SUBURBAN ACCUMULATIONS OF DISCARDED TIRES IN NORTHEASTERN ILLINOIS AND THEIR ASSOCIATED MOSQUITOES

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ABSTRACT. In response to a growing, human suburban population and an escalating problem of used tire disposal, a summer-long survey of discarded tires and their associated mosquitoes was conducted in northeastern Illinois in 1985. Within a 291 km^2 area, a monthly average of 7,823 tires were distributed among 127 sources classified into 7 categories: fields/ditches (25% of total sources); salvage yards (7%); trucking/construction companies (13%); woodlots (15%); school playgrounds (11%); service stations (16%); and tire dealers (11%). Distribution and abundance of each source category appeared to reflect local land usage and extent of urbanization. Wooded sites surpassed service stations, dealers, and salvage yards in the average percentage of flooded tires (86% vs. 25% ea.) and percentage of those larval-infested (58% vs. 25% ea.). Overall, 6,398 mosquito larvae among 9 species were collected with *Culex restuans* (82%) and *Cx. pipiens* (13%) predominating. Species segregations with respect to the tire source are revealed. Possible control strategies of mosquitoes in tires are summarized.

INTRODUCTION

Discarded tires have long been recognized as a larval habitat for some mosquitoes but today are emerging as important contributing sources of particular species in urban areas, especially those which normally reproduce in tree holes [*Aedes triseriatus* (Say)], containers [*Aedes aegypti* (Linn.), *Aedes albopictus* (Skuse)], and rock holes [*Aedes atropalpus* (Coq.)]. Recently, the problem of tire accumulation, disposal, and mosquito breeding therein has escalated in response to an ever-growing human population, increasing sale and use of automobiles, and concomitant reduction of natural breeding sites in urban areas. In the United States, the sale of merchandise by tire dealers has increased 71% from 1977 to 1982 (Anonymous 1984), with an increasing number of unscrupulous tire dealers, trucking companies, and disposal companies dumping waste tires in fields and woodlots for convenience, rather than paying high disposal fees. An estimated 200 million tires are discarded annually in the U.S. (see Beier et al. 1983a) with few options available for their ultimate disposal. Additionally, the importation of waste tires from abroad has contributed to the problem (Reiter and Sprenger 1987). *Culex pipiens* Linn., *Ae. aegypti*, and *Ae. triseriatus* are among the more important disease-vectoring mosquitoes in the U.S.A. which frequently breed in tires, in close proximity to human dwellings and activity (Beier et al. 1983b).

The tire problem is magnified by growing evidence that tires promote rapid development of mosquitoes and enhance their vector ability. Pupation of *Ae. triseriatus* occurs nearly a month earlier in discarded tires than in tree holes, with a greater percentage of females produced in the former (Haramis 1984). Female *Ae. triseriatus* derived from tires may be more aggressive and efficient in feeding, and deposit more eggs per cluster than tree hole derived colonies (Means et al. 1977). *Aedes atropalpus* emerging from rock pools are entirely autogenous during their first gonotrophic cycle while those from tires readily take blood (Restifo and Lanzaro 1980). Tire habitats tend to yield smaller, perhaps nutritionally deprived *Ae. triseriatus* females which may transmit La Crosse (LAC) encephalitis virus at elevated rates (Haramis 1984, Paulson and Kobayashi 1985).

Although tire-breeding mosquitoes have been well studied in Indiana (Beier et al. 1983a, 1983b; Berry and Craig 1984), little is known of tire mosquito dynamics in other states. Service stations, tire dealers, and salvage yards are common sources of discarded tires but knowledge of their incidence and relative importance in mosquito production is lacking. In this investigation an attempt was made to locate the majority of sources and accumulations of discarded tires in an Illinois suburban area and determine their mosquito production. The effect of tire storage patterns on water retention and mosquito colonization, and habitat partitioning with respect to tire size and seasonality were also investigated.

