JUVENILE DEVELOPMENT OF SNOW-MELT *AEDES*[1]

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ABSTRACT. Juvenile development of 14 species of snow-melt *Aedes* was studied using a standard rearing procedures. At least 85% of the juveniles could be consistently reared to the adult. Definitive developmental differences were found among several species.

From February through May larval snow-melt *Aedes* are found developing in almost any accumulation of ground water resulting from melting snow and early spring rains (Twinn, 1931). Gjullin et al. (1961) noted in delineating seasonal succession of Alaskan mosquitoes that juvenile developmental durations may be critical to the survival of a population. They observed that adult *Ae. communis* (DeGeer) frequently emerged only hours prior to evaporation of their pools. With the increasing use of pathogens and developmental inhibitors as larvicides, specific knowledge is essential when population modeling (Wagner et al. 1975) is used in conjunction with these control measures. The following study presents comparative juvenile development of 16 populations of 14 species of snow-melt *Aedes* when reared under uniform conditions.

METHODS AND MATERIALS

Fifteen populations representing 14 species were derived from eggs laid by field-captured females collected, transported, and maintained following procedures of Kardatzke (1976). The 16th population, a completely multivoltine population of *Ae. canadensis* (Theobald), was maintained in the laboratory by induced copulation (Novak and Liem 1975). All embryos of this population, designated *Ae. canadensis* A, were hatchable, 30 days after deposition, without prior exposure to cold. In contrast, only 19% of the embryos of the feral Michigan population of *Ae. canadensis* were hatchable 30 days after deposition without prior exposure to cold. *Ae. canadensis* A represents the offspring of this 19%. Eggs of *Ae. communis* were divided into 2 populations based on egg length as proposed by Kalpage and Brust (1968). All eggs having mean lengths of 830 microns or less were designated *Ae. communis* A and all eggs having mean lengths of 850 microns or more were designated *Ae. communis* B.

Postembryonic stages of all species were reared using standard procedures. For all but *Ae. diantaeus* Howard, Dyar, & Knab, the rearing medium was held at 21°C for postembryonic development. For *Ae. diantaeus*, the medium was held at 17°C during the larval stages in accordance with Brust (1971). The standard rearing

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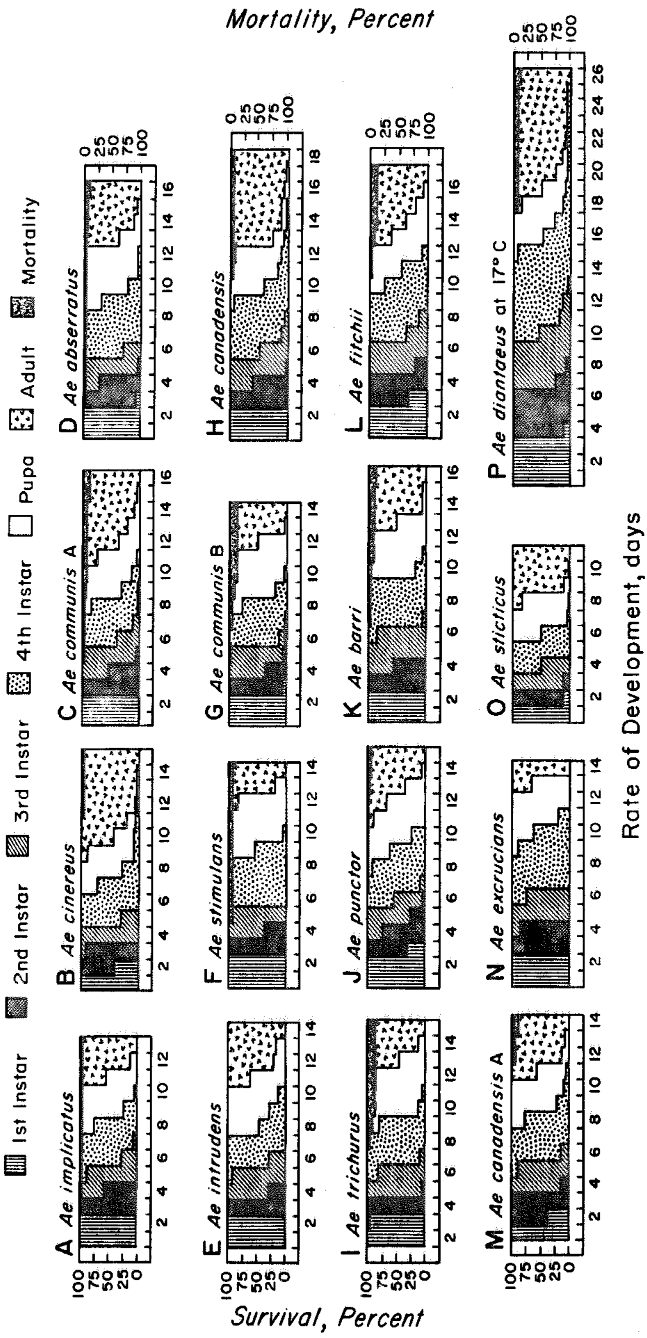
Mortality, Percent
1st Instar
2nd Instar
3rd Instar
4th Instar
Pupa
Adult
Mortality
A Ae implicatus
B Ae cinereus
C Ae communis A
D Ae abserratus
E Ae intrudens
F Ae stimulans
G Ae communis B
H Ae canadensis
I Ae trichurus
J Ae punctor
K Ae barri
L Ae fitchii
M Ae canadensis A
N Ae excrucians
O Ae sticticus
P Ae diantaeus at 17° C
Survival, Percent
Rate of Development, days

