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Seasonal surveillance of *Aedes aegypti* and *Aedes albopictus*, and development time of immatures at the university campus of Southern Chiapas – Mexico

Karolina López-Gómez[1], Fernando Isabel Velázquez-López[1], Juan Guillermo Bond[2], Carlos F. Marina[2], Armando Ulloa-García[1]

ABSTRACT

Introduction: *Aedes aegypti* is the most important vector of dengue, chikungunya and Zika viruses, while *Aedes albopictus* (Skuse) is considered a secondary vector of dengue and other zoonotic viruses. **Objective**: To study the populations of *A. aegypti* and *A. albopictus* in the rainy and dry seasons using ovitraps and to evaluate the parameters of immature development time in a laboratory setting. **Materials and methods**: The study was carried out at the Faculty of Chemical Sciences of the Autonomous University of Chiapas. The study area was divided into 4 zones: north, south, east and west, with 5 ovitraps were placed in each zone. With this design, sampling was carried out during the rainy season (August, September, October and November, 2022); and during the dry season (January, February, March and April, 2023). **Results**: Egg proportional amounts were compared between the two seasons, and significant differences were detected ($T = 4.20$; $gl = 126$; $p = 0.001$). Moreover, an analysis of variance established that there were no significant differences between the four zones or sampling sites during the rainy season ($F = 0.835$; $gl = 3$; $p = 0.48$) and the dry season ($F = 0.119$; $gl = 3$; $p = 0.94$). **Conclusion**: This study indicated that *A. albopictus* was the main dominant species in the study area, reducing the risk of dengue transmission in the university community.

Keywords: entomological surveillance; diversity; mosquito; geographical distribution; dynamical seasonal; ovitraps.

[1] Facultad de Ciencias Químicas, Campus IV, Universidad Autónoma de Chiapas, Tapachula, Chiapas; México.

[2] Centro Regional de Investigación en Salud Pública/INSP. Tapachula, Chiapas; México.

Correspondence author: Armando Ulloa-García. E-mail: armando.ulloa@unach.mx

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Vigilancia estacional de Aedes aegypti y Aedes albopictus, y tiempo de desarrollo de inmaduros en el campus universitario del Sur de Chiapas, Mexico

RESUMEN

Introducción: Aedes aegypti es el vector más importante de los virus del dengue, chikungunya y zika; mientras que Aedes albopictus (Skuse) es considerado un vector secundario del dengue y de otros virus zoonóticos.

Objetivos: Estudiar las poblaciones de A. aegypti y A. albopictus en la estación de lluvias y secas mediante el uso de ovitrampas y evaluar los paramentos del tiempo de desarrollo de inmaduros en laboratorio.

Materiales y método: El estudio se llevó a cabo en la Facultad de Ciencias Químicas de la Universidad Autónoma de Chiapas (México). El área de estudio se dividió en 4 zonas: norte, sur, este y oeste, y en cada una se colocaron 5 ovitrampas. Con este diseño se realizaron muestreos en la época de lluvias (agosto, septiembre, octubre y noviembre de 2022) y en la época seca (enero, febrero, marzo y abril de 2023).

Resultados: Se compararon las proporciones de huevos entre las dos estaciones, y se detectaron diferencias significativas ($F = 4,20$; $gl = 126$; $p = 0,001$). Por otra parte, un análisis de varianza estableció que no hubo diferencias significativas entre las cuatro zonas o sitios de muestreo en la estación de lluvias ($F = 0,835$; $gl = 3$; $p = 0,48$) y la estación de secas ($F = 0,119$; $gl = 3$; $p = 0,94$).

Conclusión: Este estudio indicó que A. albopictus fue la principal especie dominante en el área de estudio. Ello reduce el riesgo de transmisión del dengue en la comunidad universitaria.

Palabras clave: vigilancia entomológica; diversidad; mosquitos; distribución geográfica; dinámica estacional; ovitrampas.

Vigilância sazonal de *Aedes aegypti* e *Aedes albopictus* e tempo de desenvolvimento dos imaturos no campus universitário do Sul de Chiapas, México

RESUMO

Introdução: *Aedes aegypti* é o vetor mais importante dos vírus da dengue, Chikungunya e zika; enquanto Aedes albopictus (Skuse) é considerado um vector secundário da dengue e de outros vírus zoonóticos.

Objectives: Estudar as populações de *A. aegypty* e *A. albopictus* nas estações de chuva e seca por meio do uso de ovitrampas e avaliar os parâmetros do tempo de desenvolvimento dos imaturos em laboratório.

