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RESPONSE OF IOWA MOSQUITO POPULATIONS TO UNUSUAL PRECIPITATION PATTERNS AS MEASURED BY NEW JERSEY LIGHT TRAP COLLECTIONS[1]

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ABSTRACT. New Jersey light trap data from 1993, a year with unusually high amounts of precipitation, and 1994 were compared with mean light trap counts for the previous 8–10 years in each of 6 locations. The study took place in Iowa. In 1993, *Aedes trivittatus* and *Culex tarsalis* populations were unchanged. *Anopheles punctipennis* and *Culex pipiens* complex populations were significantly higher, and *Aedes vexans* populations increased in all 6 sites, significantly so in 2 sites. Species composition was unchanged. In 1994, populations of each of these species were not significantly different from the long-term means. *Aedes vexans* populations were above average in all sites and populations of the remaining species were below average.

INTRODUCTION

The midwestern United States received an exceptional amount of precipitation in 1993. Standing water was abundant, and mosquito breeding sites were ubiquitous. During June 1–August 31, 1993, most of Iowa received more than 600 mm of precipitation. Twelve weather stations recorded more than 900 mm. Normal precipitation for the period is approximately 300 mm.

Because the spring and summer of 1993 were the wettest period of the past 100 years in the Midwest (Kunkel et al. 1994), it seemed timely to compare the responses of mosquito populations to these unusual climatic conditions. This was accomplished by comparing Iowa New Jersey light trap collections from that year and the following year with historical data gathered over the previous 10 years.

The seasonal distribution of Iowa mosquitoes was first studied by Rowe (1942). Additional studies have focused on county records (Knight and Wonio 1969) and relative abundance (Pinger and Rowley 1972).

METHODS

Adult mosquito populations were monitored with New Jersey light traps in 6 locations in Iowa (Fig. 1). Sites in Council Bluffs, Ames, Des Moines, Davenport, Cedar Rapids, and Waterloo were monitored from May 17, 1993 through September 27, 1993. Mosquitoes were collected daily and transported to Iowa State University for identification and counting. Counts for collections taken over a weekend were divided by the number of days for that weekend.

Means of light trap indices for selected species were calculated from data gathered in an ongoing project begun in 1969 to study arboviruses and mosquito populations in Iowa (Wong et al. 1970). Only light trap locations that remained constant between years were used in this study. Ten-year means were available for 3 of the 6 cities studied; 9-year means were available for 2 cities, and an 8-year mean was available for the remaining city. Mosquito population counts from 1993 and 1994 were compared with these long-term means using Student's *t*-test.

Species selected for comparison were *Aedes trivittatus* (Coq.), *Aedes vexans* (Meigen), *Anopheles punctipennis* (Say), the *Culex pipiens* complex (*Culex pipiens* Linn., *Culex restuans* Theobald, and *Culex salinarius* (Coq.)), and *Culex tarsalis* Coq. *Aedes trivittatus* is a natural vector of *Dirofilaria immitis* (Leidy) (Christensen and Andrews 1976). In addition, trivittatus virus and western equine encephalomyelitis virus have been isolated from *Ae. trivittatus* collected in Iowa (Rowley et al. 1973, Green et al. 1980). *Aedes vexans* is an important annoyance mosquito in the midwestern United States. Western equine encephalomyelitis virus and St. Louis encephalitis virus have been isolated from the *Cx. pipiens* complex in Iowa (Rowley et al. 1973, Andre et al. 1985).

RESULTS

Light trap indices: Light trap indices (mean mosquitoes per New Jersey light trap per night) were calculated and Student's *t*-test was used to test for significant differences from the long-term averages. Results are summarized in Table 1.

