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Dispersion of *Aedes aegypti* (Linnaeus, 1762) and *Aedes albopictus* (Skuse, 1894) in the Rural Zone of North Paraná State

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ABSTRACT

Seventy-two tyres were placed in four transects (Northern, Southern, Eastern and Western), every 5 km, from the Londrina city limits to the rural areas, to verify the dispersion of Aedes aegypti *and* Ae. albopictus *vectors. Mosquito larvae were collected fortnightly from August 1998 to August 1999. Data were organized according to the average number of larvae collected for each species in each collection site. A total of 62,517 mosquito larvae were collected and distributed into the following species:* Aedes albopictus (21.71%); Ae. aegypti (5.54%); Ae. terrens (0.53%); Ae. fluviatilis (0.36%); Anopheles argyritarsi (0.01%); Culex quinquefasciatus (48.37%); Cx. mollis (8.88%); Cx. eduardoi (8.65%); Cx. corniger (0.61%); Cx. bigoti (0.24%); Cx. *group* coronator (0.12%); Limatus durhanii (4.61%) *and* Toxorhynchites sp. (0.32%). *There was a drastic decrease in the* Ae. aegypti *population from the city limits to the rural area ($x_1 = 21.72 \pm 4.71$; $x_2 = 0.00$) and an increase in the population of* Ae. albopictus *($x_1 = 15.64 \pm 2.73$; $x_2 = 38.37 \pm 8.87$).* Aedes aegypti *was not present in the collection sites located 30 km away from the urban area; however,* Ae. albopictus *was found in all the sites. Although the frequency rate for the* Aedes aegypti *was low, both species were dispersed in the rural area studied. The redimensioning of these vectors' control areas is recommended since rural areas can function as reservoirs for these species.*

Key words: *Aedes*, population dispersion; dengue, prevention and control; breeding sites

INTRODUCTION

Aedes (Stegomyia) aegypti (L., 1762) is the main dengue vector species found in urban areas. In some Brazilian regions, this virulent disease has reached epidemic levels, with the detection of the D1, D2, D3 and D4 sorotypes. *Aedes (Stegomyia) albopictus* (Skuse, 1894) is the main dengue and yellow fever vector found in the Asian continent, whereas in Brazil its vectorial activity has not been proved yet. However, Mitchell and Miller (1990) reported a dengue virus vertical transmission by one Brazilian population of *Ae. albopictus*. Serufo et al. (1993) detected in Campos Altos, Minas Gerais, Brazil, *Ae. albopictus* larva infected by the D1 virus.

Aedes aegypti is a highly domesticated mosquito, which prefers to lay eggs in artificial breeding places widely found in tropical urban areas. The dumping of used tyres and plastic containers has increased in the last few years, contributing to the increase of *Ae. aegypti* populations in tropical

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urban areas. Since these items retain water, they turn into breeding places, potentially increase the incidence of diseases caused by the etiological agents transmitted by these mosquitoes (Gubler, 1998).

The presence of *Ae. albopictus* in South America was firstly reported by Forattini (1986), who confirmed the homology and sympatricity in *Ae. aegypti* and *Ae. albopictus,* and the greater degree of exofilia and wild habits in *Ae. albopictus*. In the urban area of Londrina, Paraná, Brazil, *Ae. aegypti* was first detected in 1985, by Lopes *et al* (1993) and the *Ae. albopictus* was first detected by FUNASA (Fundação Nacional da Saúde) in 1993.

Recent research on the presence of *Ae. aegypti* and *Ae. albopictus* in urban areas has investigated the dispersion capacity of these species either by mark-release-recapture techniques (Edman et al., 1998; Muir and Kay, 1998) or by feeding females with blood containing rubidium, a substance that can be detected in eggs through atomic spectroscopy (Reiter, 1996). These studies showed that contrary to the current concepts of dispersion, *Ae. aegypti* females dispersed up to 800 m to lay their eggs. This dispersion pattern is related to weather conditions and to the availability of larval habitats (Edman et al., 1998). Thus, the elimination of breeding places can stimulate dispersion and/or increase the egg- laying period. Campaigns against dengue in Brazil are carried out by eradicating egg-laying sites and by forcing the vector species to disperse to the most remote areas away from the city or to the city's surrounding areas in search of breeding sites. The government had recently concluded the first phase of a national *Ae. aegypti* eradication campaign (PEAa); however, results were unsatisfactory. More scientific information on the biological and ecological characteristics of this vector species is necessary for the development of further control actions.

