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DEVELOPMENTAL RATE AND LONGEVITY OF *ILLINOIA PEPPERI* (HOMOPTERA: APHIDIDAE) ON EXCISED BLUEBERRY LEAF DISKS[1]

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ABSTRACT

The aphid *Illinoia pepperi* is the vector of blueberry shoestring virus, a serious disease of cultivated high bush blueberry. We present a laboratory study of the developmental rate of *I. pepperi* on excised blueberry leaf discs at different temperatures from 5 to 29°C. Growth rates were lowest at the upper temperature treatments (26 and 29°) and at 10°C. Growth rate and duration in degree-days for each life stage are presented as well as an overall regression equation for development. The lower developmental threshold was calculated at 3.4°C. The results are being used in a phenological management system and an epidemiological model for predicting spread of blueberry shoestring virus.

The aphid *Illinoia pepperi* (MacGillivray) is the vector of blueberry shoestring virus, a serious disease of cultivated highbush blueberry, *Vaccinium corymbosum* L. Since the description of *I. pepperi* as *Masonaphis (Ericobium) pepperi* (MacGillivray 1958), little information has been available until the vector relationship was discovered in 1978 (Ramsdell 1980). Since that time, field biology (Elsner and Whalon 1980), impact of insecticides (Whalon and Elsner 1982), and potential host plant resistance in *Vaccinium* sp. (Hancock et al. 1982) have been reported.

This paper presents a laboratory study of the developmental rate of *I. pepperi* at different temperatures. The data are being incorporated into a phenological prediction system and epidemiological model for managing of the aphid vectored virus disease in Michigan.

METHODS AND MATERIALS

Colonies of *Illinoia pepperi* were maintained at 20–24°C on two-year-old potted blueberry plants *(Vaccinium corymbosum* cv. 'Jersey') in a greenhouse with a 16L:8D photoperiod. All of the colonies were descendants of a single, field-collected, apterous, viviparous female taken from a commercial planting of 'Jersey' blueberry in western Michigan on 3 July 1980. This line had gone through several parthenogenetic generations in the greenhouse prior to the beginning of the laboratory study.

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Experiments were carried out in environmental chambers under 16L:8D photophase and ± 0.25°C temperature variation. The food source for experimental aphids was 14-mm (dia.) circular leaf disks cut from vigorously growing 'Jersey' blueberry plants maintained in a greenhouse. Leaf disks were floated on a nutrient medium (Coon 1959) in 15 by 60 mm plastic petri dishes. The dishes were kept covered to maintain a constant humidity inside and to prevent aphids from escaping. The leaf disks were changed regularly to avoid problems of tissue senescence.

Test aphids were the progeny of mature apterous, viviparous females maintained on potted blueberry plants in a growth chamber held at 23°C with a 16L:8D photoperiod. Young were removed daily and moved to individual leaf disks with a small brush. These first instar aphids were randomly assigned to one of six treatment temperatures (5, 10, 17, 23, 26, and 29°C) and placed in the appropriate environmental chamber. All aphids were observed daily; dates of instar changes and production of young were recorded. The progeny of test aphids were removed to avoid possible influences of crowding on the further production of young.

RESULTS

Table 1 presents the mean number of days per developmental stage as determined for the six temperatures. In general, nymphal instars III and IV lasted longer than earlier instars at a given temperature. At 10, 17, and 26°C, instars III and IV lasted significantly longer than the early instars ($P \leq 0.05$). At 5 and 23°C, only instar IV was significantly longer than instars I or II. Instar IV lasted significantly longer than Instar III at 10, 17, and 23°C ($P \leq 0.05$). Only in the 10°C treatment did the lengths of the early instars differ significantly. For all nymphal instars, stadium times were significantly shorter at temperatures from 17 to 29°C than at 5 or 10°C ($P \leq 0.05$).

Mortality was greatest at the highest two temperatures; no aphids reached adulthood at 29°C. The few aphids maturing at 26°C failed to reproduce. Survival was over 90% in the 10, 17, and 23°C treatments, with over 80% giving birth to young. At 5°C, survival to the adult stage was 60%; over 21% gave birth to young by the end of the study, at which time several aphids were still alive and might have eventually reproduced.

For treatments in which aphids completed development and reproduced, the developmental rates in instars/day were calculated and treatment temperatures used to obtain the following regression equation using the least squares method (Gill 1978):

$$INSTARS/DAY = 0.025\ (TEMP°C) - 0.085.$$

The regression line crossed the X axis, the lower developmental threshold temperature, at 3.4°C. With this base value, the data were converted to degree-day units, as shown in Table 2. At any temperature the mean number of degree-days per instar increased with successive instars, except for instars I and II at 5°C. In general, aphids raised at a greater temperature required more degree-days per nymphal instar, with the notable exception of treatment 2 at 10°C. Aphids at 5°C required a significantly lower number of degree-days per instar than at 10, 17, and 23°C, although some differences were demonstrated. For the instars that were completed by aphids at 26 and 29°C the degree-days per stage were significantly greater than for all other temperatures.

