THE RATE OF LARVAL DEVELOPMENT OF *AEDES IMPLICATUS* VOCKEROTH IN FIELD AND LABORATORY [1]

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ABSTRACT. The eggs of *Aedes implicatus* Vockeroth hatch while snow is still present in spring. The duration of 1st, 2nd, 3rd and 4th larval stadia in a natural pond was 25, 15, 8 and 8 days, respectively. The developmental period extended from March 26 to May 18. In the laboratory at 80° F the developmental periods were 2, 1.5, 1.4, 3 and 2.1 days for 1st, 2nd, 3rd and 4th instar larvae and pupae. The heat units required for larval development in the laboratory were almost identical to those measured at ½ in. in the pond—80, 60, 56 and 120 degree-days above 40° F for 1st, 2nd, 3rd and 4th instars in that order. The application of heat units in the practical aspect of control is discussed.

Aedes implicatus Vockeroth is distributed from about 40° N lat. northward throughout continental North America (Carpenter and LaCasse, 1955; Carpenter, 1968, 1970). It is a rather rare species throughout most of its range but where present the females are vigorous biters (Matheson, 1944; Rees and Nielson, 1951; Steward and McWade, 1961). According to Barr (1958) "practically nothing is known of the biology of this species." The period of occurrence has been outlined only generally. It is an early species, with larvae appearing early in April and adults being present June or July (Mail, 1934; Owen, 1937; Matheson, 1944; Happold, 1965). However, the rate of development of the preimaginal stages has not been reported.

During regular mosquito surveillance sampling, a pond near Saskatoon, Saskatchewan was found to contain a pure population of *A. implicatus*. This afforded an opportunity to further the knowledge of the life history of the species in the field, to compare the rate of development of the preimaginals in the field with that in the laboratory and to examine the potential utility of heat units as an aid in planning control procedures.

METHODS. The pond used for these studies was located near Saskatoon, Saskatchewan at 52° 03'N; 106° 30'W. It was a grassy roadside ditch about 20 ft by 40 ft with sloping margins and a maximum depth of 10 in. The vegetation was a sparse overwintered stand of northern reed grass, *Calamagrostis inexpansa* A. Gray and foxtail barley, *Hordeum jubatum* L., which resumes growth after the pond begins to dry in spring.

The *A. implicatus* population was sampled daily, beginning March 26, 1973, when the 1st larvae emerged from overwintered eggs. Sufficient dips were taken with a 1 litre dipper to obtain a representative sample of the population. Larvae were examined under a microscope in the laboratory to determine the stage of development. Beginning March 26, samples of 100 or more larvae were collected weekly or as the 50 percent ecdysis point in each instar was reached in the field. They were reared in the laboratory at 80° F to determine the rate of development under controlled conditions. Seven samples of larvae were reared in this sequence. Larvae were reared in covered trays in Bates' medium and fed finely ground dog chow and brewer's yeast. The food was sprinkled on the water surface daily. Two or three pond snails were placed in each tray to consume excess food and thus prevent pellicle formation. The number of preimagines in each stage was recorded daily, and dead specimens and exuviae were removed at the same time.

Developmental rate was determined

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from the mean time larvae or pupae remained in a respective instar. Thus, when sampling indicated that at least 50 percent of the population had moulted to the next instar, the time elapsed from the previous 50 percent ecdysis was considered the mean developmental period for that instar. The mean developmental period for pupae was determined in the laboratory but not in the pond. It could not be determined for eggs because they overwinter from the previous egg-laying season.

Continuous records of air temperature were taken in a Stevenson screen with a Feuss hygrothermograph and of water temperatures at ½ in. and at pond bottom with a Weksler thermograph. The maximum and minimum temperatures were converted to degree-days by the tables of Williams and MacKay (1970) and used as a basis for comparing the rate of development of the various preimagines in the field and in the laboratory.