The objective of this study was to evaluate the possible dispersion pattern of *Ae. aegypti* and *Ae. albopictus* in the periurban and rural areas of Metropolitan region of Londrina, Paraná, Brazil.

MATERIAL AND METHODS

Four transects oriented to the cardinal points were drawn from the city limits of Londrina, Paraná (23º08'47"S; 50º52'23"W), to the rural areas, as far as the neighboring counties of Cambé, Ibiporã, Sertanópolis and Rolândia (Fig. 1). The experiment was divided into 2 phases:

Phase 1: From 08.01.98 to 02.01.99

Five collection sites, set 5 km apart from each other, were established for each transect, starting at the city limit. Three tyres filled with two liters of water were placed vertically at three locations: one near the house, another at 10m from the house and other 20m from the house.

Phase 2: From 03.01.99 to 08.01.99

With the detection of *Ae. albopictus* and *Ae. aegypti* dispersion during the first phase of this study, especially in the tyres placed at collection sites closer to the city limit, a re-organization of the sites was made. All sites set along the Northern and Western transects were eliminated, and two new sites were added: one 25 km from the city limit and the other 30 km. As for the Southern transects, collection sites set at 5 and 15 km away from the city limit were eliminated and a new one was added at 25 km. A new site was added at 25 km from the city limit along the eastern transect, and the collection site at the city limit was eliminated. During this phase, all tyres placed 20 km away from the houses were eliminated.

Collection sites were checked fortnightly and the material was collected by taking all the water out of the tyres through a 100 µm meshed sieve, into a silver tray and then into a plastic receptacle. Next, the water was poured back into the tyres and filled with more water to reach the level whenever needed. First, second and third instar larva were kept alive to mature to the fourth instar. Pupae were bred into adults. Fourth instar larva and exuvia were mounted on microscope slides containing Hoyer's medium for specific identification. One sample of collected larva was reared to compare the larva exuvia to their respective adults. Data on temperature and precipitation were provided by IAPAR (Instituto Agronômico do Panará). Experimental data were organized in a graph according to distances, larval means and standard errors, to detect differences which could represent the dispersion of these species.

