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MOSQUITO-BORNE VIRUS ACTIVITY IN IOWA, 1975–1976[1]

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ABSTRACT. An unusually large number of cases of mosquito-borne encephalitis occurred in Iowa in 1975. Nineteen St. Louis (SLE) cases were confirmed from 11 scattered counties in the state between the 2nd week of August and the end of September 1975. The second highest number of LaCrosse (LAC) (California group, family Bunyaviridae) encephalitis reported in a single year also occurred in 1975. In addition, 5 human and 434 equine cases of western equine encephalomyelitis (WEE) were reported from the western region of Iowa.

In 1976, a tenfold decrease in the number of WEE cases in horses was noted. In addition, there were only 3 SLE and 5 LAC cases; 1976 was a year of unprecedented drought conditions that markedly reduced mosquito populations throughout the state.

Virus activity in mosquitoes is discussed in relation to serologically confirmed cases in humans and clinical cases in equines. *Culex pipiens* populations were considerably larger in June and July 1974 and 1975 than they were in 1973 or 1976. A strong relationship between large mosquito population levels and mosquito-borne encephalitis existed in Iowa. Three SLE virus isolates were obtained from 38 pools (741 *Culex* mosquitoes) collected in late 1975. In contrast, only one SLE virus isolate had been obtained during a 12-year period from 41,652 *Culex* mosquitoes processed for virus isolation.

During 1975, 2,113 cases of mosquito-borne encephalitis were reported from the United States. Most of the cases occurred in states in the Mississippi and Ohio river valleys (U.S. Dept. HEW 1976). This was the largest number of human cases of encephalitis reported in a single year in the United States and included 19 laboratory-confirmed cases of St. Louis encephalitis (SLE) from 11 scattered counties in Iowa. All 19 SLE cases in Iowa occurred between the 2nd week in August and the end of September. In addition to SLE, 12 cases of LaCrosse encephalitis (LAC) caused by the LaCrosse subtype of the California group (family Bunyaviridae) and 5 cases of western equine encephalomyelitis (WEE) also were confirmed by the State Hygienic Laboratory of Iowa. This was a dramatic increase in the number of annual cases of encephalitis in Iowa and generated considerable interest and concern among the general public, physicians, and health officials throughout the state. In 1976, a year of unprecedented drought conditions throughout much of the state, an additional 3 cases of SLE and 5 LAC cases were recorded.

In addition to human cases, 434 WEE cases were clinically diagnosed in horses during 1975. This represented a threefold increase over the 1974 level. Equine cases of WEE occurred in all regions of the state but, as in the past, were more common in western counties.

In the 10-year period (1965–1974), there were 56 cases of mosquito-borne encephalitis reported in Iowa. Most of these (53) were LAC encephalitis (Wong et al. 1970, 1973, Rowley et al. 1973).

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During this same period, field and laboratory studies of mosquito-borne encephalitis viruses have been conducted by the State Hygienic Laboratory of Iowa and Iowa State University. Rowley et al. (1973) reported 41 virus isolations from Iowa mosquitoes collected in 1971. In these and other studies, LAC, WEE and SLE viruses have been isolated from mosquitoes collected in Iowa (Wong et al. 1970; 1973; 1978). In addition, mosquito population studies in different areas of Iowa have been conducted for several years as part of ongoing programs designed to monitor mosquito and mosquito-borne virus activity. (Pinger and Rowley 1972, Pinger et al. 1975).

The objectives of this report are to: 1) report the human and equine cases of encephalitis that occurred in Iowa in 1975 and 1976; 2) examine differences in adult mosquito population levels (numerical abundance) during these years and the 2 years immediately preceding 1975; 3) compare virus activity in mosquitoes with clinical and serologically confirmed cases of encephalitis in horses and humans; and 4) examine factors associated with arbovirus transmission during years when extraordinary virus activity occurs.

METHODS

ADULT MOSQUITO COLLECTIONS. Several light traps have been in operation throughout Iowa during the last 10 years to monitor mosquito populations and generate data on species composition and seasonal abundance. Data from a standard New Jersey light trap equipped with a 40-watt bulb and operated in the same location in central Iowa during the mosquito season for the past 8 years were selected to illustrate dramatic differences that occurred in mosquito populations in Iowa from 1973–1976. Mosquitoes collected by this trap were picked up each morning from early May until mid-October, sorted and identified to species. Population data were plotted to illustrate seasonal fluctuations in *Culex pipiens* (group), *Cx. tarsalis, Aedes vexans* and *Ae. trivittatus* populations from year to year. These species constitute about 90% of all mosquitoes collected in Iowa by New Jersey light traps (Table 3).

