# BIOLOGY

## IV. RESPONSES OF BRUCHUS TO MODIFIED ENVIRONMENTS

J. K. Breitenbecher
From the Dept. of Zoology, University of Okla., Contribution No. 31, Second Series.

### Introduction.

The common occurence of the four-spotted cow-pea weevil (*Bruchus quadrimaculatus*), was early discovered in the tropical and sub-tropical countries, where the climatic conditions are especially favorable for its development. No comprehensive study from the standpoint of the environmental effects of temperature and humidity upon the insect have been attempted.

The original home of this insect is very much in doubt, for it was noted at widely different localities at about the same time. The earliest record of its presence in the United States seems to have been made by Oliver in 1795, who reported it from Carolina. But Fabricius first described the species in 1792 and records it from Santa Cruz, West Indies. Chittenden states that this insect is probably of foreign origin, having been carried to the United States with its favorite food plant. Very little attention was given it by entomologists until the early nineties.

### Life History.

This species has four stages in its life cycle; adult, egg, larva and pupa. The length of the egg stage depends very much upon the temperature and the hardness and dryness of the cow peas. Experiments have shown that it may vary from 3 to 21 days. On hatching the young larvae bore their way into the seed where they feed until becoming pupae. The larval stage may vary from 1 to 42 days, depending upon the environment, chiefly temperature. The transformation from larvae to pupae occurs within the larval burrow. At first the pupae are white but after a few days they change to a light tan color. The adult emerges by rotating its body, thus cutting a circular plate out of the seed coat.

It has been shown that at 100° F. the entire life cycle may be completed in 19 days and 90° F. gives a generation every 20 days, but 100° F. is the optimum for genetic researches.

## The Experimental Results.

The first experiment (Table 1) was to determine the effect of humidity upon the length of the life cycle. The results of this experiment shows that the number of offspring varies with the humidity, since the temperature was kept uniform. Seven pairs were bred together in each bottle of cow peas. One of these batches was left in the oven as a control with no moisture or calcium chloride; a second, was placed in a desiccator; while a third was put into a container saturated with water. Since moisture is required for metabolism, no offspring appeared in the desiccator; but one and a half times as many progeny were obtained with the high humidity as with the control. The length of the life cycle in days was the same (45 and 46); moisture, therefore affects the number of progeny produced.

The second experiment (Table 2) was to determine the effects of differences of temperature upon the length of the life cycle. The humidity was kept constant by saturating with water. For the first test thirty pairs of beetles were placed in a bottle outside of a window. No offspring were obtained because the water froze. Also five pairs were kept at a constant temperature of 38° C. they produced 372 offspring in 16 days, while five pairs kept at 40° C. produced 421 offspring within 20 days; the pairs kept at 44° C. gave 396 offspring within 23 days. This proves that the number of days required to produce offspring varies with temperature.

A third experiment (Table 3) was the same as the second but with no moisture in the breeding chambers. Thirty pairs were placed in the open and produced progeny at the end of 79 days, as did the five pairs at 26° C, at 38° C. and at 40° C.; while temperatures 44° C. gave no progeny. The higher temperatures caused fewer offspring because of a lowering of humidity; while in the second experiment offspring were found with every temperature at 44° C.

In the second test the bottles that were provided with water and placed out-of-doors produced no offspring. This is due to the water freezing, destroying both eggs and larvae. The test shows that in the bottles that were placed in the window without moisture adults emerged finally after 79 days, proving that cold weather retards this activity; and also shows that moisture is within the seeds or in the air in sufficient amounts for normal reproduction.

The effects of high temperature upon the larvae were also observed; it was found that the heat killed the larvae, when they were placed in an oven from 51° to 53° C. for 20 minutes. This shows that neither adults nor offspring can live and reproduce at a temperature of 51° C. Further the result indicates that a greater number of offspring was obtained when moisture was provided than when it was not.

The fourth test (Table 4) was to determine the effects of acids upon the development of *Bruchus.* The results of this experiment show that concentrated sulphuric acid produce no progeny, while an amount of acid in the water just sufficient to turn litmus, produced 325 offspring in the shortest time (14 days) ever observed. This is probably due to an optimum humidity because when ¾ $H_2O$ plus ¼ $H_2SO_4$ was used fewer offspring (219) were obtained at the end of 18 days, due probably to a lessened humidity. When ½ $H_4O$ plus ½ $H_2SO_2$ was used no offspring were found, or in any higher concentrations. With nitric ($HNO_3$) acid no offspring were found, except in very dilute solutions; then the life cycle was lengthened to 18 days. In other words sulphuric acid hastened the life cycle while nitric acid lengthened it. Nitric acid has a lethal affect, while sulphuric acid furnishes an optimum humidity. But hydrochloric (HCl) acid acted as the greatest retarder to metabolism in the development of this insect, requiring 36 days for progeny to appear, when dilute solutions were used. No offspring, however, appeared in any more concentrated solution of this acid.

The fifth test (Table 5) was to determine the affect of alkali upon the life cycle. Sodium hydroxide was the only one used and offspring appeared in concentrated as well as in dilute solutions. In dilute concentrations it required 36 days for offspring to appear and 42 days in concentrated alkali. Alkali retards the life cycle of *Bruchus*

The sixth test (Table 5) was to try the effect of alcohol upon the life cycle. The result was negative in all concentrations; that is, no offspring. The fumes of alcohol gave a lethal effect.

The seventh test (Table 6) was to determine the death points of the different mutants. The Red (R) died at 50.5° C., the Black ($R^b$) at 50° C., the Wild Stock at 49.5° C., the gray ($R^g$) died at 47° C., the tan (r r) at 48° C., and the white ($R^w$) died at 47° C. The result shows a rather close agreement for each allelomorph; however, the reds would produce offspring at a higher temperature than any other of the mutants.