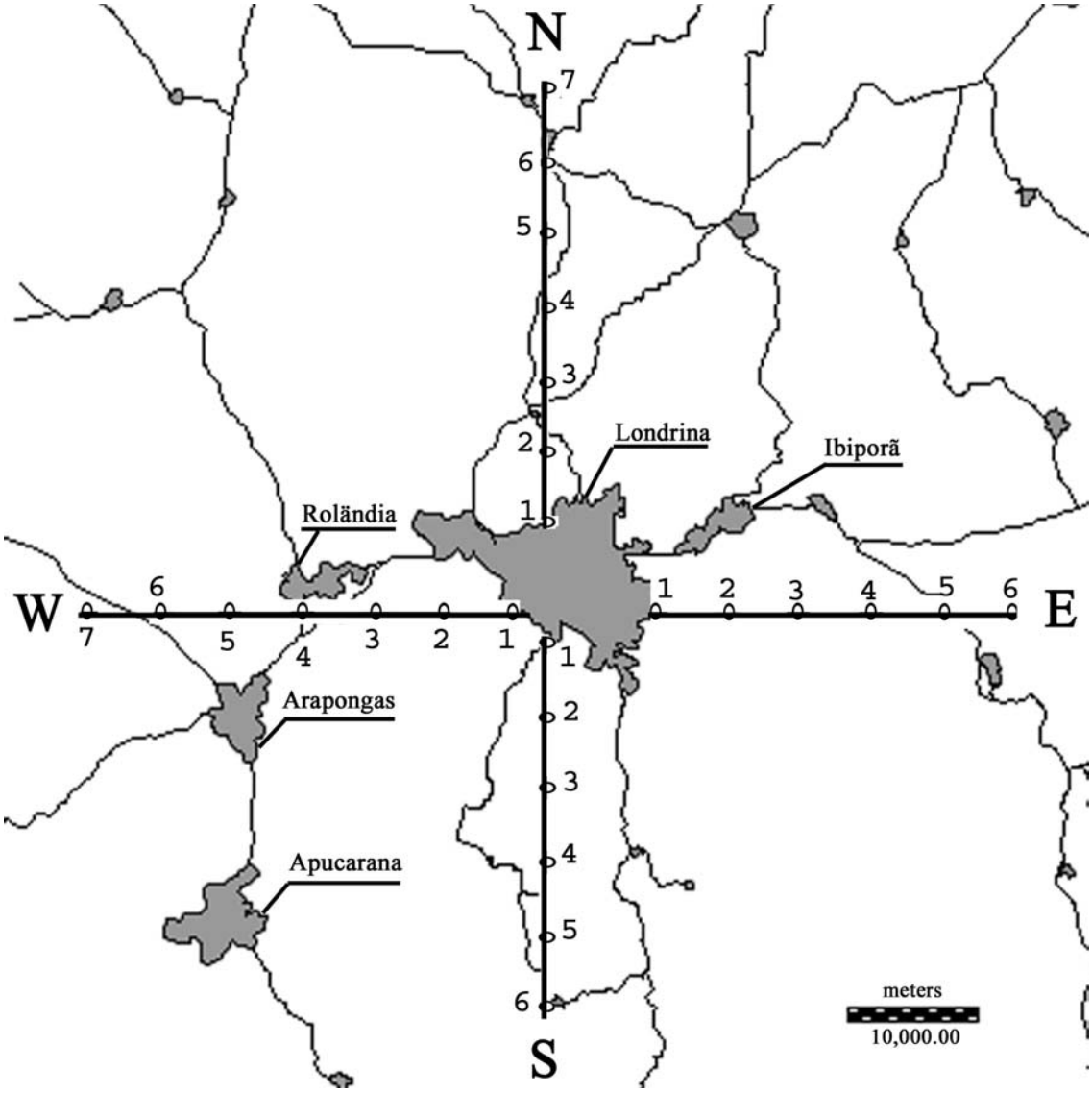

Figure 1 - Distribution of collection sites in four transects from Londrina limit to rural zone.

RESULTS

This study was carried out from August 1998 to August 1999, with pause in collects during the month of January, 1999. From the 24 collections, 62,517 samples of 13 species of Culicidae were identified (Table 1). *Aedes albopictus* was the most commonly found species (21.7%), outnumbered only by the *Culex quinquefasciatus* (48.4%), a native species (Table 2). *Culex quinquefasciatus* was the most abundant species in the periurban area, and was outnumbered by *Ae. albopictus* in the more distant collection sites (Fig. 2). *Aedes aegypti* population density decreased significantly as the transect moved farther from urban areas whereas the opposite happened with *Ae. albopictus* (Fig 2).

In this study, farm houses were always surrounded by orchards and brushwood. This could influence the activity of these hematophagus insects. Figure 2 shows the data collected from tyres placed at 0, 10 and 20 m from houses. No significant differences were found among the *Ae. aegypti* collected from tyres placed at these distances. Data showed that in the distances in which *Ae. albopictus* was more abundant, *Ae. aegypti* density was smaller (Fig. 3). *Aedes aegypti* was most frequently found in the Northern transect, followed by the Western, Southern and Eastern transects, respectively. *Aedes albopictus* also showed

preference for the Northern transect, however, the transect with the lowest frequency was the Southern and there were no significant differences between the Eastern and the Western transects (Fig. 4).

Both species were abundant during the first semester: *Ae. albopictus* in March and April and *Ae. aegypti* in June (Fig. 5). During the *Ae. albopictus* high frequency months, the precipitation was less than 130 mm per month.

Table 1 - Total and frequency of Culicidae collected in periurban and rural zone in Londrina City, Paraná, Brazil, from August 1998 to August 1999.

