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SEASONAL ABUNDANCE AND DISTRIBUTION OF MOSQUITOES AT A RURAL WASTE TIRE SITE IN ILLINOIS

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ABSTRACT. The species composition, abundance, and distribution of mosquito larvae in tires were determined on 3 dates at a relatively large rural tire dump (about 300,000 tires) in southeastern IL (Jasper County). Several observations at this site differed from those in previous reports about mosquitoes in tireyards, including 1) a relatively high percentage of tires positive for *Aedes triseriatus* larvae in an open-field area, 2) a greater abundance of *Culex pipiens* than *Cx. restuans* in late-season collections, 3) a seasonal change in the distribution of *Aedes atropalpus* larvae in tires from open field and edge of woods areas, and 4) the presence of *Ae. albopictus* as a major late-season species. *Ae. albopictus* adults were captured in sod-baited gravid traps along the edge of a wooded riparian area 200 m from the tire pile.

INTRODUCTION

Tire dumps are foci for the proliferation and dispersal of mosquitoes, potentially causing public health problems that range from an increase in nuisance complaints to an increase in the transmission of mosquito-borne pathogens (Reiter and Sprenger 1987, Mitchell et al. 1992). The interjection of nonindigenous mosquito species like *Aedes albopictus* (Skuse) into rural and urban tireyards can change blood-feeding patterns and diel activity and, in some cases, initiate interspecific competition for resources (Restifo and Lanzaro 1980, O'Meara et al. 1995). Conversely, waste tires can significantly impact larval and pupal developmental rates relative to other types of natural and artificial containers (Gomes et al. 1995). This, in turn, can affect adult size, fecundity, flight capability, and feeding behavior, all of which are related to the vectorial capacity of a mosquito species (Haramis 1984, Baumgartner 1988).

Tireyards seldom provide uniform habitats for mosquito larvae. For example, tire position and orientation influence the distribution and abundance of mosquitoes (Novak et al. 1990, Morris and Robinson 1994). Furthermore, the ecological setting of a tire pile can have a dramatic effect on species composition. For example, in IN and IL, *Ae. triseriatus* (Say) larvae are usually collected from shaded tires near trees or in woodlots, whereas *Ae. atropalpus* (Coquillet) larvae are typically collected from tires in open areas (Beier et al. 1983, Berry and Craig 1984, Baumgartner 1988). In contrast, *Culex restuans* Theobald and *Cx. pipiens* Linn. are often found in tires from a variety of habitats. Larval habitat segregation has been reported in other tireyards (Andreadis 1988) and is probably the result of a combination of factors including oviposition preference, nutritional characteristics of the larval habitat, temperature, and/or distribution pattern of predators and pathogens.

Most midwestern studies on mosquitoes in tires were conducted before the introduction of *Ae. albopictus,* a species with a broad oviposition preference for natural and artificial containers in rural and urban areas. In the spring of 1994, mosquito samples collected by Kent Johnson (a Field Investigator for the Illinois Environmental Protection Agency) from a relatively large rural tire dump in Jasper County, IL, were identified as *Ae. albopictus* at the Illinois Natural History Survey. We began collecting mosquitoes at the Jasper County tire site in Sept. 1994 in order to: 1) determine the species composition and abundance of mosquito larvae at a site where *Ae. albopictus* had been recently discovered, 2) examine the variation in species population dynamics from one year to the next and from early season to late season, and 3) compare mosquito larval distribution in tires stored along the edge of woods to that in tires stored in open areas. There were 2 additional reasons for providing a detailed record of mosquito species present at this site. First, as the Illinois Environmental Protection Agency had mandated the complete removal of tires from this site, any future investigations to determine the impact of tire removal would require a record of the mosquito composition and abundance in the area before tire removal. Second, data on species composition could be useful in understanding vector ecology, especially as the Centers for Disease Control and the Illinois Department of Public Health were actively testing pools of adult mosquitoes collected at the site for various mosquito-borne viruses (Mitchell et al. 1996).

MATERIALS AND METHODS

Description of tire site and sampling methods: The tire dump at the Jasper County site (38°52′N, 88°9′W) consisted of randomly stacked tires in 2 open field areas and one area along the edge of a woods. In the open field, tires were stacked either in a large, oval-shaped tire pile (about 125,000–150,000 tires) or in several serpentine lanes (about 75,000–100,000 tires) through a meadow. At the northernmost end of the field, there was a circular pile of tires (about 25,000–50,000 tires), with about one half of the perimeter of the tire pile adjacent to a tree-lined riparian area. Most of the tires in this ecotone area were shaded for at least part of the day and contained decaying leaf debris. The majority of tires (75–80%) in all areas were passenger or light truck tires, although larger tires were scattered throughout all the tire piles.