METHODS

From mid-April to late November, 1985, an intensive effort was made to locate and map all accumulations of discarded rubber tires within a 291 km^2 suburban area (population 404,800, 1980 census) in northwestern Cook County, northeastern Illinois. Few extensive tracts of forest or farmland remain, with the southern third of the study region heavily industrialized.

Any accumulation of 2 or more tires, without mounted rims, in woods or fields was considered a site. This small number was deemed important because of their permanence, while all other sources with a tire turn-over were considered to be a site if they possessed a minimum of 10 tires. Tire sites were grouped into 7 categories based on their location (Fig. 1): fields/ditches, service stations, wooded areas, trucking and construction companies, elementary school playgrounds, retail tire dealers, and auto salvage yards. The majority of wooded, field, and trucking/construction tire sites were discovered and noted during daily travel within the District and routine inspection of all potential mosquito production areas. The locations of all service stations, tire dealers, and elementary schools were obtained from telephone directories, and these potential sources of tires individually visited and assessed for accumulations.

All sites containing waste tires were chronologically numbered in their order of discovery and their location noted. Data recorded included: storage pattern of the tires (randomly scattered, vertically stacked, shingle/lattice stacked) (Fig. 1); their exposure to sun or shade; proximity to ground vegetation and trees; the total number; relative size (auto, truck, tractor);

Fig. 1. Suburban sources of discarded tires and mosquito oviposition sites: (A) scattered under trees behind a service station; (B) shingle stacked behind a tire dealer; (C) leaning against a trailer in a lot behind a trucking company; (D) vertically stacked in the rear of a salvage yard; (E) scattered in a sunny field; and (F) scattered in the shade of a woodlot.

number containing water and number of these with mosquito larvae; and, sporadically, tire water temperature and pH. Tires mounted on rims do not hold water generally and so were excluded. Ten to 20 tires/size-class/site were inspected for the presence of mosquito larvae. At least 3 to 5 randomly chosen tires at each site were sampled for surface larvae with a short-handled dipper (300 ml), the number of instars recorded, and the samples pooled per size class/site/day. No tire was sampled more than once and all sampled tires were from surface piles. Tire water was not mixed prior to sampling, acknowledging that collection data densities may be misleading due to larval aggregation or disturbance (larvae diving to bottom). All samples were secured with a minimum of disturbance or shading of tires. Larvae collected from tires were transported to the laboratory and refrigerated at 4°C for 1–4 days for convenience prior to identification. All identifications are based on third or fourth instars, using Ross and Horsfall (1965) and Siverly (1972). Voucher specimens were deposited at the U.S. National Museum. Adult mosquito recoveries from 6 New Jersey light traps, roughly spaced 7 km equidistant throughout the survey area and operating nightly all summer, were compared with larval recoveries from tires for seasonal differences.

All mosquito-infested tires were treated with *B.t.i.* (*Bacillus thuringiensis* var. *israelensis* Berliner) on corncob granules (5–10/tire, 0.8% active ingredient, Sandoz Inc.) following inspection. The physical attributes of this carrier made it well suited for easy dispersion and deep penetration to lowermost tires in piles. This inspection and monitoring was repeated 5 times throughout the summer (May–August) at roughly monthly intervals for 51 sites. Many other sites were subsequently discovered during an intensive fall/winter survey and remapping of regular mosquito sources at a time when leaves had fallen from deciduous trees and ground vegetation was sparse. These latter sites were sampled only once up to November 14, after which time the temperature dropped, freezing all standing water. The entire survey was conducted during a relatively dry season; monthly mean temperatures and precipitation were 1.1°C and 12.6 mm, respectively, lower than normal (20.1°C and 91.4 mm, respectively, N.O.A.A. at O'Hare Airport). It is doubtful that the mosquito control efforts enacted within the District during this study greatly affected mosquito breeding in tires; adulticiding was minimally practiced and the majority of larviciding activities were directed against floodwater *Aedes vexans* (Meigen), which is rarely reported from tires (Beier et al. 1983a).

