DISTRIBUTION IN TEXAS OF *LANKESTERIA CULICIS* (ROSS), A PARASITE OF *AEDES AEGYPTI* (L.) [1]

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Results of operational surveys in Texas from 1964 to 1968 showed the general area infested with *Aedes aegypti* to be somewhat parallel to the Gulf Coast. Its interior border extends from Webb County northward along the western edge of Uvalde County through Mason County and the northwest corner of Tarrant County and then eastward to Cass County on the Louisiana border. The Gulf Coast edge encompasses Nueces, Wharton, and Harris Counties. Nueces was the only coastal county found to be infested with *Ae. aegypti*. Bexar County, in the south central part of the area, was most heavily infested.

This paper is based on observations of the *Ae. aegypti–Lankesteria culicis* relationship in three of the six primary Texas cities included in the study referred to by Gentile *et al.* (1971) in the first paper of this series. The natural incidence of the protozoan population within the host, its seasonal and geographic occurrence, and its establishment and dispersal when artificially introduced are discussed also.

SEASONAL AND GEOGRAPHIC OCCURRENCE. The three Texas cities and their respective satellites are Houston (Cleveland), San Antonio (Seguin), and Corpus Christi (Sinton). Selected sites in each city and its satellite were surveyed during three periods in 1968—May–June, July–August, and September–October—with the exception of San Antonio and Seguin, which were not surveyed in the third cycle. A few of the sites in Corpus Christi became inaccessible during the latter inspection cycles and were eliminated from the survey.

The percent of sites and containers with *Ae. aegypti* larvae parasitized by *L. culicis* varied from none in Corpus Christi to an 86 percent infestation rate for sites in Houston (Table 1).

RATE OF PARASITISM. The infection rate of *L. culicis* in *Ae. aegypti* is based on larvae collected in Houston during the spring, summer, and fall of 1968. Table 2 summarizes the distribution of trophozoites within the larval populations. Data are collective for the entire study. The distributional range was 1 to 1,000 with a mean of 80.7. When plotted on a logarithmic scale of numbers of trophozoites per host, the resulting curve approaches normality. Most larval collections were made in residential areas with a relatively high turnover in water-holding containers and during a period of high rainfall.

Inspection of special *Ae. aegypti* breeding sites in Houston during May, July, and October indicated a buildup of individual infection rates as the season progressed (Table 3). At certain sites surveyed at three different intervals in Houston, mixed infection rates (i.e., containers with both infected and noninfected larvae) were analyzed. Of 85 containers sampled, 21 (24.7 percent) had mixed infections, and of the containers with mixed infections, 17 (81 percent) contained larvae with low infection rates of less than 100 trophozoites per larva.

Prevalence of the parasite in *Ae. aegypti* larvae from sites and containers positive for the mosquito increased with the progress of the breeding season of the host, especially in areas of low infection (Table 4). This rate remained constant, however,

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TABLE 1.—Sites and containers with *Ae. aegypti* and *L. culicis* in three Texas cities and their satellites during 1968.

Cycle	Sites Positive for *Aedes aegypti*		Positive Sites with *L. culicis*		Positive Containers with *L. culicis*	
	Positive Sites	Total Sites	Number	Percent	Number	Percent
Corpus Christi						
I	7	20	0/7		0/14	
II	10	20	0/10		0/23	
III	5	15	0/5		0/17	
Sinton						
I	0	5	0		0	
II	0	5	0		0	
III	1	5	0/1		0/1	
San Antonio						
I	10	20	2/10	20	2/28	7
II	9	17	4/9	44	9/23	39
Seguin						
I	5	6	4/5	80	7/13	54
II	1	6	1/1	100	3/4	75
Houston						
I	7	20	6/7	86	13/18	72
II	13	20	9/13	69	39/51	77
III	14	20	10/14	72	35/46	76
Cleveland						
I	0	5	0		0	
II	2	5	0/2		0/6	
III	3	5	1/3	33	1/9	11

from fall to spring. In October 1967, every fourth block of census tract zone 56 in Houston was surveyed for *Ae. aegypti*, and the collected larvae were examined for the presence of *L. culicis*. The survey was repeated in April 1968, when all blocks in the zone were surveyed. The 1967 fall survey showed that *L. culicis* was present in some containers throughout the zone. The 1968 spring survey disclosed a similar random pattern of *L. culicis* infestation. Although far fewer collections were obtained in the spring survey, the percent of collections that contained *Ae. aegypti* larvae infected with *L. culicis* remained essentially constant from fall to spring (Table 5).