Materiais e método: O estudo foi realizado na Faculdade de Ciências Químicas da Universidade Autônoma de Chiapas (México). A área de estudo foi dividida em 4 zonas: norte, sul, leste e oeste, e em cada uma foram colocadas 5 ovitrampas. Com este desenho, foram realizadas amostragens na época das chuvas (agosto, setembro, outubro e novembro de 2022) e na época seca (janeiro, fevereiro, março e abril de 2023).

Resultados: Foram comparadas as proporções de ovos entre as duas estações, e foram detectadas diferenças significativas (F = 4,20; gl = 126; p = 0,001). Por outro lado, uma análise de variância estabeleceu que não houve diferenças significativas entre as quatro zonas ou locais de amostragem na estação faz chuvas (F = 0,835; gl = 3; p = 0,48) e na estação seca (F = 0,119; gl = 3; p = 0,94).

Conclusão: Este estudo indicou que *A. albopictus* foi a principal espécie dominante na área de estudo. Isso reduz o risco de transmissão da dengue na comunidade universitária.

Palavras-chave: vigilância entomológica; diversidade; mosquitos; distribuição geográfica; dinâmica sazonal; ovitrampas.

INTRODUCTION

Mosquitoes of the species *Aedes aegypti* and *Aedes albopictus* are geographically distributed in North, Central and South America, which makes their presence a potential risk for public health, due to the transmission of Dengue, Zika, Chikungunya, and other viruses (1). Recent data has suggested that both species can coexist in urban and rural areas, due to the colonization of new habitats and possible new hosts, expanding the potential risk for public health (2,3). Based on the above-mentioned background, it is important to have surveillance studies of the distribution, temporal dynamics (rains and droughts), and abundance of *A. aegypti* and *A. albopictus* populations at the local and regional levels and thus establish control strategies to mitigate the risk of transmission (4).

In the field of entomological surveillance, there are field techniques to study the population dynamics of the vectors. One of them is the use of ovitraps for *A. aegypti* and *A. albopictus* population sampling very sensitive and cost-effective surveillance apparatus. As well as, are considered as an excellent tool to detect the presence of the vector and to compare infestations among different areas and seasons (5,6). Based on this background, the interest of this research was to compare the seasonal abundance between *A. aegypti* and *A. albopictus* at the Faculty of Chemical Sciences, Campus IV.

MATERIAL AND METHODS

Study area

This study was carried out at the Faculty of Chemical Sciences, Campus IV, Autonomous University of Chiapas (14°89´29´´N, 92°27´30´´W) located within Tapachula City, surrounded by residential areas and shopping centers (Figure 1). The total distance of the perimeter was 550 m, and proximally 15,500 m^2 of total surface. The study area was divided into four zones: north, south, east and west. In each zone, 5 ovitraps were placed (1-5, 5-10, 10-15 and 15-20). With this design3 three samples were taken in the rainy season during August, September, October, and November, 2022; with the dry season including January, February, March, and April, 2023.

The vegetation surrounding the study area is represented by oaks (*Quercus robur*), cedar (*Cedrela odorata*), primavera (*Roseodendron donnel-smithi*), strangler fig (*Ficus nymphaeifolia*); and fruit trees such as mango (*Mangifera indica*), nance (*Byrsonima crassifolia*), guanabana (*Annona muricata*), almond (*Prunus dulcis*), and ornamental trees, such as palms (*Syagrus romanzoffiana*) and Indian laurel *(Ficus microcarpa*). The average temperature and relative humidity during the rainy and dry season were 24.3 °C and 30 °C, and 89% and 83.5%, respectively. During the rainy season, a total of 2314 mm of precipitation was reported (7).

Figure 1. Map owned by Google Maps

Note: Study area (yellow letters), and neighboring houses (blue box).

Mosquito collections

For the sampling of *Aedes* spp. and mosquito eggs, ovitraps consisting of black plastic containers (10 cm diameter, 20 cm height, filled three-quarters full with 1 L of dechlorinated tap water) were used. A ring of Whatman filter paper (5 cm width × 35 cm length) was placed around the inside of each ovitrap at water level as oviposition substrate (2,8). After 48 h, the ovitraps were collected and transferred to the laboratory. Filter paper was removed from each ovitrap and the number of eggs collected was recorded visually using a stereoscope.

In the laboratory, the temperature was controlled at 70-80% relative humidity with a temperature of 27 °C during the day. Each filter paper was deposited in plastic trays without water for 2 days; each tray was labeled with the field number. After 2 days, 100 ml of purified tap water at a temperature at 28 °C, were added to each tray to stimulate larval hatching. After hatching, the number of eggs, pupae and adults were recorded in established formats.