In order to determine if partitioning exists among mosquito species in tires of different sizes, all tires were grouped into 1 of 3 size classes, and the data and larvae collected noted with respect to these classes. Automobile tires were the smallest, generally measuring ca. 0.7 m diam and containing 8–11 liters of water in a vertical position, 4–6 liters laying on its side horizontally, and ca. 5 liters in a partially stacked, diagonal position. Truck tires were intermediate in size (ca. 1 m diam), usually containing 14 liters of water when standing vertically. Tractor tires were the largest (ca. 1.8 m diam), retaining ca. 76 liters of water in a horizontal position and ca. 62 liters when partially stacked. A few even larger (2 m diam) tires from earth movers were encountered, which held 190 liters of water in a horizontal position.

RESULTS

Tire sources. Within the 291 km^2 suburban area of northeastern Illinois, 127 sources of discarded tires were located, containing a mean total standing crop of 7,823 tires per month (Table 1). Prior to this intensive survey, only 7 sources were known, mapped, and regularly inspected. Field/ditch sites comprised 25% of the 127 sources, with the remainder equally divided among service stations (16%), wooded lots (15%), trucking/construction companies (13%), school playgrounds (11%), and tire dealers (11%). Auto salvage yards with tires were scantily represented (7%). However, all salvage yards (n = 9) within the study area possessed tires which mosquitoes could colonize, while only 17% of school playgrounds (n = 86), 38% of tire dealers (n = 37), 41% of woodlots (n = 46), and 42% of service stations (n = 50) inspected had such tire deposits.

The category and number of tire sources between different townships appeared to reflect the overall land usage and extent of urbanization. Fewer total sources were found in the 2 most urbanized townships (n = 56,166 km^2 area, pop. 260,520) than the more suburban ones (n = 71,125 km^2 area, pop. 144,280). Tires in fields/ditches and woodlots made up a large part of sources (68%, n = 34) in the least urbanized area (61% urban land cover) where tires were commonly disposed of in 1 to 5 acre woodlots intermingled among populated areas and farmland rather than in forest preserve tracts which are regularly policed and maintained by state employees. Trucking/construction company sources were prevalent in the more heavily industrialized township; the number of sites there (n = 10) are probably underreported since it was not possible or feasible to inspect behind every company building. Service station and tire dealer sources were prevalent (43% of sites, n =

Table 1. Mean number of tires per month deposited at various sites over entire season which breed mosquitoes.

Source	No. sites[1]	Tire size class: Auto	Truck	Tractor	Total (%)	Mean tires per site ± SE
Fields/ditches	32	227	142	4	373 (8)	12 ± 4
Service stations	20	1,009	0	0	1,009 (21)	50 ± 8
Woodlots	18	123	19	0	142 (3)	8 ± 3
Truck/constr.	14	112	457	34	603 (12)	43 ± 5
School playgrd.	13	285	162	0	447 (9)	34 ± 7
Tire dealer	12	1,541	55	0	1,596 (33)	133 ± 25
Auto salvage	8	638	44	0	682 (14)	85 ± 39
Total	117	3,935	879	38	4,852[2]	
(%)		(81)	(18)	(1)		

[1] Sites are excluded which possessed abnormally large numbers of tires (5–10× norm), atypical of the majority of sites. This includes a service station ($\bar{x}$ = 312 car), woodlot (190 car), three truck/construction companies (178 truck, 210 and 478 car), two tire dealers (450 truck, 182 tractor), and a salvage yard (971 car).

[2] Total increases to 7,823 tires when large site accumulations mentioned above are included.

56) in the most populated and urbanized townships. School playgrounds (3–5/township) and auto salvage yards (2–3/township) containing waste tires were evenly distributed among all townships. A preliminary survey of an affluent rural area of equal land coverage, adjacent to and west of the study area, indicates that far fewer tires (among ca. 25 sources) are discarded in fields/ditches and woods there, with the absence of many of the service stations, tire dealers, and construction companies common to the more populated, lower income, eastern half of the District. However, on rural farmlands several small, old tire accumulations were discovered in farm waste heaps behind barns and at margins of corn fields.