The first collection of mosquitoes from tires at the site was conducted before the onset of tire removal (September 21, 1994). By the next collection date (June 12, 1995), about one half to two thirds of the large oval tire pile in the open area had been shredded and shipped off the site. The final collection of larvae occurred after the removal of the entire oval tire pile and about one third to one half of the open-field tire lanes (August 18, 1995). Approximately 1 month later, the tireyard cleanup was completed. The processing and removal of tires at the Jasper County site progressed from the large oval tire pile to the serpentile tire lanes and then to the shaded tires. During the cleanup, tires from open and edge areas were not mixed.

Tires selected for sampling were from the perimeters of all large aggregates in the open field and along the edge of the woods. Around the large, oval-shaped tire pile at the southern end of the open field, samples were taken about every 20 m. Two or 3 of the tire lanes in the open field were sampled about every 10 to 15 m on each collection date. Tires from the smaller pile adjacent to the woods were sampled about every 5 m.

The entire contents of tires were removed with plastic cups and large-bulb pipettes. The material was sieved through a fine-mesh screen (40 meshes per cm) to retain larvae and pupae, including most 1st instars. In the laboratory, pupae were separated from larvae and placed in containers with plastic lids. Adults that emerged in these cups were removed and identified within 1–2 days after eclosion. The larvae from each tire were transferred to individual enamel pans and reared to the 4th instar. At this stage, all *Culex* and most *Aedes* larvae were preserved in 70% ethanol for identification later. *Anopheles* species were separated from the other species and reared to the adult stage for identification. The *Aedes* larvae were carefully inspected to distinguish between *Ae. triseriatus* and *Ae. hendersoni* Cockerell and *Ae. atropalpus* and *Ae. epactius*. A subsample of *Aedes* larvae was allowed to pupate and identified as adults.

Gravid traps: Two standard CDC gravid traps, baited with Kentucky bluegrass sod infusion, were placed in the woods at 175 and 200 m from the circular tire pile. Adult mosquitoes were collected on August 18, 1995, after 18 h and later identified in the laboratory. The sod infusion was prepared by adding 2 pieces of 15 × 15-cm sections of sod to about 15 liters of water in a 19-liter plastic bucket. The mixture was aged for 2 days under ambient temperatures (27–33°C) and one half of the solution and one piece of sod were placed in each gravid trap tub.

Statistical analysis: The number of larvae of each species per tire and the number of larvae of each species per tire that was positive for that species from open and edge-of-woods areas were transformed by logarithm $(x + 1)$ for analysis of variance tests. The comparison of the mean number of larvae per tire between areas is an index of larval abundance based on all the tires sampled in that area, regardless of whether they were positive for that species. A comparison of the mean number of larvae per positive tire is essentially a mean for only those tires having that species. Statistical analyses of the number of larvae per positive tire were not conducted on data for which there were fewer than 3 positive tires. Means and standard deviations are reported for the untransformed data.

Differences in positive tires (percentage of tires sampled in an area that were positive for a particular mosquito species) between open-field tires and shade tires were determined by assigning a value of 1 to positive tires and a value of 0 to negative tires for each species and analyzing by Fisher's exact test ($\alpha = 0.05$).

To determine whether significant 2-species associations occurred in tires, chi-square analyses of expected and observed co-occurrences were conducted. The observed co-occurrence (percentage of positive tires) for every 2-species combination in each test was compared with the expected co-occurrence (the product of observed probabilities for each species).

RESULTS

Abundance, prevalence, and habitat segregation in pooled data: On all collection dates, all wet tires sampled from the perimeters of the various areas were positive for mosquito larvae. Occasionally, a tire was dry, in which case the next closest tire was sampled. A brief inspection of dry tires revealed that most had punctures or rips in the tread or sidewall.