Specie	Quantity	Frequency (%)
Aedes albopictus	13,576	21.71
Aedes aegypti	3,466	5.54
Aedes terrens	334	0.53
Aedes fluviatilis	226	0.36
Anopheles argiritarsi	6	0.01
Culex quinquefasciatus	30,245	48.37
Culex mollis	5,552	8.88
Culex eduardoi	5,408	8.65
Culex corniger	382	0.61
Culex bigoti	156	0.24
Culex group *coronator*	77	0.12
Limatus durhanii	2,884	4.61
Toxorhynchites sp.	205	0.32
Total	**62,517**	

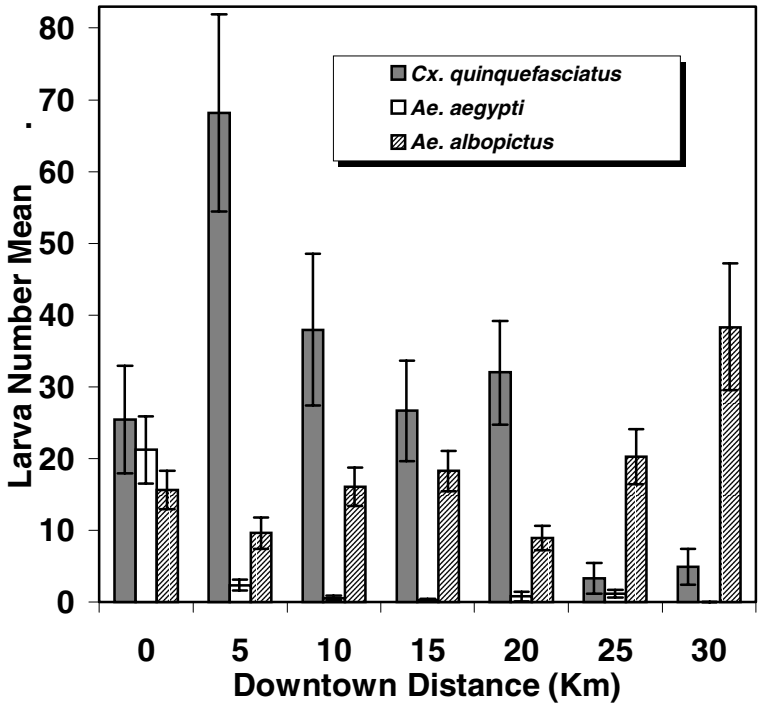

Figure 2 - Distribution of *Culex quinquefasciatus, Aedes aegypti* and *Ae. albopictus* by different distances from the Londrina urban zone limit, Paraná State, Brazil, collected in tyres located in peridomestic sites from August 1998 to August 1999.

