced higher *Ae. aegypti* larval indices than other areas which were considered to be "standard" or more affluent. As the term "substandard" is a subjective one, the ability to draw meaningful comparisons between adjacent "substandard" areas in the same city, or between "substandard" areas located in different parts of the country, may be difficult without a more objective method to quantify or describe the area studied.

The present study was conducted to develop a more objective method to quantitatively relate an area's income level to mosquito production from artificial containers. Our study was conducted from May 20 to August 23, 1984, during the peak of the mosquito season. First, information on mosquito species distribution was sought. Secondly, data were collected on the kinds of containers serving as primary mosquito oviposition sites. Finally, the principal objective was to quantify the relationship between mosquito production in manufactured containers and the income level of the residents within the areas studied.

MATERIALS AND METHODS

Three distinct economic strata within East Baton Rouge Parish, Louisiana were selected and surveyed for backyard mosquito production. Records were made of the mosquito larvae encountered and of the container types utilized as larval habitats.

SELECTION OF STUDY SITES. Small geographic political subdivisions, called census tracts, were used as the basis to evaluate the relationship between neighborhoods of differing economic status and the production of mosquitoes from containers in backyards. These geographic areas were selected because they were rather small in size (containing approximately 1,200 to 4,500 housing units), and were considered by the U.S. Department of Commerce, Bureau of the Census to be reasonably homogeneous with respect to such population characteristics as economic status, general living conditions,

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median family income, per capita income, and percent of families below the poverty level.[4]

The 66 census tracts in East Baton Rouge Parish were placed into one of three income groups, using median family income as the stratifying factor. Twenty-three census tracts whose residents had median family incomes between $6,000 and $15,000 were considered low income areas, 20 census tracts with median family incomes between $15,001 and $22,000 were considered medium income areas, while 23 census tracts with incomes between $22,001 and $40,000 were considered high income areas. Three census tracts with small differences in median family income (Table 1) were selected in each of the three income levels, while at the same time maximizing the geographic separation between sample sites within the same income level (Fig. 1). To minimize bias during the survey, each census tract was further divided into three smaller areas, with each of the three premises inspectors being assigned to conduct surveys in each of the sub-areas.

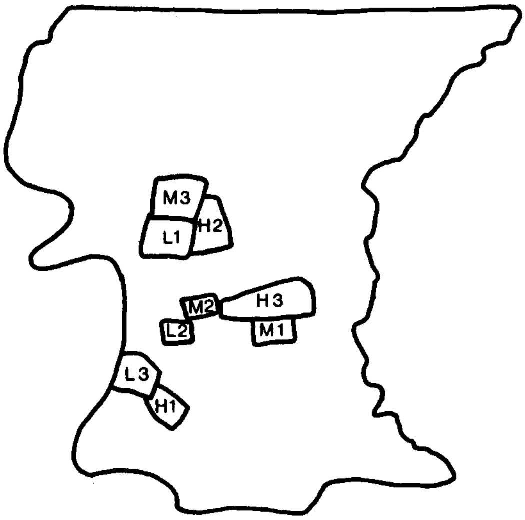

Fig. 1. Location of all census tracts studied for mosquito production from artificial containers in East Baton Rouge Parish, LA May 20 to August 23, 1984.

SAMPLING PROCEDURE. Once the study sites were selected, each inspector located 20 houses scattered throughout their inspection area where homeowner permission could be obtained to conduct a single mosquito survey. The inspector checked the exterior of each house, noting all containers capable of holding water. These were counted, described, and the condition of each container was recorded as dry or wet (not just damp, but holding at least a trace of water) and whether they were positive or negative for mosquito larvae. Container categories included tires, < 5 gallon buckets, > 5 gallon buckets, containers with small openings (tin cans, flower pots, and jars), containers with large openings (wheel barrows, wading pools, bathtubs, birdbaths, and boat hulls), and miscellaneous containers (small bottles, saucers, paper cups, pipes and other irregularly shaped objects). If containers were mosquito positive, a larval sample was collected, the collection site recorded, and later identified to species.