VIRUS ACTIVITY IN MOSQUITOES. Adult mosquitoes were collected for virus isolation studies with CO_2-baited, battery-operated CDC light traps. In 1975, CDC traps were operated in late August and early September in 3 metropolitan areas (Ames, Des Moines, and Sioux City) because of intense public concern over SLE virus activity in these areas. Mosquito collection and the processing of mosquitoes for virus isolation were accomplished in accordance with standard techniques (Sudia and Chamberlain 1967).

SURVEY FOR EQUINE ENCEPHALITIS CASES. The Veterinary Public Health Section of the Iowa State Department of Health annually conducts a retrospective survey of all practicing veterinarians for clinically diagnosed cases of equine viral encephalitis. These cases are defined as presenting typical signs of fever, deranged consciousness, depression, motor irritation, and paralysis in the absence of any other disease or condition. Confirmatory serology was arranged for a small number of cases to support clinical observations. Earlier studies showed that a high percentage of equines in Iowa with clinical symptoms of encephalitis also had rising WEE complement-fixation antibody titers (Zymet et al. 1966). Because of the lability of the virus and small numbers of fatal cases, specimens of CNS tissue for viral isolation are not routinely collected.

HUMAN CASES OF ENCEPHALITIS. Laboratory diagnostic service is routinely available in the Virology Division of the State Hygienic Laboratory of Iowa. On receipt of clinical specimens from suspected cases of infection of the central nervous system, complement fixing and neutralizing antibody studies are performed on serum samples to determine the presence of LAC, SLE, and WEE antibodies. The microtiter LBCF test using sucrose-acetone extracted infected mouse brain as antigens was used to detect CF antibody (U.S. Dept. HEW 1976). Neutralizing antibodies are determined in a microtiter tissue culture system using BHK-21 cells. In addition to WEE, LAC, and SLE viruses, all samples are also tested for the presence of Jamestown Canyon and trivittatus virus neutralizing antibodies.

RESULTS AND DISCUSSION

Table 1 shows the mosquito-borne encephalitis cases that have been serologically confirmed by the State Hygienic Laboratory of Iowa since 1965. There was an unusually large number of cases of all 3 types of encephalitis in Iowa during 1975 when a total of 36 cases of mosquito-borne encephalitis was confirmed. In contrast, only 8 cases occurred in Iowa during 1976. The distribution of these cases in the state is similar to those reported by Wong et al. (1978). The seasonal occurrence of mosquito-borne encephalitis in Iowa generally is restricted to July, August, and September, with most cases occurring in the 6-week period from 15 August through 30 September (Wong et al. 1970, 1973).

There were 12 confirmed LAC cases in 1975. This represented the 2nd largest number of cases of LAC reported in a single year from Iowa. In the 2-year period 1975–76, the total was 17 LAC cases.

Table 1. Mosquito-borne encephalitis in Iowa 1965–1976.

Year	California	Western Equine	St. Louis	Total
1965	6	—	—	6
1966	—	—	—	—
1967	11	—	—	11
1968	4	—	—	4
1969	7	—	—	7
1970	14	1	—	15
1971	3	—	2	5
1972	1	—	—	1
1973	5	—	—	5
1974	2	—	—	2
1975	12	5	19	36
1976	5	—	3	8
Total	70	6	24	100

LAC in Iowa occurs primarily in the eastern one-third of the state (Wong et al. 1973) and is associated with *Ae. triseriatus*.

The 22 SLE cases that occurred in 1975 and 1976 were scattered throughout the state, although nearly one-third were concentrated in the metropolitan area of Des Moines. SLE virus activity was first noted in the Des Moines area in 1971 when an SLE virus isolate was obtained from a pool of *Cx. tarsalis* collected in July of that year (Rowley et al. 1973). Two laboratory-confirmed cases of SLE also occurred in 1971. No cases were diagnosed in Iowa in 1972, 1973, or 1974.