The pooled data from the 3 collections over the 2-yr period (Table 1) indicate that overall species abundances (percent of the total number of larvae collected) at the tire site in descending order were: *Cx. pipiens* (30%), *Ae. atropalpus* (22%), *Ae. triseriatus* (19%), *Cx. restuans* (15%), and *Ae. albopictus* (10%). Each of the remaining species was 1% or less of the total number of larvae collected and included *An. punctipennis* (Say), *Cx. territans* Walker, *Cx. salinarius* Coquillett, *An. barberi* Coquillett, *Orthopodomyia signifera* (Coquillett), and *Toxorhynchites rutilis septentrionalis* Syar and Knab. The percentages of all tires surveyed that were positive for particular mosquito species for the pooled data differed from those based on the order of abundance: *Ae. atropalpus* were in 71% of the

Table 1. Total number of larvae collected and percentage of tires positive for a species in tires from the open field (n = 59) and along the edge of the woods (n = 31) in Jasper County, IL, 1994–95. The last column is the sum of both areas and 3 collection dates.

	Open field		Edge of woods		Total	
Species	Number of larvae	Percentage of tires positive	Number of larvae	Percentage of tires positive	Number of larvae	Percentage of tires positive
Aedes albopictus	117	21	259	20	376	41
Ae. atropalpus	597	45	205	19	802	64
Ae. triseriatus	22	9	668	15	690	24
Culex pipiens	986	17	128	8	1,114	25
Cx. restuans	414	19	129	5	543	24
Cx. salinarius	25	6	17	2	42	8
Cx. territans	25	2	18	1	43	3
Anopheles punctipennis	37	15	12	5	49	20
An. barberi	0	0	15	3	15	3
Orthopodomyia signifera	1	1	11	3	12	4
Toxorhynchites rutilis septentrionalis	0	0	4	1	4	1

tires sampled, *Ae. albopictus* were in 46%, *Cx. pipiens* were in 28%, *Ae. triseriatus* and *Cx. restuans* were in 27%, and *An. punctipennis* were in 22%. The remaining species were found in less than 10% of the tires. The location of the tires affected both abundance and prevalence of mosquito species based on the pooled data. The 3 most abundant species in the open-field tires were *Cx. pipiens, Ae. atropalpus,* and *Cx. restuans,* whereas, in tires along the edge of the woods, they were *Ae. triseriatus, Ae. albopictus,* and *Ae. atropalpus* (Table 1). The 3 most prevalent species (based on the percentage of positive tires for a particular species) in the open field were *Ae. atropalpus, Ae. albopictus,* and *Cx. restuans,* whereas, in tires along the edge of the woods, they were *Ae. albopictus, Ae. atropalpus,* and *Ae. triseriatus.*

Seasonal variation and species distribution: The pooled values (Table 1) tended to mask temporal variability in mosquito abundance and distribution, particularly between the early- and late-season collections (Tables 2–4). The mean numbers of larvae per tire and per positive tire (only those tires with a particular species) were not significantly different between the 2 late-season collections in 1994 and 1995 for *Ae. albopictus* and *Ae. triseriatus,* although there were significant differences between the 2 late-season collections for *Ae. atropalpus* and *Cx. restuans.*

On both late-season collection dates (Tables 2 and 4), *Ae. albopictus* had more larvae per tire from the edge of the woods than from the open field. Furthermore, the percentage of positive tires for *Ae. albopictus* varied between the 2 areas in the 1995 late-season collection (Table 4) and marginally so (P = 0.06) in the 1994 collection (Table 2). The number of *Ae. albopictus* larvae was about 30–40% greater in tires from the edge of the woods than from the open field in both years, respectively. However, in positive tires, the mean number of larvae per tire from the 2 areas did not significantly differ in either late-season collection. Although *Aedes albopictus* accounted for only a moderate percentage of the total number of larvae collected on both late-season dates in 1994 and 1995 (9 and 19%, respectively), it was widely distributed, being present in about 70% of the tires. *Aedes albopictus* were relatively rare in the early season collection, with no obvious difference between tires from the 2 areas (Table 3).

Aedes triseriatus also had a greater mean number of larvae per tire from the edge of the woods relative to the open field in the 1994 late-season collection (Table 2), but it was only significant at the 10% level in 1995 (Table 4). Unlike for *Ae. albopictus,* the mean numbers of *Ae. triseriatus* larvae per positive tire were significantly different between the open and edge-of-woods areas in 1995 and marginally so in 1994 (P = 0.06). Differences in the numbers of larvae per positive tire indicate that either the number of eggs oviposited in the tires or survivorship in tires from the 2 areas were different. From our data, we are not able to distinguish between the 2 possible causes of differential larval abundance.

