FREQUENCY OF OCCURRENCE OF SPRING *AEDES* (DIPTERA:CULICIDAE) IN SELECTED HABITATS IN NORTHERN MINNESOTA [1]

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Northern Minnesota is representative of regions which have a number of species of *Aedes* mosquitoes whose eggs are normally incapable of hatching the same year in which they are deposited. Therefore, the larvae of any one of these univoltine species are present in a spring habitat because of the selection of that site for egg deposition by the female parent at a much earlier time. Although I do not intend now to postulate upon factors relating to site selection for oviposition, I have had opportunity to collect mosquito larvae and pupae extensively from the same set of breeding sites over a period of seven consecutive years. In doing so I have been impressed by the consistency with which certain species of *Aedes* are found repeatedly in the same habitats yet are absent from others and by the variation of the species composition within the same habitat from year to year. It is my intent now to report these findings.

METHODS. Itasca State Park, an area of approximately 32,000 acres located in northwestern Minnesota, was chosen for this study because it contains both deciduous and coniferous forests with many marshes, bogs and other mosquito breeding sites capable of yielding a number of *Aedes* species in an abundance that only a culicidologist would appreciate. Also, since this study was based upon visitation to the same breeding sites for a number of consecutive years, this isolated relatively undisturbed and protected area afforded an ideal location.

In the spring of 1957, 24 larval habitats were selected for study. They were chosen to include a variety of types and each habitat was visited from shortly after the *Aedes* hatch until the adults had emerged, with larvae and pupae dipped from each at approximately 5 to 7-day intervals. All larvae were killed, preserved and later identified both to species and instar; pupae were retained alive to utilize the emerged adults for their identification. A few additional habitats were added in subsequent years to bring the final total to 36.

All collecting throughout the 1957–1963 period was done by me essentially on the same basis, commencing as near to the initial hatch as possible and concluding when the spring *Aedes* had completed their larval and pupal development. Each habitat was dipped until a representative group of specimens had been obtained; in general, the number of dips per habitat was inversely proportional to the population density. Considering that each habitat was visited a number of times each season, the qualitative aspects of species presence or absence are believed to be reliable. The total values are given in the tabulations to enable some degree of quantitative comparison between species and habitats.

The habitat types selected included: (1) cattail-sedge marshes, mostly open areas with abundant growth of cattails, sedges and associated plants, often surrounded by forested areas; (2) muskeg bogs, with tamarack common throughout the area and water typically limited to isolated pockets; (3) woodland pools, surrounded by either coniferous or deciduous trees or both and having a firm bottom of leaf litter, without any vegetation indicative of an aquatic habitat; and (4) roadside drainage ditches, generally without much by way of associated emergent vegetation. The classification of these habitats as permanent, semi-permanent and temporary was based on my observation of their

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ability to retain water throughout the year.

RESULTS AND DISCUSSION. Over 92,000 specimens representing 19 of the 26 known species of Minnesota *Aedes* were taken during this 7-year study. The annual totals of each species and the number of different habitats from which each was taken are summarized in Table 1. Tables 2 and 3 show the number of years each species was taken from any one habitat. Support of the following discussion may be found in these tables; the species groups referred to follow essentially the organization of Barr (1958).

The first 5 species in Tables 2 and 3 are members of the *Aedes stimulans* group. Numerically, *A. excrucians* (Walker) represented the most abundant of all 19 species, having been taken from every habitat but 3 highly transitory woodland pools. Although the heavier populations consistently occurred in the cattail-sedge marshes, the ubiquity of this species, as well as of several others, lends support to the statement by Barr (1958) that ". . . the more abundant a particular species is in a particular locality, the wider variety of breeding places its larvae will inhabit in that locality."

A close associate of *A. excrucians* was *A. barri* Rueger, which occurred in all of the same 33 habitats and which was numerically second in rank among the univoltine species. Aside from reference by Steward and McWade (1960) to a statement from Vockeroth that he had recently found *A. barri* at several localities and believes the species will be found to be widespread in Ontario, I know of no other records of *A. barri* outside of Itasca State Park. Whether this is due to a highly restricted distribution, which I doubt, or more likely to its failure to be recognized, it certainly is no rarity within the specific area of this study.

TABLE 1.—Annual totals of specimens and different habitats (in parentheses) for species of *Aedes* taken at Itasca State Park, Minn., 1957–1963.