In 1939, WEE virus was first isolated in Iowa from the brains of horses with encephalitis (Biester and Schwarte 1940). It continues to be a significant cause of equine disease inasmuch as the number of clinically diagnosed cases has varied annually from 41 to 449 for the period 1967–1976. During this same 10-year period, only 1970 and 1975 are considered to have been epidemic years in the state (Iowa State Dept. Health 1967–1976). Table 2 shows the number of cases of WEE in horses during the last 4 years; case fatality rates attributed to WEE are computed and range from 19.5 to 28.4 percent.

Serologic studies corroborate evidence from other sources that clinical encephalitis in horses continues to result from WEE infections (Zymet et al. 1966, Pearson 1977). Additional evidence includes the observation that case diagnoses are concentrated in the July-August-September quarter (Fig. 1) when mosquito populations generally are highest.

Cases of WEE in humans in Iowa are

Table 2. Clinically diagnosed cases of encephalomyelitis in horses in Iowa 1973–1976.

Year	Cases	Deaths	Percent (Death/Cases)
1973	95	27	28.4
1974	154	40	26.0
1975	434	94	21.7
1976	41	8	19.5

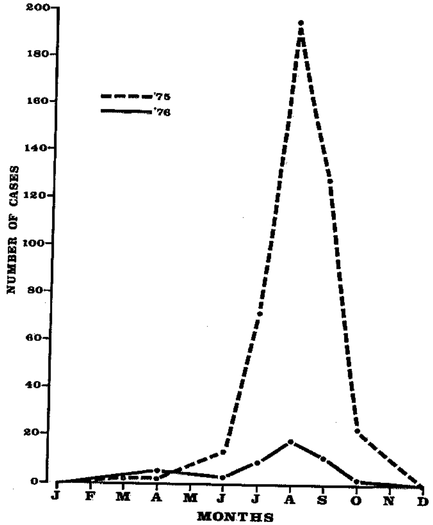

Figure 1. Number of clinical equine viral encephalomyelitis cases by month in Iowa, 1975–1976.

rarely reported. In 1975 five cases occurred in Woodbury County. The only previous laboratory-confirmed case of WEE in Iowa occurred in 1970. The 1970 case and the 5 cases in 1975 were from the extreme western region of the state. WEE virus activity in mosquitoes has been recorded for several years from the western portions of Iowa (Rowley et al. 1973). During the late spring and early summer of 1975 climatic conditions resulted in large populations of *Cx. tarsalis* throughout Iowa (Fig. 3). Likewise, during 1975, equine cases increased threefold over the previous 4 years and were concentrated in the western half of the state (Fig. 2).

The same general associations were demonstrated during 1976 when climatic conditions (extreme drought) restricted *Cx. tarsalis* as well as other mosquito populations. No human cases of WEE were reported in 1976, compared with 5 cases in 1975. Equine cases totaled a mere 41, representing a tenfold decrease over 1975 (Fig. 2). In addition to weather and vector factors, increased immunization

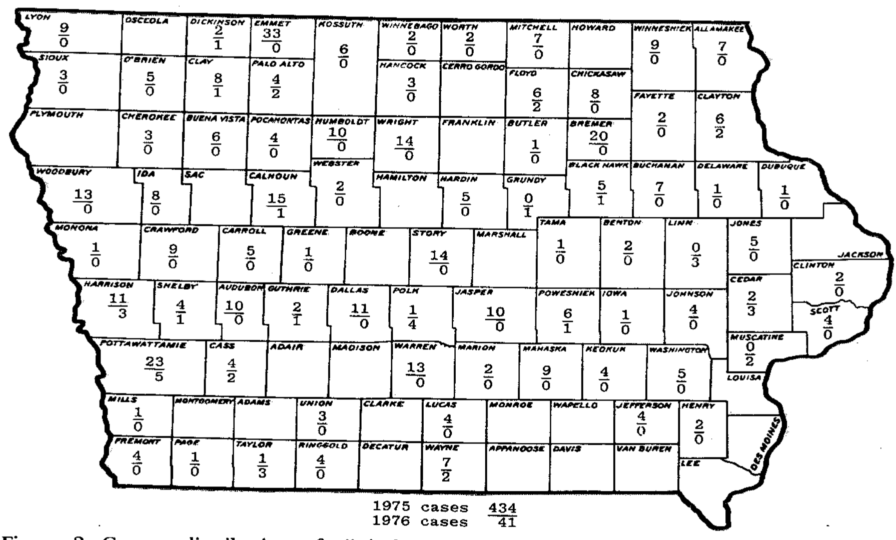

Figure 2. County distribution of clinical equine viral encephalomyelitis cases reported in Iowa, 1975–1976.