Aedes triseriatus also differed from *Ae. albopictus* in that the percentage of positive tires did not significantly differ between areas in either late-season collection, despite the pronounced differences in numbers of larvae per tire or per positive tire (as discussed above). Some of the positive tires were located about 300 m from the edge of the woods in the open field. *Aedes triseriatus* accounted for 13 and 40% of the total number of larvae and 33 and 35% of the positive tires in the late-season collections in 1994 and 1995, respectively (Tables 2 and 4). In the early-season collection (Table 3), *Ae. triseriatus* larvae were found exclusively in tires from the edge of the woods, with about 60% of those tires being positive for that species. This species

Table 2. Mean number of larvae per tire, mean number of larvae per tire positive for a species, and percentage of tires positive for a species in tires from the open field (n = 22) and from the edge of the woods (n = 11) in Jasper County, IL, September 1994.

Species	Location	Mean no. of larvae per tire	P	Mean no. of larvae per positive tire	P	Percentage of tires positive	P
Aedes albopictus	Open field	3.7 ± 5.8		6.3 ± 6.4		59.1	
	Edge of woods	9.4 ± 11.3	0.03	10.3 ± 11.4	0.28	90.9	0.06
Ae. atropalpus	Open field	4.1 ± 9.7		8.2 ± 12.7		50.0	
	Edge of woods	1.5 ± 2.5	0.49	4.0 ± 2.7	0.47	36.4	0.47
Ae. triseriatus	Open field	0.9 ± 1.7		3.0 ± 2.1		27.3	
	Edge of woods	22.3 ± 53.5	0.05	49.0 ± 74.3	0.06	45.5	0.31
Culex pipiens	Open field	40.0 ± 64.6		62.9 ± 72.1		63.6	
	Edge of woods	10.4 ± 26.0	0.13	22.8 ± 36.6	0.17	45.5	0.33
Cx. restuans	Open field	11.0 ± 29.2		24.2 ± 40.5		45.5	
	Edge of woods	14.0 ± 31.8	0.96	31.0 ± 47.0	0.78	36.4	0.63
Cx. salinarius	Open field	1.1 ± 3.0		4.2 ± 4.8		27.3	
	Edge of woods	0	NA[1]	0	NA	0	>0.1
Cx. territans	Open field	0.1 ± 0.4		2		4.5	
	Edge of woods	1.6 ± 5.4	NA	18	NA	9.1	>0.05
Anopheles punctipennis	Open field	0.6 ± 1.2		2.3 ± 1.0		27.3	
	Edge of woods	0.2 ± 0.4	NA	1	NA	18.2	0.58
An. barberi	Open field	0		0		0	
	Edge of woods	0.6 ± 1.4	NA	3.5 ± 0.7	NA	18.2	>0.05
Orthopodomyia signifera	Open field	0.05 ± 0.2		2.0 ± 1.4		4.5	
	Edge of woods	0.4 ± 0.9	NA	1	NA	18.2	>0.05
Toxorhynchites rutilis septentrionalis	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA

[1] NA = Not analyzed due to a zero value, absence of variance, or fewer than 3 positive tires (for mean per tire or mean per positive tire). Fisher's exact test was used to test differenes between percentages of tires positive for a species in each area.

Table 3. Mean number of larvae per tire, mean number of larvae per tire positive for a species, and percentage of tires positive for a species in tires from the open field (n = 27) and from the edge of the woods (n = 10) in Jasper County, IL, June 1995.

Species	Location	Mean no. of larvae per tire	P	Mean no. of larvae per positive tire	P	Percentage of tires positive	P
Aedes albopictus	Open field	0.1 ± 0.5		1.3 ± 0.6		11.1	
	Edge of woods	0.1 ± 0.4	0.80	1.0	NA[1]	10	>0.50
Ae. atropalpus	Open field	12.3 ± 9.4		13.8 ± 8.8		88.9	
	Edge of woods	12.0 ± 10.7	0.80	12.0 ± 10.7	0.54	100	0.28
Ae. triseriatus	Open field	0		0		0.0	
	Edge of woods	3.0 ± 3.9	NA	5.0 ± 3.8	NA	60.0	<0.05
Culex pipiens	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA
Cx. restuans	Open field	6.4 ± 19.9		19.1 ± 31.8		33.3	
	Edge of woods	0.5 ± 1.6	0.27	5	NA	10.0	>0.10
Cx. salinarius	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA
Cx. territans	Open field	0.9 ± 4.4		23		10.0	
	Edge of woods	0	NA	0	NA	0	>0.10
Anopheles punctipennis	Open field	0.8 ± 1.5		2.6 ± 1.6		29.6	
	Edge of woods	0.4 ± 1.3	0.36	4.0	NA	10.0	>0.10
An. barberi	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA
Orthopodomyia signifera	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA
Toxorhynchites rutilis septrionalis	Open field	0		0		0	
	Edge of woods	0	NA	0	NA	0	NA