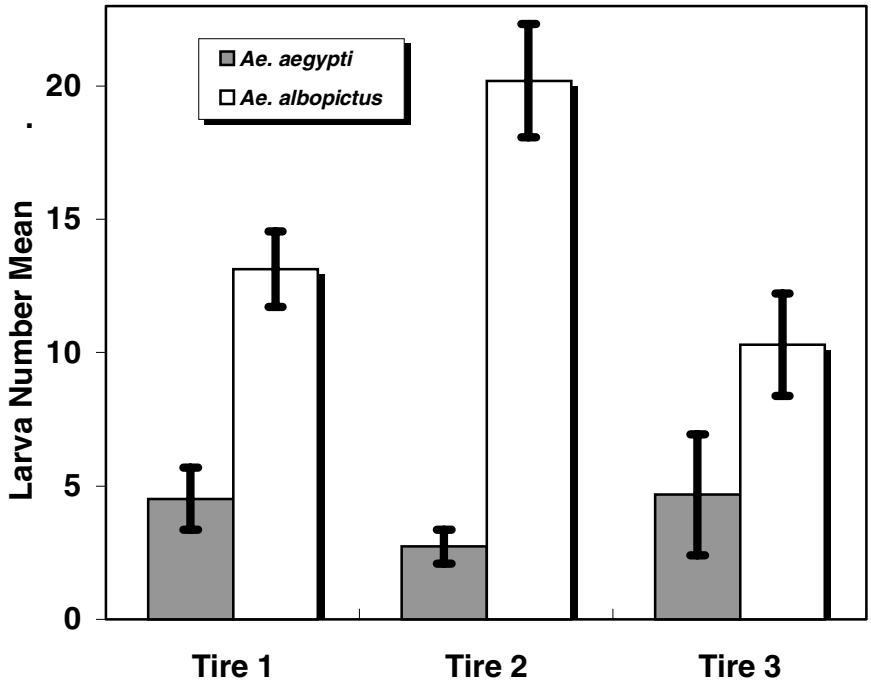

Figure 3 - Populational density variation of *Aedes aegypti* and *Aedes albopictus* by distance of tyres from residences, collected in Londrina, Paraná, Brazil. Tire 1 - 0 m; Tire 2 - 10 m; Tire 3 - 20 m.

Table 2 - Total and average of larval number of the most frequent species collected in tyres installed in rural peridomestic sites, distributed from Londrina urban area to rural locations, Paraná, Brazil, from August 1998 to August 1999.

Distance from Londrina	***Culex quinquefasciatus***	***Cx. mollis***	***Cx. eduardoi***	***Aedes albopictus***	***Ae. aegypti***
0 km	3,257	233	934	2,002	2,716
Mean	**25.45**	**1.82**	**7.02**	**15.64**	**21.22**
5 km	10,645	689	1,837	1,502	370
Mean	**68.22**	**4.17**	**11.13**	**9.63**	**2.37**
10 km	6,151	1559	1,234	2,602	95
Mean	**37.96**	**9.62**	**6.73**	**16.06**	**0.59**
15 km	3,895	635	614	2,670	44
Mean	**26.65**	**3.60**	**4.21**	**18.28**	**0.30**
20 km	5,830	1,896	630	1,622	143
Mean	**32.01**	**10.42**	**3.46**	**8.91**	**0.79**
25 km	270	249	159	1,643	98
Mean	**3.33**	**3.07**	**1.96**	**20.28**	**1.21**
30 km	197	291	0	1,535	0
Mean	**4.93**	**7.28**	**0.00**	**38.38**	**0.00**
Total	**30,245**	**5,552**	**5,408**	**13,576**	**3,466**

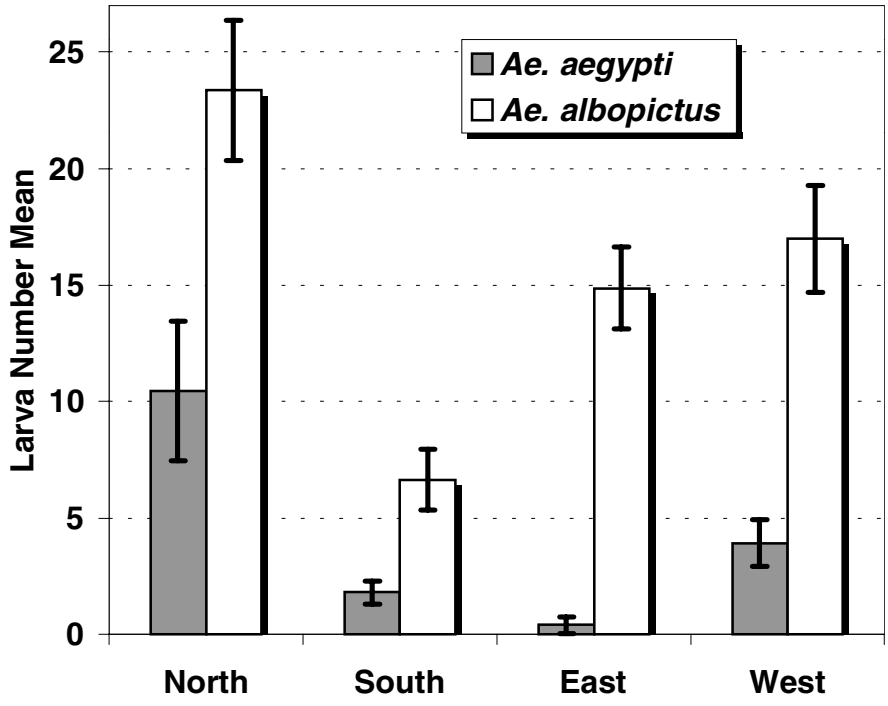

Figure 4 - Distribution of *Aedes aegypti* and *Ae. albopictus* in tyres in the four different transects in Londrina City, Paraná, Brazil, collected from August 1998 to August 1999.

