FIELD INVESTIGATIONS ON *AEDES FITCHII* MOSQUITO POPULATIONS IN A WOODLAND POOL ECOSYSTEM[1]

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ABSTRACT. Field investigations into specific areas of immature *Aedes fitchii* Felt and Young population dynamics were conducted at Yankee Springs recreational area in southwestern Michigan. A representative breeding site was sequentially sampled during the spring months of 1972 and 1973. Data were collected on instar composition and developmental rates while observations were made on aquatic environment—immature life stage interactions. Immature mortality rates and larval densities for a population cohort were also calculated. The practical significance of this study as it related to possible control strategies is discussed.

Introduction. A previous survey (Wagner and Newson 1975) has established that species of the *Aedes stimulans* complex are largely responsible for biting insect problems in southern Michigan state parks. These mosquitoes are the woodland variety and utilize temporary lentic pools as breeding sites. These pools are formed as a result of snow melt and flooding conditions prevalent in forested areas during early spring. Due to the importance of the woodland *Aedes* group as potential disease vectors and nuisances in the park system, a study was undertaken to clearly define the relationship between the aquatic environment and the immature life stages. If these interactions were better understood, then insights into the regulation of population densities could be obtained. Accordingly, biological analysis would provide a framework upon which to base decisions concerning strategies to be taken in altering the *Aedes* ecosystem to obtain adequate management of these pests.

Survey Methods. Larval surveys conducted at Yankee Springs recreational area in southwestern Michigan showed that four woodland pools were major breeding sites for the *A. stimulans* group of mosquitoes. These pools are in public use areas and resulted in substantial mosquito populations that disrupted human recreational activities throughout the summer months. As preliminary studies indicated uniform larval densities among pools, a representative breeding site was chosen for in-depth surveys (Wagner).[4] It consisted of an oval microbasin area subject to seasonal, temporary flooding with maximum flood occurring in early spring. This flooding produced an estimated surface of 200 m^2 and provided suitable habitat for the hatch and development of the immature stages.

Quantitative field studies consisted of larvae and pupae collections during and after periods of maximum flooding. Sampling procedures and techniques used were modified from Cummins (1962) and Coffman et al. (1971). Samples were taken along 4 transect lines at right angles to the long axis of the pool. Each transect was subdivided into 3 sampling stations, one at each pool margin and one at the center. A 12.7 cm diameter plexiglass cylinder was utilized in collecting the immature stages. The cylinder was firmly placed into the bottom substrate and removal of the contained specimens was facilitated by a small mesh dip net. Aquatic invertebrates collected by this method were

[1] Journal article No. 7329, Michigan Agricultural Experiment Station. This research was supported by a fellowship grant from the Michigan State Department of Natural Resources.

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[4] V. Wagner. Data from a completely randomized transect sampling procedure were analyzed by a nested analysis of variance. The variance component due to pools was not significant at the .05 or .01 levels (unpublished data).

preserved in 70% alcohol for later identification. During 1972, samples were taken at 7-day intervals beginning April 14 and ending May 10. A total of 24 water samples (2 per station) was taken at each trial. In 1973 the procedure was repeated except 60 samples (5 per station) were taken at each trial and the sampling period extended from March 27 to April 24 due to earlier egg hatch.

Specimens were submitted to the medical entomology laboratory at Michigan State University for identification to species level. Due to the minute size of 1st and 2nd instar stages, observations of slide mounted specimens under oil immersion were necessary. Taxonomic keys for these early stages are contained in Dodge (1966). The later stages were identified with the aid of keys contained in Barr (1958) and Carpenter and LaCasse (1955).

RESULTS. Table 1 shows the composition of the immature stages of *A. fitchii* at Yankee Springs in 1972. All collected on April 12 were either first or second instars with the latter representing 57.4 percent of the total. In the second collection 12 or 21.4% had matured to the third instar while 30 were in the first instar. All stages (I–IV) were present in the April 26 sample with fourth instars comprising 7.3% of the total and present for the first time. Immature development was rapid from April 26 to May 10. Of the 27 collected on May 3 all larvae were either third or fourth instars with the former comprising 62.9% of the total. The last collection made on May 10 contained only fourth instars and pupal stages, each representing approximately 50% of the total. No first or second instars were present in the last two trials and adult emergence was first observed May 11.

Egg hatch occurred earlier in 1973 than in 1972 (Table 2). The first collection made on March 31 contained primarily first and second instars although approximately 2% had progressed to the third instar. The number of first instar present in the April 3 sampling trial increased substantially (335 as compared with 94 the previous week) with 76.5% of the total being at this stage of development. In the third trial all larval stages were present with 69.8% in the second, 22.9% in the third and approximately 2% in the fourth stage of development. The fourth collection on April 17 contained instars two through four with the majority (71.7%) still in the second stage. Fourth instars had increased to 5%. The last samples contained 76.3% fourth instar larvae and 8.5% in the pupal stage. Adult emergence was first observed a week later on May 1.

MORTALITY. Mortality rates for immature stages were obtained from life tables (Table 3) utilizing data contained in Tables 1 and 2. During 1972 mortality was estimated as increasing from 0.082 during the first age interval to 0.445 for the last. Mortality for the 28-day period was 0.754. Overall mortality in 1973 was estimated as 0.731 with no mortality estimated within the first age interval. Rates of 0.283, 0.179 and 0.543 were calculated for the remaining intervals. Immature

Table 1. Immature *Aedes fitchii* sampled from a woodland pool at Yankee Springs recreational area, 1972.