Aedes trivittatus populations were not significantly different from the previous long-term av-

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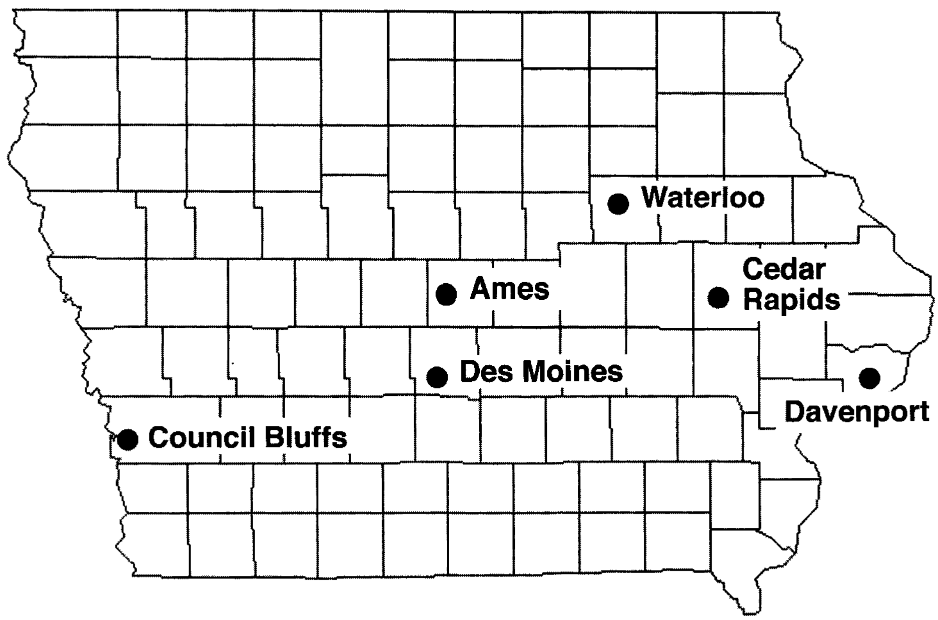

Fig. 1. New Jersey light trap locations in Iowa used for long-term averages and comparison with 1993 and 1994 counts.

erage ($P > 0.10$) in any of the cities in 1993. Populations of *Ae. vexans* were higher in all 6 cities and were significantly higher in Council Bluffs ($P = 0.01$) and Des Moines ($P = 0.04$) in 1993 when compared to the long-term average (Fig. 2).

A marked numerical increase occurred in the *Cx. pipiens* complex in all sites. In 4 of the 6 cities monitored, counts were significantly higher. The increase in Davenport approached significance ($P = 0.07$) and in Ames and Des Moines *Cx. pipiens* complex counts were within the expected range. *Culex tarsalis* populations were lower in 4 of the 6 cities.

T-tests indicated that *An. punctipennis* counts were significantly higher than the long-term mean for all locations (Table 1). The count was greatest in Ames, where 1993 counts were more than 7 times the 9-year mean (Fig. 3). Council Bluffs, which typically has a low light trap index, had an increase in *An. punctipennis* numbers of nearly 10 times over the 9-year average.

Mosquito population counts in 1994 were within the expected range for all 5 species in all locations. *Aedes trivittatus* and *Cx. tarsalis* counts were below the long-term averages in all locations, though not significantly so. *Aedes vexans* populations were above average in 5 of 6 locations—again, not significantly higher.

Species composition: The species composition of the 1993 collections closely resembled the composition over the past 10 years (Table 2). The most commonly collected mosquito was *Ae. vexans,* constituting 73.0% of 1993 collections. *Aedes vexans* is historically the species making up the greatest part of New Jersey light trap collections in Iowa. Pinger and Rowley (1972) observed that *Ae. vexans* accounted for 76 and 74% of the catch in 1969 and 1970, respectively. The *Cx. pipiens* complex was the second most common, comprising 13.1% of the 1993 catch, followed by *Ae. trivittatus, An. punctipennis,* and *Cx. tarsalis.* In 1994, the order remained the same but *Ae. vexans* made up 84.5% of the total. All other species made up less of the catch than normal (Table 2).

