IMPORTANCE OF CONSTRUCTION SITES AS FOCI FOR URBAN *CULEX* IN NORTHERN ILLINOIS

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ABSTRACT. Expanding urbanization in America has created many new artificial sources which serve as focal points for urban, opportunistic and disease-vectoring mosquitoes. One such urban source, building construction sites, has received little attention despite a growing construction industry. During the summer of 1985, 522 unfinished buildings, 90% as single-family homes, were surveyed for water accumulation, larval mosquito occurrence and density, and species involved. Sump-pits and basements proved to be the most abundant sites of water accumulation of unfinished homes in the later stages of completion with *Culex restuans* and *Cx. pipiens* dominating the collections from these sites. Buildings at early stages of construction were much less productive, probably due to sun-exposure. Factors which favor mosquito colonization such as reduced illumination and temperatures, and increased organic content are discussed. Various cultural and insecticidal controls of mosquitoes breeding at construction sites are suggested.

INTRODUCTION

Man's encroachment on natural areas and modification of the environment have resulted in the local suppression of some mosquito species through habitat destruction, concurrently creating new artificial sources which are emerging as the primary sources of opportunistic, annoying, and medically important species. Catch basins, septic tanks (Babu et al. 1983, Lam and Dharmaraj 1982), subsurface electric transformer enclosures (Myers et al. 1973), utility tunnels and air shafts (Spielman 1964), and other concrete containers (Toma et al. 1983, Narayanan and Maruthanayagam 1985) are some of these new artificial sources. It is imperative that mosquito abatement districts maintain surveillance on these urban sources and know of their importance in mosquito production so that effective control operations can be maintained. The data presented herein are concerned with another artificial source, construction sites.

In Russia, larvae of *Culex pipiens* Linnaeus and *Culex molestus* Förskal (= autogenous *Cx. pipiens*) have frequently been collected in flooded basements (Aksenova et al. 1973, Sichinava 1981, Aksenova 1982). Since 1968, the city of Leningrad has reduced mosquito breeding in basements through insecticidal treatments and water removal (Vansulin 1975), and in Moscow methoprene has controlled basement populations of *Cx. molestus* (Pridantseva et al. 1979). Other species reported from flooded basements include *Anopheles atroparvus* van Thiel in Romania (Giurca et al. 1978) and *Anopheles plumbeus* Stephens in Yugoslavia (Tovornik 1978).

In the United States, the construction industry has been steadily growing since 1981. In 1985, 686,000 single-family homes were sold, 47,000 above the 1984 total and is approaching the 1977 high of 819,000 homes (Anonymous 1986). Expansion seems to be occurring mostly in the suburbs of large metropolitan areas. Although many American mosquito abatement districts recognize that construction sites are mosquito sources, little is known of their real threat. In 1984, Fairfax County (Virginia) Mosquito Control Program employees noted a large number of mosquito complaints originating from areas under development near Washington, DC (Kraft 1985). Incomplete roadside gutters and storm drains, water in tire ruts, and improperly graded yards, combined with the common practice of adding straw to muddy puddles, contributed to their mosquito problems. I now report on a survey conducted during 1985 in northeastern Illinois on the mosquito dynamics associated with building construction areas. Methods of mosquito suppression are included.

MATERIALS AND METHODS

From May 24 to September 19, 1985, a survey was made of larval mosquito production in and around buildings under various stages of construction. These included new single-family homes, apartment buildings, condominiums, office complexes, factories and other unfinished dwellings, which were encountered during the daily inspection of all mosquito sources within the jurisdiction of the Northwest Mosquito Abatement District. This area encompasses 118 sq. miles (307 km^2) within 5 townships (Wheeling, Maine, Elk Grove, eastern half Palatine, one-quarter Northfield) with a population of 417,050 (1980 census, Anonymous 1982) in northwestern Cook County of northeastern Illinois. Relatively few tracts of forest or farmland remain in this sprawling suburban area.

The extent of construction at all sites was arbitrarily divided into 3 stages, each representing a slightly different environment. The first, "ground breaking", is represented by a large depression in the landscape, the future site of a cement foundation, in which rain or ground water may accumulate. The second stage, "foundation", is characterized by a cement foundation and basement floor which have been poured into the ground depression. Stagnant water in this and the previous stage is exposed to daily sunshine. At a later time, stage 3, "framed", is achieved, characterized by the erection of a wood floor over the basement and a wood frame delineating the rest of the building. Water which accumulates in the basement at this time is completely shaded. Lastly, an intermediate stage between the previous 2 was recognized as a time when the floor boards are being laid.