DISCUSSION

A large number of *Ae. aegypti* and *Ae. albopictus* were collected from the tyres placed in the periurban and rural areas of Londrina, Paraná. At the most distant sites, *Ae. albopictus* was more than *Cx. quinquefasciatus*. Data suggested some type of competition, once *Cx. quinquefasciatus* showed low density where the *Ae. albopictus* was highly dense. *Aedes albopictus* was an introduced species that showed more competitive advantages over the native species *Cx. quinquefasciatus*. Moreover, *Cx. quinquefasciatus* tolerated more polluted water, condition find frequently in urban areas. Service (1966) reported on a similar situation in Africa, right after WWII, when *Culex fatigans* Wieldmann, 1828, an introduced species, displaced *Cx. nebulosus* Theobald, 1901. Rios et al. (1978) reported on the adaptative advantages of *Ae. aegypti* over the *Cx. fatigans* since the metabolics produced by the first species made it difficult for the latter to procreate.

Aedes aegypti was significantly abundant in the collections carried out in the periurban area, confirming its well-known urban habits; *Aedes albopictus*, on the other hand, was abundant at the collection sites located 30 km from the city limits. There was a tendency for the *Ae. albopictus* population to increase as collection site distances increased. According to O'Meara et al.(1995) *Ae. albopictus* prevailed under an apparent lack of human resources for blood meals in Southern Florida. This could explain the high density of *Ae. albopictus* observed in this study at collection sites away from the city where blood repast resources were limited. The decrease in *Ae. aegypti* numbers as distances from the city limit increased, could not be ignored because the mosquito was present in all the collection sites located up to 25 km away from the urban area. In Brazil, control campaigns for this vector has been carried out by eliminating breeding sites which, according to Edman et al. (1998), could induce dispersion. This effect can happen by the many control campaigns being conducted in Londrina.

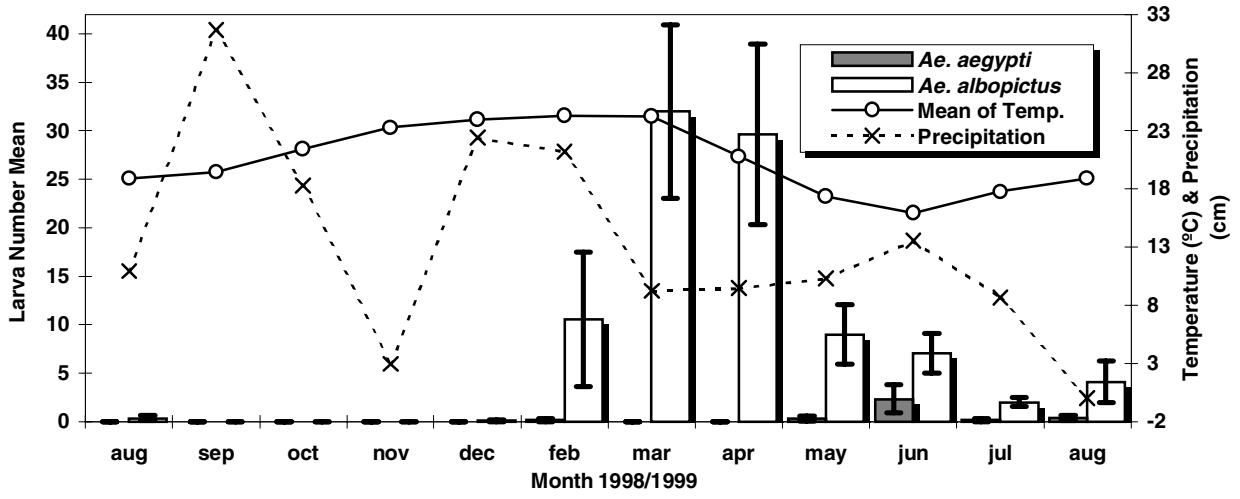

Figure 5 - Distribution of *Ae. aegypti* and *Ae. albopictus,* temperature average and precipitation index in Londrina City, Paraná, Brazil.