Frequency of occurrence is the percentage of light trap collections in which a given species was present. Of 1,357 trap-nights in 1993, *Ae. vexans* was present in 81.3% of all collections (Table 3). The *Cx. pipiens* complex was the second most frequently collected, occurring in 74.8% of collections. Although we, like Pinger and Rowley (1972), collected *Cx. tarsalis* at every site studied, they found that *Cx. tarsalis* had the 2nd highest frequency of occurrence of all species in New Jersey light traps. Our results indicate that in 1993, this species ranked 4th in frequency of occurrence, appearing in 22.8% of light trap collections. *Anopheles punctipennis* occurred in 48.9% of collections, more than double the average frequency of occurrence for the last 10 years (22.2%). In 1994, frequency of occurrence was above average for *Ae. vexans* and *Cx. pipiens,*

Table 1. Iowa 1993 New Jersey light trap indices (LTI) compared with long-term means.[1]

Species and city	Mean LTI	1993 LTI	Difference (%)	No. years data	P-value[2]
Aedes trivittatus					
Ames	10.98	4.12	−37.5	9	0.34
Cedar Rapids	1.22	1.37	112.1	8	0.47
Council Bluffs	1.03	1.39	135.5	9	0.34
Davenport	0.44	0.08	−18.6	10	0.30
Des Moines	2.60	1.39	−53.5	10	0.34
Waterloo	2.94	4.92	167.5	10	0.40
Aedes vexans					
Ames	39.72	70.20	176.7	9	0.20
Cedar Rapids	7.17	8.37	116.8	8	0.45
Council Bluffs	14.86	59.40	399.9	9	0.01
Davenport	4.04	6.47	160.1	10	0.30
Des Moines	47.82	108.15	226.1	10	0.04
Waterloo	16.04	19.25	120.0	10	0.42
Anopheles punctipennis					
Ames	2.69	19.32	718.7	9	<0.001
Cedar Rapids	0.23	1.97	864.7	8	<0.001
Council Bluffs	0.15	1.53	994.2	9	<0.001
Davenport	0.13	0.73	581.5	10	<0.001
Des Moines	1.10	6.49	592.0	10	<0.001
Waterloo	0.21	1.11	534.6	10	<0.001
Culex pipiens complex					
Ames	13.40	15.60	116.4	9	0.42
Cedar Rapids	0.68	3.14	463.2	8	<0.001
Council Bluffs	2.61	10.75	411.8	9	<0.001
Davenport	0.85	2.04	241.2	10	0.07
Des Moines	4.87	8.19	168.0	10	0.25
Waterloo	4.56	8.77	192.2	10	0.03
Culex tarsalis					
Ames	1.77	0.66	−37.3	9	0.26
Cedar Rapids	0.03	0.01	−36.7	8	0.21
Council Bluffs	3.09	2.84	−91.8	9	0.49
Davenport	0.07	0.02	−26.5	10	0.22
Des Moines	0.44	0.55	124.7	10	0.43
Waterloo	0.39	0.65	166.4	10	0.32

[1] LTI = mean number of mosquitoes per light trap per night.
[2] Comparison of indices based upon t-test.

and below average for *Ae. trivittatus* and *Cx. tarsalis.*

DISCUSSION

Results from comparison of New Jersey light trap indices from 1993 with those of the past decade indicate that, even with the extraordinary amount of rainfall and flooding in 1993, not all mosquito populations increased significantly. Only the *Cx. pipiens* complex, *An. punctipennis,* and some *Ae. vexans* populations increased significantly, whereas *Cx. tarsalis* populations decreased and *Ae. trivitattus* and some *Ae. vexans* populations remained within expected values. *Culex* populations generally peaked later than *Aedes* populations (Figs. 2 and 4). *Aedes* populations peaked at about the first week in July, just before the heaviest rainfall event of the summer (Kunkel et al. 1994).