TABLE 2.—Frequency distribution of trophozoites within larval hosts.

Class (log scale)	Frequency
1.0–2.5	38
2.6–6.4	56
6.5–16	95
17–40	130
41–100	151
101–250	86
251–640	31
641+	5*
	592**
$\bar{x}$=80.7	

* Highest number recorded was judged to be 1,000 trophozoites in each of two larvae.
** Of approximately 3,300 larval dissections.

A survey of Harris County was conducted from June 10 to July 26, 1968, in an effort to determine the distribution and prevalence of *Ae. aegypti* larvae and *L. culicis* in the county. One residential city block or block equivalent in each census tract zone of the county was thoroughly examined for *Ae. aegypti*, and the collected larvae were examined in the laboratory to determine the incidence of the parasite. *Ae. aegypti* in Harris County occurred in the north central portion of Houston and the area immediately ad-

TABLE 3.—Seasonal change of infection rate in Houston special sites.

Month	*Ae. aegypti* positive sites	Positive sites with *L. culicis*	Positive sites with higher rate of infection *	*Ae. aegypti* positive containers	Positive containers with *L. culicis*	Positive containers with higher rate of infection *
May	7/11	6(86%)	3(43%)	18	13(72%)	3(17%)
July	11/11	9(82%)	5(45%)	44	39(89%)	8(18%)
October	11/11	10(91%)	9(82%)	40	35(88%)	14(35%)

* Some larvae present with infection rates of 200 or more trophozoites.

TABLE 4.—Change in parasite prevalence by cycle.

Cycle	*Aedes aegypti* positive sites with *L. culicis*	*Aedes aegypti* positive containers with *L. culicis*
First	55%(12/22)	37%(22/59)
Second	56%(14/25)	61%(51/84)
Third	65%(11/17)	65%(36/55)

joining the northern limits of the city; *L. culicis* was found to be generally distributed throughout the infested area in all types of containers where *Ae. aegypti* larvae were found (Table 6).

Rainfall in Houston during the spring and summer of 1968 was unusually heavy, and *Ae. aegypti* were found breeding in many small and temporary containers such as automobile hub caps and garbage cans. Even though the survey was directed toward residential premises, approximately one-third of the containers with larvae were discarded automobile tires. The affinity of this species for tires has been reported previously (Haverfield and Hoffmann, 1966; Hoffman and Killingsworth, 1967).

ESTABLISHMENT AND DISPERSAL OF *L. culicis*. From May 14 to 17, 1968, a survey of Corpus Christi, Texas, was made

TABLE 5.—*Aedes aegypti* and *L. culicis* collections in fall and spring, Houston, Texas.

Date	Collections positive for *Aedes aegypti*	Positive collections with *L. culicis*
October 1967	59/586 10%	31/59 52.5%
April 1968	23/2344 1%	12/23 52.2%

to ascertain the presence of *Ae. aegypti* and *L. culicis*. Twenty-one sites were found infested with *Ae. aegypti* larvae. No evidence of the presence of *L. culicis* was encountered. Subsequent inspections in July, August, September, and October of 1968 confirmed negativity for *L. culicis* except where it was deliberately released after the original surveys were made.

TABLE 6.—Results of *Aedes aegypti* and *L. culicis* survey of Harris County.

	Collections positive for *Aedes aegypti*		Positive collections with *L. culicis*	
Census Tract Zones	42/201	20.9%	22/42	52.4%
Residential Premises	101/1769	5.9%	43/101	42.6%
Containers	141/4950*	2.9%	59/141	41.8%

* Approximate.

On August 7 and again on September 12 approximately 10,000 *L. culicis* sporocysts were placed in each of 10 tires at two recapping plants. On August 7, about 5,000 sporocysts were dispersed in each of six tires at a wrecking yard and in each of two potting cans at a nursery. Care was taken to put sporocysts only in containers where *Ae. aegypti* larvae were present. Each chosen container was filled with water to hatch any *Ae. aegypti* eggs that might be present and to allow enough water for larval development. The four release sites were separated by approximately 1 mile.