The presence of *Ae. aegypti* in rural areas produces an increase in the incidence of public health problems/diseases since these campaigns seldom reach these areas, which could become reservoirs for the mosquito.

There was no significant preference by the *Ae. aegypti* for the tyres placed at different distances from houses; however, *Ae. albopictus* was frequently found 10 m from the house, which could indicate endophilia.

The highest dispersion of *Ae. aegypti* and *Ae. albopictus* was found along the Northern transect, located next to the PR-445 state highway, an area with several gas stations and restaurants, and close to Warta Village and to the Ibiporã and Sertanópolis counties. Results from the Western transect, which showed the second highest larval mean for *Ae. aegypti,* could have been influenced by the proximity of the urban areas of the Cambé and Rolândia counties. The Western transect ran through the least urbanized areas which could explain the greatest mean difference between *Ae. albopictus* and *Ae. aegypt*i as well as the smallest density for the latter.

Rain indexes influence the availability of breeding sites for the Culicidae as higher indexes tend to produce an increase in the population density of some species after a certain period, as the number of breeding places increases during the rainy months (Marquetti et al., 1986). The temperature, however, influences insect metabolism directly, since they are ectotherms and their vital activities are regulated by external temperature. *Aedes aegypti* density increased when the temperature was at its lowest mean and the rain index for the previous month was relatively low. However, *Ae. albopictus* population density increased after rain index was associated with high temperatures, going down as the index decreased. This is an expected behavior for the Culicidae. It could be inferred that the high *Ae. albopictus* population density observed in the breeding places could have had a negative influence on the settling of *Ae aegypti* under good temperature and humidity conditions. Data from Juliano (1998) corroborated with this finding by showing that the presence of *Ae. aegypti* persisted only in places where its interspecific competition with *Ae. albopictus* was less intense. Some other non-evaluated factors could have influenced the low means obtained for the species during the first part of the experiment. One of the probable factors could be the presence of substances produced by larva in the water inside the tyres, which could be attracting pregnant females to lay eggs, since the water was poured back into the tyre after the larva were collected.

Results from this study showed that *Ae. aegypti* and *Ae. albopictus* were found in the rural areas of Londrina, the first species being less abundant and the latter well-adapted to the area's conditions. We recommend the inclusion of the rural areas in future methods for controlling these mosquitoes in Londrina, Paraná, Brazil.

RESUMO

Com o objetivo de avaliar a dispersão de *Aedes aegypti* e *Ae. albopictus* para a área rural, foram instalados pneus em quatro transectos (Norte, Sul, Leste e Oeste), a cada 5 Km, do limite da zona urbana de Londrina em direção a zona rural. Larvas de Culicidae foram coletadas quinzenalmente de agosto de 1998 a agosto de 1999. Um total de 62.517 larvas de Culicidae foram coletadas, distribuídas entre as seguintes espécies: *Aedes albopictus* (21.71%); *Ae. aegypti* (5.54%); *Ae. terrens* (0.53%); *Ae. fluviatilis* (0.36%); *Anopheles argyritarsi* (0.01%); *Culex quinquefasciatus* (48.37%); *Cx. mollis* (8.88%); *Cx. eduardoi* (8.65%); *Cx. corniger* (0.61%); *Cx. bigoti* (0.24%); *Cx.* grupo *coronator* (0.12%); *Limatus durhanii* (4.61%) e *Toxorhynchites* sp. (0.32%). Houve uma drástica diminuição na população de *Ae. aegypti* dos limites da cidade para a zona rural (x_1= 21.72 ± 4.71; x_2=0.00) e um aumento da população de *Ae. albopictus* (x_1 = 15.64 ± 2.73; x_2 = 38.37 ± 8.87). *Aedes aegypti* não foi encontrado somente nos pontos situados a 30 Km da cidade; no entanto, *Ae. albopictus* foi encontrado em todos os pontos. Conclui-se que ambas espécies encontram-se dispersas para a zona rural da área estudada e que é necessário um redimensionamento da área de controle destes vetores, já que a zona rural pode servir como um refúgio destas espécies.

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