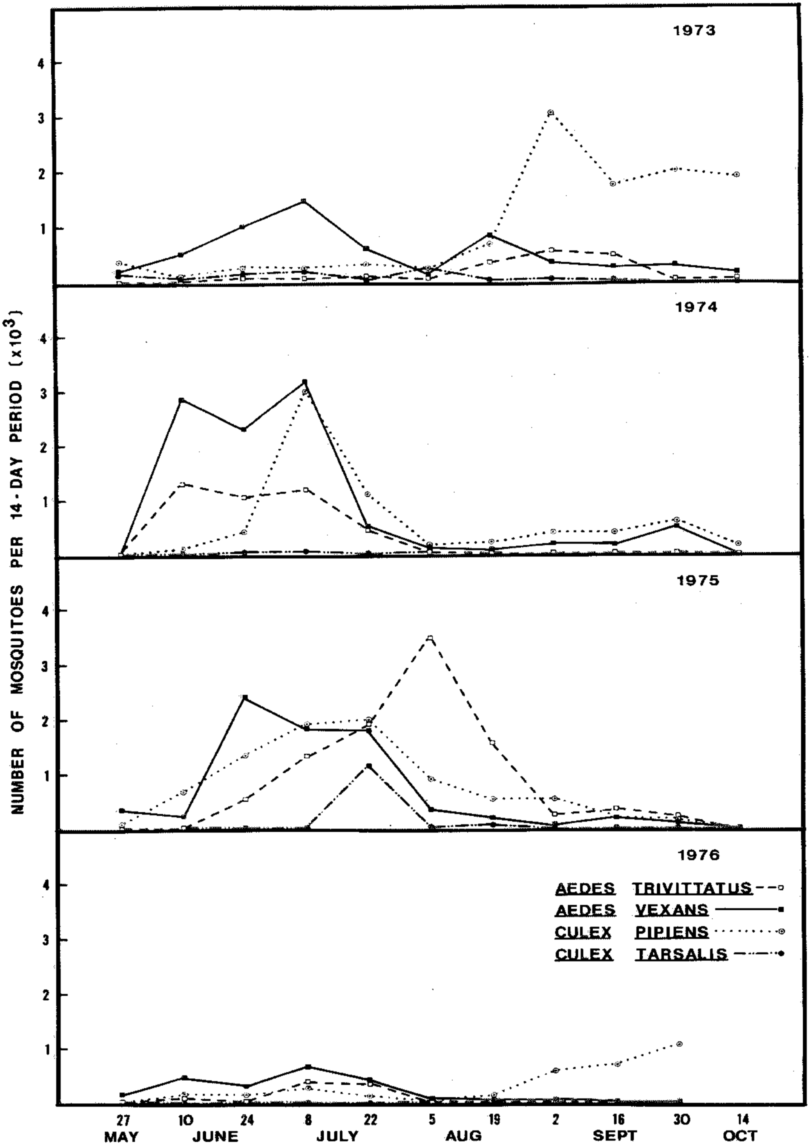

Figure 3. Seasonal distribution of the major species collected in a New Jersey light trap in central Iowa, 1973–1976.

resulting from publicity during 1975 may have influenced the small number of equine cases in 1976. Epidemiologic study of encephalitis in Minnesota and North Dakota during 1975 demonstrated that equine cases do not always correlate with human cases, although equine cases peak about 3 weeks before human cases (Potter et al. 1977). In Iowa equine cases of WEE are widespread and occur as early as May and June and may have a sporadic distribution due to variations in horse populations and vaccination levels. For these reasons, equine encephalitis is a sentinel system that qualitatively reflects viral activity, but does not provide any reliable means to determine the relative risk of human transmission.