The total number of unmounted outdoor tires within the District is presented in Table 1. Automobile tires dominated most sources except at trucking/construction companies, which frequently discarded larger truck and tractor tires. Accumulations of tires at service stations, tire dealers, and salvage yards accounted for 66% of the tires (n = 7,823) available for mosquito colonization, with the mean number of tires at a single site/source also high (50, 133, 85, respectively). Fewer mean tires per site were discarded in fields/ditches (12) and woodlots (8).

Other sources of waste tires were encountered which were not surveyed for water content or mosquito larvae and not included in this study, but nevertheless deserve mention. Twelve automobile tires were found scattered on the lawn and bare ground at a seldom used police academy training facility. Sixty truck and 130 automobile tires were discovered in a refuse pile near the service hanger of a small, local airport. Automobile tires (n = 139) scattered among weedy margins of a gravel parking lot served as a bumper guard at a retail business. Tires discarded by construction firms were observed near land development areas. Numerous tires were used to delineate a race track at a go-cart establishment. Tires lacking drainage holes have also been sighted in park playgrounds behind several day-care (nursery) centers. Tires were present outdoors, behind some private residences (2–13/yard), contributing to the overall mosquito problem. In older neighborhoods with large yards and mature trees (5–10 residences/mile^2) water-filled tires (1–2/yard) suspended from tree limbs were common in backyards for children's recreation, albeit infrequently used and continually collecting rainwater and leaf litter to support mosquito populations. Outside the survey region tires were also used as holddowns for large tarpaulins at a garden nursery; as guides for a driveway; and as bumper guards at factory docks.

Method of storage and their frequency of removal are critical factors which determine water and organic matter accumulation in tires, and influence mosquito colonization. Tires at fields, woods, and salvage yard sites were considered to be permanent with little removal or disturbance throughout the entire study. Such was not the case at service stations and tire dealers where, upon questioning, 18 managers profess to have their discarded tires removed by a disposal service at mean intervals of 13 ± 7 days (range 7–30). Extremes omitted from this average are 2 service stations which disposed of tires at 2 day and 6 month intervals. All tires in fields/ditches and woodlots, and most at salvage yards and construction companies were randomly scattered about which maximized their water collection, while tires at service stations and tire dealers were frequently vertically stacked or shingle stacked horizontally (Fig. 1). A survey of automobile tires stored at service stations and tire dealers over the summer confirmed the suspicion that vertically stacked tires are less likely to trap rain water than scattered tires, with those shingle stacked intermediate. Significantly fewer (χ^2 = 40, P < 0.01) vertically stacked tires held water (22%, n = 1,337) at the time of inspection compared to scattered tires (32%, n = 1,980), with shingle stacked tires intermediate (28%, n = 4,497). However, 25% (n = 298) of these water-filled column stacked tires contained larvae compared to 41% (n = 1,254) of shingle stacked and only 14% (n = 626) of scattered, flooded tires (all significantly different, χ^2 = 147, df = 2, P < 0.01).

The mean number of water-filled tires and mosquito breeding in all automobile tires from each of the 7 sources were compared. Service stations, dealers, salvage yards, and construction companies exhibited similar mean percentages of tires containing water (ca. 25%) and mean proportion of these breeding (ca. 25%) over the entire season. Wooded sites differed though, with 86% of tires water-filled and 58% of these mosquito infested. Too few field/ditch and playground sites were surveyed for any meaningful conclusion. Generally, mosquito larvae were rare in tires situated in direct sun, on gravel or cement, and/or away from vegetation, while those in the shade, under trees, and/or on grass beds bred abundantly.

