THE OVIPOSITIONAL RESPONSE OF THE CIGARETTE BEETLE TO TEMPERATURE AND TO SELECTED ODORS

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The cigarette beetle, *Lasioderma serricorne* (F.), is a cosmopolitan insect species with an exceptionally wide host range (1, 2). It is also the principal pest of stored tobacco. In our laboratory most of the research is directed towards finding suitable methods of control for this insect. Part of the ongoing research is the study of behavior as affected by physical factors. One phase of this, the ovipositional response of the beetle as affected by temperature was studied earlier by Fletcher and Long (3). However, their experimental design permitted only the exposure of test insects to preselected temperatures. Part of this report is concerned with ovipositional response in a free-choice chamber to temperatures, most of which might be found in natural situations.

Another area of our research is the ovipositional response of cigarette beetles to attractants with emphasis at this time being placed on food odors. In an earlier study (4) we found that females responded about equally to ethanol extracts of whole wheat flour and of flue-cured tobacco impregnated in filter paper pads. However, little or no survival occurred when these eggs were placed on finely ground tobacco. After many unsuccessful attempts to transfer the wheat flour reared cultures to tobacco, the results suggested that our laboratory strain might be physiologically different from wild colonies reared on tobacco. Indeed, it raised questions about the validity of accepting all data acquired from laboratory reared wheat flour strains in laboratory and field tests as being analogous with results that would be obtained if wild tobacco reared colonies had been used.

A successful technique for collecting large numbers of eggs (5) led to the establishment of a large colony of cigarette beetles that is readily reared on finely ground flue-cured tobacco. This has permitted us to search for differences in the behavior of strains of beetles reared on whole wheat flour-brewers yeast medium and on flue-cured tobacco to food odors. With other insects it has been shown that the substrate upon which they are reared has an effect on their ovipositional feeding and response (6, 7, 8, 9, 10). The purpose of this portion of the study was to see if such a difference in response might occur in cigarette beetles that were reared on different medium.

METHODS AND MATERIALS: An experimental arena for observing the effects of temperature on cigarette beetle ovipositional response was formed by placing a plexiglass cover (61 x 61 x 38 cm ID) over a sheet metal plate (76 x 76 x 0.3 cm) Figure 1.

