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Selection for a Nondiapausing Strain of Artificially Reared Red Oak Borers

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Abstract

The incidence of nondiapause in artificially reared red oak borers increased from 4 to 61 percent in five generations. Fecundity dropped by more than 50 percent, but fertility was unaffected. Sixty percent of the nondiapausing larvae formed prepupa by the 12th week of development in the F_1 and in the F_4 generations.

The red oak borer (ROB), *Enaphalodes rufulus* (Haldeman), is a primary borer in living oak, *Quercus* sp. Losses in degraded lumber caused by ROB amount to millions of dollars annually (Donley 1974). Its life history was reported by Hay (1969).

The ROB is a good candidate for control by the release of sterile insects for several reasons: (1) small numbers of borers (1 to 2 dozen per acre) cause accumulative damage over the 80 to 120 years it takes to grow oak to sawtimber size; (2) emergence is synchronized within 4 to 6 weeks in odd-numbered years in the Northeast and Midwest; (3) peak emergence of males occurs about 2 weeks ahead of peak emergence of females, making possible the release of both sterile females and males; (4) the reproductive potential of ROB is low (70 to 100 eggs per female), and epidemic populations are rare; (5) the female emerges full of eggs and flight is restricted until she "lightens" her load; thus, migrations in a given generation are short and would allow block-by-block treatment of an area; (6) only a few adults emerge in even-numbered years. If the odd-year population could be suppressed sufficiently over a very large area, economic losses could be greatly reduced.

Large numbers of artificially reared insects would be required for a sterile-insect release program. Although we have reared ROB artificially for 9 years, it takes 7 to 9 months to rear a complete generation (Galford 1974). About 4 to 5 months of the rearing cycle is involved in the diapause cycle, which is broken by cold treatment. Seventy to eighty percent of the time and labor involved in rearing could be eliminated if a short-cycle nondiapausing strain of beetles could be selected.

While testing the effects of various nutrients on fertility and fecundity of the beetles, we noticed that a few larvae on one particular diet did not diapause and developed into adults in 8 to 14 weeks. We conducted a study to select for a short-cycle, nondiapausing strain of ROB that would allow us to rear large numbers of beetles.

Materials and Methods

The diet was prepared by heating agar and H_2O to boiling and pouring the contents into a gallon-size blender. Sorbic acid, methylparaben, and chloramphenicol dissolved in 5 ml of absolute ethanol were added and blended for 30 seconds. Olive oil was added and blended for 15 to 20 seconds and casein, raw wheat germ, vitamin supplement, torula yeast, and stigmasterol were added and blended for 1 minute. About half of the 300 grams of Celufil[1,2] was added and blended for 15 to 20 seconds; the remaining Celufil was added and blended in thoroughly by hand; with a spatula, the putty-like diet was placed in three plastic food boxes (13.5 cm square by 3.5 cm deep) and stored at 2° to 3°C until used. The following is a listing of the diet formula:

Ingredient	Grams
Celufil	300
Agar	32
Raw wheat germ	120
Torula yeast	20
Vanderzant vitamin supplement-insect	4
Casein	8
Stigmasterol	0.4
Sorbic acid	2
Methylparaben	2
Chloramphenicol	0.6
H_2O (ml)	1000
Olive oil (ml)	20

[1]The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

[2]All dietary ingredients purchased from United States Biochemical Corp., Cleveland, Ohio 44122.

In rearing neonate larvae, a piece of diet about 30 mm square was cut and placed between two folded sterilized paper towels and squeezed in a laboratory press to remove excess water. A 12.5-mm-diameter cork borer was used to cut plugs from the pressed diet. The plugs were placed in 16 evenly spaced 12.5-mm holes drilled through an aluminum plate (6 mm thick by 100 mm square) that had been placed on a 100-mm-square glass plate. The diet plugs were pressed firmly into the holes and a dissecting needle was used to make a hole about 2 mm in diameter in the center of each plug. Neonate larvae were transferred to the holes with a small artist brush. Another 100-mm-square glass plate was placed on top of the aluminum plate. Binder clips were used to hold the assembly together while the edges of the plates were double sealed with 25-mm-wide masking tape.

When 2 weeks old, larvae in plates were transferred to fresh diet placed in 1-ounce plastic cups. The larvae were transferred to fresh diet biweekly until they formed prepupae or went into diapause (cessation of feeding for 2 to 3 weeks without the formation of prepupae). Diapausing larvae were stored in a refrigerator at 5° ± 2°C for 2 to 6 months. Prepupae were placed in 2- by 15-cm glass test tubes partially lined with moistened filter paper. The tubes were stoppered with corks with ventilation slots cut about 1 to 2 mm wide along their length. Pupation and adult emergence dates were recorded on each tube.

When adults were 7 to 8 days old they were paired for mating in 41 glass jars. Freshly cut sticks of oak (about 30 to 40 mm wide and 150 mm long), wrapped with 12.5-mm-wide cotton tape and held down with thumbtacks, were provided for oviposition. After 7 days the oak sticks were removed, the tape removed, and the sticks placed in 41 glass jars until egg hatch was complete. Neonate larvae were collected daily and placed in artificial diet within 24 hours.

All rearing was conducted at 27° ± 2°C. Data on survival, fertility and fecundity, and percentage of nondiapause were kept for four generations for the offspring of nondiapausing beetles. Data on diapausing offspring of the parental nondiapausing beetles were kept for one generation.

Results

Although the percentage of nondiapausers increased from 4 percent in the 1st generation to 61 percent by the 5th generation, the fecundity of the nondiapausing strain declined by more than 50 percent (Tables 1 and 2). Nutrition is involved in nondiapause and probably is a quantative deficiency. However, there may be a "sparing" effect in which a chemically related nutrient is partially replacing a required nutrient and a gradual depletion is occurring.

Fertility of the beetles did not change significantly for five generations (Table 2). If inadequate nutrition is responsible for nondiapause and associated reduced fecundity, it is not linked to fertility.

In the F_1 generation, 60 percent of the nondiapausing larvae had formed prepupae by the 12th week of development. The remaining 40 percent formed prepupae between 14 and 22 weeks. These figures were the same for the F_4 generation. The range of number of weeks to prepupa in both the F_1 and F_4 generations was 6 to 22 weeks. In the F_1 generation the mean time to prepupa was 12 weeks compared with 10 weeks in the F_4 generation.

The factor or factors responsible for nondiapause in ROB have not been determined. However, the information presented here shows that an insect with a long life cycle can be reared in a relatively short time when diapause is eliminated. While diapause in other species of artificially reared insects has been eliminated by genetic selection or by controlling temperature, here it was being eliminated by dietary effects.

Table 1.—Rearing data for the selected nondiapausing strain

Generation	Number of neonate larvae started	Percent survival to diapause	Diapaused		Nondiapaused	
			Number	Percent	Number	Percent
Parental	401	83	317	79	18	4
F_1	564	71	227	40	175	31
F_2	916	81	312	34	432	47
F_3	435	87	180	41	202	46
F_4	155	76	24	15	95	61
Diapausing offspring of parental generation	216	84	172	80	8	4

Table 2.—Fecundity and fertility of selected nondiapausing strain

Nondiapausing females	Number of beetles	Number of eggs laid	Eggs hatched		Average number of eggs/female
			Number	Percent	
Parental	4	389	335	86	97
F_1	25	1652	1409	85	66
F_2	25	1393	1154	83	56
F_3	25	1109	974	88	44
F_4	22	874	689	79	40
Diapausing females of parental strain	25	1650	1395	85	66

Literature Cited

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