Each construction site was visited only once, inspected for standing water, surveyed for mosquito larvae, and then promptly treated with larvicides if larvae were detected. Data routinely recorded included the date of inspection, location, stage of construction, water sources, presence or absence of larvae, and number of larvae per dip (density). Data occasionally recorded included air and water temperatures, water pH (full-range test paper, Micro Essential Lab, NY), presence of other aquatic invertebrates, and physical characteristics of, and debris in, the water. Spot temperatures were taken (1330–1500 hr) with a standard lab thermometer, allowing 5 min equilibration between recordings. Temperatures were taken at 3 locations of stage 3 buildings: in shade at ground level (0.5 m), exterior to building; inside the basement at 0.5 m and; in sump-pit water at a depth of 5 cm. All larval samples were standardized by pushing a "soup ladle" type, semicircular hand dipper (11 cm diam, 6 cm deep, holds 375 ml water) vertically into the mosquito infested water, near the edge of the source. Each larval source was sampled only once, being careful not to create shadows over the water or other disturbances which may repel surface larvae. Even so, this sampling may be biased for particular species and instars, as well as clumping of larvae (Service 1976). The number of instars present in the water sample were noted and transported to the laboratory for identification. For convenience, samples were refrigerated at 4°C for 1–5 days prior to identification. All identifications are based on larvae, usually 4th instar, using Ross and Horsfall (1965) and Siverly (1972). No effort was made to distinguish between *Cx. pipiens* and *Culex quinquefasciatus* Say. Taxonomic and distributional studies suggest that only *Cx. pipiens* occurs in this study area (Barr 1957). Voucher specimens from this study are deposited at the U.S. National Museum. New Jersey light traps operating seasonally for the past 5 years have attracted 25 mosquito species with *Aedes vexans* (Meigen) (78% of females, n = 95,808) and *Cx. pipiens* (10%) dominant. Other species such as *Aedes trivittatus* (Coquillett), *Anopheles punctipennis* (Say), *Anopheles quadrimaculatus* Say, *Culiseta inornata* (Williston), and *Coquillettidia perturbans* (Walker) each comprised no more than 1–2% of the total.

All mosquito infested waters at construction sites were treated after sampling with methoprene briquets (1/sump-pit) or oil (100% mineral seal oil, tergitol adjuvant), depending on the area to be treated and its accessibility.

Total larvae per source area was extrapolated through calculation of the Mosquito Production Index [number of larvae per dip area multiplied by total water area (Service 1976)]. Lab measurements of styrofoam (expanded polystyrene) beads spread on the water surface showed that the dipper utilized in the aforementioned sampling manner drew in 0.0314 m surface area of water.

RESULTS

During the course of this study 522 buildings under construction were inspected and 8,343 mosquito larvae among 11 species were collected. The construction sites included 468 (90% of total) single-family residential homes, 41 (8%) townhouse buildings, 6 (1%) apartment buildings, 4 high-rise office buildings, 1 factory, 1 condominium and 1 parking garage. Of these sites, only 19 (4%) were at the ground breaking stage of construction (stage 1) at the time of inspection, 90 (17%) were at stage 2 (foundation), 368 (70%) were at stage 3 (framed), and 45 (9%) were intermediate between stages 2 and 3. These numbers reflect the transitory nature of each stage of construction. Usually, the cement foundation was laid within a few days following ground breaking and, once begun, the wood flooring and building frame could be installed in 1–2 weeks. Stage 3, however, may continue to accumulate water and produce mosquitoes for 3 weeks or more, until the building is wired for electricity, the grounds leveled and planted, and the building advertised for sale. In all, 1–2 months may elapse before building completion. If financially depressed, some building contractors cease work, abandoning an unfinished site which may be a source of mosquitoes throughout the entire breeding season.

