LIFE HISTORY AND RESPIRATION OF THE MILKWEED BUG ONCOPELTUS FASCIATUS (DALLAS)[1]

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The milkweed bug *Oncopeltus fasciatus* (Dallas) goes through five instars before the adult stage is reached. The incubation period for the eggs is about five days at 76° F. Newly deposited eggs are a light lemon-yellow gradually changing with age to reddish. The red eyes within become distinct as incubation progresses. A short time before hatching a back and forth movement of the eyes can be seen after which the shell membrane at the cephalic end ruptures and the nymph emerges. This movement is the first sign of hatching. The appendages unfold from the cephalic end posteriorly, however, one of the last portions of the nymph to become free of the egg is the proboscis which is long and extends posteriorly between the appendages on the ventral surface.

The abdomen of the nymph is elongate when first hatched but soon becomes more oval and the entire body darkens. The first and second instars are difficult to separate by appearance only. To be positive that the second instar is under observation one should see molting or find the cast skin.

The third instar is easily recognized by the appearance of swellings caused by the metathoracic wing-pads located on the posterior margin of the metathorax.

The fourth instar is recognized by the appearance of swellings caused by the mesothoracic wing-pads located on the posterior margin of the mesothorax.

The fifth instar is considerably larger than other instars. There are lateral spots on all of the abdominal segments and median dorsal spots on the fifth, sixth, seventh, eighth and ninth abdominal segments. These spots are more pronounced than in any other instar. The remainder of the abdomen varies in individuals from yellow to reddish-orange.

The recognition of adult males and females is easy. The female pygidium is triangular in outline and cleft, whereas, that of the male is rounded and shining. In addition, the margins of the abdominal sternites are all straight in the male, whereas in the female the posterior margin of the third abdominal sternite is drawn out backward into a low median point. The female is usually larger than the male.

Mating begins from 5–12 days after emergence, and oviposition 5–15 days after the first copulation. The amount of food available has much to do with the fecundity of the bugs. It was observed that they may survive for a considerable time on limited food but no eggs were produced. It was also observed that virgin females rarely lay eggs. If they did the eggs were infertile.

Longevity of life is variable, the males usually living slightly longer than the females.

LENGTH OF INSTARS

The length of a stadium varies primarily with temperature and food condition. The following table shows the rate of development from egg to adult stage with

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the temperature averaging about 76° F. Andre (1934) shows that the incubation period of the eggs varies only three days when temperatures of over 17 degrees difference are used, e.g., at 76.1° F. six days are required for incubation and at 93.2° F., three days. For the longevity of adult life at 76° F. the variation was about four and a half days and for the instars about ten days.

The data in Table I are based upon thirty eggs placed in separate containers and observations made to determine the time of hatching and the length of each stadium. No appreciable difference was observed in the rate of development between males and females. The experiments in this investigation are based on the following table, and no appreciable variation in development was found when the insects were used for testing.

TABLE I

SUMMARY OF LIFE HISTORY IN DAYS AT TEMPERATURE RANGE OF 74°–80°F.

	Egg	Instar					Total Days		
		1st	2nd	3rd	4th	5th	Nymphal Life + Egg	Adult Life	
								Male	Female
Average Days..........	5	4.32	3.70	3.52	5.47	8.78	30.75	30.4	23.95
Range in Days..........	......	4–6	3–5	3–5	4–7	8–10	22–34	27–34*	22–27

*A number of adult males used in testing lived for 35 and 36 days and one lived for 39 days.

METHODS AND MATERIAL

The milkweed bug is reared easily under laboratory conditions. The food used was milkweed seeds. Strips of cellucotton in which the females deposited their eggs were placed with the bugs. The eggs were removed daily so that their age was known. If the eggs were not used for testing they were placed in small containers with a piece of wet cellucotton to prevent desiccation. The nymphs after hatching were placed in plastic refrigerator dishes. By this means insects of known age were available. After a "run," the insects were placed again in the container and used for subsequent testing.

It was found that watermelon seeds could be used in place of milkweed seeds as a source of food supply. The bugs did not feed on the watermelon seeds unless the seed coat was removed or cracked. Seeds were run through a hammer mill with no screens so that they were cracked open but not crushed. The bugs apparently cannot feed on finely ground seeds but most probe the seed with their proboscides. The ground embryo and seed coats need no separation before being used.

