BLOOD-FEEDING PATTERNS OF IOWA MOSQUITOES[1]

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ABSTRACT. Blood-fed mosquitoes were collected principally from urban sites in Iowa. *Aedes* mosquitoes fed predominantly on mammals; rabbits were the primary host of *Ae. trivittatus* and *Ae. vexans*. *Ae, trivittalus* frequently fed on birds where birds were a predominant part of the local fauna. This finding strengthens the hypothesis that *Ae. trivittatus* is a secondary vector of WEE virus in Iowa. *Culex* mosquitoes fed predominantly on birds; *Culex* spp. (*Cx. pipiens, Cx. restuans* and *Cx. salinarius*) exhibited a midsummer increase in their feeding on mammals. This may increase their vector potential. Nine, 13 and 8 multiple blood meals were identified for *Ae. vexans, Ae. trivittatus* and *Culex* spp., respectively. The incidence of multiple feeding contributes to the vector status of these Iowa mosquitoes.

INTRODUCTION

The mosquito-borne viruses LaCrosse encephalitis (LAC), St. Louis encephalitis (SLE) and western equine encephalitis (WEE) are an annual public health concern in Iowa. During the 1975 encephalitis epidemic, 12, 19 and 5 human cases of LAC, SLE and WEE, respectively, were confirmed in Iowa (Rowley et al. 1979). Additionally, 434 equine cases of WEE were reported in the state (Rowley et al. 1979). Previous studies indict *Cx. pipiens* and *Cx. tarsalis* as primary vectors of SLE and WEE viruses in Iowa (Dorsey et al. 1978, Wong et al. 1978, Rowley et al. 1979). However, the isolation of WEE viruses from field-collected *Aedes trivittatus* in Iowa (Dorsey et al. 1978) and the laboratory demonstration that this mosquito can become infected with WEE virus (Green et al. 1980) suggest that *Ae. trivittatus* may be a secondary vector of WEE virus in Iowa. This study was initiated to elucidate the vector potential of Iowa mosquitoes, especially the role that *Ae. trivittatus* plays in the natural history of WEE virus.

MATERIALS AND METHOD

Blood-fed mosquitoes were collected during 1979 with dry-ice-baited CDC miniature light traps, a Malaise trap, suction traps, resting boxes and sweep nets. Collections were made at urban sites in Ames, Council Bluffs, Davenport, Des Moines, Dubuque, Iowa City, Sioux City and Waterloo and at rural localities near Hornick and Story City. Mosquito blood meals were prepared and identified following the procedure of Tempelis and Lofy (1963). *Cx. restuans, Cx. pipiens* and *Cx. salinarius* were classified as *Culex* spp. because species identification of trapped specimens is usually impossible. Antisera were provided by the National Institutes of Health and by a stock produced by Pinger and Rowley (1975). Anti-raccoon and anti-skunk sera exhibited cross reactivity and were subsequently pooled.

RESULTS

The blood-feeding patterns of *Ae. trivittatus* collected in Iowa in 1979 indicated that these mosquitoes feed primarily on mammals (Table 1). One hundred and ninety-seven *Ae. trivittatus* feedings (90.8%) were on mammals. Rabbits (56.7%), raccoons or skunks (15.2%), humans (5.5%) and fox squirrels (5.0%) were the most frequent mammalian hosts. Only 19 *Ae. trivittatus* feedings (8.6%) were on birds and one (0.5%) was from an amphibian. Twelve *Ae. trivittatus* blood

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Table 1. The blood-feeding patterns of *Aedes* mosquitoes collected in Iowa in 1979.

Blood meal origin	*Aedes trivittatus* No.	(%)	*Aedes vexans* No.	(%)	*Aedes triseriatus* No.	*Aedes stimulans* No.
Cattle—Deer	1	0.5	3	(2.8)	—	—
Cat	5	(2.3)	4	(3.7)	—	—
Dog	6	(2.8)	5	(4.6)	⅛	—
Horse	1	(0.5)	3	(2.8)	1	—
Human	12	(5.5)	13	(12.0)	—	—
Opossum	2	(0.9)	1	(0.5)	—	—
Rabbit	123	(56.7)	59	(54.7)	1	4
Raccoon + Skunk	33	(15.2)	9	(8.3)	1	—
Fox Squirrel	11	(5.0)	6	(5.6)	—	—
Unidentified mammal	3	(1.4)	2	(1.9)	3	—
Total mammal	197	(90.8)	104	(96.3)	7	4
Bird	19	(8.7)	4	(3.7)	—	1
Amphibian	1	(0.5)	—	—	—	—
Nonreactors	40	—	26	—	2	—
Total	257		134		9	5