Identification of the species

For the taxonomic identification of the mosquito species, a stereoscopic microscope using morphological characteristics described by Savage and Smith (9) and Rueda (10) was used.

Data processing

The total number of eggs collected in the dry and rainy season in each sampling area was grouped and the abundance was expressed as the number of mosquitoes collected in each area. An analysis of variance test was used to test for differences between collection areas. Differences in hatching versus not hatching rates were examined by contingency table analyses. The data were subjected to an analysis of normality and homogeneity of variations, using the Kolmogorov-Smirnov test. Upon determining that no normal distribution was observed, these were transformed to Log $X + 1$. Egg abundance t-tests were used to compare egg abundance between data obtained in the dry and rainy seasons.

RESULTS

Overall, in the rainy season, a total of 68 ovitraps were placed in the study area, of which 88% (60 of 68) were positive, for the presence of eggs, while in the dry season, 60 ovitraps were placed, of which 58% (35 of 60) were positive, for the presence of eggs. The total number of eggs in the positive ovitraps, in the rainy season was 3361 (mean $\bar{X} = 49.4 \pm 5.8$ eggs per ovitrap), while in the dry season was 1191 eggs ($\bar{X} = 19.8 \pm 3.6$ eggs per trap). Significant differences were detected in the total number of eggs between the two seasons ($T = 4.20$; $df = 126$; $p = 0.001$). Data obtained in each station were compared among the four zones using a univariate analysis of variance test, which suggested that there were no significant differences among the four zones or sampling sites between the rainy ($F = 0.835$; $df = 3$; $p = 0.480$) and dry ($F = 0.119$; $df = 3$; $p = 0.94$) seasons.

Based on the same idea, each ring of Whatman filter paper from the egg-positive ovitraps was immersed in water for larval hatching. Of the 60 positive papers obtained in the rainy season, 53% (32 of 60) showed hatching, and 28 did not hatch. Of the 35 positive papers obtained in the dry season, 77% (27 of 35) hatched and the remaining 8 did not. Chi-square analysis showed a significant difference between those that hatched and those that not hatched ($\chi^2 = 4.37$; $df = 1$; $p = 0.03$) (Table 1).

Table 1. Number of ovitraps with hatching and no hatching rain season and dry season

Rain season	Total 68	Ovitraps	Hatching	No hatching
	Positive ovitrap	60 (88%)	32 (53%)	28 (47%)
	Negative ovitrap	8 (12%)		
Dry season	Total 60	Ovitraps	Hatching	No hatching
	Positive ovitraps	35 (58%)	27 (77%)	8 (33%)
	Negative ovitraps	25 (42%)		
				(χ^2 = 4.37; df = 1; p = 0.03)

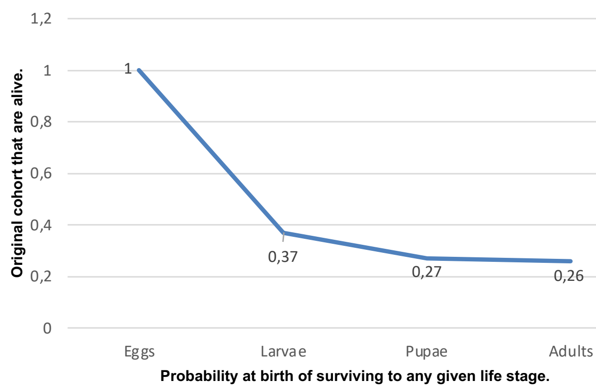
In relation to the cohorts of immature stages under laboratory conditions, of the 3361 eggs collected in rainy season, a total of 1262 (38%) hatched as larvae, of these, a total of 941 pupae (75%), and 898 (95%) emerged as adults. Similar results were obtained with eggs collected in the dry season, of 1191 eggs a total of 739 (62%) hatched as larvae, and of these a total 464 (37%) became pupae, of which a total of 431 (93%) emerged as adults. These data are shown in a life table for further interpretation of survival by stage (Table 2, Figure 1).

Table 2. Life table of *Aedes aegypti* y *Aedes albopictus*

	nx	Lx	dx	qx	% mortality apparent	% mortality real
Eggs	3361	1.00	0.600	0.60	0	0
Larvae	1262	0.37	0.100	0.27	452	38
Pupae	941	0.27	0.010	0.00	275	37
Adults	898	0.26			33	7

nx: The number of individuals from the original cohort that are alive at the specified age, age class, or life stage (x). *lx:* The number of individuals surviving to any given life stage as a proportion of the original cohort size. lx represents the probability at birth of surviving to any given life stage. *dx:* The difference between the number of individuals alive for any age class (*nx*) and the next older age class (*nx* + 1 + 1) is the number of individuals that have died during that time intervals. dx is a measure of age-specific mortality. *qx:* The number of individuals that died during any given time interval (dx) divided by the number alive at the beginning of that interval (nx) provides an age-specific mortality rate.