Locations of standing water and larval infestation. Table 1 is a summary of the major locations of standing water at single-family home construction sites. Water was commonly found in sump-pits, in basements, and in tire ruts adjacent to buildings. Occasional accumulations of water were found in other depressions near the foundation, at the base of beam supports (in basements), and at the bottom of window wells (Fig. 1). Most water originated from rainfall and/or ground seepage, with tap water from construction crews an infrequent contributing source. During a relatively dry season, as was the case for 1985 in Cook County (361 mm rain May–September, 468 mm norm, National Oceanic and Atmosphere Admin.), these construction sources held water and produced mosquitoes even though nearby ditches and marshes were dry.

Stage 1 of construction was frequently of the shortest duration and the least important in terms of mosquito production. Of 19 sites encountered, 13 (68%) possessed standing water with only 5 (38%) of these sources containing mosquito larvae.

Stage 2 construction sites played a more important role in mosquito production. Of 90 surveyed, 76 (84%) were found to have some standing water with 50 (66%) of these containing *Culex* larvae. Thirty-eight of 60 (63%) water-containing, sun-exposed sump-pits had larvae while only 6 of 33 (18%) sun-exposed, flooded basements were sources of larvae.

Stagnant water with mosquito larvae was most frequently encountered at construction sites of stage 3. These unfinished buildings may host several generations of *Culex* mosquitoes if given enough time. Of 356 buildings surveyed, 344 (97%) had water pools with 266 (77%) supporting larval development. Sump-pits and flooded basements were the major sources of water, but unlike stage 2, these areas are shaded by floorboards.

Sump-pits. Sump-pits were the most frequently encountered sites of stagnant water (Table 1); all ground seepage, because the water pump is usually not installed and wired until much later in the construction process (Fig. 1C). In most single-family residential buildings there were 2 basement pit depressions of equal size and shape, one serving as the sump-pit and the other serving as the septic pit. These cylindrical pits are either 40 or 43 cm diam with a mode depth of 61 cm. On 2 occasions, abnormally large (diam 0.9 m and 1.2 m) sump-pits were encountered in basements of multistory office buildings. Water within sump-pits is kept cool by surrounding soil; temperatures in stage 3 sites ranged from 17° to 21°C ($\bar{x}$ = 18.9°C, n = 9), 4–10°C ($\bar{x}$ = 6.5) below that of basement air temperatures and 5.5–17°C ($\bar{x}$ = 9.9) less than that of outside ground air temperatures.

Shaded sump-pits (stage 3) proved to be the most frequent sites of stagnant water and mosquito larvae at high densities (Table 2). Eighty-nine percent (n = 261) of these pits contained water, from which 7 species among 4,822 mosquito larvae were sampled. The number of *Culex* larvae per dip varied from 1 to 300 ($\bar{x}$ = 29.5, n = 145), with 60–130 not uncommon. Given these numbers, the surface area of the sump-pits (1,256 cm^2), and the average sampling surface area of the dipper (314 cm^2), an estimated 4 to 1,200 ($\bar{x}$ = 118) larvae can infest a single sump-pit, with totals of 300 common. Depending on the period a building remains uncompleted, multiple generations of mosquitoes may emerge from a single pit, potentially yielding hundreds of adults. These totals are surprisingly low, however, considering that the entire size range of instars and egg rafts were frequently observed in sump-pits, implying multiple ovipositions yielding potential larval densities of at least 5x greater than that observed. This suggests heavy larval mortality within the confines of sump-pits.

Sun-exposed (stage 2) sump-pits differed from shaded sump-pits (stage 3) in water retention, percentage containing larvae, larval density and species composition. Nineteen percent (n = 74) of stage 2 sump-pits were dry, as compared to 11% (n = 261) of stage 3. Although not significantly different (χ^2 = 0.089; df = 1; p > 0.01),

Table 1. Incidence of standing water and mosquito larvae at unfinished single-family homes.[1]

Sites	Ground Breaking (stage 1)	Foundation (stage 2)	Framed (stage 3)
	Stage of Construction		
Inspected	19	90	356
Standing water	13	76	344
Larvae present	5 (38)[2]	50 (66)	266 (77)
Dry sump pits		14	28
Water-filled sump pits[3]		60	233
Larval infested sump pits		38 (63)	144 (84)[4]
Sump pump working, no larvae			62
Sump pump working, larvae present			6
Pools/flooded basements		33	117
Larval infested basements		6 (18)	88 (75)
Water-filled tire ruts		14	137
Larval infested tire ruts		1 (7)	26 (19)
Water exterior to foundation		6	35
Larval infested foundations		4 (67)	19 (54)
Water-filled support post holes			20
Larval infested post holes			9 (45)

[1] Data are absent for structures which are not present at that stage of construction.
[2] Percent larval infested of total structures holding water.
[3] Counts are excluded for which entire basements are flooded.
[4] Percentage based on total containing water minus those operational and without larvae.