medium consisted of a mixture of deionized water and a sufficient water extract of dried oak leaves to color the water a tawny shade. Rearing was always performed in tightly covered plastic pans (265×165×100 mm). On Day 0, the depth of the medium in the pan was 5 mm. After medium had been added to the pan, loose sand was placed in several small plaques (diameter 1 cm) on the bottom of the pan, below the water surface. Food was provided as a water slurry of coarsely ground Tetramin® staple food. Food was added as needed in small amounts by pipetting it below the water surface onto the sand plaques. Larvae were preconditioned one day (Day 0) by concentrating them in a small 100-mesh screen basket located in the pan containing sand and food. Thirty larvae were placed in each basket. On Day 1, larvae were released into the rearing pan. The depth of the rearing medium was increased to 10 and 15 mm during the 2nd and 4th larval instars, respectively. Pupae were transferred to 4-oz jars and placed in Illinois emergence cages (Horsfall et al. 1973).

RESULTS

The duration of aquatic development of the species collected from Michigan varied from 8 to 14 days at 21°C (Table 1). *Ae. sticticus* (Meigen) had the shortest mean juvenile developmental duration of any species in the study. Mean duration of development at 21°C was 8 days (Table 1). Except for the last 2 molts, ecdysis was synchronous (Fig. 1-0). Survival to the adult was 100%.

Juveniles of 9 species, *Ae. implicatus* Vockeroth, *Ae. intrudens* Dyar, *Ae. communis*, *Ae. abserratus* (Felt and Young), *Ae. punctor* (Kirby), *Ae. trichurus* (Dyar), (*Ae. provocans* [Walker] according to Knight, 1978) *Ae. barri* Rueger (*Ae. euedes* Howard, Dyar, and Knab according to Knight, 1978), *Ae. excrucians* (Walker), and *Ae. stimulans* (Walker) had essentially identical juvenile developmental durations. The mean total juvenile duration varied from 10.6 days for *Ae. implicatus* to 12.7 days for *Ae. excrucians* (Table 1). Ecdysis for *Ae. stimulans* (Fig. 1-F), *Ae. barri* (Fig. 1-K), *Ae. excrucians* (Fig. 1-N) and *Ae. trichurus* (Fig. 1-I) was generally synchronous. Ecdysis for *Ae. communis* (Fig. 1-C,G), *Ae. implicatus* (Fig. 1-A), and *Ae. punctor* (Fig. 1-J) generally lacked synchrony. The lack of synchrony and the extension of instar duration was generally accompanied by the death of some larvae prior to emergence. Survival to the adult ranged from 82% for *Ae. barri* to 89% or greater for the other eight species (Table 1). There was no difference in juvenile

Figure 1. Effect of a standardized rearing procedure on the development and mortality of 16 populations of snow-melt mosquitoes.

Figure 1-A. *Aedes implicatus* at 21°C.
Figure 1-B. *Aedes cinereus* at 21°C.
Figure 1-C. *Aedes communis* group A at 21°C.
Figure 1-D. *Aedes abserratus* at 21°C.
Figure 1-E. *Aedes intrudens* at 21°C.
Figure 1-F. *Aedes stimulans* at 21°C.
Figure 1-G. *Aedes communis* group B at 21°C.
Figure 1-H. *Aedes canadensis* at 21°C.
Figure 1-I. *Aedes trichurus* at 21°C.
Figure 1-J. *Aedes punctor* at 21°C.
Figure 1-K. *Aedes barri* at 21°C.
Figure 1-L. *Aedes fitchii* at 21°C.
Figure 1-M. *Aedes canadensis* population A at 21°C.
Figure 1-N. *Aedes excrucians* at 21°C.
Figure 1-0. *Aedes sticticus* at 21°C.
Figure 1-P. *Aedes diantaeus*, larvae at 17°C, pupae and adults at 21°C.

Table 1. Percentage of survival and mean duration of aquatic stages of 16 populations of snow-melt mosquitoes when reared at 21° using a standardized rearing procedure.

