ARTICLES

MOSQUITO STUDIES IN NORTHERN WISCONSIN II. LIGHT TRAPPING STUDIES[1]

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In the first paper in this series, data were presented concerning larval populations, sources of mosquito production, description of habitats, relative numbers of the several species in the study area, and some of the characteristics of these species. This study was made to determine the species which comprise adult mosquito populations, the relative abundance of these species components, and their seasonal succession.

A limited number of trap samples was taken during the summer of 1966. That study was preliminary in nature, helping to gain an acquaintance with the area, and to obtain specimens for arbovirus isolation. More intensive trap sampling was conducted during June, July, and part of August, 1967. Results from the 1967 studies are reported in this paper.

METHODS. *Study area.* The study area includes five counties in north central Wisconsin (Figure 1). This is in the conifer-hardwood zone of Wisconsin (Curtis, 1959). Dairying, with attendant cultivation of small grains, and evergreen tree production constitute the main agricultural pursuits. The many lakes and streams provide attraction for tourists, especially during summer months. The resort business is well established in the area.

The nature of the terrain, and the production sites created by windfall of trees on sidehills bordering bogs were described in the first paper in this series (Siverly and DeFoliart, 1968). The sidehills also proved to be better trap sites than the bogs proper. However, this was partly due to thermal stratification. Nighttime bog temperatures, even in summer, drop to 30° F. or lower.

Most of the sampling sites were in Lincoln and Forest Counties. Sites in Forest County were within the Nicolet National Forest (Figure 1). In general, the same sites used for larval sampling also were used for light-trapping. The following criteria were observed in selecting sites: (1) previously noted concentrations of larval and/or adult mosquito populations, (2) areas responsive to flooding, with poor drainage, and presence of standing water a good part of the year, (3) areas believed to be frequented by large populations of birds and/or mammals. If later, epidemiological studies involving capture of birds and mammals for arbovirus studies are conducted, background data on mosquito populations will be available. Glacial kettles (sites 2, 8, 11, 12) satisfy the first two criteria very well; sites 3, 5, 9, 10, 13, and 24 fulfill the third criterion.

Sampling pattern. An attempt was made to obtain eight trap samples per week for the 10-week period. There was no set pattern in utilizing the 24 sites shown in Figure 1. It seemed desirable to integrate both the elements of consistency and flexibility in the sampling pattern. Four sites in Lincoln County were trapped five times or more (site numbers 4, 5, 7 and 8). One site in Oneida County was sampled seven times (site number 10), and four sites in Forest County were trapped four times or more (site numbers 16, 17, 21 and 22).

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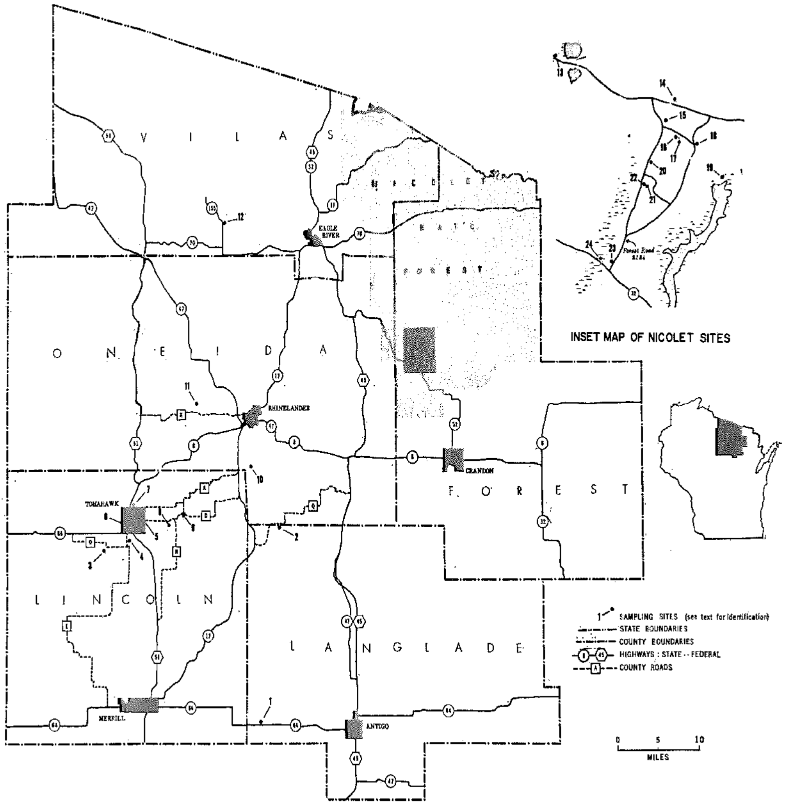

FIG. 1.—Sampling sites, Northern Wisconsin Mosquito Studies, 1966–1967.

