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THE ABUNDANCE AND SEASONAL DISTRIBUTION OF *CULEX* MOSQUITOES IN IOWA DURING 1995–97

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ABSTRACT. The abundance and seasonal distribution of *Culex* mosquitoes were monitored by measuring oviposition activity during the summers of 1995, 1996, and 1997. Five species of culicine mosquitoes laid egg rafts in ovitraps. Egg rafts of 4 *Culex* species—*Cx. restuans* (54.98%), *Cx. pipiens* (25.41%), *Cx. salinarius* (12.18%), and *Cx. tarsalis* (0.14%)—constituted more than 92% of the total egg rafts collected. *Culiseta inornata* (0.1%) was the only other species to lay viable egg rafts in the ovitraps. A small percentage (7.19%) of egg rafts did not hatch; thus identification was not possible. Compared with New Jersey light trap data in a nearby area, the abundance of *Cx. tarsalis* and *Cs. inornata* was markedly underestimated with ovitraps. These data may also reflect differences in the specific location of the 2 trap sites rather than attractiveness of ovitraps for *Cx. tarsalis* and *Cs. inornata*. In general, *Cx. restuans* oviposition activity began in late May, and it was the dominant *Culex* species through June. After July 1, the number of egg rafts laid by *Cx. restuans* decreased continually until the end of the summer. *Culex pipiens* and *Cx. salinarius* oviposition began in early June and increased gradually during the summer. Over the course of a summer, there were about twice as many *Cx. pipiens* as there were *Cx. salinarius*. A crossover in the number of *Cx. pipiens* and *Cx. restuans* egg rafts occurred in late July or early August, depending on the year. By late August each year, *Cx. pipiens* was the most abundant species. At this time, *Cx. restuans* and *Cx. salinarius* populations were similar, but each was about half of the *Cx. pipiens* population. Differences in the abundance of all 3 species could not be explained by changes in ambient temperature (both minimum and maximum) or relative humidity, either within or among years.

KEY WORDS *Culex* species, abundance, seasonal distribution, ovitrap, Iowa

INTRODUCTION

In the Midwest, there seems to be a correlation between *Culex* spp. abundance and the incidence of St. Louis encephalitis (SLE) virus (Tsai and Mitchell 1989). However, this has been difficult to estimate because regular collecting intervals and standard sampling techniques have not been maintained throughout interepidemic periods and SLE epidemics (Mitchell et al. 1980). It is believed that information on interepidemic abundance and seasonal distribution of these species may be important in SLE epidemic development (Tsai and Mitchell 1989).

Measuring oviposition activity is an effective method for monitoring the seasonal distribution of *Culex* populations (Leiser and Beiser 1982, Reiter 1986, Lampman and Novak 1996), especially for those species (*Cx. pipiens* L., *Cx. restuans* Theobald, and *Cx. salinarius* Coq.) that are impossible to separate to species on the basis of adult female characteristics.

The objectives of this study were to determine if temporal changes occur in the abundance of *Culex* species in Iowa and to observe the effects of ambient temperature and relative humidity on the seasonal distribution of *Culex* species in Iowa.

METHODS

To monitor temporal changes in populations of *Cx. salinarius, Cx. restuans,* and *Cx. pipiens*, ovitraps were used for 13 wk from the 1st week of June through the last week of August during the summers of 1995, 1996, and 1997. Ovitraps were made from 20-liter buckets containing 8 liters of tap water flooding a section of 30 by 45-cm Kentucky bluegrass (*Poa pratensis* L.) lawn sod. Two ovitraps were placed under the eaves of a wooden warehouse near a cornfield on the Iowa State University campus. Egg rafts were collected Monday through Friday throughout each summer. Egg rafts were placed in 24-well tissue culture plates. If more than 25 egg rafts were obtained on any given night, 25 were randomly selected, and the rest were destroyed. New ovitraps were made every Friday to replace the old ones.

In the laboratory, individual egg rafts were transferred to 0.47-liter ice cream cartons and reared with tropical fish food, Tetramin®, to the 4th instar. Larvae from each egg raft were identified to species (Siverly 1972). Analysis of variance was used (SAS Institute, Inc. 1988) to determine the effects of age of oviposition substrate on the efficiency of ovitraps to attract each species and the effects of ambient temperature and relative humidity on the seasonal distribution of *Culex* species.