Aedes trivittatus populations increased in 3 of the 6 cities trapped and decreased in 3 cities; neither the increases nor the decreases were significant. This is surprising because *Ae. trivittatus*

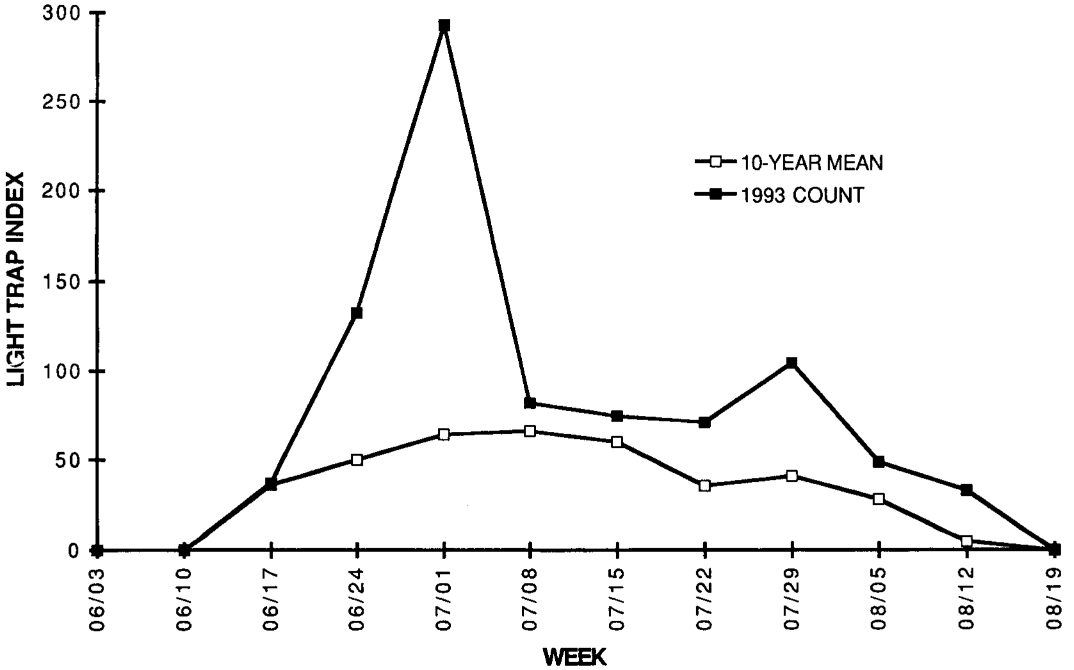

Fig. 2. Weekly New Jersey light trap counts of *Aedes vexans* in Des Moines, Iowa, 1993 compared with 10-year mean.