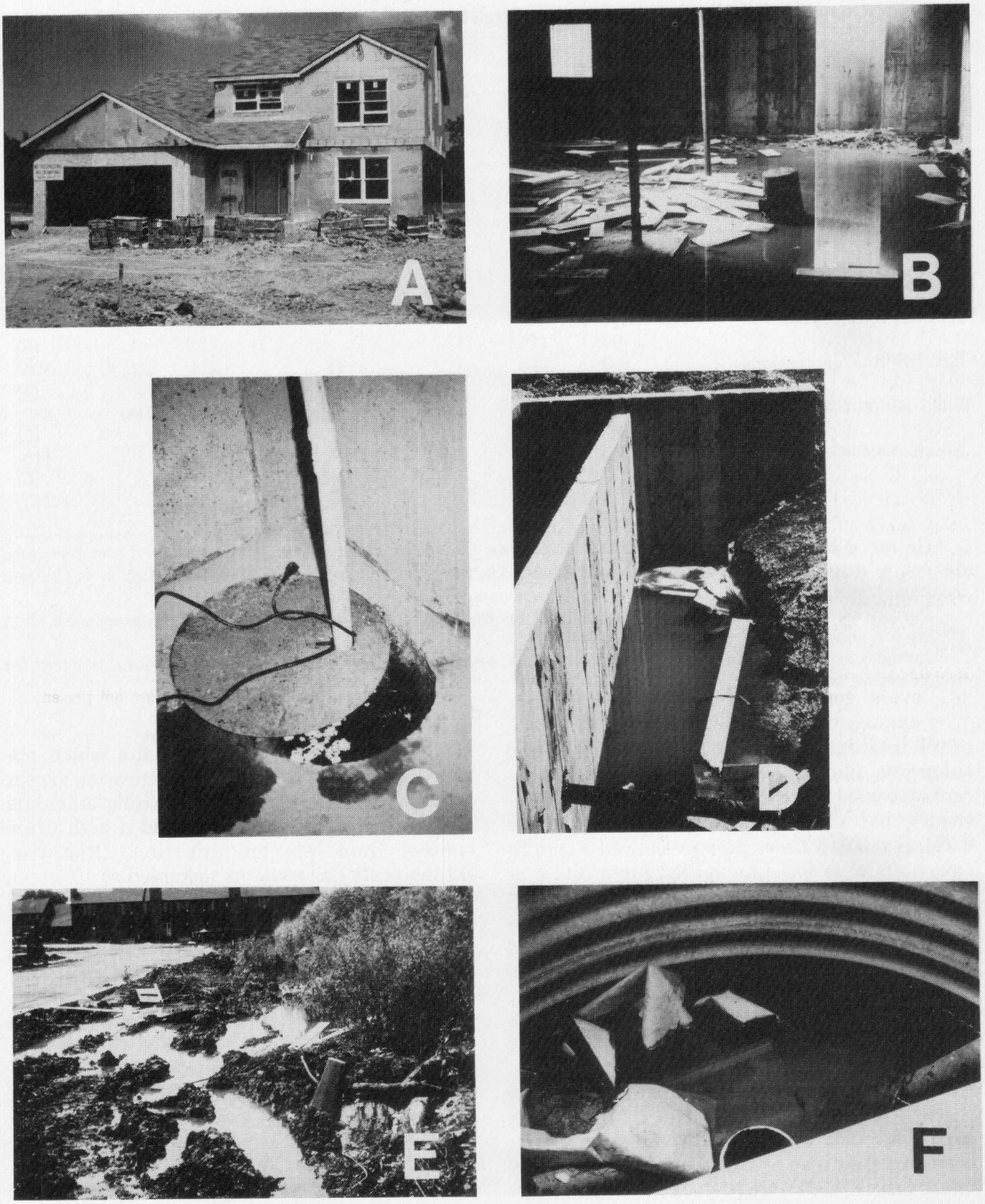

Fig. 1. Common sites of water accumulation and sources of *Culex* mosquitoes around home construction: (A) Unfinished single-family residential building at stage 3; (B) Mud floor of flooded basement littered with scrap lumber and other debris; (C) Water-filled sump-pit containing urine, wood debris and floating styrofoam pellets, house not yet wired but sump-pump in place as evidenced by the cord; (D) Flooded depression adjacent to cement foundation at stage 2 construction, containing waste lumber, cardboard and other debris; (E) Tire ruts and other ground depressions along a new residential road; and (F) Flooded window well containing paper debris, infested with ca. 70 *Culex* egg rafts (visible as black specks) and hundreds of late instar larvae.