RESULTS

Species composition and the number of egg rafts collected in Kentucky bluegrass lawn sod ovitraps in Ames, IA, 1995–97

A total of 4,180 egg rafts were collected in ovitraps during the 3-year study (1,364 in 1995; 1,411

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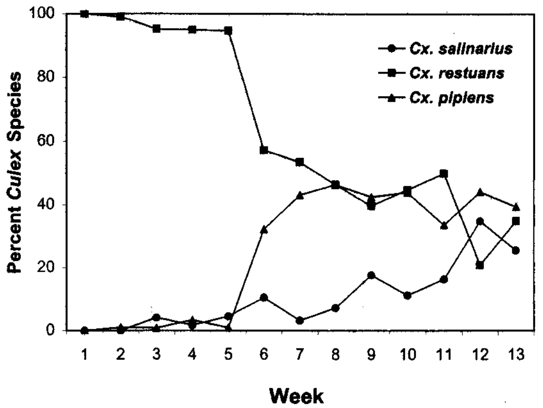

Fig. 1. Weekly percentage of egg rafts of *Culex restuans, Cx. pipiens,* and *Cx. salinarius* collected for 13 wk from the 1st week of June in 1995, Ames, IA.

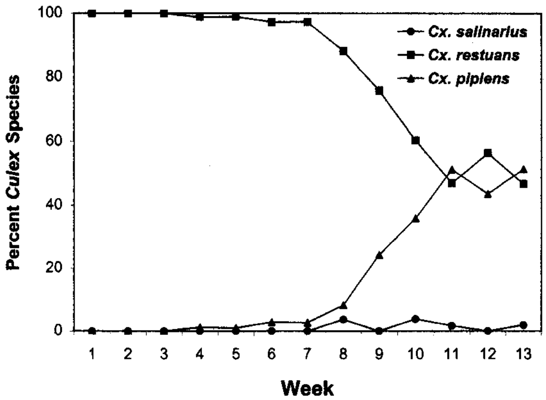

Fig. 2. Weekly percentage of egg rafts of *Culex restuans, Cx. pipiens,* and *Cx. salinarius* collected for 13 wk from the 1st week of June in 1996, Ames, IA.

in 1996; and 1,405 in 1997). Five species of mosquitoes (4 *Culex* spp. and *Culiseta inornata*) laid egg rafts in our ovitraps. Three *Culex* species—*Cx. pipiens, Cx. restuans,* and *Cx. salinarius*—constituted 93% of all egg rafts collected. *Culex tarsalis* and *Culiseta inornata* Williston accounted for only 0.14 and 0.1% of the egg rafts. A small percentage (7%) of egg rafts did not hatch, thus identification of these was not possible. Nearly 55% of all egg rafts were *Cx. restuans*; *Cx. pipiens* (25%) and *Cx. salinarius* (12%) made up the rest. The number of egg rafts of each species varied from year to year. In 1996, ca. 76% of all egg rafts collected were *Cx. restuans,* but only ca. 31% of the rafts were *Cx. restuans* in 1997. In 1997, 35% were *Cx. pipiens,* whereas 25% in 1995 and 16% in 1996 were *Cx. pipiens. Culex salinarius* made up 26% of the egg rafts in 1997, whereas 9% in 1995 and only 0.85% in 1996 were *Cx. salinarius.*

Abundance and seasonal distribution of *Culex* mosquitoes in 1995

During the 1st 5 wk of summer in 1995, more than 90% of the egg rafts were *Cx. restuans* (Fig. 1). *Culex pipiens* and *Cx. salinarius* oviposition began in the middle of June, but the number of egg rafts was negligible until the 1st week of July. After that, the number of *Cx. pipiens* egg rafts increased rapidly, reaching 46% of the total by the 8th week (late July). During the 9th week (beginning of August), the number of *Cx. pipiens* and *Cx. restuans* egg rafts crossed over. There were 2 additional crossovers by the end of August. *Culex restuans* (38%) and *Cx. pipiens* (41%) had similar oviposition activity during August. From the 5th week (beginning of July), oviposition activity of *Cx. salinarius* gradually increased to ca. 35% of the total during the 12th week (late August).