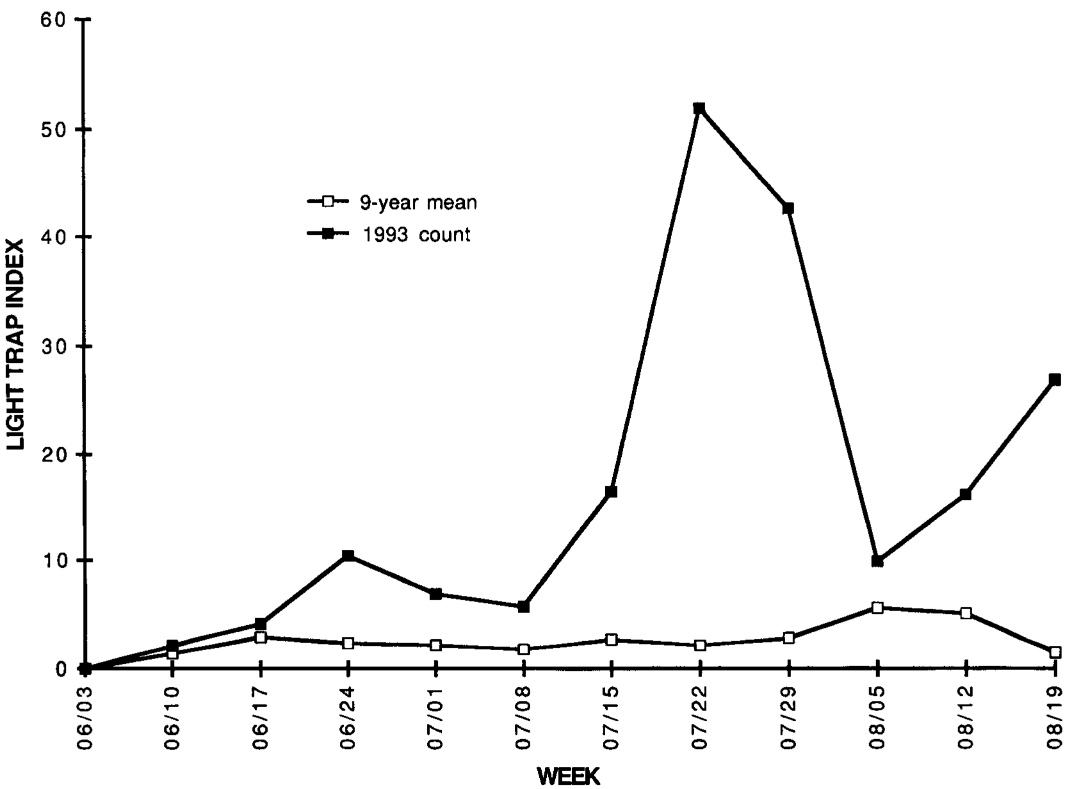

Fig. 3. Weekly New Jersey light trap counts of *Anopheles punctipennis* in Ames, Iowa, 1993, compared with 9-year mean.

Table 2. Species composition of Iowa 1993 and 1994 New Jersey light trap counts as compared to long-term means.

Species	Long-term mean (%)	1993 count (%)	1994 count (%)
Aedes vexans	69.2	73.0	84.5
Culex pipiens complex	15.4	13.1	10.6
Aedes trivittatus	4.4	8.0	1.2
Anopheles punctipennis	7.6	2.5	1.1
Culex tarsalis	1.6	1.9	0.7
Other	1.8	1.5	1.9

is normally characterized as a species that undergoes larval development in temporary rain pools, a larval environment abundant in Iowa in 1993 (Knight and Wonio 1969, Pratt et al. 1969, Siverly 1972).

Aedes vexans is the most important annoyance mosquito in the midwestern USA. Its ability to fly several miles or more to find suitable hosts makes this mosquito especially notorious and

Table 3. Frequency of occurrence of selected species in Iowa New Jersey light trap collections in 1993 and 1994 as compared to long-term means.

	Percentage of collections in which species occurred		
Species	Long-term mean	1993	1994
Aedes vexans	76.0	81.3	87.7
Culex pipiens complex	59.9	74.8	73.1
Aedes trivittatus	24.5	35.4	12.5
Culex tarsalis	17.0	22.8	5.0
Anopheles punctipennis	22.2	48.9	26.5

may make urban control programs ineffective (Clarke and Wray 1967). As evidenced by our collections, *Ae. vexans* populations increased across the state in 1993. Statistically significant increases were observed in 2 of the 6 cities ($P < 0.05$). Numbers increased rapidly and peaked in late June/early July, then decreased steadily