On August 12, September 12, Septem-

ber 24, and October 29, 1968, and on April 10 and May 28, 1969, the sites where *L. culicis* had been released were examined. Infected larvae were found in the containers where the parasite had been released and in other containers at each site. By October 29 and on subsequent inspections, most containers sampled at the recapping plants contained larvae with *L. culicis*. In May 1969, *L. culicis* were found in larvae at each of the four release sites.

Adult collections were made at the recapping plant having the larger population. One hundred adults (61 male, 39 female) were collected on November 11, 1968. All were post-teneral (i.e., males had completely rotated hypopygia and females lacked pupal muscle remnants and meconium) and 30 (77 percent) of the females were inseminated. Thirty-one (79 percent) of the females and 52 (85 percent) of the males were parasitized.

Malpighian tubule damage, as described by Barrett (1968), was determined by measuring with an ocular micrometer the portion of the tube that showed some cellular destruction. Damage ranged up to greatly distended and eroded tubules with more than half of some individual tubes being affected, although the average damage per tube was only 280 microns. Twenty-five percent of the infected mosquitoes had five tubules affected; 23 percent had four; 16 percent, three; 18 percent, two; and 18 percent, one. No difference in the extent of damage was detectable between males and females. Forty adults were collected from the same site on April 10, 1969. Dissection showed a 70 percent infection rate, and the average extent of damage to Malpighian tubules was 284 microns per tube.

A limited larval survey in areas near the release points during September 1968 and May 1969 disclosed that several *Ae. aegypti* sites had become infested by the parasite. An auto body 210 feet north of one recapping plant was found to be infested in September. An additional infestation was found 900 feet north of the same release point in an auto tire in May. Three infested tires were found 250 feet southwest of the other recapping plant in September. In May, the same premises were found to be positive for the parasite. Two infested tires were found 300 feet from the auto wrecking yard in September. It is possible, of course, that this dispersion was the result of container movement. This is improbable, however, since the new sites were overgrown with grass and shrubbery and the containers appeared to have been unmoved for several months.

DISCUSSION. In Texas, major *Ae. aegypti* population foci tend to develop in situations where water-holding containers are continuously available. Containers on residential premises have a relatively high movement and removal rate. Permanent water containers have been found to yield larvae with higher infection rates, and where larval infection rates are high (200 or more trophozoites per host), a greater proportion of the larvae in the container are infected with *L. culicis*.

Because of container movement and removal, perhaps further influenced by the survey activities, the figures indicating increased infection rates (Table 3) and increased prevalence (Table 4) as the season progresses probably are conservative estimates of what occurs in well established, major foci.

L. culicis appears to be rather generally present throughout the *Ae. aegypti* infested area of Houston and Harris County. The parasite was not found in Corpus Christi or Sinton, however, prior to its release. Release experiments in Corpus Christi have shown that the parasite can become established and can spread from a release point.

L. culicis has an adverse effect on *Ae. aegypti* (Barrett, 1968). Further, the presence of the parasite reduces host fecundity. Some organisms, notably bacteria, have been found in association with *L. culicis* in *Ae. aegypti* under natural conditions, and observations indicate that the combined effect of an undescribed hemocoel-invading bacterium and *L. culicis* is lethal to *Ae. aegypti*.

Houston, situated near the Gulf Coast,

appears to have a climate well suited for *Ae. aegypti*. By contrast, San Antonio appears to be less suited for this species because of greater extremes in temperatures, lesser annual rainfall, and extended periods of dryness, but populations of the species in San Antonio are the highest in the state. Although *L. culicis* is found in San Antonio, the data indicate that it is much less common there than in Houston. This inverse relationship of host population density and parasite prevalence may not be related; however, further investigation of the effects of *L. culicis* and of *L. culicis* in association with other organisms upon the biotic potential of *Ae. aegypti* is warranted.

SUMMARY. Results of spring, summer and fall surveys in Houston, Texas, showed 592 *Ae. aegypti* larvae from approximately 3,300 dissections to be infected with *L. culicis* with a distributional range of 1 to 1,000 and a mean of 80.7 trophozoites per host larva. Individual infection rates built up during the summer season, but little change was noted over the winter season. *L. culicis* were not detected in *Ae. aegypti* larvae in the spring survey at Corpus Christi, Texas, but sporocysts placed in *Ae. aegypti* positive containers established the parasite and evidence of limited dispersion was noted.

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