[1] NA = Not analyzed due to a zero value, absence of variance, or less than 3 positive tires (for mean per tire or mean per positive tire). Fisher's exact test was used to determine significant differences between the number of positive tires in each area.

Table 4. Mean number of larvae per tire, mean number of larvae per tire positive for a species, and percentage of tires positive for a species in tires from the open field (n = 10) and from the edge of the woods (n = 10) in Jasper County, IL, August 1995.

Species	Location	Mean no. of larvae per tire	P	Mean no. of larvae per positive tire	P	Percentage of tires positive	P
Aedes albopictus	Open field	3.1 ± 4.5		6.2 ± 4.7		50	
	Edge of woods	15.5 ± 16.0	0.02	17.2 ± 15.9	0.19	90	0.05
Ae. atropalpus	Open field	17.5 ± 15.5		17.5 ± 15.5		100	
	Edge of woods	6.9 ± 8.7	0.05	13.8 ± 7.3	0.82	50	<0.05
Ae. triseriatus	Open field	0.4 ± 0.7		1.3 ± 0.6		30	
	Edge of woods	39.3 ± 73.7	0.09	98.3 ± 92.6	0.05	40	0.66
Culex pipiens	Open field	10.7 ± 32.4		35.7 ± 58.3		30	
	Edge of woods	1.4 ± 3.2	0.58	4.7 ± 4.7	0.60	30	NA[1]
Cx. restuans	Open field	0.0		0.0		0	
	Edge of woods	0	NA	0.0		0	NA
Cx. salinarius	Open field	0		0		0	
	Edge of woods	1.9 ± 5.3	NA	8.5 ± 10.6	NA	20	>0.05
Cx. territans	Open field	0		0		0	
	Edge of woods	0	NA	0		0	
Anopheles punctipennis	Open field	0.2 ± 0.6		2		10	
	Edge of woods	0.6 ± 1.6	0.53	3.0 ± 2.8	NA	20	>0.05
An. barberi	Open field	0		0		0	
	Edge of woods	0.8 ± 2.5	NA	8	NA	10	>0.05
Orthopodomyia signifera	Open field	0		0		0	
	Edge of woods	0.7 ± 2.2	NA	7	NA	10	>0.05
Toxorhynchites rutilis septentrionalis	Open field	0		0		0	
	Edge of woods	0.4 ± 1.3	NA	4	NA	10	>0.05

[1] NA = Not analyzed due to a zero value, absence of variance, or fewer than 3 positive tires (for mean per tire or mean per positive tire). Fisher's exact test was used to test differences between percentages of tires positive for a species in each area.

exhibited the only early-season significant difference between open-field tires and tires along the edge of the woods in terms of number of larvae per tire and percent positive tires.

In the 2 late-season collections of 1994 and 1995, *Ae. atropalpus* accounted for 5 and 25% of the total number of larvae in tires and were in 45 and 75% of the tires surveyed. There was a significant increase in the number of *Ae. atropalpus* per tire between 1994 and 1995 (P = 0.001). The pooled data (Table 1), as well as the late-season collection in August 1995 (Table 4), indicated a greater number of larvae and a higher percentage of positive tires in the open field for *Ae. atropalpus*. This trend was not apparent in the early-season collection (Table 3) or in September 1994 (Table 2). The number of larvae per positive tire did not differ between the 2 areas on any of the collection dates. *Aedes atropalpus* was the most prevalent species in the early-season collection in 1995 (Table 3) (present in 92% of all tires surveyed) and was equally abundant and distributed in tires from the open field and from the edge of the woods (accounting for 63% of all the mosquito larvae collected in June 1995).