Abundance and seasonal distribution of *Culex* mosquitoes in 1996

Culex restuans laid the most of egg rafts through the 7th week of 1996 (middle of July), after which the relative abundance declined (Fig. 2). *Culex pipiens* oviposition activity began in late June but was low until the 8th week (late July). At that time, the number of *Cx. pipiens* egg rafts increased markedly and reached 51% of the total by the 11th week (middle of August). Then, a crossover occurred between the number of *Cx. restuans* and *Cx. pipiens* egg rafts deposited. Oviposition activity of *Cx. salinarius* began in the 8th week (late July) but was low during the entire summer.

Abundance and seasonal distribution of *Culex* mosquitoes in 1997

Culex restuans oviposition activity was predominant in early June (Fig. 3). However, oviposition

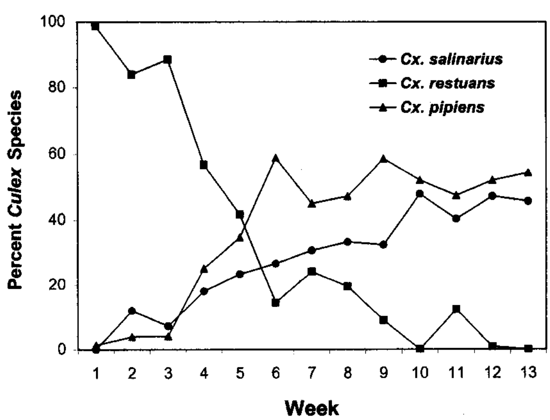

Fig. 3. Weekly percentage of egg rafts of *Culex restuans, Cx. pipiens,* and *Cx. salinarius* collected for 13 wk from the 1st week of June in 1997, Ames, IA.

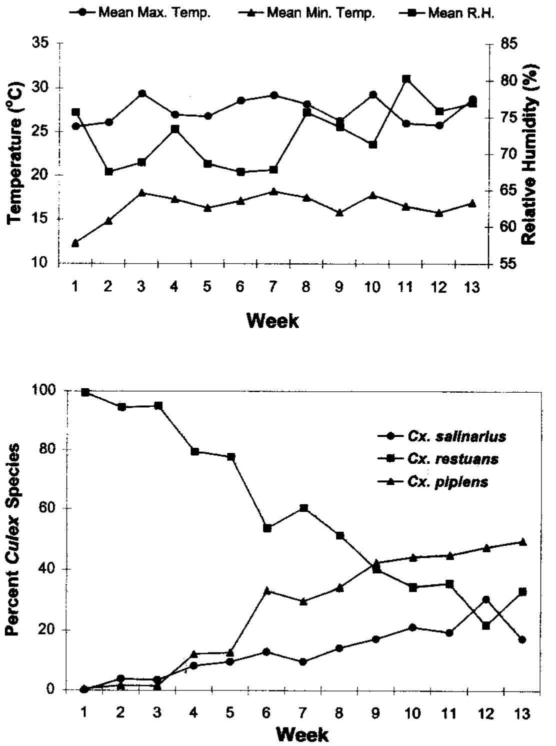

Fig. 4. Three-year average of daily temperatures (minimum and maximum) and relative humidity in a week, and weekly percentage of egg rafts of *Culex restuans, Cx. pipiens,* and *Cx. salinarius* collected for 13 wk from the 1st week of June in 1995–97, Ames, IA.

activity of *Cx. pipiens* and *Cx. salinarius* markedly increased during June of 1997. A crossover of oviposition activity between *Cx. restuans* and *Cx. pipiens* occurred at the 5th week. There was a crossover between *Cx. restuans* and *Cx. salinarius* egg rafts deposited in early July (the 6th week). Crossovers in oviposition activity between *Cx. restuans* and the other two *Culex* spp. occurred earlier than crossovers during the previous 2 years. *Culex restuans* population decreased continuously, and no oviposition activity of *Cx. restuans* was observed at the end of August. *Culex pipiens* and *Cx. salinarius* populations were dominant during August. *Culex salinarius* populations were higher in 1997 than during the previous 2 years.