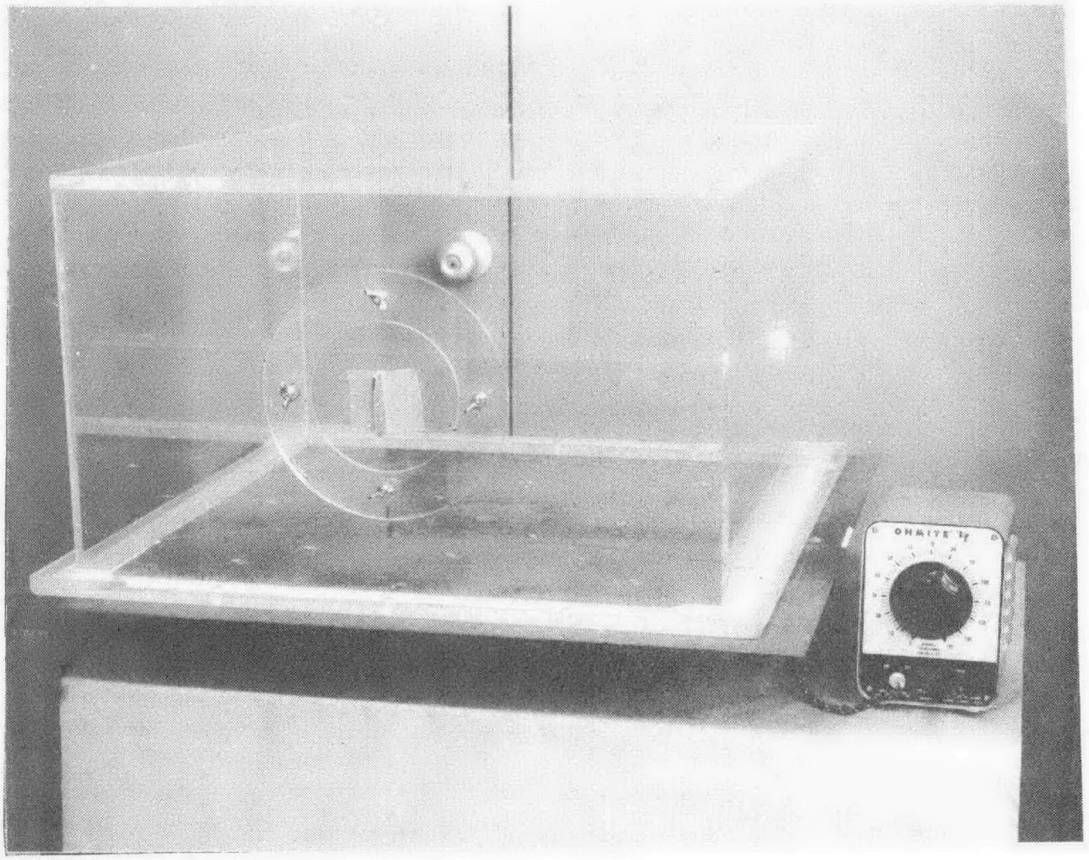

FIGURE 1. Temperature gradient chamber

The plate resting on a center over a 15 cm^2 hot plate was fitted with 20 equally spaced copper-constantan thermocouples arranged in a radial manner and attached to the underside by machine bolts. In addition one thermocouple was placed in air space approximately 20 cm above the arena floor. Temperature within the arena was regulated with a rheostat so that a gradient of 10°- 40.6° C was maintained. Temperature ranges selected for study were 10-15°, 15.6-21.1°, 21.7-26.1°, 26.7-31.7°, and 32.2-40.6°C. Temperatures were recorded at intervals on a multipoint recorder. The test arena was mounted on a work table in a 13 m^3 conditioned room which maintained temperature and relative humidity of 10±2°C and 80±10% respectively. Relative humidity within the test arena was not monitored. Prior to the release of about 600 unsexed insects

(300 males, 300 females assuming a 1:1 sex ratio) within the arena the floor was covered with a thin layer of finely sifted wheat flour. After five days the insects were removed from the test. Isotherms were outlined on the flour covered floor and the medium from each area was removed and placed in separate containers. These were held in our insectory (26.7 ±1°C, 70±5% rh) until emergence was completed. Thus, the ovipositional response or the number of eggs laid was determined by the numbers of adults emerging from each temperature range. In one replicate the true number of eggs laid at the 32.2° - 40.6° C temperature range was calculated by adding the number of emerged adults to the number of unhatched eggs.

The arena used for the ovipositional response to food odors was similar in design and size to the one used for ovipositional response to temperatures (Figure 2). However, the floor