meals were double feedings, and all but one contained strictly mammalian blood. A triple blood meal containing cat, dog and rabbit blood also was identified. Forty (16.5%) *Ae. trivittatus* blood meals could not be identified. Different feeding patterns of *Ae. trivittatus* occurred at different sites. Fourteen (20.9%) of the *Ae. trivittatus* collected in Council Bluffs fed on birds compared with only 3 (4.0%) and 2 (2.6%) at Ames and the other sites combined, respectively. Nine of the feedings on birds were from mosquitoes collected in Council Bluffs on July 23. With the exception of the July 23 collection, no seasonal fluctuations in the feeding pattern of *Ae. trivittatus* were observed.

Table 1 shows that *Ae. vexans* fed predominantly on mammals. Rabbits (54.7%), humans (12.0%) and raccoons or skunks (8.3%) were the predominant source of blood. Only 3 feedings were on cattle-deer, 3 on horses and 4 on birds. Nine *Ae. vexans* feedings were multiple, all were double feedings on mammals. Twenty-six (20.8%) *Ae. vexans* blood meals could not be identified. Seasonal variations in the feeding pattern of *Ae. vexans* are minimal.

Limited data restrict the elucidation of the feeding patterns of *Ae. triseriatus* and *Ae. stimulans*. These mosquitoes tend to feed on mammals in that 11 of 12 feedings were on mammals (Table 1).

The precipitin test revealed that *Culex* spp. fed predominantly on birds (Table 2). Ninety-three (62.0%) feedings were on birds, 52 (34.7%) were on mammals and 5 (3.3%) were on amphibians. A majority of the *Culex* spp. feedings were on columbiform birds (28.7%), passeriform birds (20.7%) and rabbits (9.3%). The substantial number of feedings on birds of an indeterminate order may reflect the fact that piciform birds were not included in the testing protocol. Seven *Culex* spp. blood meals were double; 4 contained bird and mammal blood, and 3 contained only bird blood. One triple blood meal containing columbiform bird, passeriform bird and dog blood was identified. As was the case for *Ae. trivittatus*, bird feeding was most pronounced at Council Bluffs; 73.9% of the *Culex* spp. from Council Bluffs had fed on birds. The seasonal distribution of the *Culex* spp. feedings showed that these mosquitoes utilized mammals as hosts to a greater extent as the summer progressed. Only 4 (15.4%) *Culex* spp. feedings were on mammals during May and June. However, after June, 43 (38.1%) *Culex* spp.

Table 2. The blood-feeding patterns of *Culex* mosquitoes collected in Iowa in 1979.

Blood meal origin	*Culex* spp.	%	*Cx. tarsalis*	%
Columbiformes	43	(28.7)	4	(20.0)
Anseriformes (goose)	—	—	1	(5.0)
Passeriformes	31	(20.7)	8	(40.0)
Galliformes (chicken)	3	(2.0)	1	(5.0)
Unidentified bird	16	(10.7)	2	(10.0)
Total bird	93	(62.0)	16	(80.0)
Cat	2	(1.3)	—	—
Cattle—Deer	2	(1.3)	—	—
Dog	3	(2.0)	—	—
Horse	2	(1.3)	—	—
Opossum	5	(3.3)	—	—
Pig	2	(1.3)	—	—
Rabbitt	14	(9.3)	2	(10.0)
Raccoon + Skunk	8	(5.3)	—	—
Fox Squirrel	4	(2.7)	—	—
Unidentified mammal	10	(6.7)	2	(10.0)
Total mammal	52	(34.7)	4	(20.0)
Amphibian	5	(3.3)	—	—
Nonreactors	49	—	3	—
Total	199		23	

feedings were on mammals. This trend was consistent throughout the late summer. The limited data suggest that *Cx. tarsalis* feeds primarily on birds. Sixteen (80.0%) feedings were on birds, only 4 (20.0%) were on mammals. Two double blood meals containing columbiform and passeriform bird blood were identified.