Three-year abundance and seasonal distribution from 1995 through 1997

Culex restuans oviposition activity began in late May each year, and it was the dominant *Culex* species through June (Fig. 4). After July 1, the number of egg rafts laid by *Cx. restuans* decreased continually until the end of the summer. Oviposition activity of *Cx. pipiens* and *Cx. salinarius* began in early June and increased gradually during each summer. There were approximately twice as many *Cx. pipiens* as there were *Cx. salinarius* for the 3 years combined. *Culex restuans* and *Cx. pipiens* populations crossed over at the end of July or the beginning of August for the 3 years combined. In late August of each year, *Cx. pipiens* was always the most abundant species. At this time, *Cx. restuans* and *Cx. salinarius* populations tended to be similar, and each was about half that of the *Cx. pipiens* population.

Effects of ambient temperatures and humidity on abundance and distribution of *Culex* mosquitoes

Ambient temperatures (both maximum and minimum) and relative humidity did not affect temporal differences in oviposition activity (Fig. 4). The highest average maximum and minimum temperatures during the 3 years were 28.7°C and 17.6°C in 1995. But populations of the 3 *Culex* spp. in 1995 were 2nd highest for the 3 years of the study. Oviposition activity of each species varied in spite of the fact that both average temperature and relative humidity were similar in 1996 and 1997.

Effects of age of oviposition substrate within a week

The age of ovitraps made of Kentucky bluegrass lawn sod did not affect oviposition activities of 3 *Culex* mosquitoes within a week (Table 1). The number of egg rafts of each *Culex* species laid in ovitraps was not significantly different from Monday through Friday within a week (Table 1).

DISCUSSION

Five species of mosquitoes (*Cx. pipiens, Cx. restuans, Cx. salinarius, Cx. tarsalis,* and *Cs. inornata*) laid eggs in ovitraps during 1995, 1996, and

Table 1. Effects of age of oviposition substrate made of Kentucky Bluegrass (*Poa pratensis* L.) lawn sod on daily mean number of egg rafts (mean ± SD) by each species of 3 *Culex* spp. in Ames, IA from 1995 through 1997.

	Substrate age (days)					
Species	3	4	5	6	7	*P* value
Cx. salinarius	2.5 ± 3.5	2.4 ± 3.3	2.8 ± 3.6	2.7 ± 3.7	2.7 ± 3.8	0.95
Cx. restuans	11.4 ± 8.5	11.3 ± 7.9	11.7 ± 7.7	11.7 ± 8.4	12.7 ± 8.4	0.92
Cx. pipiens	4.8 ± 5.0	5.2 ± 5.1	6.6 ± 6.1	5.4 ± 5.3	5.3 ± 4.7	0.60

1997 in Ames, IA. New Jersey light trap data in Ames during the same period (Lee and Rowley, unpublished data) showed that the abundance of adult *Culex* mosquitoes was similar to the seasonal abundance of *Culex* spp. in oviposition buckets. In earlier studies, Leiser and Beiser (1982) and Hoban and Craig (1981) had similar results in Indiana. Madder et al. (1980) also reported that the abundance of *Culex* spp. collected with CO_2-baited Centers for Disease Control (CDC) light traps was similar to the seasonal abundance reflected by egg rafts in oviposition buckets.

On the basis of ovipositional activity, *Cx. restuans* (55%) was the most abundant species, followed by *Cx. pipiens* (25%) and *Cx. salinarius* (12%) during the 3-year study. These data are similar to data collected in Indiana (Corsaro and Munstermann 1984).

According to Lampman and Novak (1996), *Cx. restuans* preferred to oviposit on a sod and grass infusion oviposition medium, whereas *Cx. pipiens* laid more egg rafts on a rabbit chow infusion. Even though Corsaro and Munstermann (1984) reported the presence of *Cx. salinarius* populations in a light trap study in St. Joseph County, Indiana, egg rafts of *Cx. salinarius* were not recovered in cow manure traps in the same county (Hoban and Craig 1981; Leiser and Beiser 1982).