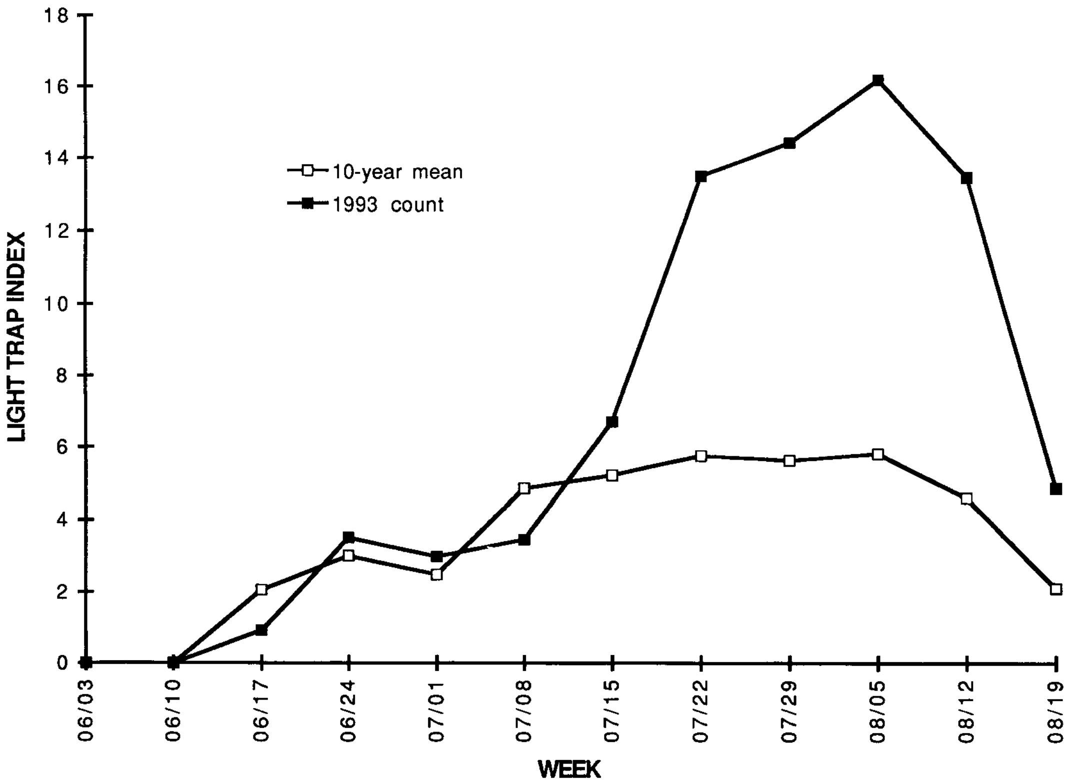

Fig. 4. Weekly New Jersey light trap counts of *Culex pipiens* complex in Waterloo, Iowa, 1993, compared with 10-year mean.

throughout the rest of the season. *Aedes vexans* collections in Council Bluffs increased the most, rising by a factor of 4 in 1993. Although *Ae. trivittatus* is locally abundant and a source of annoyance with a painful bite (Pratt et al. 1969), it is probable that most of the mosquito annoyance problems associated with flooding in Iowa in 1993 can be attributed to *Ae. vexans.*

The significant increase of the *Cx. pipiens* complex of mosquitoes was expected, because the eggs rafts are laid on standing water. The 1993 collections in both Cedar Rapids and Council Bluffs were more than 4 times the mean light trap index for each city. Because *Cx. pipiens* is ornithophilic, it is less important than *Ae. vexans* as a nuisance mosquito. However, because of its role in the transmission of St. Louis encephalitis (and possibly western equine encephalomyelitis) (Wong et al. 1978), it remains an important mosquito.

Culex tarsalis populations did not undergo the same significant increase in 1993 as *Cx. pipiens.* Indeed, New Jersey light trap indices for this species decreased in 4 of the 6 cities (Table 1). Both *Cx. pipiens* and *Cx. tarsalis* are primarily ornithophilic but will feed on other hosts. Both deposit egg rafts on the water's surface and prefer water with a high organic content (Pratt et al. 1969). Much of the floodwater present in Iowa in 1993 probably had a high organic content due to livestock runoff, flooded sewer systems, debris, and the like. It is not known why *Cx. pipiens* complex and *Cx. tarsalis* populations exhibited such different responses to the excessive rainfall of 1993.

Though *An. punctipennis* made up only 2.5% of the 1993 count compared with an average of 7.6% over the last 10 years (Table 2), this was due to the great increase in numbers of *Ae. vexans* and *Cx. pipiens,* because populations of *An. punctipennis* showed a significant increase ($P < 0.001$) in all locations. As further evidence of this, *An. punctipennis* appeared in 48.9% of collections in 1993, compared with the 10-year mean of 22.2% (Table 3).

The changes in 1994 species composition resulted from above-average *Ae. vexans* populations. This is interesting because many *Ae. vexans* would have been forced to oviposit above the normal high-water mark in 1993, and without excessive precipitation in 1994 these eggs would not have been flooded. Thus, below-average populations could be expected. One possible explanation is that enough mosquitoes remained at the end of the summer to oviposit as the floods were subsiding. The remaining species had below-average populations in 1994. However, all light trap indices for 1994 were within the expected range of variation, based on the long-term averages.

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