Fig. 3 shows the seasonal distribution of the 4 major mosquito species for 1973 and through 1976 as represented by a single light trap operated at the same location each year. Table 3 shows the species composition and numbers of mosquitoes collected in New Jersey light traps in 8 widely scattered cities in Iowa in 1976. It should be noted that almost 90% of all mosquitoes collected throughout the state belong to the *Cx. pipiens* group or are *Cx. tarsalis, Ae. vexans* or *Ae. trivittatus.* These data (Fig. 3) illustrate how drastically mosquito populations differed during this 4-year period in central Iowa. *Cx. pipiens* group populations were much larger during the latter part of June and the entire month of July in both 1974 and 1975 than in either 1973 or 1976. Large populations of *Cx. pipiens* group mosquitoes during the late spring and early summer of these 2 years probably contributed to significant amplification of SLE and WEE viruses in vertebrate hosts in that area. The importance of 2 consecutive years with unusually large early summer *Culex* populations and their effect on the epidemic of 1975 is not known. It is possible that there was a cumulative effect and that 2 successive years of large *Culex* mosquito populations led to high infection rates in mosquitoes in 1975. The single most important factor related to SLE and WEE transmission in Iowa in 1975 was the unusually large population of *Cx. tarsalis* that occurred in July of that year.

Table 4 shows the results of mosquito-arbovirus isolation studies conducted during the last week of August and the 1st week of September 1975. SLE virus isolates were obtained from mosquitoes collected in 3 different cities in Iowa in 1975. SLE virus was isolated each time that mosquitoes were collected for virus isolation studies. The isolation of SLE in 3 cities of Iowa from small numbers of mosquitoes indicates the magnitude of SLE virus activity in Iowa mosquitoes in late 1975. The 3 SLE isolates were obtained from only 741 *Culex* mosquitoes (38 pools). In 12 years of collecting mosquitoes for virus isolation throughout Iowa, only 1 SLE isolate had previously been obtained from 41,652 *Culex* mosquitoes (Rowley et al. 1973).

Cx. pipiens "group" mosquitoes, i.e., *Cx. pipiens, Cx. quinquefasciatus, Cx. restuans,* and *Cx. salinarius* occur in Iowa. In addition, *Cx. tarsalis,* a vector of SLE virus in the western United States, occurs throughout the state. During 1975, *Cx. restuans* and *Cx. salinarius* were considered to be of significance in the infection of wild birds in some areas of the Mississippi River Valley. In urban communities of central Iowa, the most common species of mosquito usually is *Cx. pipiens*, although *Cx. salinarius* and *Cx. restuans* can be locally abundant.

In Iowa, drought conditions prevailed from early July 1975 through the entire spring and summer of 1976. These conditions contributed to a steady decline in adult mosquito populations in August and September 1975. In addition to dry weather conditions, unseasonably cold temperatures during the last week of August and the 1st week of September in 1975 markedly restricted mosquito activity. The combination of a sharp decline in adult mosquito population levels in August and 2 weeks of unseasonably cool weather most certainly contributed to a natural abatement of SLE and WEE virus transmission to humans in Iowa during the early fall of 1975.

Several workers have investigated

Table 3. Mosquito species collected in Standard New Jersey light traps in Iowa Communities in 1976.

Species	Ames	Des Moines	Waterloo	Iowa City	Council Bluffs	Sioux City	Davenport	Dubuque	Total	% Total
Aedes spp.	57	10	16	84	205	523	42	90	1027	2.57
triseriatus	32	15	2	103	2	11	8	2	175	0.44
trivittatus	1240	41	198	94	108	252	36	269	2238	5.60
vexans	3120	1320	1568	2901	1466	1403	1005	915	13698	34.29
Anopheles punctipennis	789	259	131	360	21	273	197	108	2138	5.35
quadrimaculatus	2	2	—	—	3	—	2	—	9	0.02
walkeri	—	—	—	—	4	—	—	—	4	0.01
Culex spp.	4	1	32	3	3	51	7	17	118	0.29
pipiens group*	7494	919	568	3225	232	3314	1498	437	17687	44.29
tarsalis	313	254	61	104	202	959	72	17	1982	4.96
territans	31	5	12	3	—	9	2	—	62	0.16
erraticus	9	3	5	1	4	—	1	—	23	0.07
Culiseta inornata	137	71	13	16	4	67	31	2	341	8.85
Coquillettidia perturbans	30	13	11	1	3	121	2	1	182	0.46
Uranotaenia sapphirina	21	3	28	82	4	6	19	1	164	0.41
Other species	11	10	5	27	12	20	5	8	98	0.24
Total	13290	2926	2650	7004	2273	7009	2927	1867	39946	100
% Total	33.27	7.32	6.63	17.53	5.69	17.55	7.33	4.67	99.9	

* *Culex pipiens* group=*Cx. pipiens*, *Cx. quinquefasciatus*, *Cx. restuans* and *Cx. salinarius*.