The eighth test (Table 7) was to determine the effect of cow pea meal upon the life cycle. The result is negative but offspring were obtained with cracked beans however. It appears that the larvae must have something to bore into.

The last experiment (Table 8) was to determine the effect of soaked cow peas upon the number of progeny. If seeds were soaked for 5, 10 and 15 minute periods, progeny appeared at the end of 40 days, and if soaked for 30 minutes offspring appeared at the end of 41 days; but 1, 3, and 24 hour soakings gave no progeny. No doubt this result is due to the fact that the larvae can not live within seeds which through the soaking may have removed vitamines, or other essentials for life.

In carrying out the experiments above described the writer was greatly assisted by Miss C. M. Seitz, a former student of this department.

## TABLE 1

| Different Tests | Pairs Mated | Date Began | Date Em. | No. Da. | Offspring |
|---|---|---|---|---|---|
| With $H_2O$ | 7 | 10-5-20 | 11-19-20 | 45 | 121 |
| Dry air with $CaCl_2$ | 7 | 10-5-20 | 11-19-20 | -- | None |
| Control | 7 | 10-5-20 | 11-19-20 | 46 | 81 |

## TABLE 2

| Temp. Differences | Pairs Mated | Date Began | Date Ended | Recorded life cycle from egg to adult. | Summary |
|---|---|---|---|---|---|
| Open weather | 30 per bottle | 1-5-21 | | (Water) | No Offspring |
| 38° F. | 5 per bottle | 2-23-21 | 3-20-21 | 16 | 372 |
| 40° F. | 5 per bottle | 4-13-21 | 5-9-21 | 20 | 421 |
| 44° F. | 5 per bottle | 4-13-21 | 5-6-21 | 23 | 396 |

TABLE 3

| Tests | Pairs Mated | Date Began | Date Ended | No. Days | Results |
|---|---|---|---|---|---|
| In window | 5 per bottle | 12-7-20 | 2-24-21 | 79 | Few offspring |
| Oven 28° C. | 5 per bottle | 12-7-20 | ------ | -- | None |
| Room 28° C. | 5 per bottle | 12-7-20 | ------ | -- | None |
| 26° C. | 5 per bottle | 12-7-20 | 1-21-21 | 45 | Offspring |
| 38° C. | 5 per bottle | 2-22-21 | 3-16-21 | 18 | Offspring |
| 40° C. | 5 per bottle | 4-13-21 | 5-9-21 | 20 | Offspring |
| 40° C. | 5 per bottle | 4-13-21 | ------ | -- | None |

**TABLE 4**

| Test | Date Began | Date Em. | No. of Days | Summary |
|---|---|---|---|---|
| $H_2SO_4 \dagger H_2O$ | 1-4-21 | 1-18-21 | 14 | 325 |
| $H_2SO_4$ cons. | 1-4-21 | ------ | -- | None |
| ½ $H_2SO_4 \dagger$ ½ $H_2O$ | 1-4-21 | ------ | -- | None |
| ¼ $H_2SO_4 \dagger$ ¾ $H_2O$ | 1-4-21 | 1-22-21 | 18 | 219 |
| $HNO_3 \dagger H_2O$ | 1-4-21 | 1-22-21 | 18 | 198 |
| $HNO_3$ (cons.) | 1-4-21 | ------ | -- | None |
| $HCl \dagger H_2O$ | 1-4-21 | 2-9-21 | 36 | 172 |
| HCl (cons.) | 1-4-21 | ----- | -- | None |

**TABLE 5**

| Alkali | Date Began | Date Em. | No. Days | Results |
|---|---|---|---|---|
| NaOH† $H_2O$ | 1-4-21 | 2-9-21 | 36 | 196 |
| NaOH | 1-4-21 | 2-15-21 | 42 | 87 |
| Alcohol 75% | 4-4-21 | | | None |
| Alcohol 95% | 4-4-21 | | | None |
| Alcohol 50% | 4-4-21 | | | None |
| Alcohol 30% | 4-4-21 | | | None |

**TABLE 6**

| Mutants | Min. | Max. | Mean |
|---|---|---|---|
| Black | 47° C. | 50° C. | 48°2 C. |
| White | 45° C. | 47° C. | 46° C. |
| Grey | 46° C. | 47° C. | 46°5 C. |
| Red | 48° C. | 50°5 C. | 49°2. C. |
| Tan | 45° C. | 48° C. | 46°5 C. |
| Wild (Okla.) | 47° C. | 49°5 C. | 48°5 C. |

**TABLE 7**

| Proportion of bottom covered | Date of Test | Pairs Mated | Result |
|---|---|---|---|
| ¼ meal in bottle | 2-18-21 | 25 | No Offspring |
| ½ meal in bottle | 2-18-21 | 25 | No Offspring |
| 2-3 meal in bottle | 2-18-21 | 25 | No Offspring |
| Paper and meal | 2-18-21 | 25 | No Offspring |

**TABLE 8**

| Hours soaked | Date of test | Date of Emergence | No. of Days | Offspring |
|---|---|---|---|---|
| 5 min. | 4-4-21 | 5-14-21 | 40 | 401 |
| 10 min. | 4-4-21 | 5-14-21 | 40 | 392 |
| 15 min. | 4-4-21 | 5-14-21 | 40 | 422 |
| 30 min. | 4-4-21 | 5-14-21 | 41 | 197 |
| 1 hr. | 3-16-21 | | | None |
| 3 hrs. | 3-16-21 | | | None |
| 24 hrs. | 3-16-21 | | | None |