Most of the remaining sites were sampled at least once, on a random basis. Actually, with one exception (a pulp mill site in Lincoln County) the sites were quite homogeneous with respect to species components. Essentially, the same results probably would have been obtained had the same eight selected sites been trapped each week during the 10-week period.

Sampling method. A few New Jersey light trap samples were taken in 1966, but this trap attracted so many midges and other small insects that it soon was replaced by the CDC trap (Sudia and Chamberlain, 1962). Dry ice was used at each trap setting (Newhouse *et al.*, 1966). Approximately five pounds of dry ice was wrapped in heavy paper and suspended at about the same level as the trap hood and a few feet away from the trap unit.

RESULTS. Numbers of species of mosquitoes taken in CDC trap collections are shown in Table 1. Actually, these numbers are somewhat misleading, because of the variance in numbers of collections from one 10-day period to the next. Figure 2 is designed to facilitate interpretation of data in Table 1.

Figure 2 was derived from Table 1. Note the arrangement of species into three groups in Table 1. Totals and percentages for each group and each 10-day interval were calculated. When these percentages are treated as moving averages, and the percentage values plotted on a graph, results appear as in Figure 2. Thus, the mos-

TABLE 1.—Species composition of CDC trap collections by 10-day intervals, northern Wisconsin, 1967.

10-day intervals	June 1–10	June 11–20	June 21–30	July 1–10	July 11–20	July 21–31	Aug. 1–10	Total
No. collections	11	6	15	6	15	9	13	75
Group One								
Aedes abserratus	109	0	272	25	..	..	..	406
Aedes aurifer	4	3	85	1	..	..	1	94
Aedes communis	648	366	202	39	34	31	1	1321
Aedes diantaeus	21	7	88	7	10	5	11	149
Aedes implicatus	1	..	1	..	..	..	..	2
Aedes intrudens	8	2	..	..	..	..	..	10
Aedes punctor	1138	432	656	71	275	545	50	3167
Aedes sticticus	..	..	..	13	168	574	89	844
Aedes trichurus	95	14	10	2	3	11	..	135
Aedes spp.	4	4	1	19	18	63	202	311
Aedes excrucians	19	19	144	8	157	79	134	560
Aedes fitchii	..	..	2	..	4	44	6	56
Aedes flavescens	..	..	1	..	..	..	..	1
Group Two								
Aedes canadensis	1	4	52	1	472	166	296	992
Aedes cinereus	13	17	142	5	127	13	51	368
Aedes triseriatus	..	..	..	1	..	..	..	1
Aedes vexans	..	..	122	120	787	89	31	1149
Anopheles earlei	..	..	..	..	..	..	3	3
Anopheles walkeri	..	..	3	1	..	..	3	7
Culex restuans	..	7	4	..	69	..	52	132
Culex tarsalis	..	..	..	..	..	..	2	2
Culex territans	..	..	..	..	..	..	5	5
Culiseta inornata	5	2	..	..	1	1	11	20
Culiseta melanura	..	..	..	..	1	1	..	2
C. silvestris minnesotae	..	..	..	..	..	2	..	2
Culiseta morsitans	1	..	10	1	81	3	134	230
Group Three								
Mansonia perturbans	..	..	180	589	5164	4520	1368	11821
Total	2067	877	1975	903	7371	6147	2450	21790

quito populations of the study area in 1967 are depicted in Figure 2 as three discrete components corresponding to Groups One, Two, and Three in Table 1.

Single generation *Aedes* spp. comprise Group One. Most of the members of this group are black-legged *Aedes*, members of the *Aedes communis* complex. *A. excrucians, A. fitchii* and *A. flavescens* are band-legged *Aedes*, members of the *A. stimulans* complex. With the exception of *A. sticticus*, all develop at low water temperatures. Eggs are laid the previous season, and overwintering is in the egg stage. Larvae hatch from eggs at snow melt, and achieve second or third instar while ice is present in the pools and the water temperature is less than 45° F.

