EFFECTS OF TEMPERATURE ON THE DEVELOPMENTAL STAGES OF *PSYCHODA ALTERNATA* (DIPTERA—PSYCHODIDAE) [1]

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Although the "trickling filter fly," *Psychoda alternata* Say, has been the subject of many papers, only a few have been concerned with the relationships of temperature to development. Headlee (1919) reported that the larval period on the average was 12 days and the pupal period was 20–48 hours at a temperature of 70° F. In New Jersey it was found that during the summer months a period of two weeks was needed for the completion of one generation under natural conditions in a sprinkling sewage filter (Headlee, 1919). Turner (1923) found that at 15–18° C. the time necessary to complete the cycle in the laboratory was 16 to 21 days; at 22–25° C. it was 12 to 15 days and at 27–30° C. only 7 to 12 days. Quate (1955) found the life cycle to be 21–27 days when the species was raised under room conditions. Lloyd (1940) determined the duration of the life cycle at various temperatures in the laboratory ranging from 10 to 33° C. The shortest duration of 13 days occurred at 30° C. and each temperature had a fluctuation of 2–3° C. He also determined the life cycle to take 16–20 days for completion under warm summer conditions in the field. (Lloyd, 1935).

Psychoda alternata has been found to live in a variety of sources such as hay infusion (Haseman, 1907), decaying vegetables, cow and horse dung (Turner, 1925), seaweed piles (Saunders, 1928) and in other sources of nutrients. These insects create a source of annoyance to persons living in the vicinity of prolific breeding sites.

The primary purpose of this study was to obtain information upon the minimal, maximal and average durations of the larval and pupal stages when reared at various constant temperatures. Additional information was also acquired on crowding effects and on the influence of temperature on color.

METHOD AND MATERIALS. For these studies a stock colony of *P. alternata* was maintained in a plastic rearing unit constructed from two ½-gallon units measuring 6½″ in diameter and 3⅞″ in depth (Figure 1). The lower unit was divided into two sections by a piece of 100 mesh brass screen attached by means of a hot soldering iron. Fine desert sand was placed on one side and distilled water on the other. The second unit was inverted over the lower one and held in place by stapling the polyethylene covers of the two units together around their periphery and then cutting out the entire central portion of both, leaving a 5½″ opening.

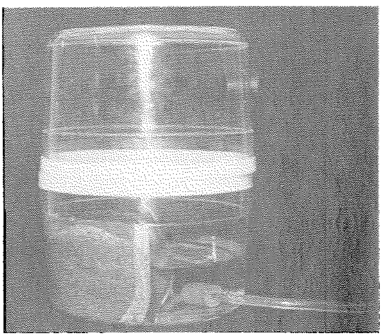

FIG. 1.—Rearing unit for *Psychoda alternata*.

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With these two attached rings the units were securely fastened together and could still easily and conveniently be snapped apart to allow cleaning of the units. Also in the upper section a hole about one inch in diameter was cut and stoppered with a cork. Through this opening food and water were added and adult flies were removed. The unit was aerated via an air stone attached to an air line entering the side of the unit. This was done to keep the water from fouling as previous workers found it necessary to change water in rearing units (Lloyd, 1940). In this manner our colonies have been successfully maintained for well over 1 year with only the addition of food and water and have required no water change or cleaning.

For food source it was found that Dog Kisses, a commercial dog food, were as suitable for the rearing of *P. alternata* as they were for chironomids (Biever 1965). Approximately 1.0 g. was placed weekly on the sand and water was periodically added to maintain it at a level of ¼ to 1 inch below the surface level of the sand in the other part of the unit. A colony of this size provided a continuous supply of several hundred adults daily, thus an ample supply of eggs could always be obtained for experiments.

Eggs used in these studies were obtained from females which were removed from the colony and placed in covered plastic petri dishes in which they oviposited on moist filter paper. After egg hatch the newly hatched first instar larvae were used to set up the tests.

Preliminary studies were conducted to establish a suitable small rearing unit for use in the temperature studies. It was found that 100 mm x 20 mm disposable plastic petri dishes were quite suitable (Figure 2). The same results were obtained whether the dishes had closed covers or when they had covers with a screened portion. The completely covered type was chosen for the studies as it had the advantage of reducing water loss. Eight to 10 layers of filter paper of sufficient size to cover about 2/3 of the total

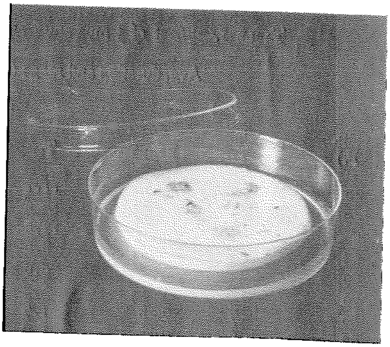

Fig. 2.—Rearing unit for temperature studies on *Psychoda alternata.*

bottom surface were placed in the units. Distilled water was added as needed to maintain the water at a level just below the upper layer of the filter paper.

Each rearing unit was stocked with 25 larvae and placed in a constant temperature cabinet with a photoperiod of 12 hours. The ten constant temperatures tested were: 40, 45, 50, 55, 60, 70, 80, 85, 90 and 95° F. maintained within ± 1° F. At each temperature four units of 25 larvae were used for each experiment and experiments were replicated 2 or 3 times. For each unit daily emergence and mortality records were obtained.