The *Culex* species exhibited considerable variability in abundance between the 2 late-season collections (Tables 3 and 4); however, none of the *Culex* species showed a pronounced habitat segregation as with the *Aedes* species. The overall percentages of total number of larvae collected (abundance) and of positive tires (prevalence) of *Culex* species in 1994 were 50% abundance and 58% prevalence for *Cx. pipiens,* 18% abundance and 42% prevalence for *Cx. restuans,* 1% abundance and 18% prevalence for *Cx. salinarius,* and 1% abundance and 6% prevalence for *Cx. territans.* In 1995, the overall abundance and prevalence (in parentheses) for *Cx. pipiens* were 12% (30%) and for *Cx. salinarius,* 2% (10%). *Culex restuans* and *Cx. territans* were not present in the late-season collection in 1995. Furthermore, there were significantly more *Cx. pipiens* larvae per tire in 1994 than in 1995 (P < 0.0001). The *Culex* data were extremely variable due to the occasional collection of recently hatched egg rafts and their sporadic distribution. *Culex pipiens* was absent early in the season (Table 3) but was abundant in the later season collections (Tables 2 and 4). *Culex restuans* had an opposite seasonal abundance, being present early in the season (25% of the total number of larvae collected) and either absent (Table 4) or less abundant than *Cx. pipiens* later in the season (Table 2). The incidence of *Cx. territans* and *Cx. salinarius* was so low that little can be said about their distribution and abundance or seasonal changes in these factors.

Aedes albopictus and *Culex territans* were relatively rare in the early-season collection (Table 3). *Culex pipiens, Cx. salinarius, An. barberi, Orthopodomyia signifera,* and *Toxorhynchites rutilus septentrionalis* were not collected from any of the tires sampled in early 1995. *Anopheles punctipen-*

nis was also not abundant in any of the collections, but it was consistently recovered from tires both in the open field and along the edge of the woods in both late-season collections. In contrast, *An. barberi* was recovered only from tires along the edge of the woods, although it was relatively rare (Tables 2 and 4).

Species associations: Chi-square tests for all possible 2-species associations revealed that none were significant; therefore, the 2-species assortment of mosquito larvae in tires appears to be random. However, the co-occurrence of *Ae. atropalpus* and *Ae. triseriatus* in tires from the edge of the woods appeared to have an effect on the number of *Ae. triseriatus* larvae per tire based on the pooled data from the 2 late-season collections. In the open-field tires, the mean numbers of larvae for *Ae. triseriatus* were 2.7 and 1.5 larvae per tire in the presence and absence of *Ae. atropalpus,* respectively, whereas along the edge of the woods there were 4.6 and 124.4 *Ae. triseriatus* larvae per tire in the presence and absence of *Ae. atropalpus,* respectively. Analysis of variance indicated a significant difference in mean number of *Ae. triseriatus* larvae due to location ($P = 0.0001$), co-occurrence with *Ae. atropalpus* ($P = 0.0002$), and the interaction of the 2 factors ($P = 0.0001$). Thus, the presence of *Ae. atropalpus* larvae had little impact on *Ae. triseriatus* numbers in the open field; however, in tires along the edge of the woods, the presence of *Ae. triseriatus* and *Ae. atropalpus* in the same tire was marked by a significant reduction in the number of *Ae. triseriatus* larvae. The nature of this interaction or whether it is a statistical aberration cannot be determined from our field data.

Collection of adults in gravid traps: Two gravid traps were placed along the tree line at 175 and 200 m from the tire pile (August 17, 1995). Three species were collected *Ae. albopictus, Cx. pipiens,* and *Ae. triseriatus.* There were totals of 128 females and 2 males of *Ae. albopictus,* 34 females of *Ae. triseriatus,* and 57 females and 1 male of *Cx. pipiens.*

DISCUSSION

Several observations at the Jasper County site differed from those in previous reports of midwestern tireyards (Beier et al. 1983, Berry and Craig 1984, Baumgartner 1988), including 1) a relatively high percentage of tires positive for *Ae. triseriatus* in open-field areas, 2) a greater abundance of *Cx. pipiens* than *Cx. restuans* in late-season collections, 3) seasonal variation in the abundance and distribution of *Ae. atropalpus* larvae in the tireyard, and 4) *Ae. albopictus* as a major late-season species. Furthermore, sod-baited gravid traps collected *Ae. albopictus* at least 200 m from the tire pile, indicating that this species either forages along the edges of wooded areas or has become established in natural (treeholes) or artificial (cans, buckets, and other debris) containers along the edge of the woods. A survey of larvae from a large basal treehole and 2 artificial containers recovered only *Ae. triseriatus* larvae.