Species segregation. During this study 413 samples (73% from service stations, tire dealers, and trucking/construction companies) containing 6,398 mosquito larvae among 9 species were collected from tires (Table 2). *Culex restuans* Theobald and *Cx. pipiens* comprised 82 and 13%, respectively, of the larvae collected. *Culex territans* Walker, *Culex salinarius* Coq., and *Ae. triseriatus* were rarer, each representing 1–2% of the total collections. *Anopheles punctipennis* (Say), *Aedes hendersoni* Cockerell, *Orthopodomyia signifera* (Coq.) and *Culex tarsalis* Coq. were scarce, all totaling less than 1%. Other immature flies (Chironomidae, Stratiomyidae, Psychodidae, and Syrphidae) were also occasionally recovered from woodlot tires. Larvae of *Cx. restuans, Cx. pipiens, Ae. triseriatus, Ae. hendersoni, and Or. signifera* were abundant and active in the cool water of sun-exposed tires up to the first freeze on November 14 (midday air temp. 4–7°C, water 5–7°C).

Data in Table 2 shows that species are generally indiscriminate and do not preferentially oviposit in tires of different size classes. Additionally, the mean number of larvae/dip (300 ml) in auto (20.3 ± 24.2), truck (15.5 ± 17.2), and tractor tires (11.1 ± 8.5) declined slightly with increasing tire size, suggesting that ovipositions do not greatly increase with increasing water volume or surface area. Tractor tires hold 13-fold more water volume than auto tires but larval density was one-half as much.

Species exhibited segregation with respect to the tire source (Table 3). *Culex restuans* was most frequently encountered at service stations and represented the majority of species breeding at all other sources. *Culex pipiens* was second of importance at all sources, showing minimal breeding at service stations and school playgrounds. *Culex territans* and *Cx. salinarius* were rare at service stations and tire dealers, with the former collected mostly from trucking companies and salvage yards, and the latter from trucking companies, fields/ditches, and woodlots. *Aedes triseriatus, Ae. hendersoni,* and *Or. signifera* were found only in wooded sources. Overall, tires in woodlots supported the greatest species diversity and service stations the least.

Aedes triseriatus infested auto and truck tires in woodlots, varying in size from 10 to 1,560 m^2, with 7-85 m (mode 25 m) the shortest distance from these tires to nearby human habitation. From August to October, only 6–11% of the water-filled tires available for mosquito colonization in woodlots (n = 133) contained *Ae. triseriatus*, the remainder infested with either *Cx. restuans* or *Cx. pipiens*. Frequently, *Ae. triseriatus* was the dominant or sole species when

Table 2. Number (percent/tire size) of mosquito larvae sampled from tires (May–November, 1985).

Species	Tire size class: Auto (269)[1]	Truck (95)	Tractor (49)	Total: n	%
Cx. restuans	3,774 (84)	957 (80)	543 (76)	5,274	82
Cx. pipiens	536 (12)	135 (11)	142 (20)	813	13
Cx. territans	45 (1)	46 (4)	12 (2)	103	2
Cx. salinarius	37 (1)	39 (3)	12 (2)	88	1
Ae. triseriatus	70 (2)	6	0	76	1
Or. signifera	18	2	0	20	<1
An. punctipennis	4	2	5	11	<1
Ae. hendersoni	9	2	0	11	<1
Cx. tarsalis	1	1	0	2	≪1
Total	4,494	1,190	714	6,398	100

[1] Number of dipper samples (300 ml ea).

Table 3. Frequency (%) of species per source/frequency source per species.