63% (n = 60) of sun-exposed sites contained larvae whereas 84% (n = 233) of shaded pits were larval infested. Larval density was also lower in sunny sump-pits (range 1–50/dip, $\bar{x}$ = 11.3, n = 32), probably resulting from reduced ovipositions, as compared to shaded sources (1–300/dip, $\bar{x}$ = 29.5, n = 145). *Culex restuans* Theobald comprised 85% and *Cx. pipiens* 15%

Table 2. Number of mosquito larvae (all instars) collected at construction sites.

Water Location	Species[1]								
	Cx. res.	*Cx. pip.*	*Cx. sal.*	*Cx. terr.*	*Ae. vex.*	*Cx. tar.*	*An. punc.*	Other	Total
Shaded sump-pit	4,087	711	4	13	1	4	2		4,822
	(85)[2]	(15)							(58)
Sun-exposed sump-pit	239	180	8		3				430
	(56)	(42)							(5)
Shaded basement	797	426	3	8	1	2	4	2(a, b)	1,243
	(64)	(34)							(15)
Sun-exp. basement	41	25		1					67
	(61)	(37)		(2)					(1)
Exterior to foundation	541	73	7	1		6			628
	(86)	(12)	(1)			(1)			(8)
Ext. tire ruts/depressions	163	113	1		42		4	2(c, d)	325
	(50)	(35)			(13)		(1)		(4)
Shad. support post hole	229	146	3	1				1(a)	380
	(60)	(38)							(5)
Miscellaneous[3]	236	208	3	1					448
									(5)
Total	6,333	1,882	29	25	47	12	10	5	8,343
	(76)	(23)							

[1] *Cx. res.* = *Culex restuans*, *Cx. pip.* = *Culex pipiens*, *Cx. sal.* = *Culex salinarius*, *Cx. terr.* = *Culex territans*, *Ae. vex.* = *Aedes vexans*, *Cx. tar.* = *Culex tarsalis*, *An. punc.* = *Anopheles punctipennis*. Other: a = *Culiseta inornata*; b = *Anopheles quadrimaculatus*; c = *Aedes dorsalis*; d = *Aedes cinereus*.

[2] Percent of total species per site. Percentages may not total 100 because of rounding. Percentages less than 1% are not considered significant and not shown.

[3] Includes elevator shafts, sunken swimming pools, new bathtubs, and other ground depressions. See text for breakdown of sources.

of the total larval species sampled from shaded sump-pits, but at sun-exposed sources the percentages were more equal (56 and 42%, respectively), but still significantly different (χ^2 = 8.291; $p < 0.01$). *Culex pipiens* showed a significant preference for sun-exposed sump-pits over shaded (42 vs. 15% of totals; χ^2 = 346.6; $p < 0.01$). *Culex territans* Walker, *Culex tarsalis* Coquillett, and *An. punctipennis* were recovered from shaded sump-pits but never found in sun-exposed sources (Table 2).

Functional sump-pumps of late stage 3 pumped water and displaced larvae outside where the exposed larvae often died from drying. The pump may even deter further oviposition through mechanical disturbance. Only 6 of 68 sump-pits with operational sump-pumps contained *Culex* larvae or egg rafts; only a few early instar larvae (1–2) were present (1/4 dips), atypical for sump-pits. In two instances larvae were absent in pits with a working pump but abundant in the septic pit lacking a pump in the same basement.