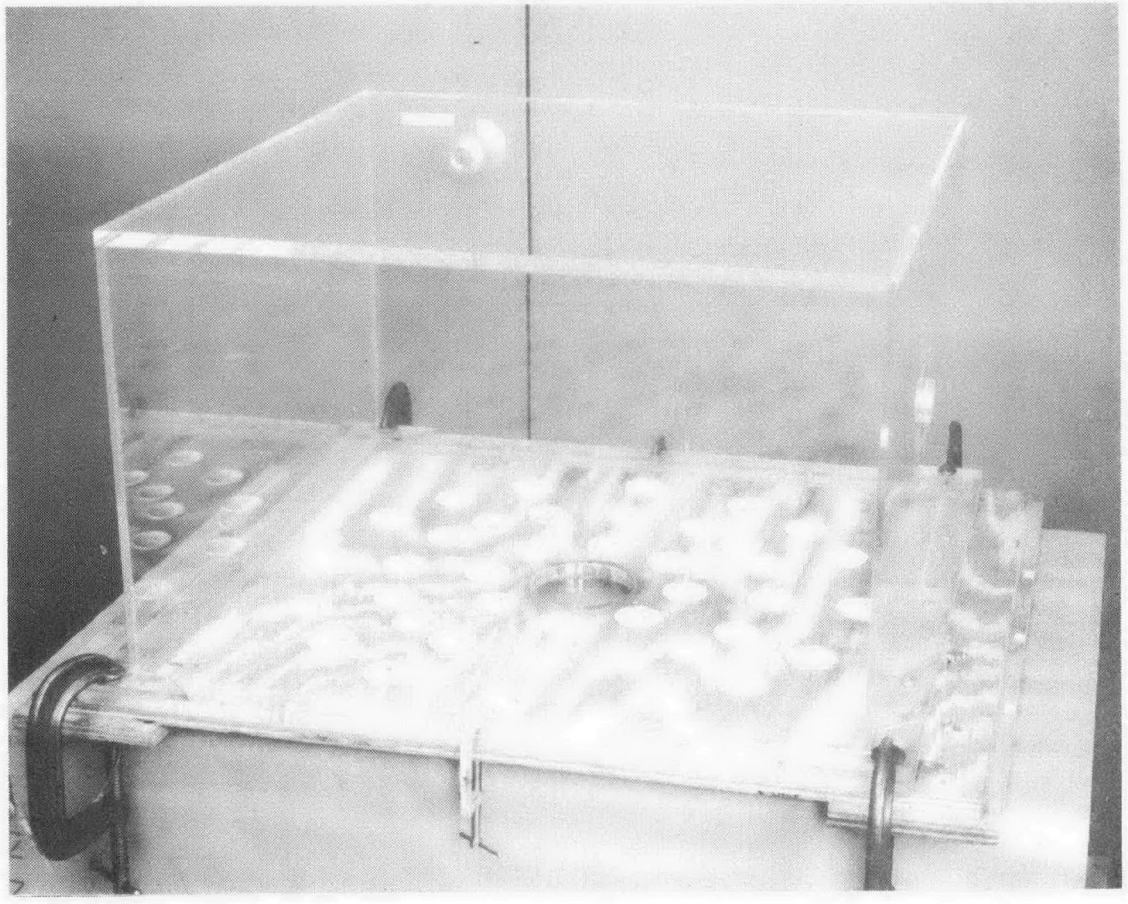

FIGURE 2. Test arena for ovipositional response

was made of 12.7 mm plywood. It contained 40-3.8 cm holes that were arranged radially around a 10 cm center hole. Paper cups 2.5 cm high and 4 cm in diameter were inserted in the smaller holes and the center hole was fitted with the bottom of a 100 mm petri dish. Each cup contained a muslin strip (60 x 1.5 cm), folded into a pad. The pads impregnated with ethanol extracts of food materials served as ovipositional sites and were arranged in a random fashion. Each test (8 odors, 5 replicates) was initiated untreated by releasing 800 unsexed adults (400 males, 400 females assuming a 1:1 sex ratio) into the petri dish. At this time 6-C clamps were used to secure the arena top to the bottom. The tests were made in a room maintained at 26.7±1°C and 70±5% relative humidity. The light regime was 12:12 hours of light and darkness. After 5 days the adults were recovered, the pads were removed, and the numbers of eggs were counted. Two strains of the cigarette beetle were used in this test. One strain reared in our laboratory on whole wheat flour-brewers yeast medium (ca. 14 years) was the source of the second strain that has been reared on tobacco for ca. 4 years.

RESULTS AND DISCUSSION: The effects of temperature on oviposition are shown in Table 1. Based upon adult emergence and upon an egg

TABLE 1. Numbers of cigarette beetle eggs oviposited on a gradient heat bar covered with a thin layer of finely ground wheat flour as determined by adult emergence. a/

Replicate	Number of adults				
	Temperature range (C°)				
	10-15	15.6-20.6	21.1-26.1	26.7-31.7	32.1-40.6
1	25	210	348	239	1
2	43	332	400	189	0
3	52	135	250	85	0
4	b/	159	146	17	13
5	-	87	105	79	0
6	-	63	150	14	0
7	-	91	173	55	3
8	10	7	87	74	15
Av.	32.5	135.5	207.4	101.5	c/4

a/ Ca. 300 females/replicate.

b/ Temperature rise due to malfunction of 1 conditioning unit.

c/ 211 nonviable eggs sifted from sample.