Species	Source of used tires							
	Service station (109)[1]	Tire dealer (78)	Truck co. (116)	Auto salvage (16)	School[2] (5)	Field ditch (34)	Woods (55)	Total (413)
Cx. restuans	38/96	30/89	17/76	6/85		4/57	5/50	5,274
Cx. pipiens	9/4	22/10	26/18	18/25	9/92	13/31	18/25	813
Cx. territans	9/<1	9/<1	30/3	24/7	6/8	14/4	9/2	103
Cx. salinarius		10/<1	30/2	5/1		30/8	26/4	88
Ae. triseriatus			1/<1				99/13	76
Or. signifera							100/4	20
An. punctipennis		27/<1	45/<1				27/<1	11
Ae. hendersoni							100/2	11
Cx. tarsalis		50/<1				50/<1		2
Total	2,074	1,800	1,167	375	78	338	566	6,398

[1] Number of dipper samples, 300 ml ea.
[2] Source sampled meagerly and only in early fall.

present in tires, with associated *Culex* species rare or absent, while nearby (1–2 m) organically rich tires lacking *Ae. triseriatus* often held large numbers of *Culex*.

Species seasonality. Proportions of *Cx. restuans* from tires remained high (98% of all *Culex* spp.) and stable through May and June, decreasing slightly in July (90%, n = 1,401) and substantially so in August (65%, n = 1,393). Light trap collections of this species followed a similar, but more substantial, seasonal decline; representing 37% of all *Culex* spp. (n = 386) in May to 5% (n = 928) in August. *Culex pipiens*, not present in tires until July (9.6%), peaked in August (29%), while light trap collections reflect its presence throughout the summer (62% May–June) with increases in the latter half (95% in July, 88% in August). *Culex territans* was equally represented throughout the season in tires and traps; *C. salinarius* only appeared in late summer.

DISCUSSION

The results indicate that a potentially large, unrealized number of tires may be hidden in the suburbs of large metropolitan areas, contributing significantly to the seasonal population growth of particular, medically important mosquitoes. Although most of these accumulations may be relatively small, they should not be overlooked but regularly monitored as additional mosquito breeding sites since their cumulative number can be quite substantial. Sources of these tires are numerous, but most can be grouped into 1 of 7 categories with the abundance of these different sources a reflection of local land usage and development. For example, in St. Joseph Co., Indiana, salvage yards and tire dealers were productive sources of mosquitoes, with larvae recovered from 60–100% of exposed tires (Beier et al. 1983b), but in this study larval infestations at these sources were much lower (25%). Differences in the surrounding urbanization, tire turnover time, organic content, and weather are just some of these factors which may account for this discrepancy. The apparent paucity of tire sources in the more affluent, rural western half of the District and greater abundance in more urban, lower income eastern half agrees with another survey in Louisiana which found that the economic level of the resident human population definitely influences the number of artificial containers deposited (Chambers et al. 1986).

Although every effort was made to locate and sample all waste tires within the survey area, several hundred additional scrap tires discarded in backyards were excluded since it was impossible to inspect every residence. Backyard tire accumulations may be important contributing sources of urban, disease-vectoring mosquitoes (Hedberg et al. 1985, M. A. Parsons, personal communication). Other surveys of smaller residential areas have yielded backyard tire frequencies of 3/block to 1/household, representing 25–31% of all larval positive backyard containers (Chambers et al. 1986). Once again, the average economic income of the surveyed area influences these proportions.

Tire orientation influences water accumulation and subsequent mosquito colonization. A significantly greater proportion of scattered tires at service stations and dealers contained water (32%) as compared to vertically stacked tires (22%), but the percentage of these larval-infested was inversely related (14 vs 25%, respectively). The greater sun exposure of scattered tires likely deters *Culex* oviposition as observed in sunny, subsurface concrete containers (Baumgartner 1987).