Most construction employees regard sump-pits as a disposal area and toilet for scraps of lumber, cardboard, paper cups, human food, cigarette butts, other discarded items, feces and urine. This foul water usually attracted ovipositing *Culex* and promoted larval development. However, larvae were absent in 9 of 25 pits and sparse (1–8/dip) in another 7 pits which appeared suitable for mosquito colonization except for a deep yellow color and a strong ammonia odor. Presumably, these pits had a high urine content from repeated urination. Otherwise, coinhabiting *Cx. restuans* (sampled at 10 sites), *Cx. pipiens* (8), and *Cx. salinarius* Coquillett (1) larvae were present in urine water. Water samples (n = 7) averaged 8.4 pH (normal $\bar{x}$ = 6.4), with 1 pit containing 2nd instar *Cx. pipiens* larvae (3/dip) at pH 10.

Basements. Flooded basements and pools on basement floors (Fig. 1B) ranked second as a site of stagnant water at construction sites (Table 1). Basements varied in size from 27 to 81 m^2 ($\bar{x}$ = 48.8, n = 14) and, when inundated by ground water from rain, flooded to a depth of 1.3-61 cm (mode = 5.1, $\bar{x}$ = 11.4, n = 60). Water commonly remained 2 weeks or more if not pumped out. Thirty-five percent of basements at stage 2 and 3 construction sites were flooded. Lumber, empty cardboard boxes and other debris were common in basements, with straw occasionally spread over wet and muddy basement floors to facilitate human movement. At ca. 2 m below the ground, basement air temperatures varied from 23 to 28°C and were generally 1.5° to 7°C cooler ($\bar{x}$ = 3.5, n = 9) than outside air temperatures in the shade.

Larval incidence among stage 2 (sun-exposed) and stage 3 (shaded) sites varied greatly. Significantly fewer sun-exposed flooded basements contained *Culex* larvae (18%, n = 33) as compared to shaded basements (75%, n = 117) ($\chi^2 = 37.66$; $p < 0.01$). Relative proportions of *Cx. restuans* and *Cx. pipiens* were equivalent between sun and shaded basements, although *Cx. tarsalis*, *Cx. salinarius*, *An. punctipennis*, *Anopheles quadrimaculatus*, *Cs. inornata* and *Ae. vexans* were recovered only from shaded basement water.

Although shaded basement water yields far fewer *Culex* larvae per dip ($\bar{x} = 12.4$, range 0.5-62, n = 76) than sump-pits ($\bar{x} = 29.5$), the total potential larval production and subsequent adult emergence from basements greatly exceeds sump-pits. Based on actual samples, an estimated 780 (at 0.5 larvae/dip in 49 m^2 area) to 154,000 (60/dip, 81 m^2 area) and an average 18,700 larvae (12/dip, 49 m^2) may mature in a single basement. These estimates are only gross approximations which may differ greatly from absolute numbers, since the estimates depend on samples of larvae which are not always evenly distributed (Service 1976).

Tire ruts. Water from rain, sump-pump ejection and garden hoses of work crews often accumulated in tire ruts and other surface depressions adjacent to buildings (Fig. 1E), but was only transient because of evaporation and contributed little to the total mosquito production from construction sites. Ground depressions were more numerous, contained more debris, and possessed more peripheral vegetation at stage 3 sites than stage 2. More water-filled tire ruts were found at stage 3 sites (38%) than stage 2 (16%) ($\chi^2 = 17.426$; $p < 0.01$), with 19% and 7%, respectively, containing larvae. Tire ruts and depressions yielded a different array of mosquito species (Table 2) with floodwater *Ae. vexans* a more important constituent at these sites, and *Aedes dorsalis* (Meigen) and *Aedes cinereus* Meigen only recovered from these areas.

Other sources. Numerous other infrequently encountered locations held water in which mosquitoes oviposited. Ten percent of the depressions around foundations (stage 3), littered with wood and paper debris, were flooded, with 54% of these supporting larvae. In 20 basements (stage 3) water containing mostly *Cx. restuans* and *Cx. pipiens* was found in small square post-hole depressions (30 cm^2 area, 10 cm depth) surrounding floor support beams. At 3 buildings larvae were found in flooded window wells (36 x 61 cm) (Fig. 1F). At most high-rise office and apartment buildings inspected, water inundated cement elevator shafts (1.5 x 2.4 m) contained paper and wood debris, and had larvae. An indoor sunken swimming pool at a residential home was also infested. Water and larvae also collected in ground depressions for future curbs along new roads and sidewalks. Holes (1 m diam, 0.25 m deep) filled with water on front lawns intended for new tree implantations were larval-infested. Lastly, rainwater and paper debris from workmen accumulated in ceramic bathtubs, which were installed in high-rise apartment buildings before completion of the roof, supported *Cx. restuans* larvae.