Date	Sampling Trial	No. of Larval Instars (I-IV) and Pupae (P)					Total
		I	II	III	IV	P	
4/12	1	26	35				61
4/19	2	30	14	12			56
4/26	3	14	12	12	3		41
5/3	4			17	10		27
5/10	5				8	7[a]	15

[a] Adult emergence first observed on 5/11/72 and completed 5/17/72.

Table 2. Immature *Aedes fitchi* sampled from a woodland pool at Yankee Springs recreational area, 1973.

Date	Sampling Trial	No. of Larval Instars (I-IV) and Pupae (P)					Total
		I	II	III	IV	P	
3/27	1	94	41	2			137
4/3	2	335	94	9			438
4/10	3	17	219	72	6		314
4/17	4		185	60	13		258
4/24	5			18	90	10[a]	118

Adult emergence first observed on 5/1/73 and completed by 5/10/73.

mortality rates of age intervals 7–28 are adequate estimations of larval mortalities with late instar mortality approximately 0.50. However, it was necessary to eliminate certain cohorts during the first age interval as serial egg hatch (caused by additional flooding of the woodland pool) introduced first instars into the larval population resulting in an underestimation of mortality rates. This was especially true in 1973 when the 335 count for instar I at the second sampling trial consisted entirely of newly hatched immatures and occurred after the depth of the pool went from 18 inches to a maximum flood of 36 inches. The elimination of this cohort from the life table resulted in more realistic mortality values. These values are shown in the following table:

Sampling Trial	Instar Population			Total
	I	II	III	
1	94	41	2	137
2		94	9	103

which gives a mortality rate of 0.247 (survival rate 0.752). A similar procedure was utilized for data collected in 1972 when 30 first instars were collected during the second sampling trial and consisted of 9 newly hatched immatures. When these individuals were eliminated a mortality rate of 0.230 (survival rate 0.770) was obtained. The revised totals are shown in the following table:

Sampling Trial	Instar Population			Total
	I	II	III	
1	26	35		61
2	21	14	12	47

These values indicated that early development mortality was approximately 0.25 for both years. Inspection of immature life tables indicated that mortality occurred primarily during transition from one instar to the next. Although some daily mortality is indicated, the data do not allow an adequate separation of daily

Table 3. Life tables for immature *Aedes fitchii* in a woodland pool ecosystem at Yankee Springs recreational area, 1972–1973[a]

Age Interval (Days) x	No. Surviving at Start of x l_x		No. Dying Within Interval x to x + 1 d_x		Mortality Rate q_x[b]		Survival Rate p_x[c]	
0	1,000	1,000	82	0	0.082	0.000	0.918	1.000
7	918	1,000	246	283	0.268	0.283	0.732	0.717
14	672	717	229	128	0.341	0.179	0.659	0.821
21	443	589	197	320	0.445	0.543	0.555	0.457
28	246	269	...	...	...	...	...	...

[a] The two columns under each heading are for the years 1972 and 1973, respectively.
[b] Overall mortality rates for 1972 and 1973 are 0.754 and 0.731, respectively.
[c] Overall survival rates for 1972 and 1973 are 0.246 and 0.269, respectively.

mortality effects. The substantial late instar mortality observed during 1972 and 1973 was due largely to inadequate nutritional resources in the woodland pool breeding sites (Cummins).[5] These depositional aquatic systems contained a variety of fine particle detritus utilized as food by mosquito larvae. As nutritional requirements increase significantly for successive developmental stages, the amount of available detritus was seen as a limiting factor. Although a chaoborid, *Mochlonyx* sp., a predator of mosquito larvae, was consistently sampled throughout the 2-year study, developmental rates of both insects were in phase and no significant mortality was observed. This suggested that the *A. fitchii* ecosystem was essentially predator free during 1972 and 1973.

DISCUSSION. Field studies indicated extreme daily variability in immature mosquito dynamics as well as weather conditions from March 1 to April 15. Examples included serial egg hatch over a 14-day period resulting in the addition of first instar cohorts and an immature population consisting of all four instars during the month of April. Biological and physical parameters were much more stable in late April and early May. The water depth in the pool was steadily receding and all cohorts were in late instars and uniform in distribution and composition. The former phenomenon was due to the progressively decreasing pool depth which constricted the larval population into a smaller geographical area. The more uniform instar composition previous to adult emergence was due to the warmer water temperature which accelerated growth rates of all immature cohorts. Seasonal inundation of the microbasin area was consistent for the two years with the highest water levels measured in 1973. This was a factor in determining immature population densities as the higher population totals in 1973 were due to the flooding of additional egg-containing soil gradients of the pool. Overall mortality was approximately 0.75 for both years with the highest rates observed in the late instar stages. As the rate of larval development and biomass increase was rapid in a temporary aquatic ecosystem, nutrient restrictions placed on immature mosquito populations would explain the substantial attrition during later developmental stages.

The practical significance of this study indicates two possible control strategies. One is to apply larvicides late in the development season when biological and physical parameters have stabilized. The uniformity of larval distribution and composition in addition to reduced pool size would result in efficient control with minimum dosage. It is evident by allowing natural mortality during the late instars one would have a smaller population to control than at the beginning of the developmental season. The disadvantage of this strategy in terms of on-going control programs is that adequate treatment of substantial numbers of breeding sites late in the season would be virtually impossible. An alternate strategy is to adjust dosages to maximum flood conditions. This would insure adequate control of all serially hatched larvae and would minimize the dilution factor of additional flooding. For this control strategy to be effective each microbasin area must be thoroughly surveyed as to depth and total area during maximum flood conditions. Knowledge of mosquito egg placement would also clarify the zone of maximum flood. Sampling procedures and techniques to determine local egg distribution in areas subject to seasonal flooding are discussed in Horsfall (1963).

[5] K. Cummins. Personal communication, September 1973. Kellogg Biological Station, Michigan State University.

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