Aedes trichurus and *A. punctor* males were on the wing in Lincoln County by the third week in May. By the fourth week in May, many black-legged females and band-legged males emerged. As much as a week's difference between peaks in Lincoln County and peaks in the Nicolet area was noted. The emergence of *Aedes* mosquitoes during the first week in June created virtual population explosions. The five-county area literally became saturated because of population pressure from production sites. The year 1967 was reported to be one of the worst mosquito years in the history of northern Wisconsin. In Rhinelander, merchants complained of mosquitoes in their stores during the day as well as during the evening hours.

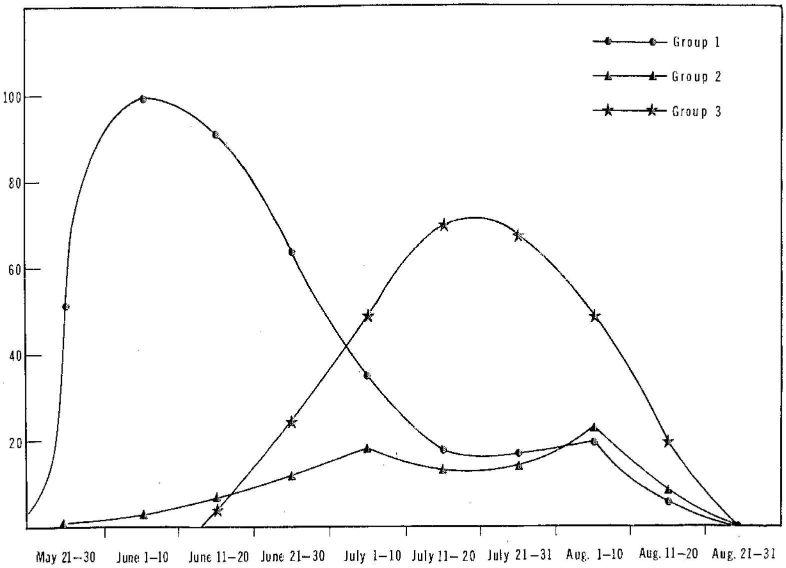

Fig. 2.—Profiles of mosquito populations in northern Wisconsin—1967.

Populations of Group One mosquitoes dwindled rapidly. Delayed hatch (or possibly second generation) *A. punctor,* and occurrence of *A. sticticus* in 1967 tended to sustain these populations.

Although few *A. sticticus* were observed in 1966, considerable numbers were trapped in 1967. The population peak for this species occurred the last part of July. Of the *Aedes* spp. comprising the early spring hatch, *A. excrucians* persisted longer than representatives of the *A. communis* group. *Aedes* spp. listed in Table 1 were senile specimens, belonging to the *A. communis* group, too badly rubbed for species determination.

Mosquitoes which occurred during summer and fall are listed under Group Two (Table 1). Some of these also occurred during spring. Happold (1965) lists both *A. canadensis* and *A. cinereus* as univoltine in Alberta, Canada. Detinova (1968) states that *A. cinereus* completes three seasonal generations in Russia. Collecting of larvae of *A. canadensis* and *A. cinereus* throughout spring and summer was reported in the first paper in this series. This is evidence that these species (along with *A. punctor,* to a limited extent) either are multivoltine or have delayed hatch in northern Wisconsin (Siverly and DeFoliart, 1968).

Included also in Group Two are two species of *Anopheles,* two species of *Culex,* and four species of *Culiseta.* The population profile of this group, in any given year, will vary with the pattern of summer rains. In 1966, June was quite dry, and the troublesome biters in this group did not appear in numbers until after early fall rains in August. This year, rains occurred in June, and populations of Group Two mosquitoes were more or less sustained, with a slight secondary peak the first week of August (Figure 2).

Group Three mosquitoes includes but one species, *Mansonia perturbans.* There is but one generation a year, but emergence is sustained over several weeks and the population profile for a given area probably approaches a normal distribution curve. Bodies of permanent or semi-permanent water serve as sources of production, hence the *Mansonia* population is largely independent of pattern of precipitation in any given year.

In a personal communication, Mr. A. W. Buzicky reports that the peak for *Mansonia* was reached in 1966 in the St. Paul area during the week of July 16. This is in good agreement with observations in northern Wisconsin, where both in 1966 and 1967, peak populations of *M. perturbans* were attained about the middle of July.

Discussion. Population profiles, as shown in Figure 2, will vary from one year to the next. In fact, no two sets of population samples taken during the same year, when shown as in Figure 2, will show the same configurations. Figure 2 is intended only to illustrate, in an extreme simplification, the main features or characteristics of the main components of mosquito populations in the study area which probably follow the same general pattern from year to year.