Larval collections. The greatest number of larvae (58%, n = 8,343) were sampled from shaded sump-pits, followed by shaded basements (15%) which also supported the greatest species diversity (Table 2). Stagnant water was common at many other sources but yielded fewer larvae and contributed minimally to the overall mosquito production.

Culex restuans (76%) and *Cx. pipiens* (23%) were dominant among larvae sampled from all water sources. Other species sampled included *Cx. salinarius*, *Cx. territans*, *Ae. vexans*, *Cx. tarsalis*, *An. punctipennis*, *An. quadrimaculatus*, *Cs. inornata*, *Ae. dorsalis* and *Ae. cinereus*. Proportions of *Cx. restuans* and *Cx. pipiens* varied only slightly over the entire mosquito breeding season. *Culex restuans,* already present in moderate numbers at the start of the survey (24 May), remained high during the season, and only declined in mid-August, with specimens collected up to the end of the study (19 September). *Culex pipiens* did not appear in the collections until mid-June with low numbers sustained until mid-July, after which time it became more prominent and remained so up to the last collection date. This late season build-up of *Cx. pipiens* is similar to patterns observed elsewhere (Wood et al. 1979). Both *Cx. territans* and *Cx. salinarius* were collected sporadically throughout the season.

Adult emergence. At 12 construction sites, numerous (hundreds at 2 sites) adult *Cx. restuans* and *Cx. pipiens*, presumably only recently eclosed, were observed flying out of untreated flooded basements and sump-pits. This mass exodus is evidence that many larvae encountered throughout the course of this study may develop to maturity if uncontrolled. However, not all the actual and estimated larvae in the aforementioned water sources, especially sump-pits, may survive to adulthood. Overcrowding, intra- and interspecific competition, desiccation, invertebrate predators, human-derived chemicals (urea), and other biotic and abiotic factors are known to take their toll on mosquito larvae (Horsfall 1955).

Control. Two hundred and ninety-nine sites required larvicidal treatment (surface oil or methoprene briquets). Oil effectively eliminated mosquito larvae at all outdoor sources and in flooded basements as determined by follow-up inspections. Methoprene briquets were deposited in sump-pits to attack mosquitoes within these sources. The use of briquets enabled quick treatment of many larval-rich sump-pits, eliminating the need for heavy and cumbersome spray equipment required with oils. Entry to many basements was gained through window wells since basement stairs were frequently absent or incomplete.

DISCUSSION

The data presented affirm that sump-pits and basements of unfinished, single-family homes are important sites of water accumulation and sources of *Cx. restuans* and *Cx. pipiens* in northern Illinois. This is not surprising in view of the amount of organic matter (lumber, other wood products, human waste) which decomposes in this water. This pollution likely releases strong ovipositional attractants and promotes bacterial growth for developing instars. In Oregon, log ponds produce substantial numbers of *Culex* (including *pipiens*) mosquitoes (Harmston et al. 1960). Experimentally, log pond water and its derivatives, methane, produced by cellose decomposition, are strong attractants to ovipositing *Cx. quinquefasciatus* (Gjullin et al. 1965).

Human feces and urine in sump-pit water further enhances this site for mosquito colonization. Stale urine has long been known as an ovipositional attractant to *Cx. pipiens* in the field (Crumb 1924). Sewage disposal lagoons are prolific breeding sites of *Cx. pipiens* in Illinois (Wray 1959). In vitro experiments demonstrate that *Cx. restuans* prefers to oviposit in water contaminated with animal feces, depositing 100x more rafts in this water than that contaminated with alfalfa pellets (Hoban et al. 1980).

In low dilutions, water containing some urine is generally attractive to *Cx. pipiens* (Crumb 1924) but high concentrations may be slightly toxic or inhibitory to gravid females. *Culex quinquefasciatus* prefers ovipositing in water at 7.3–8 pH but under more alkaline conditions (>8.2 pH) it is inhibited (DeAlwis and Munasinghe 1971). In this study, larvae were absent or at a low density in urine-rich sump-pit water. Seven sump-pits which were high in ammonia and contained few larvae averaged 8.4 pH.