The feeding patterns of *Anopheles, Coquillettidia, Culiseta, Psorophora* and *Uranotaenia* mosquitoes are difficult to determine because of the paucity of data. Only 35 blood-fed specimens of these mosquitoes were collected. They had fed primarily on mammals, although one *Ps. ciliata* fed on a reptile. Three *Coq. perturbans* and the 2 *Cs. inornata* tested had taken double blood meals on mammals.

DISCUSSION

Identification of *Ae. vexans* blood meals collected from geographically and ecologically diverse areas of North America indicate that this mosquito feeds almost exclusively on mammals (Tempelis 1975). *Ae. vexans* seems to have a propensity for large hosts such as domestic livestock (Edman 1971, Tempelis 1975, Suyemoto et al. 1973). Although nearly all the *Ae. vexans* collected in this study had fed on mammals, only 6 (5.5%) had fed on livestock. This probably reflects the fact that the majority of collecting occurred at urban sites.

Similarly, *Ae. trivittatus* was mammalophilic and rabbits were the principal host. Pinger and Rowley (1975) obtained similar results for *Ae. trivittatus* collected in Ames, Iowa. The association of *Ae. trivittatus* and birds (8.7% of the identified *Ae. trivittatus* feedings were on birds) strengthens the possibility that this mosquito may be a secondary vector of WEE virus in Iowa. Interestingly, 20.9% of the *Ae. trivittatus* collected from Council Bluffs fed on birds. The Council Bluffs site features a cattail marsh dominated by passeriform and columbiform birds. This suggests that *Ae. trivittatus* frequently will feed on birds and may significantly contribute to the natural history of WEE virus in localities where birds are a predominant part of the fauna.

The ornithophilic feeding habits of *Culex* spp. and *Cx. tarsalis* are supportive of similar studies conducted in other areas of the United States (Tempelis 1975). The midsummer feeding shift from birds to mammals exhibited by *Cx. pipens* has been documented in Colorado (Tempelis et al. 1967). The feeding shift by Iowa *Culex* spp. mosquitoes may reflect the seasonal abundance of *Cx. salinarius* because this mosquito was the predominant *Culex* mosquito in July (Rowley, unpublished data). Several studies indicate that *Cx. salinarius* feeds predominantly on mammals (Edman 1974, Suyemoto et al. 1973, Tempelis 1975). However, the feeding habits of *Cx. salinarius* are geographically variable; *Cx. salinarius* fed principally on passerine birds in Minnesota (Tempelis 1975). Thus, the increased feeding on mammals is difficult to explain by the relative abundance of *Cx. salinarius*. Additionally, the increased feeding on mammals by *Culex* spp. persisted through August, although the *Cx. pipiens* replaced *Cx. salinarius* as the dominant *Culex* mosquito in Iowa.

Edman et al. (1974) demonstrated that the feeding success of *Cx. nigripalpus* on some passerine birds (several of which are common in Iowa) is reduced as mosquito density increases. Additionally, the proportion of mosquitoes feeding on alternate hosts increased (Edman et al. 1974). This might account for the observed feeding shift inasmuch as *Culex* spp. populations peaked in late summer during 1979.

The prevalence of multiple feeding by Iowa mosquitoes also contributes to their vector potential. Five of 8 multiple feedings by *Culex* spp. involved birds and mammals. In contrast, only 1 of 21 multiple feedings by *Ae. trivittatus* and *Ae. vexans* involved birds and mammals (Table 3). Multiple feedings involving birds and mammals increase the likelihood that an infected mosquito will disseminate virus to mammals. This is especially significant considering that a partial blood meal precursive of a multiple feeding may be infective (Mitchell et al. 1979). Also, multiple feeding increases the likelihood of mechanical transmission of arboviruses. The epidemiological significance of multiple feeding probably has been underestimated because most host preference studies could not distinguish feedings on different individuals of the same species, yet alone order.

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Table 3. Summary of multiple blood feeding hosts by various species of mosquitoes.

Mosquito species	Host		Total mixed feeds	
	Mammal	Bird	Bird-Mammal	Mammal
Ae. trivittatus	X	X	1	11
Ae. vexans	X		0	9
Ae. triseriatus	X		0	1
Cx. spp.	X	X	5	8
Cx. tarsalis		X	0	2
Coq. perturbans	X		0	3
Cs. inornata	X		0	2
Total			6	36

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