RESULTS AND DISCUSSION. Standing water from the spring thaw gathered at the edge of the snow-filled pond on March 23, 1973. Hatch began on March 26 even though unmelted snow persisted in the pond until April 10. During the period from hatch to 50 percent ecdysis of second instar larvae, March 26 to May 2, the minimum water temperature at ½ in. was below 32° F for short periods every night except two; the maximum daily temperature reached 68° F once and the mean temperature was 38.5° F. During the developmental period for 3rd and 4th instar larvae, May 3 to May 20, the minimum temperature of the water at ½ in. was below 32° F only once; the maximum for the period was 71° F and the mean 51° F. These low temperatures no doubt account for the lengthy period of 54 days required for larval development. Table 1 shows that the mean duration of larval instars in the pond was 23, 15, 8 and 8 days for 1st, 2nd, 3rd and 4th instars, respectively. In the laboratory at 80° F the periods were 2, 1.5, 1.4 and 3 days and the pupal period was 2.1 days. As usual, at constant rearing temperature, the developmental period for 4th instar larvae exceeded that for any of the preceding 3 instars. However, in the pond, it is apparent that the rate of larval development increased as the season advanced and ambient temperatures rose.

The effects of temperature on growth rates of insects have been reviewed by Clements (1963). Williams and MacKay (1970) have prepared tables of "degree-days" or "heat units" based on the triangle method of Lindsey and Newman (1956). By this method the degree-days are calculated from the daily maximum and minimum temperature relative to a base temperature. These tables were used in our computations. The base temperature chosen was 40° F because it approximated the mean temperature of the pond during the period when 1st instar larval growth occurred. Thus, from the field data, the maximum and minimum temperatures of air, of water at a depth of ½ in. and at pond bottom were converted to degree-days above 40° F. These were then compared with degree-days in the laboratory (Table 1).

The heat units (degree-days) measured at ½ in. depth in the pond during each larval instar, and for the total of 4 instars, compare almost identically to the heat units required for similar larval development in the laboratory (Table 1). The heat units per instar based on air temperature in the early season diverged greatly from those in the laboratory but coincided more closely as the season progressed to warmer weather. Similarly the heat units per instar at the pond bottom agreed less well than those at the ½ in. depth. It is to be expected that air heat units would reflect developmental rate of larvae less accurately than water heat units because the larvae live in water which undergoes narrower daily temperature fluctuations. It is noteworthy that the water heat units at ½ in. depth and larval development are so nearly identical to those recorded in the laboratory.

It is suggested that heat units of degree-days above 40° F measured at ½ in. in the pond can be used to advantage in the

TABLE 1. Developmental rate in terms of 50 percent ecdysis of larvae of *A. implicatus* in the field and in the laboratory.

	Developmental stage *				
	L_1	L_2	L_3	L_4	Pupae
Duration					
Field—date	Mar. 26–Apr. 17	Apr. 18–May 2	May 3–10	May 11–18	...
days	25	15	8	8	...
Laboratory—days	2	1.5	1.4	3	2.1
Degree days above 40° F					
Field					
Air	42.4	14.2	46.5	102.3	...
Pond bottom	76.6	52.5	61.1	127.0	...
½ in. water	80.5	60.7	54.8	121.2	...
Laboratory	80.0	60.0	56.0	120.0	84.0
Mean temp. ° F					
Field					
Air	34	35	45	53	...
Pond bottom	40	40	48	56	...
½ in. water	39	38	46	56	...

* $L_{1, 2, 3, 4}$ equal first, second, third, fourth instar larvae respectively.

practical aspects of mosquito control. Under natural conditions in spring *A. implicatus* larvae required 80.5, 60.7, 54.8 and 121.2 degree-days to complete development of 1st, 2nd, 3rd and 4th instars, respectively. Other snow-melt species would likely have similar requirements; this could be determined by laboratory rearing and related to actual field conditions. Thus, by recording accumulated degree-days in natural ponds the period of occurrence of the larval instars that are most susceptible to control could be determined and the larvicide applied at the most efficacious time.

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