NOTE

REARING *MONOCHAMUS* SPECIES LARVAE ON ARTIFICIAL DIET (COLEOPTERA: CERAMBYCIDAE)

Key Words: Rearing, *Monochamus,* Cerambycidae.

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Some wood-boring insects can be reared continuously on artificial diet. Wollerman et al. (1969. Ann. Entomol. Soc. Am. 62: 647-49) reared the locust borer, *Mygacyllene robiniae* (Forster), for seven generations by modifying a diet media originally developed for the pink bollworm (Adkisson et al. 1960. J. Econ. Entomol. 5: 759-62). Gardiner (1970. Can. Entomol. 102: 113-17) reared over 50 species (17 from the egg stage) of Cerambycidae, Harley, and Willson (1968. Can. J. Zool. 46: 1265-66) reared *Plagohammus spinipennis* (Thomson), and Payne et al. (1975. Ann. Entomol. Soc. Am. 68: 680-82) reared *Prionus imbricornis* (L.) on similar diets. Ten species of wood-boring insects were reared on an artificial diet devised originally for *Scolytus multistriatus* (Marsham) (Galford. 1969. U. S. Dept. Agric., For. Serv. Res. Note NE-102, 6 p.). We reared first-instar larvae of *Monochamus titillator* (Fab.) and *M. carolinensis* (Olivier) on three selected diets at four temperatures of 23, 26, 29, and 32°C to determine the optimal temperature and the most suitable diet for *Monochamus* spp. based upon survival and development time. These objectives should establish the temperature and diet to rear field collected larvae primarily for identification.

The three diets (modifications of Adkisson et al. 1960. J. Econ. Entomol. 5: 759-62) were selected because of excellent results obtained with other cerambycids. Diet I was originally devised by Galford (1967. J. Econ. Entomol. 60: 1192), diet II from Harley and Willson (1968. Can. J. Zool. 46: 1265-66), and diet III was reported by Wollerman et al. (1969. Ann. Entomol. Soc. Am. 62: 647-49).

The ingredients of each diet are shown in Table 1. The agar, sugars, and water were mixed in a beaker and the solution brought to a boil. Sorbic acid and methyl paraben for diets I and III (to control fungal and bacterial growth) were dissolved in 15 ml of warm 95% ethanol denatured and added to the solution which was kept boiling until the alcohol boiled off. The solution was poured into a Waring blender and allowed to blend for several minutes. The remaining ingredients, except the alphacel, were poured into the blender and whipped for two minutes at high speed. The alphacel was then slowly added until the mixture became too viscous for the blender. The remaining alphacel was blended by hand. The resulting diet was placed in plastic petri-dishes with a spatula, pressed smooth, and set aside to cool at room temperature for 12 hours.

Monochamus eggs of both species were allowed to hatch in infested pine logs and the first-instar larvae were removed by carefully peeling the bark. Twenty first-instar larvae per diet and temperature class were reared individually (one larvae per dish) to prevent cannibalism. The rearing containers were kept in controlled temperature cabinets at 23, 26, 29, and 32°C. Thus, each of the three diets was tested at four temperatures. The larvae were transferred to fresh diet at intervals of not less than one month. The experiment was repeated twice.

Table 1. Ingredients of three artificial diets used to rear *Monochamus titillator* and *M. carolinensis*.