The number of egg rafts of both *Cx. tarsalis* and *Cs. inornata* was much lower than the number of adult mosquitoes of both species (4.6%) collected in New Jersey traps operating in Ames, IA during the same time period (Lee and Rowley, unpublished data). Differences in the numbers of both species collected by light traps and ovitraps suggests a possible lack of attraction for the oviposition substrate by these 2 species.

Geery and Holub (1989) reported a weak positive correlation between water temperature and larval abundance in catch basins in Illinois. In our study, differences in the abundance of 3 *Culex* mosquitoes (*Cx. pipiens, Cx. restuans,* and *Cx. salinarius*) were not explainable by changes in ambient temperature (both minimum and maximum) or relative humidity within or among years.

Oviposition activity for each species varied within and among years ($P < 0.0001$). Oviposition activity by *Cx. restuans* began during May. It was the only *Culex* species represented until *Cx. pipiens* began oviposition in late June. The number of *Cx. restuans* egg rafts decreased from late June to late August. Oviposition by *Cx. pipiens* started in the beginning of June and increased until the end of August of each year. The time at which *Cx. restuans* and *Cx. pipiens* oviposition activity crossed over varied from year to year. Oviposition patterns of *Cx. salinarius* in Ames changed from year to year, but generally this species appeared during early June and increased in numbers throughout the remainder of the summer (Fig. 4). In September, *Cx. pipiens* was the dominant species, followed by *Cx. salinarius* (Lee and Rowley, unpublished data).

Ovitraps were effective in monitoring populations of all 3 species of *Culex* mosquitoes (Table 1). Brust (1990) suggested that the interval between changes of oviposition medium (Kentucky bluegrass lawn sod) for effective monitoring of *Culex* spp. in Manitoba, Canada, was 1 wk. The 1-wk interval for changing oviposition medium also seemed to be effective in our study. There were no statistically significant differences in the attractiveness of the oviposition medium to mosquitoes within a week.

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REFERENCES CITED

Brust RA. 1990. Oviposition behavior of natural populations of *Culex tarsalis* and *Culex restuans* (Diptera: Culicidae) in artificial pools. *J Med Entomol* 27:248–255.

Corsaro BG, Munstermann LE. 1984. Identification by electrophoresis of *Culex* adults (Diptera: Culicidae) in light-trap samples. *J Med Entomol* 21:648–655.

Geery PR, Holub RE. 1989. Seasonal abundance and control of *Culex* spp. in catch basins in Illinois. *J Am Mosq Control Assoc* 5:537–540.

Hoban B, Craig GB Jr. 1981. Effectiveness of the ovitrap for monitoring *Culex* populations. *Proc Indiana Acad Sci* 90:235–236.

Lampman RL, Novak RJ. 1996. Oviposition preferences of *Culex pipiens* and *Culex restuans* for infusion-baited traps. *J Am Mosq Control Assoc* 12:23–32.

Leiser LB, Beiser JC. 1982. A comparison of oviposition traps and New Jersey light traps for *Culex* population surveillance. *Mosq News* 42:391–395.

Madder DJ, McDonalds RS, Surgeoner GA, Helson BV. 1980. The use of oviposition activity to monitor populations of *Culex pipiens* and *Culex restuans* (Diptera: Culicidae). *Can Entomol* 112:1013–1017.

Mitchell CJ, Francy DB, Monath TP. 1980. Arthropod vectors. In: Monath TP, ed. *St. Louis encephalitis* Washington, DC: American Public Health Association. p 313–379.

Reiter P. 1986. A standardized procedure for the quantitative surveillance of certain *Culex* mosquitoes by egg raft collection. *J Am Mosq Control Assoc* 2:219–221.

SAS Institute, Inc. 1988. The ANOVA procedure. In: *SAS/STAT® user's guide* Version 6, 3rd ed. Cary, NC: SAS Institute Inc. p 125–154.

Siverly RE. 1972. Genus *Culex* and genus *Culiseta.* In: *Mosquitoes of Indiana* Indianapolis, IN: Indiana State Board of Health. p 84–100.

Tsai TF, Mitchell CJ. 1989. St. Louis encephalitis. In: Monath TP, ed. *The arboviruses epidemiology and ecology* Volume 4. Boca Raton, FL: CRC Press Inc. p 113–143.