Table 4. Viruses isolated from mosquitoes collected in late August and early September in Iowa during 1975.

Location	Species	No. Mosquitoes (Pools)	No. Isolates
Sioux City	*Culex tarsalis*	84 (11)	1 (St. Louis)
Sioux City	*Culex pipiens* group	165 (12)	0
Sioux City	*Aedes triseriatus*	3 (1)	1 (LaCrosse)
Des Moines	*Culex tarsalis*	21 (3)	0
Des Moines	*Culex pipiens* group	90 (4)	1 (St. Louis)
Des Moines	*Aedes trivittatus*	19 (2)	1 (Trivittatus)
Ames	*Culex pipiens* group	132 (6)	1 (St. Louis)
Ames	*Culex tarsalis*	43 (2)	0
Ames	*Aedes vexans*	413 (9)	1 (Trivittatus)

epidemics of mosquito-borne encephalitis in the United States and speculated on the sequence of events and factors that lead to epidemics of these diseases (Reeves and Hammon 1962, Hess et al. 1963, Reeves 1971). Reeves (1971) established predictive parameters for WEE in California on the basis of the number of mosquitoes caught per night in light traps.

Hacker et al. (1973) used time-series analysis to show that minimum temperatures in Iowa must exceed a threshold for at least 2 weeks before a peak in *Cx. tarsalis* numbers occurs in light traps. Reeves and Hammon (1962) concluded that a minimal threshold of sustained temperature is required for effective virus transmission and that this temperature is higher for SLE than it is for WEE; however, little information is available concerning transmission potential as a result of elevated *Cx. tarsalis* and *Cx. pipiens* group populations in Iowa. This is particularly true in the late spring and early summer when high *Cx. tarsalis* populations can best be dealt with from a control standpoint but, at the same time, have the greatest influence on the amplification of WEE and SLE viruses. Formulae such as those developed by Hacker et al. (1973) have a possible predictive value to a community with an on-going mosquito-control program but are of little value in predicting virus transmission in rural Iowa.

Conditions in Iowa during the spring and early summer of 1975 were almost identical to those described by Reeves (1971) for establishing critical thresholds for virus transmission. There were marked numerical increases in *Culex* mosquito populations (*Cx. pipiens* group and *Cx. tarsalis*) that were concomitant with a warm, wet spring. Reeves also indicated that critical levels of vector mosquitoes become important when the increased (high) mosquito populations shift feeding habits from wild birds to aberrant mammalian hosts. The absence of human cases of SLE and WEE during years *Cx. tarsalis* mosquito population levels are low suggests that transmission of these viruses to mammalian hosts does not occur.

It is not known what effect, if any, conditions that lead to large numerical numbers of *Aedes* mosquitoes have on the transmission of LAC virus. No data exist that show changes in seasonal abundance of *Ae. triseriatus*. It seems reasonable to conclude that weather conditions that contribute to large numbers of *Ae. vexans* and *Ae. trivittatus* in Iowa might also lead to increased numbers of *Ae. triseriatus*. In 1970, *Aedes* mosquito populations were extremely high throughout much of Iowa (Pinger and Rowley 1972). Table 1 shows that the largest number of LAC cases ever reported from Iowa also occurred in 1970. It seems more than coincidental that the 2 years with the highest incidence of LAC cases in Iowa (1970 and 1975) also were 2 years with unusually large populations of *Ae. vexans* and *Ae. trivittatus*. It may be that a relationship similar to that described by Reeves (1971) for WEE and *Cx. tarsalis* exists for LAC virus and *Ae. triseriatus* in the upper Midwest. More importantly, it may be possible to correlate LAC transmission to humans with the abundance of floodwater species *Aedes* mosquitoes in Iowa.

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