All of the 9 mosquito species recovered from tires in northeastern Illinois (Table 2) have also been reported from tires elsewhere (Rupp 1977, Barton 1978, Gordon and Peterson 1980, Restifo and Lanzaro 1980; Beier et al. 1983a, 1983b). However, the relative proportion of each of these species differs from 2 tire surveys in nearby Indiana (Beier et al. 1983a, 1983b); likely a reflection of environments and habitats unique to this study. *Culex restuans* and *Cx. pipiens* comprised 82 and 13%, respectively, of all larvae collected from mostly sun-exposed tires while in Indiana each represented 18–52% and 6–8%, respectively, of mosquitoes from exposed tires. Proportions of *Cx. territans*, *Or. signifera*, and *An. punctipennis* were in agreement with Indiana populations while *Ae. triseriatus* was rarely encountered in northern Illinois (1%) but was more abundant (15–23%) in Indiana. Among shaded tires in Indiana, *Ae. triseriatus* was predominant (62–89%), and *Cx. restuans* (7–32%) and *Cx. pipiens* (0.2–4%) were lesser constituents. In this study, shaded tires of woodlots contained a much lower percentage of *Ae. triseriatus* (13%) with *Cx. restuans* (50%) and *Cx. pipiens* (25%) more prevalent (Table 3). The relatively dry season during this survey could account for the lower proportion of *Ae. triseriatus* since frequent rainfall and floodwater are necessary to stimulate the hatching of eggs. However, the species proportions herein reported are in better agreement with data collected by Berry and Craig (1984) from recently discarded tires at the same tire yards in Indiana, showing that *Cx. restuans*, *Cx. pipiens*, and *Ae. triseriatus* comprised 92%, 1%, and 1%, respectively, of the exposed tires and 90%, <1%, and 8%, respectively, of shaded tires. As the water in tires age, they are reported to undergo a succession of species from *Cx. restuans* to *Ae. triseriatus* (Blaustein 1983). The closer fit of species proportions from Illinois suburban tires to that of "colonizing" tires (Berry and Craig 1984) than to "aged" tires (Beier et al. 1983a, 1983b) reaffirms the fact that most tires encountered in this study were of recent depositions. *Aedes aegypti*, *Ae. atropalpus*, *Ae. albopictus*, *Ae. vexans*, *Toxorhynchites rutilus septentrionalis* Dyar and Knab, *Anopheles barberi* Coq., *Culiseta melanura* (Coq.), and *Orthopodomyia alba* Baker are among the other species known to occur, or may range, in Illinois (Ross and Horsfall 1965) and have inhabited tires elsewhere (ref. cit.) but were not collected in this study. However, the former 3 species have been subsequently recovered from a large tire dump in Chicago (40 km distant from study site), likely introductions within tires imported from southern states (Bob Farmer, Clarke Outdoor Spraying Co., personal communication, Sept. 1987). The great productivity of *Cx. restuans* and *Cx. pipiens* from northern Illinois tires, in close proximity to human dwellings, and their implicated role as an avian amplifier and bird-to-man vector, respectively, of St. Louis encephalitis (see Baumgartner 1987) poses a constant threat to residents.

Each category of tire source provides a different habitat which, in turn, dictates a particular array of mosquito species (Tables 2 and 3). Species such as *Cx. restuans*, *Cx. pipiens*, *Cx. territans*, *Cx. salinarius*, and *An. punctipennis* which are able to tolerate a wide range of habitats (Siverly 1972) were present in varying but similar proportions intraspecifically at each source. The low species diversity and predominance of *Cx. restuans* at service stations (96% of total spp.) is likely a reflection of rapid turnover ($\bar{x}$ = 13 days) and minimal leaf debris accumulation in these tires since it is a pioneer species of new tire habitats (Berry and Craig 1984). *Aedes triseriatus*, *Or. signifera*, and *Ae. hendersoni*, which normally inhabit tree holes in forests, were mostly recovered from smaller auto tires of woodlots and rare or absent in the larger truck and tractor tires on open ground at all other sources. This preference of *Ae. triseriatus* for shaded tires rich in organic material has been repeatedly observed in Indiana (Beier et al. 1983a, 1983b; Berry and Craig 1984).