STATISTICAL ANALYSIS. Statistical analysis on the effect that income level and inspector had on the mosquito-container data (total, dry, wet, and positive containers) was based on a split-split-split plot model containing the following sources of variation: income, replicate (income), inspector, inspector/income, inspector/replicate (income), house (income/replicate/inspector), type, income/type, inspector/type and inspector/income/type. The effects of replicate differences within each income level on these same data were tested using a model with the following sources of variation: replicate, inspector and replicate/inspector. There were three income levels, three replicates (census tracts) within each income level, three inspectors within each replicate, and 20 houses in each inspection area. On one occasion, only 18 houses were checked, and the resulting missing observations were replaced by calculated values. These calculated values were configured from the observed means for the houses actually checked in that inspection area. When more than 20 houses were checked by an inspector (twice 21 houses were checked instead of the requested 20), the last observations were deleted to assure equal sample size for statistical analysis. These modifications resulted in a total of 540 houses inspected (180 in each income level). Where overall significant differences were found from ANOVA, means were separated using Fisher's least significant difference (LSD) criterion. A standard transformation ($\sqrt{X+0.5}$) was performed on the container data, with all analysis of variance tests and LSD comparisons being conducted using the transformed data.

Additionally, a series of two-way contingency chi-square tests were run on the data to elucidate the relationship, if any, of container type to income, mosquito species to container

[4] From "Baton Rouge Income Statistics by Census Tract" and "1984 Population and Housing Estimated by Census Tracts East Baton Rouge Parish" obtained from the Office of the Planning Commission, City of Baton Rouge, Parish of East Baton Rouge, LA.

Table 1. Descriptive statistics of census tracts surveyed for backyard mosquito production in East Baton Rouge Parish, LA.

Category	Official census tract number	Median family income	Per capita income	% of families below poverty level
Low				
L-1	31.00	$10,886	$4,128	30.0
L-2	10.00	$ 9,288	$3,667	35.3
L-3	25.00	$10,233	$4,270	35.9
Medium				
M-1	36.02	$19,398	$7,129	8.6
M-2	7.02	$16,994	$6,734	13.5
M-3	42.01	$20,717	$6,297	10.1
High				
H-1	29.00	$27,119	$9,924	7.7
H-2	32.01	$25,484	$8,014	4.4
H-3	35.03	$26,344	$8,690	2.3

type, and mosquito species to income by comparing the observed values against the expected values. Where the overall table chi-square statistics were significant, a series of single degree of freedom chi-square tests were conducted on each cell of the table. This subsequent analysis determined which cells contributed significantly to the overall table chi-square. Mosquito species and mosquito combinations which occurred only once during the course of this study were eliminated from this analysis. And finally, differences in the various income level mosquito production indices (Container, House and Breteau) were analyzed using analysis of variance with income level as the sole source of variation.

RESULTS AND DISCUSSION

TYPE AND FREQUENCY OF CONTAINERS. During the course of this study, an average of 12.89 containers per household were observed at the 540 premises surveyed. Of these, containers having small openings were the most common type, accounting for approximately 61% of the total. These were followed in order by < 5 gallon buckets, > 5 gallon buckets, discarded automobile tires, miscellaneous containers, and containers having large openings, accounting for 10.8, 9.9, 7.2, 5.7 and 4.7% of total containers observed, respectively.

When the condition of the containers (dry, wet and/or positive) were tabulated, an average of 10.20, 2.68 and 0.75 containers per household were dry, wet and positive for mosquito larvae, respectively. As the number of wet containers observed would be affected by the amount of precipitation received, rainfall data compiled by the East Baton Rouge Parish Mosquito Abatement and Rodent Control District were reviewed. Prior to the initiation of the study (from January through May 1984), a total of 17.7 inches (44.9 cm) of precipitation was recorded. This was 6.5 inches (16.5 cm) below the 40 year average for the first five months of the year. However, during the majority of the study (June through August 1984), 16.04 inches (40.7 cm) of rainfall was recorded. This was only 0.24 inches (6 mm) below normal for that time of year. Therefore, the percentage of wet containers was probably representative of this period in a normal mosquito season.

When the types of wet containers were ranked according to frequency of occurrence, virtually the same ranking as with total containers was seen. Containers with small openings were the most common, accounting for 28% of all wet containers. These were followed closely by < 5 gallon buckets, miscellaneous containers, discarded automobile tires, > 5 gallon buckets, and containers with large openings, accounting for 23, 14.7, 13.3, 12.2 and 7.8% of all wet containers, respectively. When the types of wet containers found to be positive for mosquitoes were ranked, an interesting departure was seen from the above patterns. Discarded automobile tires, the fourth most common type of wet container observed, was the most common larval positive container, accounting for 30.8% of all positive containers. Tires were followed by < 5 gallon buckets, miscellaneous containers, > 5 gallon buckets, containers with small openings, and containers with large openings, which accounted for 23.6, 14.2, 12.7, 10.9 and 7.7% of all positive containers, respectively. These trends (small containers being the most frequently observed wet container, while tires were the most frequently observed mosquito positive container), were similar to the trends reported in the earlier studies of Prock and Eatherly (1944) in New Orleans, Louisiana; Tinker (1964) in

Table 2. Mean container condition per household (HH) inspected in the three income levels surveyed in East Baton Rouge Parish, LA May 20 to August 23, 1984.