count fewer eggs were laid at the lower temperatures. The average emergence for temperature ranges of 10-15°, 15.6-20.6°, 21.7-26.7°, 27.2-32.2°, and 32.2-40.6° was 32.5, 135.5, 207.7, 101.5 and 4 respectively. However in last replicate at the highest temperature range 211 unhatched eggs were recorded. So it is quite evident that the data recorded for this range does not reflect what actually happened. In all tests many dead adults were observed in this temperature zone. Their death along with the poor egg hatch observed was probably due to desiccation. The preferred temperature range of 21.7-26.7°C for oviposition partially overlapped the range preferred reported for fourth instar larvae of the cigarette beetle 25.6-27.8°C (11). The finding that oviposition occurred over the entire temperature test range lends some support to the work of Fletcher and Long (3) who reported both oviposition and egg hatch at temperatures below 20°C. However, the numbers of adults emerging from the lower temperature ranges was surprising because in this test females had a freedom of choice in selecting temperatures for oviposition.
This information may be useful when planning fumigation of tobacco warehouses located in colder climates.

The ovipositional response of a cigarette beetle strain reared on whole wheat flour-5% brewers yeast to selected odors is shown in Table II. The preference as indicated by the percent of

Table II. Ovipositional response by a cigarette beetle strain, reared on wheat flour-brewers yeast medium, on muslin strips impregnated with ethanol extracts of M (untreated muslin, WF (wheat flour), Y (yeast), CSM (corn-meal-soybean meal-milk), CMB (comb. tobacco-CSM-Y Y-citrus pulp), UM (used medium), CP (citrus pulp) and T (tobacco) a/ b/

Extract	Percent eggs oviposited Replicate					
	1	2	3	4	5	Average
M (control)	3.5	6.5	8.6	2.1	4.0	4.9
WF	11.4	12.4	9.8	7.1	10.1	10.2
Y	18.8	21.3	31.2	34.2	37.7	28.7
CSM	23.4	26.0	23.3	22.8	13.6	27.8
CMB	9.1	8.9	3.7	8.6	6.0	7.3
UM	1.3	1.2	0.9	1.4	1.0	1.2
CP	26.4	20.2	19.2	16.6	22.9	21.1
T	5.0	3.4	3.2	7.2	4.7	4.7

a/ Ca. 400 females/replicate. b/ Total eggs laid 15,696.

eggs oviposited was as follows: Yeast (Y) 28.7, cornmeal-soybean meal-milk (CSM) 27.8, citrus pulp (CP) 21.1, wheat flour (WF), 10.2, combination of tobacco (T)-CSM-CP and WF (CMB) 7.3. These were followed by tobacco (T) 4.7, and untreated muslin (M), the controls 4.4. The least attractive compound was an extract of used medium (UM) 1.2. The total number of eggs laid by the wheat flour strain was 15,696.

The strain of beetles reared on finely ground flue-cured tobacco preferred the tobacco extract (Table 3) for oviposition. Of the total number of eggs laid (22,281) 26.8% were found on toaacco. Others preferred were extracts of CMB (which contained tobacco) 23.4%, CSM 16.4%, CP 15.5%, Y 11.7%, WF 3.5%, UM 1.9%, and M or controls 0.9%. A comparison of the ovipositional response by both strains is shown in Figure 3.