Species	1957	1958	1959	1960	1961	1962	1963	Total Specimens
abserratus	84(4)	19(4)	13(4)	63(7)	59(9)	51(9)	..	289
barri	1112(18)	785(17)	207(17)	1815(28)	1778(26)	4500(27)	430(19)	10637
canadensis	1122(18)	220(8)	212(13)	773(18)	313(16)	93(9)	22(4)	1999
cinereus	1035(21)	2247(21)	1847(25)	4263(35)	700(29)	337(24)	61(11)	10490
communis	612(9)	23(2)	190(6)	1304(9)	1020(4)	385(12)	5(2)	3539
diantaeus	707(13)	295(7)	230(8)	558(16)	412(17)	572(16)	183(8)	2957
excrucians	1797(18)	4019(19)	1800(20)	5317(33)	3015(27)	4427(29)	804(22)	21779
fitchii	887(15)	1061(14)	224(11)	928(22)	317(22)	403(20)	154(11)	3974
implicatus	436(6)	30(5)	95(5)	906(9)	505(5)	688(8)	24(3)	2684
intrudens	533(16)	70(5)	209(10)	1811(20)	1092(18)	2024(26)	99(6)	5838
pionips	..	3(1)	..	96(2)	20(1)	2(1)	..	121
punctor	437(7)	251(7)	1099(10)	1079(14)	448(11)	261(13)	139(6)	3714
riparius	9(3)	1(1)	2(2)	1(1)	7(3)	23(4)	3(2)	46
spencerii	5(5)	..	..	..	..	..	..	5
sticticus	501(6)	579(11)	972(7)	66(5)	2357(6)	363(5)	175(9)	5013
stimulans	133(10)	113(5)	18(4)	503(16)	280(11)	1029(20)	154(10)	2230
trichurus	653(16)	21(7)	64(13)	525(24)	379(21)	776(25)	59(9)	2477
trivittatus	..	2(1)	..	..	..	..	1(1)	3
vexans	15(3)	5168(17)	5364(21)	383(8)	1608(6)	128(5)	1887(11)	14553
Total specimens	9332	14907	12546	20391	14910	16062	4200	92348
Total habitats	24	32	33	35	35	35	33	

TABLE 2.—Number of years species of *Aedes* occurred in 19 cattail-sedge marshes, Itasca State Park, Minn., 1957–1963.

Species	Permanent															Semi-permanent				Total specimens
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
excrucians	7	7	6	7	7	7	6	5	4	6	6	4	4	5	4	5	6	6	4	19571
borri	7	7	7	7	7	6	5	3	2	5	5	3	3	3	4	5	7	6	3	8693
fitchii	7	6	6	4	6	6	1	3	4	6	4	4	4	4	4	5	3	5	4	2951
stimulans	4	4	4	1	7	1	1	1	1	3	..	1	2	3	2	5	2	3	3	1242
riparius	4	..	..	1	1	..	..	..	..	1	2	1	..	1	2	..	..	..	..	21
punctor	3	3	1	4	..	..	2	..	..	4	4	..	..	..	3	..	1	..	..	298
aberratus	4	3	..	6	..	..	4	..	..	3	3	..	..	..	1	..	1	..	..	145
communis	1	2	..	1	..	..	1	..	..	3	..	..	..	..	..	3	..	..	..	67
diantaeus	2	7	2	4	1	..	3	2	..	5	..	..	..	..	3	..	4	..	..	332
implicatus	..	..	1	..	1	..	..	..	..	1	..	..	..	..	1	4	..	..	..	65
intrudens	2	4	5	3	3	3	2	..	1	3	1	2	2	..	3	5	5	6	4	3018
trichurus	7	6	5	7	5	4	4	..	..	5	4	1	1	..	4	5	6	3	1	1784
pionips	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
spencerii	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
cinereus	7	6	5	6	6	6	5	4	3	6	4	4	4	4	4	6	6	5	2	5151
canadensis	..	2	4	2	1	..	..	1	1	..	..	3	1	1	..	1	3	..	..	64
vexans	1	..	3	1	2	..	..	2	1	1	1	1	1	1	..	7	2	5	4	6771
sticticus	1	..	2	..	1	..	..	1	..	..	..	..	..	..	..	5	1	4	3	653
trivittatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Years collected	7	7	7	7	7	7	7	6	6	6	6	6	6	6	4	7	7	7	6	
Total specimens	5981	4518	2695	3201	5110	2416	1177	1193	898	2285	1405	1032	1449	527	2491	7311	2669	3239	1240	50837

TABLE 3.—Number of years species of *Aedes* occurred in 17 habitats other than cattail-sedge marshes, Itasca State Park, Minn., 1957–1963.