Table 3 gives information on aphid maturation, generation time, and longevity. Relatively large differences in the number of degree-days needed to reach maturity were observed. As noted earlier, the results for the 10°C treatment required the greatest number of degree-days to complete development and produce young. The longevity of *Illinoia pepperi* as found in this study is most likely not a true representation of the potential life span of this aphid. Many aphids walked off their leaf disks and drowned; this was more frequently the case at the higher treatment temperatures. With the possibility of drowning eliminated, mean aphid life spans may have been longer.

Table 1. Mean days per developmental stage of *Illinoia pepperi* on excised blueberry leaf disks at six treatment temperatures (16L:8D photoperiod).

Temperature	Instar I			Instar II			Instar III			Instar IV			Instar V			Pre-Reproductive Period		
	N[a]	X̄	SD	N	X̄	SD	N	X̄	SD	N	X̄	SD	N	X̄	SD	NP[b]	X̄	SD
5°C	25	16.4	6.5	19	15.4	4.9	21	16.1	3.0	20	18.8	5.1	5	19.8	12.3	8	32.6	6.7
10	28	6.0	1.7	28	6.9	1.2	29	7.8	1.3	28	9.2	1.8	17	20.6	6.3	26	11.6	1.2
17	35	2.5	1.0	33	2.4	0.7	31	2.8	0.7	31	3.9	0.8	29	17.8	7.2	26	3.3	1.1
23	37	1.9	0.9	36	2.1	0.5	36	2.2	0.8	36	2.9	0.8	29	14.6	6.8	36	2.5	1.0
26	43	2.1	0.7	35	2.5	0.7	26	3.9	1.2		c			c			c	
29	80	1.9	0.9	36	2.3	0.9		c			c			c			c	

[a]N = number of aphids completing the stage.
[b]NP = number of aphids producing young.
[c]Insufficient replication.

DISCUSSION AND CONCLUSIONS

Illinoia pepperi survived well at temperatures ranging from 5 to 23°C. The lower developmental threshold temperature determined for this species is 3.4°C. This compares well with the temperature of 3.3°C for a related species, *Illinoia maxima* (Mason), found by Gilbert and Gutierrez (1973).

Growth rates of *I. pepperi* were lowest at the upper temperature treatments (26 and 29°C), and, unexpectedly, at 10°C. At the upper temperatures, reduced food quality (through breakdown of the leaf disks), dessication, and enzyme denaturation may cause a reduction in aphid metabolism and slow development. The results at 10°C cannot be explained by such arguments. It is unlikely that the reduced rate of development at this temperature was due only to a direct temperature effect on *I. pepperi*, since aphids raised at 5°C and 17°C had higher developmental rates. It is more likely that there were temperature effects on the leaf disks. Blueberry tissue may undergo specific changes in physical or chemical properties in the range of 10°C which do not occur to the same extent at the other temperatures used in this study. Senescence or "hardening off" of the leaf tissue may have been triggered at 10°C, inhibited at 5°C, and not induced at higher temperatures. Reddening is a characteristic of senescing blueberry leaves; leaf disks occasionally were observed to develop a reddish discoloration at the lower temperatures. This study would have to be repeated using an artificial food source for the aphids in order

Table 2. Mean degree-days calculated from a base of 3.4°C for developmental stages of *Illinoia pepperi* at six temperatures (16L:8D photoperiod).

Temperature	Instar I	Instar II	Instar III	Instar IV	Instar V	Pre-Reproduction Period
5°C	26.2 A[a]	24.6 A	25.8 A	30.1 A	31.7 A	52.2 A
10	39.6 B	45.9 B	51.2 B	60.8 B	135.5 B	76.4 B
17	34.0 B	32.7 C	37.7 C	50.4 C	248.7 C	44.7 A
23	36.6 B	40.3 B	43.0 C	56.6 B	286.6 C	49.8 A
26	47.3 C	55.2 D	86.9 D	[b]	[b]	[b]
29	48.3 C	59.0 D	[b]	[b]	[b]	[b]

[a]Means in a column followed by the same letter are not significantly different according to the Waller-Duncan Bayesian K Ratio procedure, K Ratio = 100.
[b]Insufficient replications.

Table 3. The mean[a] ages and degree-days (base 3.4°C) for the molt to the adult stage, generation time, and longevity of *Illinoia pepperi* apterous, viviparous females on excised blueberry leaf disks.

	Molt to adult		Generation time		Longevity	
Temp.	Days	DD	Days	DD	Days	DD
5°C	65.1	104.1 A	93.1 A	148.9 A	87.0 A	139.2 A
10	29.8	196.5 B	40.9 B	270.1 B	48.9 B	323.0 B
17	11.1	151.2 C	14.5 C	196.7 C	29.8 C	398.2 C
23	8.2	161.2 D	11.3 D	222.1 D	23.8 D	467.1 C

[a]Means in the same column followed by the same letter are not significantly different according to the Waller-Duncan Bayesian K Ratio procedure, with a K Ratio = 100.

to avoid the influence of temperature on leaf disk quality if the true developmental rate of *I. pepperi* in the range of 10°C is to be determined.

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