Ingredients	Amount (g)		
	Diet I	Diet II	Diet III
Agar	40	29.8	33.3
Alphacel (hydrolyzed)	400	62.9	133.3
Sucrose	20	14.3	46.7
Fructose	10	0	0
Glucose	10	0	0
Vitamin diet fortification mixture	15	23.8	13.3
Soybean protein	20	0	0
Brewer's yeast	50	0	0
Wesson's salt mixture	25	4.3	13.3
Cholesterol	1	0.6	0
Kretschmer wheat germ	25	0	40
Vegetable lecithin	1	0	0
Vitamin Bt (L-Carnitine)	1	0	0
Sorbic acid	2.5	0	2.7
Methyl paraben	1.25	0	2.7
Wheat germ oil	5 ml	0	0
Soluble starch	0	14.3	0
Casein	0	28.5	46.7
Linoleic acid	0	0.6	0
Antimicrobial mixture*	0	17.9	0
10% potassium hydroxide	0	11.9 ml	0
Pine phloem powdered	0	0	133.3
Ascorbic acid	0	0	5.3
Chlorine chloride	0	0.6	0
Butyl paraben	0	0	2.7
Water	1000 ml	1000 ml	1000 ml

* Sorbic acid, 20.0 g; methyl p-hydroxybenozate, 15.0 g; ethyl alcohol (95%), 170.0 ml.

To evaluate the effect of diets and temperature on *Monochamus* survival and development time, the General Linear Model (GLM) procedure (Statistical Analysis System Institute. 1982. SAS User Guide, SAS Institute, Cary, NC 921 p.) was used to perform an analysis of variance and a multiple regression analysis. Since the diets showed no significant differences, only temperature was used in the multiple regression. The model considered only the larvae that survived to adults. Mean temperature treatment differences were compared by Tukey's multiple-comparison test. Data for *M. titillator* and *M. carolinensis* were combined for this experiment, because they cannot be differentiated in the larval stage.

A total of 264 insects were reared, 156 *M. carolinensis* adults and 109 *M. titillator* adults. Survival increased as the temperature was increased to 29°C, and decreased sharply at 32°C (Table 2). Diet and the diet-temperature interaction were not statistically significant (only temperature affected survival). Based on Tukey's multiple-comparison test, all temperature level means, except 23 and

Table 2. Percent survival and mean development time (days) of *Monochamus* species on artificial diets at four constant temperatures.

	Temperature (°C)								
	23		26		29		32		
Diet	Survival ± SE	Development time ± SE	Survival ± SE	Development time ± SE	Survival ± SE	Development time ± SE	Survival ± SE	Development time ± SE	Mean
D I	50 ± 1.4	93.3 ± 5.8	52.5 ± 3.5	86.2 ± 4.8	75.0 ± 4.0	82.5 ± 7.3	37.5 ± 2.1	75.9 ± 4.6	84.5
D II	40 ± 1.4	94.7 ± 6.6	67.5 ± 0.7	86.4 ± 6.0	80.0 ± 2.5	80.5 ± 5.9	30.0 ± 1.4	75.6 ± 6.9	84.3
D III	45 ± 1.1	94.9 ± 7.2	65.0 ± 2.2	88.4 ± 5.7	87.5 ± 1.4	82.7 ± 6.9	32.5 ± 2.1	74.4 ± 6.1	85.1
Mean	45 c*	94.3	61.6 b	87.0	80.8 a	81.9	33.3 c	75.3	

* Means for survival with the same letters are not significantly different according to Tukey's multiple-comparison test at the 0.05 level.

32°C, were significantly different. Based upon the multiple regression analysis, larval survival was a cubic function of temperature ($P < 0.05$).

Temperature had an effect on the development time of both larvae and pupae, development time being shorter at higher temperatures (Table 2). Based on Tukey's multiple-comparison test, all temperature level means were significantly different for larvae and pupae. The larvae and pupae developed faster at 32°C, but their survival was less than when reared at 23 to 29°C. Diet and the diet-temperature interaction was not statistically significant. The multiple regression analysis showed that the developmental times of both life stages and the combined stages were linear functions of temperature ($P < 0.05$). We concluded that these *Monochamus* species can be optimally reared at 29°C on any of the three diets. — A. B. Alya and F. P. Hain, Dept. of Entomology, N. C. State Univ., Raleigh, NC 27695-7626. Paper no. 9525 of the Journal Series of The North Carolina Agricultural Research Service, Raleigh, NC. (Accepted for publication October 27, 1986)