The challenge of mosquito control in northern Wisconsin is mentioned in the first paper in this series. Obviously, the main problem does not involve control of multivoltine *Aedes* species, as in other parts of Central United States. Rather, the early univoltine *Aedes* species which emerge en masse and in astronomical numbers pose the greatest problem in the area.

The pest importance of these mosquitoes is well recognized. In northern Wisconsin, the annoyance problem involves man in his recreational as well as in vocational pursuits, and wildlife as well as domestic animals.

The population wave of *Mansonia perturbans* which follows on the wake of coldhardy *Aedes* species gives brief respite from annoyance, except that *M. perturbans* is less abundant than the combined *Aedes* populations, and tends to be nocturnal in habit. In the case of *M. perturbans,* of course, the target for source reduction is the permanent or semi-permanent water habitat. Determination of host plants of *M. perturbans* is a priority problem in the study area.

The study area would lend itself well to the kind of study conducted by Price (1963) at Itasca State Park, Minnesota. Larval habitats were classified in four categories: cattail sedge marshes, muskeg bogs, woodland pools and roadside drainage ditches. In Price's study, 36 larval habitats were sampled each spring over seven consecutive seasons. Species and relative abundance of species components which comprise adult populations in that study appears well documented from the extensive larval sampling.

The study area as shown in Figure 1 contains all of the type habitats used in the Price study, and in addition, wet prairie sites, and one pulp mill site. Site 1, and an area just north of the junction of highways 32 and 45 are good candidate wet prairie sampling sites. No collections have yet been made from either of these areas. A pulp mill (Site No. 4) produced a few *Aedes dorsalis* in overflow from a lagoon impoundment in 1966. No *A. dorsalis* were collected in 1967.

There are other challenging problems: parasite-host relationships, dispersal to and from sources of production, host preference, and egg sampling studies. Answers to these and other basic questions will provide the only satisfactory foundation for control efforts. The control of mosquitoes and other biting arthropods is requisite to realization of economic potential in the study area.

Summary. During the summer of 1967, 21,790 mosquitoes, representing 26 species, were collected by CDC trap in northern Wisconsin. Based on CDC trap collections, three rather discrete components in mosquito populations are recognized. Population Group One consists of univoltine *Aedes* species, predominantly those in the *A. communis* group. Group Two consists of *A. canadensis, A. vexans, A. cinereus,* and to a lesser extent, three species of *Culex,* four species of *Culiseta,* and two species of *Anopheles.* Group Three consists solely of *Mansonia perturbans.*

The population peak for Group One was rapidly attained the first week of

June. The population peak for *M. perturbans* was reached about the middle of July. The population profile for *M. perturbans* approximated that of the normal distribution curve. The timing of peaks for Groups One and Three is independent of precipitation patterns in a given year. This timing is more closely correlated with temperature, or day-degrees. Profiles of populations for Group Two will differ from year to year, depending upon amounts and occurrences of summer rains.

The mosquito pest problem in northern Wisconsin is primarily a univoltine *Aedes* species problem, and secondarily a *Mansonia perturbans* problem.

Sampling sites appeared homogeneous in terms of adult species collected; however, more extensive sampling from more sharply defined habitats, including wet prairie communities and sites of environmental disturbance, probably would reveal greater differences in mosquito populations at different sampling sites.

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References

Curtis, John T. 1959. The vegetation of Wisconsin. Univ. of Wisconsin Press. 657 pp.

Detinova, T. S. 1968. Age structure of insect populations of medical importance. Ann. Rev. Ent., Vol. 13:427–450.

Happold, D. C. 1965. Mosquito ecology in central Alberta. I. The environment, the species, and studies of the larvae. Canad. J. Zool. 43(5): 795–819.

Newhouse, Verne F., Roy W. Chamberlain, J. Gibson Johnston, and W. Daniel Sudia. 1966. Use of dry ice to increase mosquito catches of the CDC miniature light trap. Mosq. News 26(1): 30–35.

Price, Roger D. 1963. Frequency of occurrence of spring *Aedes* (Diptera:Culcidae) in selected habitats in northern Minnesota. Mosq. News 23(4):324–329.

Siverly, R. E., and Gene R. DeFoliart. 1968. Mosquito studies in northern Wisconsin. I. Larval Studies. Mosq. News 28(2):149–154.

Sudia, W. D., and R. W. Chamberlain. 1962. Battery-operated light trap, an improved model. Mosq. News 22(2):126–129.