The preponderance of *Ae. triseriatus* in woodlot tires (Table 3) is not particularly surprising since it is principally a forest, tree hole species (Siverly 1972). All the necessary requirements of a prime oviposition site such as shade, rough textured and dark-colored walls, presence of organic matter, and dark-colored water (Wilton 1968) are met in woodland tires. *Aedes triseriatus* readily attacks humans and is the primary vector of LAC encephalitis in the upper midwest (Clark et al. 1983). Old tires containing *Ae. triseriatus* near residences in Minnesota (Hedberg et al. 1985) and Ohio (Gordon and Peterson 1980) have been incriminated as the major source of LAC cases. The close proximity (7-85 m) of *Ae. triseriatus* infested tires to human activity as found in this study implies that residents near woodlots containing tires are at an elevated risk for LAC encephalitis since it is known to disperse 100 m from woodlands into open terrain in search of blood meals and oviposition sites (Mather and DeFoliart 1984). *Aedes triseriatus* is also emerging as an important vector of canine heartworm [*Dirofilaria immitis* (Leidy)] in the Midwest (Rogers and Newson 1979).

Seasonality of the predominant mosquito species recovered from tires generally agrees with their phenology in Indiana tires (Berry and Craig 1984), and from light traps and other container collections within the survey area (Baumgartner 1987). The large representation of larval *Cx. restuans* over *Cx. pipiens* in tires (65 vs 5% of all *Culex* larvae, respectively, in August) despite an abundance of adult *Cx. pipiens* in the environment (29 vs. 88%, respectively, from light traps) suggests that tires are selectively favored and generally more attractive to *Cx. restuans* than *Cx. pipiens*. Species compositions from other tire surveys support this (Beier et al. 1983a, 1983b; Berry and Craig 1984). Although *Cx. restuans* is generally considered a cool weather, spring species (Siverly 1972), its abundance throughout the summer in tires in Connecticut (Andreadis 1988) and herein reported, and summer abundance in construction sites (Baumgartner 1987), suggest that it may be more prevalent during warm periods than previously thought or implied by light trap collections.

Control of tire mosquitoes in metropolitan suburbs may involve several possible strategies, depending on the source category. Informational pamphlets may be distributed to service stations, tire dealers, and salvage yards alerting them to the hazard. Indoor storage or outdoor storage of tires under a roof would certainly prevent rainwater entry and associated mosquito colonization. If outdoor roofs are not possible or desired, mosquito production can be minimized by combining frequent disposal with careful storage; vertical stacking of tires in steep pyramids, rather than shingle stacking or random scattering, so that only uppermost tires receive rainwater, and in sunny areas away from vegetation. Those businesses concerned with disposal should not discard tires in landfills because of eventual resurfacing but may accept tires for: recapping; shredding for use in molded products, playgrounds, or asphalt (Frank 1981); or incineration to produce electricity or oil (Anonymous 1987). Tires deposited at school playgrounds should: possess large (>5 cm) drainage holes to prevent water accumulation; be placed on sand beds, not woodchips or lawns, and; be regularly inspected for clogged drain holes. Wood chips, frequently employed as a substrate for playgrounds, are not recommended around tires because they are easily kicked into tires and are excellent mosquito ovipositional attractants and larval growth propagators when inundated (see Baumgartner 1987). Discarded tires in woodlots, fields, and ditches may be regularly monitored and treated with granular insecticides or removed and properly disposed. For many mosquito abatement districts tire removal, perhaps best performed during fall and winter months, is less expensive than periodic control and is the best permanent solution (S. A. Wagner, Saginaw Valley Mosquito Abatement, MI, personal communication). In the case of backyard, residential tire sources, the public can be directed to disposal facilities or instructed to retain only rim-mounted tires outdoors. Abatement district cooperation with local and state governments in developing legislation and enforcing a tire removal and storage ordinance is certainly advantageous. Besides these, several other options exist for the utilization of discarded tires (Reiter and Sprenger 1987). As a possible future control technique, predaceous tree hole mosquitoes (*Toxorhynchites* spp.) are currently being evaluated as biocontrol agents for container-breeding mosquitoes (Focks et al. 1985).

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