Many construction firms commonly spread straw onto wet and muddy areas in unfinished basements, in exterior depressions, and in tire ruts to facilitate human movement. Not surprisingly, mosquito larvae often occur in such locations where they may complete development, providing the water is permanent enough. Hay infusions, and bacteria that flourish in it, emit volatile chemicals which are strong ovipositional attractants to *Cx. quinquefasciatus* (Hazard et al. 1967).

Low illumination alone within basements at stage 3 may attract gravid females. In Nebraska, *Cx. pipiens*, *Cx. restuans*, and *Cx. salinarius* larvae generally occur in shaded areas (Edmunds 1958), and *Cx. restuans* prefers to oviposit in black-lined (low reflectance) woodland pools (Belton 1967). Low temperatures of basement and sump-pit water ($\bar{x} = 3.5°$ and 9.9°C, respectively, less than ambient at $\bar{x} = 28.8°$C) may also attract gravid *Culex*. Basement temperatures in July averaged 25.3°C, within the range of 20–25°C at which *Cx. pipiens* deposits the greatest number of egg rafts (Gillespie and Belton 1980).

The discovery of significant *Cx. restuans* and *Cx. pipiens* breeding in construction areas has a great potential impact in view of their medical importance. *Culex restuans* probably plays a role in the early amplification and maintenance of St. Louis encephalitis among avian reservoirs (Francy et al. 1981) and *Cx. pipiens* is recognized as the principle vector of this virus to man in eastern North America (Wood et al. 1979). Although *Cx. restuans* and *Cx. pipiens* are generally reported as ornithophilic, several studies show *Cx. restuans* (King et al. 1942, Means 1968) and *Cx. pipiens* (Means 1968, Wright and DeFoliart 1970, Ekis 1971) to substantially feed on mammals and man. In Illinois, *Cx. pipiens* is said to be a persistent but wary biter (Ross 1947). In Russia, basement-derived *Cx. pipiens* are highly endophilic and actively attack people (Aksenova et al. 1973). In Virginia, a large number of mosquito complaints originated from areas under development (Kraft 1985) and in this study construction workers admitted being bothered and bitten by mosquitoes while on the job.

Alerting local construction firms and contractors through informative leaflets to the potential mosquito production from building sites, and seeking their cooperation in reducing or minimizing standing water, may help in preventing mosquito colonization. Suggested cultural control practices include: proper discarding/removal of waste lumber and paper; frequent janitoral maintenance; drainage of standing water; immediate installation of sump-pumps; direction of sump-water far from building via downspout extenders; covering sump-pits with nonporous plates; and providing clean, portable toilets near buildings for construction crews. Drainage practices have proved successful in eradicating basement populations of *Culex* in Russia (Vansulin 1975, Sichinava 1981). Application of expanded polystyrene balls (EPB) to sump-pits may be another useful nontoxic and inexpensive physical control technique which construction firms or mosquito abatement districts can utilize. In this study, mosquito larvae were unexpectantly absent or rare in sump-water with a surface covering of styrofoam pellets, waste packing material from appliance shipping containers swept into the pits by workers, but numerous in sump-pits which lacked a styrofoam covering in nearby buildings. The use of EPB has been suggested as a control for septic tank mosquitoes in Malaysia (Lam and Dharmaraj 1982) and has effectively controlled mosquitoes in African pit latrines (Reiter 1985). Theoretically, this "floating blanket" hinders oviposition.

Insecticides are useful in the absence or failure of physical control methods. In this investigation, methoprene and oil were successfully used to depress mosquito larvae within construction sites. Methoprene has also been used in Russia to inhibit *Cx. molestus* development in flooded basements (Pridantseva et al. 1979).

Further studies are needed to address the question whether construction sites serve as breeding areas for autogenous *Culex*. *Culex molestus,* which is entirely autogenous, is common in Russian basements (see introduction) and autogenous *Cx. pipiens* have been recovered from a water-filled hole in a storeroom floor in Illinois (Wray 1946). Many records of *Cx. molestus* are known from urban loci, where its breeds in enclosed areas (Spielman 1971). Hybridization between autogenous and anautogenous populations may explain episodes of human feeding by temperate zone *Cx. pipiens* (ref. cit.).

As a result of this investigation, it is now known that *Cx. restuans* and *Cx. pipiens* prevail around construction areas in northern Illinois, and that control efforts should be directed at sump-pits and basements. Information such as this is useful to many other mosquito abatement districts with extensive building within their jurisdiction.

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