Species of *Aedes*	No. larvae treated	Instar 1 larvae surviving %	Instar 1 mean duration days	Instar 2 larvae surviving %	Instar 2 mean duration days	Instar 3 larvae surviving %	Instar 3 mean duration days	Instar 4 larvae surviving %	Instar 4 mean duration days	Pupa pupae surviving %	Pupa mean duration days	Mean total juvenile duration Days ± S.E.
implicatus	60	100	2.0	100	1.6	100	1.6	100	2.8	100	2.6	10.6±0.16
intrudens	60	100	2.0	100	1.3	100	2.0	100	2.6	100	3.4	11.0±0.21
communis A	60	100	2.0	98	1.6	95	1.8	93	3.0	91	3.3	11.4±0.17
communis B	60	100	2.1	96	1.3	94	1.8	89	3.1	89	3.5	11.6±0.09
trichurus	60	100	2.0	97	1.0	97	1.6	90	3.3	90	3.6	11.6±0.14
punctor	60	100	2.3	98	1.5	98	1.6	98	3.5	93	3.3	12.0±0.16
abserratus	60	97	2.1	97	1.7	97	1.9	97	3.6	90	3.6	12.4±0.13
diantaeus[1]	60	100	3.2	96	3.2	96	3.6	92	6.3	88	3.1	18.9±0.26
sticticus	60	100	1.2	100	1.0	100	1.4	100	2.1	100	2.4	8.1±0.16
stimulans	60	100	2.0	95	1.4	95	2.3	95	3.6	89	3.5	12.1±0.14
canadensis	60	100	2.1	100	1.8	100	2.0	97	3.1	97	3.2	12.2±0.19
barri	60	100	2.0	100	1.5	96	2.3	89	3.4	82	3.5	12.5±0.11
excrucians	60	100	2.0	100	1.9	100	1.9	100	4.0	100	2.9	12.7±0.10
fitchii	60	100	2.3	100	1.9	100	2.3	90	3.8	86	3.3	13.4±0.30
cinereus	60	100	1.4	100	1.5	100	1.4	97	2.9	97	2.3	9.6±0.21
canadensis A	60	100	1.4	100	1.8	100	1.9	95	2.9	91	2.7	10.6±0.15

[1] Larval instars 1 through 4 held at 17°c, pupal stage held at 21°C.

development between the 2 populations of *Ae. communis* (Table 1, Fig. 1-C,G).

The juvenile developmental duration of *Ae. fitchii* (Felt and Young) was the longest of any species reared at 21°C. The mean total juvenile duration was 13.4 days, nearly a full day longer than *Ae. excrucians*, the next longest (Table 1). Survival to the adult stage was 86% (Table 1). Ecdysis was synchronous during early molts and became increasingly less synchronous with later molts (Fig. 1-L). Lack of synchrony in molting was generally accompanied by larval mortality.

The duration of juvenile development of *Ae. diantaeus* was the longest of all species, but this was due to the temperature regime. Instars 1 to 4 were reared at 17°C while the pupae were maintained at 21° C. Using the combination of 17°C and 21°C., juvenile development required a mean of 18.9 days (Table 1). Ecdysis became less synchronous as development progressed beyond instar 1 (Fig. 1-P). Mortality did not generally accompany prolongation of instar duration.

Juvenile development of *Ae. cinereus* (Meigen), the only totally multivoltine species, was relatively brief. The mean total juvenile duration was 9.6 days with survival to the adult being 97% (Table 1). Ecdysis was generally synchronous except for those few individuals which died prior to emergence (Fig. 1-B).

The two populations of *Ae. canadensis* differed in the duration of juvenile development. The mean total juvenile duration of *Ae. canadensis* A was 10.6 days and for the Michigan population of *Ae. canadensis* it was 12.2 days (Table 1). Survival to the adult was essentially identical for both populations. Adult emergence commenced the same day (Day 10) with both populations (Fig. 1-H,M). Adult emergence of *Ae. canadensis* A was essentially completed by Day 12, a time when only 50% of Michigan population of *Ae. canadensis* had emerged.

DISCUSSION

The duration of juvenile development is a factor in the seasonal succession of snow-melt *Aedes*. Univoltine species which require the least time to complete juvenile development are obviously also the first to be reported as adults in the spring (Gjullin et al. 1961). The effect on adult emergence is additionally enhanced by the hatching response of embryos of these species (Kardatzke, 1979). This hatching response can explain why species such as *Ae. cinereus* and *Ae. sticticus*, which have relatively short juvenile developmental durations, appear late in the spring and why species with essentially identical juvenile developmental durations emerge at different times.

The duration of juvenile development may be a factor in the distribution of a snow-melt species. *Ae. communis*, which is reported as far north as 70° N Latitude (Horsfall 1955), required only 11 days at 21° C to complete juvenile development. *Ae. stimulans*, which is reported only as far north as 60° N Latitude (Horsfall 1955), needed more than 12 days at 21° C to complete juvenile development.

Multivoltine species are characterized by a short juvenile development time. Evidence of this adaptation by multivoltine species was demonstrated by the 2 populations of *Ae. canadensis*. The Michigan population which had both multivoltine and univoltine components required almost 2 days more to complete juvenile development at 21° C than the completely multivoltine population, *Ae. canadensis* A. Both populations commenced emergence on the same day (Fig. 1) reflecting the multivoltine portion of the field population. However, the Michigan population required 13 days for greater than 50% emergence while *Ae. canadensis* A required 11 days.

The division of *Ae. communis* eggs into 2 populations, based on egg length, appears to have no relation to the juvenile developmental duration. The juvenile durations of populations A and B were essentially identical, requiring 11.4 days and 11.6 days, respectively, to complete development at 21° C.

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