	Low	Medium	High
Mean Total Container/HH.	14.95[a]	11.59[a]	12.14[a]
Mean Dry Container/HH.	11.09[a]	9.61[a]	9.92[a]
Mean Wet Container/HH.	3.86[a]	1.99[b]	2.22[b]
Mean Pos. Container/HH.	1.13[a]	0.76[b]	0.35[b]

Note: Means on the same line followed by different letters had transformed means that were significantly different ($p<0.05$) using Fisher's protected LSD.

the southeastern United States, Moore et al. (1978) in Puerto Rico, and Focks et al. (1981) in New Orleans, Louisiana.

As the data presented above were collected from three distinct quantifiable income levels, from three different replicates (census tracts) within each income level, from three different inspection areas within each replicate, and from three different inspectors, means for the total, dry, wet and positive containers observed in each of these regions were computed and compared. When replicates within income level, inspection areas within replicate and inspector were compared, no significant differences ($p > 0.05$) were detected. However, as shown in Table 2, when these means were compared across income levels, significantly more ($p < 0.05$) wet and positive containers were observed in low income areas than in the other two areas studied, while no significant differences ($p > 0.05$) in either total or dry containers were detected.

The lack of statistically significant differences in the mean number of total and dry containers per household encountered could be partially explained by the similar trash collection program carried out throughout all study areas by the City-Parish government. The observed income level differences in the mean number of wet containers encountered could at least be partially explained if residents of low income areas did not empty water-filled containers as frequently as residents in either the medium or high income areas studied. The income level differences in the mean number of positive containers could at least be partially explained if containers having a high breeding potential (i.e., discarded automobile tires) had been clustered in one income level, while containers having a low breeding potential (i.e., containers with large openings) had been clustered in another income level. To determine if this type of clustering had occurred, a two-way contingency chi-square test of the frequency of occurrence of each container type by income was conducted. This analysis produced an overall significant table chi-square ($\chi^2 = 36.383$, $p < 0.0001$, df = 10). Subsequent single degree of freedom chi-square tests showed that tires were observed more frequently ($\chi^2 = 4.2$, $p < 0.05$) in low income areas and less frequently ($\chi^2 = 4.0$, $p < 0.05$) in high income areas than would have been expected, while containers with large openings were observed more frequently ($\chi^2 = 4.6$, $p < 0.05$) in high income areas and less frequently ($\chi^2 = 5.5$, $p < 0.05$) in low income areas than would have been expected.

MOSQUITO SPECIES BREAKDOWN. During this study, four mosquito species (*Ae. triseriatus*, *Ae. aegypti*, *Culex quinquefasciatus* and *Cx. salinarius* Coquillett), and three combinations of species (*Ae. triseriatus*/*Ae. aegypti*, *Ae. triseriatus*/*Cx. quinquefasciatus*, *Cx. quinquefasciatus*/*Cx. salinarius*) were collected from individual containers in East Baton Rouge Parish. When these mosquito species/combinations were ranked with regard to their frequency of occurrence, *Ae. triseriatus* was determined to be the most common mosquito species encountered, occurring in 57.3% of the positive containers. This species was followed in descending order by the species *Cx. quinquefasciatus*, the combination *Ae. triseriatus*/*Ae. aegypti*, the species *Ae. aegypti*, the combination *Ae. triseriatus*/*Cx. quinquefasciatus*, the species *Cx. salinarius*, and the combination *Cx. quinquefasciatus*/*Cx. salinarius* being observed in 17.5, 14.7, 5.9 3.9, 0.4, and 0.4% of the remaining positive containers.