Although *Ae. triseriatus* was more abundant in the shaded ecotone tires than in the exposed field tires, the percentage of tires positive for this species did not differ between the 2 areas in the September 1994 and August 1995 collections. A small percentage of *Ae. triseriatus* adults may disperse into open areas and oviposit, thus increasing the potential risk to humans that live near tireyards of LaCrosse encephalitis (Berry and Craig 1984, Andreadis 1988). Some of the tires positive for this species in our study were farthest from the woods (200–300 m). The 16–75-fold difference in mean numbers of *Ae. triseriatus* larvae per positive tire between tires along the woodland ecotone and those in the open field indicates either that fewer eggs were oviposited in the open-field tires or that there was greater mortality in these tires. In a previous study, when *Ae. triseriatus* larvae were found in exposed tires, their abundance was usually one third of that in shaded tires (Beier et al. 1983). Additional studies will be necessary to determine the cause of this difference in larval abundance due to tire placement.

Several investigators have noted a greater abundance of *Cx. restuans* than of *Cx. pipiens* in tireyards despite a prevalence of *Cx. pipiens* in the surrounding environment, especially late in the season (Baumgartner 1988, Beier et al. 1983, Berry and Craig 1984, Andreadis 1988). This was not observed in our study, although we did not determine the relative abundance of *Culex* adults in the surrounding area. Berry and Craig (1984) noted that the *Culex* preference for tires may vary with the age of tires. We recorded a change of early-season abundance by *Cx. restuans* to a late-season abundance by *Cx. pipiens* at the Jasper County site in 1995. This pattern is common in urban habitats in central IL (Lampman and Novak 1996a). Based on our results, pooled data from early- and late-season collections should not be used to infer a preference of *Cx. restuans* for tires (Baumgartner 1988, Beier et al. 1983).

Although most studies indicate that *Ae. atropalpus* is primarily restricted to open areas (Beier et al. 1983, Berry and Craig 1984), it is occasionally found in shaded tires (Andreadis 1988). In Jasper County, the high abundance and wide distribution of *Ae. atropalpus* in open-field and ecotone tires in the early-season and very-late-season collections may reflect a strategy by this species to exploit a variety of habitats before other species are abundant. *Aedes atropalpus* has several characteristics that favor a rapid exploitation of early-season habitats. For example, at least a portion of the first generation may be produced autogenously, and some eggs are oviposited on the surface of the water and therefore do not necessarily require a flood to hatch, as do the eggs of *Ae. albopictus* and *Ae. triseriatus* (Berry and Craig 1984). The only biting species that we noted during the June collection at the tireyard was *Ae. atropalpus*, which was particularly abundant early in the season. This may indicate that this species has a shorter diapause in this area than *Ae. albopictus* and *Ae. triseriatus*. Berry and Craig (1984) found that *Ae. atropalpus* was present in early June (before *Ae. triseriatus*) in northern IN, but their data suggest that *Cx. restuans* is the earliest colonizer of tireyards. In our collection (southeastern IL), *Ae. atropalpus* was the most abundant species in June and was equally distributed throughout the tireyard. There was a significant increase in *Ae. atropalpus* abundance from 1994 to 1995, which supports the conclusion that this species can rapidly dominate a tireyard (Andreadis 1988).

Aedes albopictus was, in general, more frequently encountered in tires along the edge of the woods than in tires from the open field, which agrees with other studies on the habitat distribution of this species (Peacock et al. 1988). The majority of recaptured marked *Aedes albopictus* adults at a tireyard was also found along the edge of the woods (Niebylski and Craig 1994). In southeastern FL, *Ae. albopictus* is a dominant container species in rural areas or areas with undeveloped tracts of land (O'Meara et al. 1995). Since *Ae. albopictus* and *Ae. triseriatus* share a preference for tires along the edges of woods, the potential for an interaction between these species is high. At the Jasper County tire site, *Ae. albopictus* was less abundant than *Ae. triseriatus* in the tires along the edge of the woods; however, *Ae. albopictus* was more widely distributed in both the edge and open-field tires.