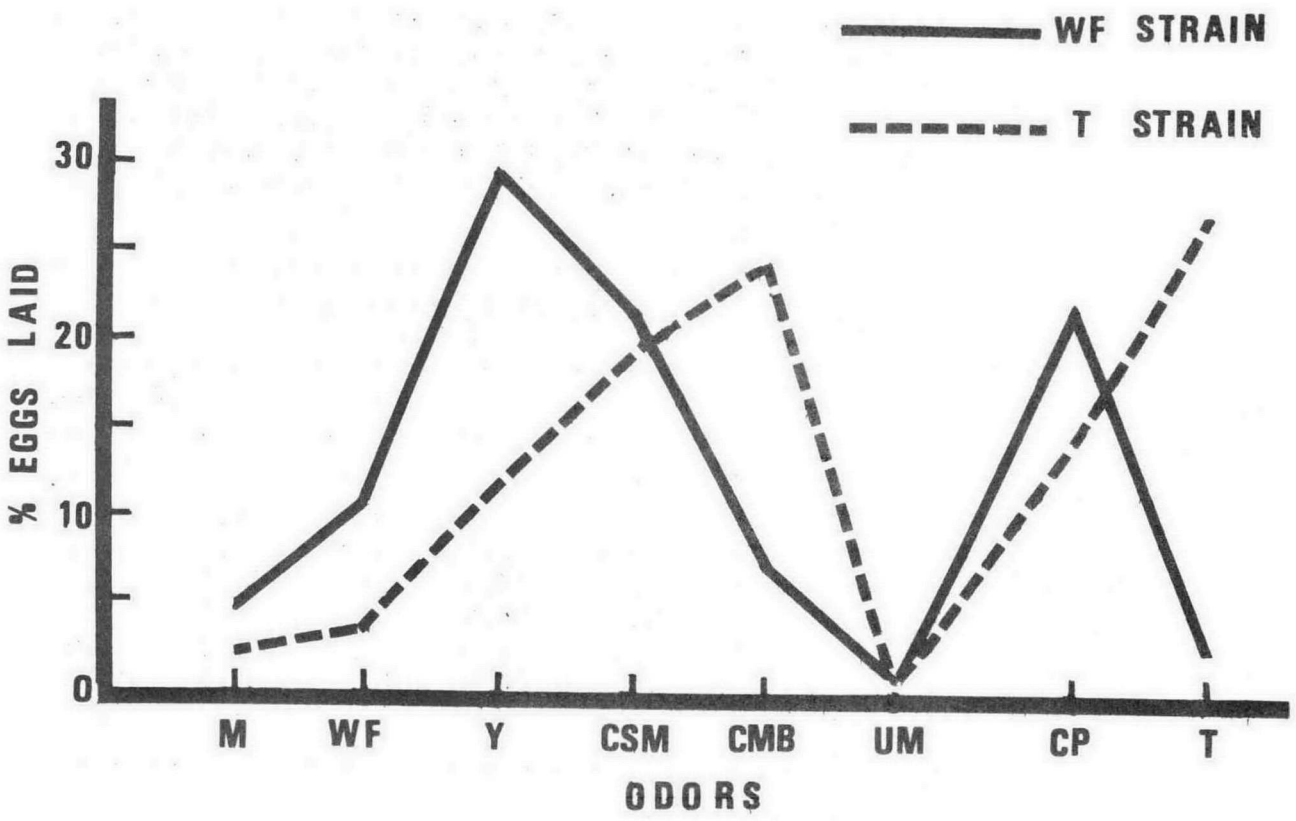

Figure 3. Comparison of ovipositional response of two strains of cigarette beetles to selected food odors

The response of both strains to food odors other than tobacco showed similarities. With the extracts of tobacco and the mixture containing tobacco there is a significant difference in the response. The tobacco strain laid 50% of their eggs on the ovipositional sites containing these 2 extracts while only 12% of the wheat flour strain eggs were laid on sites having the same odors. Other differences in behavior may exist as it has been shown by Yamamoto and Frankel that tobacco reared insects are smaller (12). Any further information in this area of research would be most useful in establishing the quality of laboratory reared insects so that they would compare favorably with wild-standard populations.

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Table III. Ovipositional response by a cigarette beetle strain reared on finely ground flue-cured tobacco on muslin strips impregnated with ethanol extracts of : M (untreated muslin) WF (wheat flour), Y (yeast, CSM (cornmeal-soybean meal-milk), CMB (comb. tobacco-CSM-Y-ci citrus pulp), UM (used medium), CP (citrus pulp), and T (tobacco) a/ b/

Extract	Percent eggs oviposited Replicate					
	1	2	2	4	5	Average
M (control)	1.2	1.2	0.47	1.0	0.51	0.9
WF	5.3	4.0	2.7	4.2	1.1	3.5
Y	12.4	12.4	12.6	11.9	9.3	11.7
CSM	18.3	19.7	14.6	15.0	14.6	16.4
CMB	21.9	25.6	25.8	22.5	21.0	23.4
UM	1.4	2.0	1.9	3.0	1.1	1.9
CP	14.2	13.1	14.5	15.0	20.6	15.5
T	25.3	22.0	27.4	27.5	31.8	26.8

a/ Ca. 400 females/replicate.

b/ Total eggs laid 22,281.

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