	Permanent							Temporary										
	Muskeg			Roadside ditch				Woodland										Total
Species	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	specimens
excrucians	7	5	4	3	3	6	3	6	..	..	..	4	4	7	6	1	3	2208
hirsuti	5	3	4	1	1	6	3	6	..	..	..	2	7	6	7	1	5	1944
fitchii	1	..	..	..	..	7	..	5	1	..	..	3	5	1	2	..	4	1023
stimulans	3	..	..	..	..	7	..	3	..	1	..	4	3	1	1	2	3	988
riparius	..	1	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	25
punctor	7	6	5	6	6	3	1	..	..	2	..	..	1	1	3	..	2	3416
aberratus	..	4	4	..	3	1	..	..	..	..	..	..	..	..	..	..	..	144
communis	..	1	1	1	..	2	1	..	6	1	..	2	2	5	4	..	7	3472
diantaeus	1	4	4	..	..	..	5	4	4	1	..	4	6	7	7	..	5	2625
implicatus	1	..	..	1	..	6	5	..	7	..	1	1	..	3	2	..	6	2619
intrudens	..	1	1	..	..	3	6	5	1	..	2	4	5	5	7	1	6	2820
trichurus	1	4	4	..	1	7	4	4	..	..	1	4	4	3	5	..	5	693
pionips	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	3	121
spencerii	..	1	..	..	..	1	..	1	..	..	..	..	..	..	..	..	1	4
cinereus	6	4	3	3	3	7	5	6	5	3	1	3	4	7	5	2	6	5339
canadensis	5	1	2	3	2	5	6	1	7	2	2	4	3	5	3	2	7	1935
vexans	1	..	..	..	..	4	4	3	5	1	3	2	4	2	2	2	5	7782
sticticus	..	..	..	..	..	1	1	3	2	..	3	6	4	..	1	4	6	4350
trivittatus	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	3
Years collected	7	7	7	6	6	7	6	7	7	4	3	6	7	7	7	4	7	
Total specimens	2683	2027	1162	1351	981	5689	1407	2295	3505	167	2716	3068	1918	3428	2510	1300	5304	41511

The remaining 3 species of this group tended to favor the marshes but often occurred elsewhere. *A. fitchii* (Felt and Young) was taken from all 19 marsh habitats but only 9 of the 17 others. Although totaling about half as many specimens as *A. fitchii*, *A. stimulans* (Walker) had essentially the same habitat distribution. *A. riparius* Dyar and Knab, while collected oftener in marshes than elsewhere, must be considered a rare species within the Park.

The next 9 species in Tables 2 and 3 fall within the *Aedes communis* group. Although occasionally in limited numbers in marshes and woodland pools, *A. punctor* (Kirby) was consistently found in larger numbers in tamarack muskeg and in roadside drainage habitats 23 and 24, both of which contained water permanently and were backed by extensive tamarack growths. The 12 sites where *A. abserratus* (Felt and Young) occurred also all contained *A. punctor* at some time, reaffirming the close association of these 2 species. *A. communis* (DeGeer), *A. diantaeus* (Howard, Dyar, and Knab) and *A. implicatus* Vockeroth favored the temporary woodland and roadside habitats, whereas *A. intrudens* Dyar and *A. trichurus* (Dyar) were never too abundant but rather ubiquitous in their habitat selection. *A. pionips* Dyar was taken only from 2 woodland pools and 114 of the 121 specimens were from habitat 36; the only previous record of this species in Minnesota had been 4 larvae taken by Barr in Itasca State Park in 1954 (Barr, 1958). *A. spencerii* (Theobald) was so rare as to make generalizations unreliable.

Whereas all 14 of the above univoltine species may hatch in quite cold water, both *A. cinereus* (Meigen) and *A. canadensis* (Theobald) are somewhat different in being normally univoltine in nature and hatching in cold waters, but capable of repetitive generations in the laboratory (Horsfall, 1963). *A. cinereus* represented the only species in this study to occur in all 36 habitats. In many of these sites it was noted to have fair population density and to have been taken in at least 3 years, all of which would seem to indicate almost total lack of site discrimination for oviposition on the part of the female. *A. canadensis* preferred all habitat types other than the cattail-sedge marshes.