Results and Discussion. Table 1 shows the results of the temperature studies presenting the average time required for the first half of the larvae and pupae to complete development at the various constant temperatures. Ranges for duration of development as well as mortality data and emergence information on the adults are also presented. From this table it can be seen that the optimum temperature for survival of the larval stage is near 80° F. and that for the pupae, both 70° F. and 80° F. are optimum, thus the overall optimum temperature for survival is about 80° F.

Figure 3 shows the temperature-development curves for both stages with temperature plotted against development velocity given as 1/time in days. From this figure it is evident that the optimum temperature for high rate of development for both

TABLE 1.—Effect of temperature on the development of *Psychoda alternata*.

Temp. (° F.)	Avg. duration and range (days) Larvae T_{50}	Larvae Range	Pupae T_{50}	Pupae Range	Mortality (%) Larvae	Mortality (%) Pupae	Emergence adult (%)
40	..	.....	....	.....	100	..	..
45	78	66–94	18.2	16–21	83	4	13
50	47	37–66	12.5	11–14	47	3	50
55	32	26–45	8.0	7.2–9.2	13	3	85
60	20	17–25	5.0	3.7–6.2	10	1	89
70	11	9–14	2.5	2.0–3.2	6	0	94
80	7	5–8	1.7	1.5–2.2	5	0	95
85	6	5–8	1.5	1.0–2.0	42	5	53
90	7	6–9	2.5	2.0–3.2	80	5	15
95	..	.....	....	.....	100	..	..

stages is 85° F., which is a temperature 5 degrees higher than that which is optimum for rate of survival as there is only a 53 percent adult emergence at 85° F. compared with 95 percent emergence at 80° F. (See table 1). In units kept at 40° F. there was no larval development and at 95° F. there was no pupation. However, about 50 percent of the larvae developed to maturity or to nearly mature larvae but instead of pupating they crawled into the water at the periphery of the units and died. It was also observed that mating and oviposition of fertile eggs occurred at 55° F. through 90° F.

It was noted that this species has a wide range of coloration in both the pupal and the adult stage even though the stock source was initially started from one female, thus yielding an inbred colony. Generally, as the rearing temperature was lowered the intensity of the color increased. In the pupal stage the color varied from light tan to black whereas in the adult stage the range was from brown to black with various shades in between.

Data were also obtained on the effects of crowding in the rearing units. When units were stocked with an over-supply of eggs or larvae there occurred not only an increase in mortality of the larvae but also a tremendous decrease in the size of most of the adults. This agrees with earlier work (Gohighty, 1940). Many of the adults were only ¼ to ⅓ the size of those produced under uncrowded con-

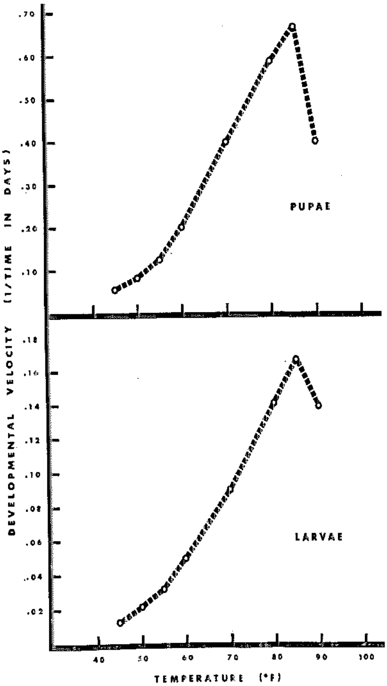

FIG. 3.—Development of *Psychoda alternata* at constant temperatures. Plotted points are based on average time required for the 50 percent of the stage to transform ($1/T_{50}$). To transform into days, divide 1 by the value of developmental velocity.

ditions. Although the crowding had a pronounced effect on the size, the time required for the first individuals to develop remained constant. The total time span through which emergence occurred and the average time for the first half of the population to emerge was slightly increased. At 80° F., emergence occurred over a period of 12 days under crowded conditions whereas in uncrowded conditions only 4 days were required (Figure 4). This figure also illustrates the normal pattern of emergence of this species, with the males emerging 1–2 days before the females and female emergence lasting 1–2 days longer. This figure also typifies the nearly 1:1 sex ratio which occurs under both sets of conditions.

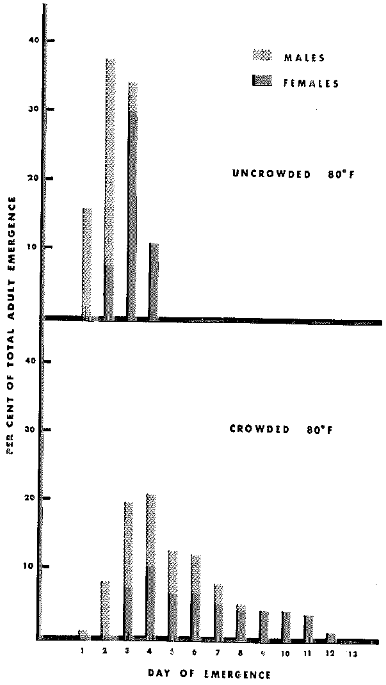

FIG. 4.—Emergence patterns under crowded and uncrowded conditions. Day 1 signifies the first day of the emergence period.

SUMMARY. This study shows that the temperature range at which development of *Psychoda alternata* occurs is from about a minimum of 45° F. to a maximum of 90° F. Temperature-development curves for the larval and pupal stages have been established. The optimum temperature for survival is near 80° F. whereas the optimum temperature for development is 85° F. The length of the emergence period of the adults is greatly increased when rearing takes place under crowded conditions and the size of the individuals produced is markedly decreased. Temperature has an influence on the color of the individuals with darker adults occurring at the lower temperatures.

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