The pooled data provided an index of the relative abundance and prevalence of each mosquito species at the tire site in Jasper County; however, they tended to mask seasonal differences. For example, *Ae. albopictus* was a rare species in early 1995, yet it was the 3rd most abundant and 2nd most prevalent species later in the season. In Louisiana, pupal densities of *Ae. albopictus* are generally high from June through September (Willis and Nasci 1994). The low early-season abundance of *Ae. albopictus* in our study may be due to a high winter mortality of eggs (Hanson and Craig 1995) and/or a slower development due to the cooler IL temperatures. Similarly, *Ae. triseriatus* was collected exclusively in tires from the edge of the woods, albeit in relatively low numbers, in June 1995, but it was the most abundant edge-of-woods species by August 1995.

The distribution of mosquitoes in a tireyard is primarily influenced by the age, size, and physical structure of the tire dump; the heterogeneity of the environment; weather conditions (temperature and rainfall); availability of suitable bloodhosts; and the bionomics and behavior of the associated mosquito species (Novak et al. 1990). Habitat segregation, a difference in larval abundance, and/or prevalence in the open and edge-of-woods tires was documented in one or more collections for *Ae. albopictus, Ae. triseriatus,* and *Ae. atropalpus.* In some cases (e.g., *Ae. albopictus* and *Ae. atropalpus*), the mean numbers of larvae per tire and the percentages of positive tires were significantly different between the open field and ecotone areas, but the mean number of larvae per positive tire was not different between the 2 areas. This probably indicates that the gravid female selected specific areas to oviposit, but when she oviposited in a less preferred area she still oviposited a normal complement of eggs. Conversely, when the mean numbers of larvae per tire positive for a species differed between open tires and ecotone tires (e.g., *Ae. triseriatus*), this indicated that either the gravid female oviposited fewer eggs in one area or there was a differential survival (Beier et al. 1983). Our experimental design does not allow us to differentiate between these two options. Habitat segregation may also be seasonally labile. For example, *Ae. atropalpus* was equally distributed between open-field and edge tires early in the season and was more frequently found in open tires later in the season. The difference in this case may be the amount of shade. Very early (June 1995) and very late (September 1994) in the season, there was less foliage present, thus reducing the amount of shade, especially in comparison to the August 1995 collection.

At the Jasper County site, there was an absence of significant 2-species interactions in regard to co-occurrence, unlike in the report of Beier et al. (1983) in IN. They found a negative interaction between *Ae. triseriatus* and *Cx. pipiens* in shade tires and a negative interaction between *Ae. atropalpus* and *Cx. restuans* in open-field tires. The differences between the two studies may be due to smaller sample size on our part, differences in the species composition, and/or the physical structure of the tireyards. Beier et al. (1983) also pooled early- and late-season collections from several different sites, which may have created statistical artifacts. Surprisingly, we did find an apparent association in our study between *Ae. atropalpus* and *Ae. triseriatus.* The 2 species were usually in equal numbers when collected together or separately from tires in the open field; however, when collected together from tires along the edge of the woods, there was a disproportionately lower number of *Ae. triseriatus* larvae than of *Ae. atropalpus* larvae. The low number of *Ae. triseriatus* larvae was not found in tires from the same edge of the woods area when *Ae. triseriatus* was present but *Ae. atropalpus* was not. The absence of an association between these species in open-field tires is probably because the number of *Ae. triseriatus* larvae in each tire was already low, regardless of the presence or absence of *Ae. atropalpus.* However, from our data, we were unable to determine the cause of the variation in larval abundance when these 2 species were found together in tires along the edge of the woods.

The capture of *Cx. pipiens*, *Ae. albopictus*, and *Ae. triseriatus* in gravid traps placed in the woods indicates that adults of these species either move at least 200 m away from the main tire dump or are well established in containers in the woods (Lampman and Novak 1996b). The latter explanation is unlikely as we only found *Ae. triseriatus* in natural and artificial containers in the woods. The relative proportions of species caught in the gravid traps was unlike the abundance and prevalence of larvae in the tireyard. The most abundant species in the tires, *Ae. triseriatus*, was underrepresented in the gravid traps, and *Ae. atropalpus*, which was abundant in the tires, was not collected in the gravid traps. This may indicate that *Ae. atropalpus* adults are not foraging in woods, unlike *Ae. albopictus*. Alternatively, the factors attracting *Ae. albopictus*, *Ae. triseriatus*, and *Cx. pipiens* to the gravid traps may not affect the searching behavior of *Ae. atropalpus*. *Aedes albopictus* are known to readily disperse from tire sites to nearby wooded areas (Niebylski and Craig 1994).

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