The remaining 3 species resemble one another in being multivoltine, in hatching at intermediate temperatures, and in being found in the same types of habitats. *A. vexans* (Meigen), *A. sticticus* (Meigen) and *A. trivittatus* (Coquillett) occurred primarily in woodland pools, temporarily flooded roadside ditches and semi-permanent marshes that had been dry and then flooded later in the season. Smaller numbers of these species would occur in the permanent waters after a lowering of the water level and subsequent rise later in the spring due to heavy rainfall.

Of interest in this study not only is the general habitat association of the mosquito species as discussed above but also the variation in species content within the same habitat from year to year. The permanent marshes, as would be anticipated from their more stable water level, were more predictable in their major species composition. *A. excrucians*, *A. barri*, *A. fitchii* and *A. cinereus* were taken from all of them in many of the years of this study; *A. stimulans*, *A. trichurus* and *A. intrudens* occurred with less frequency but were fairly common inhabitants. If the permanent marshes are subdivided into (1) those that are essentially open, without shrubs or small trees within the habitat proper, and (2) those that have a cover to varying degrees of shrubs and/or small trees, one finds habitats 3, 5, 6, 8, 9, 11, 12, 13 and 14 in the open class and 1, 2, 4, 7, 10 and 15 in the shrubby class. Reference to Table 2 shows how closely *A. punctor*, *A. abserratus*, *A. communis* and *A. diantaeus* were associated with the shrubby marshes, in the few times that they did occur in marshes.

Habitat 16 presents a good example of species variation within a semi-permanent marsh. In each of 5 years when flooding

occurred early in the season (1957–1958 and 1960–1962), 9–11 different species of *Aedes* were taken, including good numbers of such species as *A. excrucians, A. barri, A. fitchii, A. intrudens* and others. In the drier years of 1959 and 1963, when flooding occurred considerably later, only 4 species (79 *A. cinereus*, 2 *A. sticticus*, 1 *A. trichurus*, 957 *A. vexans*) and 2 species (23 *A. sticticus*, 404 *A. vexans*), respectively, were taken.

Citing some examples from the temporary sites, habitat 36 at one time or another yielded a total of 17 species of *Aedes*, yet the maximum for any one year was 15 (1960) and the minimum 7 (1959), even though the level of flooding appeared similar both years. Habitat 35 was dry in 1958–1959, but had 7 species when flooded in 1960. Habitat 33, an ideal site for collecting many *A. communis* in 1957 and 1959–1962, had none of this species in 1958 and 1963 in spite of the presence of numbers of the usual associated species. On the other hand, for consistency, over half of all specimens from habitat 34 were *A. diantaeus;* this site every year was the most reliably heavy producer of this species and in fact yielded 46.5 percent of all *A. diantaeus* taken in this entire study. Other examples similar to these could be cited, but scrutiny of the tabular material will disclose their presence.

Undoubtedly the exact site of egg deposition coupled with the time and volume of precipitation are the principal factors for explanation of the above phenomena. Horsfall (1963) has recently reported upon this for some *Aedes* and *Psorophora* species in Illinois. At least for northwestern Minnesota, if the potential sites were filled by melted snow or by a heavy rain in early to mid April, the heaviest and most varied larval production of univoltine species of *Aedes* was observed. If, however, the habitats remained dry until temperatures had moderated, then a large proportion of the larvae hatched were the multivoltine *A. vexans* and *A. sticticus*. In 1957, 1960 and 1962, snowfall measured over 40 inches and good April and May precipitation fell; the production of multivoltine species was quite low (Table 1). In the other 4 years, snowfall was less than 40 inches (in 1958 and 1961 only around 15 inches) and April and early May precipitation was either quite light or of a type allowing little accumulation. The increased proportion of *A. vexans* and *A. sticticus* can be noted in Table 1.

The consistency with which certain species of mosquitoes select the same sites for oviposition year after year and apparently avoid others, while other species are more or less nondiscriminatory in their egg-laying activities, further points up the need for field studies on mosquito oviposition. Our present knowledge enables us to predict in a general way what species may be anticipated in certain categories of habitats, but, as pointed out in this study, there are numerous exceptions to be accounted for. The need now is to elucidate the factors explaining why mosquitoes lay their eggs where they do.

SUMMARY. Intensive collecting of *Aedes* larvae and pupae was carried out at Itasca State Park, Minn., during the springs of 1957–1963. During this 7-year period, over 92,000 mosquito specimens were taken from a series of 36 different habitats. Observations were made on the association of *Aedes* species with certain habitat types and on the number of years each of the 19 different species occurred within each specific habitat.

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