When income level was taken into account, two species (*Ae. triseriatus* and *Cx. quinquefasciatus*) and two combinations (*Ae. triseriatus*/*Ae. aegypti* and *Ae. triseriatus*/*Cx. quinquefasciatus*) were collected from containers encountered in all three income levels, while larvae of one species, *Ae. aegypti*, was collected by itself in only the medium and low income areas. One species, *Cx. salinarius*, and one combination, *Cx. quinquefasciatus*/*Cx. salinarius* were collected only once during the entire study, with that occurrence being in a high income area.

The frequency of occurrence of these mosquito species and combinations within each income level were analyzed to check for any mosquito species-income level interactions using a two-way contingency chi-square test. This analysis produced a significant overall table chi-square ($\chi^2 = 34.485$, $p < 0.0001$, df = 8).

Subsequent single degree of freedom chi-square tests showed that *Ae. aegypti* occurred more frequently ($\chi^2 = 7.3$, $p < 0.05$) in low income areas and less frequently ($\chi^2 = 4.1$, $p < 0.05$) in middle income areas than would have been expected, while *Cx. quinquefasciatus* occurred more frequently ($\chi^2 = 7.2$, $p < 0.05$) in high income areas and less frequently ($\chi^2 = 6.2$, $p < 0.05$) in low income areas than would have been expected.

This observed grouping of mosquito species within income level could be partially explained if these mosquitoes exhibited an ovipositional "preference for" or "avoidance of" container types which had previously been shown to occur more frequently within certain income levels. To test for possible ovipositional "preference" (based on significantly more mosquitoes being observed within a container type than would have been expected) or "avoidance" (based on significantly fewer mosquitoes being observed within a container type than would have been expected) in this study, a two-way contingency chi-square test was conducted. This analysis also produced a significant overall chi-square ($\chi^2 = 59.358$, $p < 0.0001$, df = 20). Subsequent single degree of freedom chi-square tests showed that the species *Ae. aegypti* and the combination *Ae. triseriatus/Ae. aegypti* "preferred" to oviposit in tires ($\chi^2 = 13.9$, $p < 0.05$ and $\chi^2 = 12.2$, $p < 0.05$, respectively), while the species *Cx. quinquefasciatus* "preferred" to oviposit in containers with large openings ($\chi^2 = 5.6$, $p < 0.05$) and tended to "avoid" ovipositing in tires ($\chi^2 = 5.9$, $p < 0.05$).

Using the data above, a number of indices usually used to describe *Ae. aegypti* production from manufactured containers were computed to better describe the overall mosquito population in East Baton Rouge Parish. Due to the disease vector potential for the mosquito species encountered during this study, a Container Index (percent of water filled containers positive for mosquito larvae) of 27.7, a House Index (percent of positive houses) of 37.9, and a Breteau Index (number of positive containers per 100 houses) of 74.5 were computed for East Baton Rouge Parish without regard to mosquito species observed.

As the information necessary to compute the overall indices was collected from three different income levels, separate Container, House, and Breteau indices were computed for each income level studied. As shown in Table 3, significant differences ($p < 0.05$) were observed when each of these indices were compared across income levels, with the areas categorized as low income producing the highest mosquito breeding indices. Not only did low income areas have significantly more houses positive for mosquito larvae than middle income areas (which had significantly more houses positive for mosquito larvae than high income areas), they also had significantly more positive containers per inspected premises than in either of the other two income levels. The low and the middle income areas had approximately the same number of water filled containers positive for mosquito larvae, with these being significantly more than were located in high income areas.

CONCLUSIONS

The differences in the three income levels studied were significantly associated with the amount, type and condition of the containers encountered, as well as the mosquito species and extent of breeding observed in these areas. Low income areas usually produced more mosquitoes than either of the other two income levels studied, mainly as a result of the types of containers which were found there. Additionally, this study illustrated the usefulness and importance of using census tracts, and their accompanying statistics, to objectively select (instead of a more subjective method) areas used for artificial container mosquito production studies. Once such baseline data are collected, mosquito abatement districts may more objectively select areas for community source reduction (clean-up) campaigns, and/or may use the information to support educational programs.

Table 3. Indices for mosquito production from artificial containers in the three income levels surveyed in East Baton Rouge Parish, LA between May 20 and August 23, 1984.

Index	Low	Medium	High
Container (%)	29.25[a]	38.36[a]	15.74[b]
House (%)	56.67[a]	36.11[b]	21.11[c]
Breteau	112.76[a]	75.89[b]	34.98[b]

Note: Indices on the same line followed by different letters were significantly different ($p<0.05$) using Fisher's protected LSD.

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