Figure 1. lx: Proportion of the original cohort of survival in each age group



Finally, *A. albopictus* was the most abundant specie caught in the rainy and dry seasons, with a total of 898 specimens (436 females and 462 males) and 295 (162 females and 132 males), respectively. In relation to *A. aegypti*, an unexpected abundance was recorded, with only 136 specimens in the dry season (85 females and 51 males) (Table 3).

Table 3. Abundance of species of mosquitos in rain and dry season, in the study area

	Total: 898 (67%)	Mosquitoes species
Rain season	436	A. A. albopictus, females
	462	A. albopictus, males
Dry season	Total: 295 (22%)	Mosquitoes species
	162	A. albopictus females
	133	A. albopictus males
	Total: 136 (11%)	Mosquitoes species
	85	A. aegypti females
	51	A. aegypti males
	Total: 1329	

DISCUSSION

In the present study was observed a dominance of positive ovitraps more than 50%, being 60 and 35 in rainy and dry seasons, respectively. It is possible that this result is related to the finding that the distribution of both species were the same in the four sampling sites in rainy and dry conditions, despite other possible breeding sites where they reproduce naturally and which may increase abundance in the study area, and which were not the subject of this study (11,12). Our results contrast with those obtained by Trava et al. (6), who conducted a seasonal study using ovitraps, in which was observed a higher proportion of negative ovitraps in the dry season. In order to identify the presence of *A. aegypti* and *A. albopictus* in the study area, data on their presence was obtained by laboratory rearing using eggs collected in the different study areas. We deduce that the presence of gravid adult mosquitoes could come from populations breeding within the study area or from mosquitoes spreading into the study area from neighboring houses. Interestingly, during the rainy season only *A. albopictus* was recorded, while during the dry season both species were found, although *A. albopictus* was dominant with respect to the presence of *A. aegypti*. The predominance of *A. albopictus* in the area studied may be due to a higher density of vegetation compared with the surrounding inhabited areas (9). It is also likely to benefit from a combination of the preference of this species to oviposit in natural sites over artificial containers and their ability to feed on a range of different peridomestic animal species over humans (12,13). It has been shown that the environmental conditions of the dry season can favor the increase of the populations of *A. aegypti* and influence the decrease of those of *A. albopictus* (2). High temperatures and low humidity conditions are generally less favorable for *A. albopictus* because eggs are less tolerant to desiccation and decrease their populations. In contrast, these conditions are more favorable for *A. aegypti* because its eggs are resistant to desiccation (14). Therefore, we think that the presence of *A. aegypti* in the study area during the dry season may be due to a repopulation of this species from the surrounding inhabited areas, taking advantage of the decrease in the *A. albopictus* population.

In relation to the duration of the cycle from egg to adult, which can be influenced by temperature, light, food quality, intra and interspecific competition, the complete cycle was on average 14 and 15 days in samples collected in dry and rainy season respectively. Lwande et al. (15) reported that under favorable conditions, especially at high temperatures and flooding, eggs of both *A. aegypti* and *A. albopictus* hatch within a few days into larvae. Thereafter, the larvae undergo four molts, which can last from 9 to 13 days. Male mosquitoes develop faster than the females and molt earlier into pupae. After a period of 2 days, pupae develop further into adult mosquitoes. This survival behavior depends on the rearing conditions. Finally, a decreasing ratio of eggs to larvae, larvae to pupa and another minimal ratio to adult was observed. This relation between different stages was also observed in this study, according to the life table reported. Thirion (16), mentions that the time that each individual remains in this stage depends mainly on the availability of food, temperature, and larval density in the hatchery. Therefore, if this phenomenon occurs at the laboratory rearing level where appropriate conditions are available, at the natural level it would be expected that these events would occur in a more critical way, due to other factors such as predation, organic matter, among other etc.

CONCLUSION

In this study, we found a low presence of *A. aegypti*, so we concluded that *A. albopictus* was the main dominant species in the study area, reducing the risk of dengue transmission in the university community.

LIMITATIONS OF THE STUDY

The main limitation of this study was that there were no resources to continue sampling for at least one more year in order to have evidence on the behavior of both populations.

ETHICS STATEMENT

All methods were carried out in accordance with relevant guidelines and regulations and approval for collecting and handling animal.

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FINANCING

Own resources.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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