The Warburg direct method, using a "Warburg" apparatus, was used for the study of oxygen consumption and carbon dioxide production. The procedure is like the methods described by Dixon (1943) and Umbreit (1949).

RESULTS

It was found that during the first two days of incubation of the eggs there is a low oxygen consumption as compared to the remaining days. This same observation has been made by Melvin (1928) while investigating other insect eggs. He also found that in this early part of incubation, temperature had very little effect on oxygen consumption, so that during early embryonic development there is a period when metabolic activity is low. Fink (1925) in his investigations found a low period of metabolism which he called the formative period.

If one compares the oxygen consumption with a study of embryology at this time one finds that about eight hours after the egg has been laid (milkweed bug) the cleavage nuclei can be seen migrating toward the periphery of the egg. By the fourteenth hour the nuclei are all in the thin cytoplasm at the surface (Johannsen and Butt 1941). Perhaps this migration would explain the low oxygen consumption; as the nuclei migrate there is less mitotic division and thus a small amount of oxygen utilized.

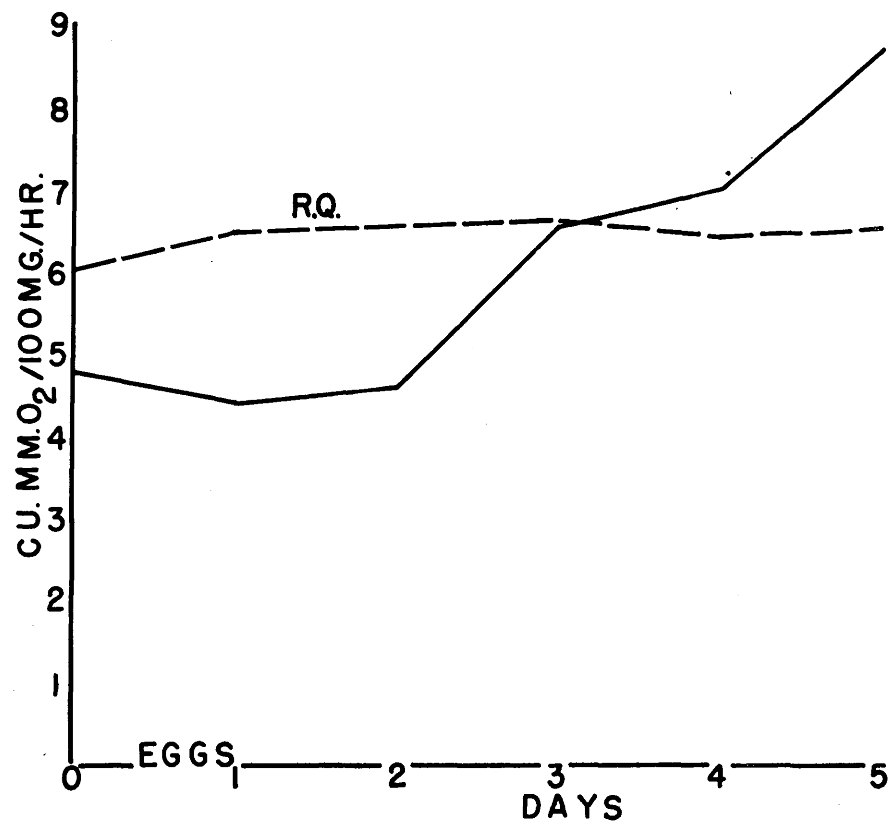

FIG. 1. Cell growth and reproduction may explain the increase in oxygen consumption as shown by this curve.

By the twentieth hour the blastoderm appears thinner on the dorsal side which is the first indication of the differentiation of the serosa from that part of the blastoderm which will form the germ band. This cell growth and reproduction might then explain the increase in oxygen consumption as shown in Fig. 1. With continued mitotic division and organogenesis the oxygen consumption continues to rise and at the time of hatching it has about doubled the amount utilized the day the eggs were laid. Since there is no histolysis taking place at hatching the oxygen consumption is due to the activity of the cells formed. Toward the end of the incubation period there is considerable muscular activity, which can be observed by placing the egg under a binocular and observing the red eye spots which turn intermittently back and forth. Soon after this is observed the egg hatches. One can probably explain the high rate of oxygen consumption by the movements of the individual plus the greater number of cells which now make up the individual.

The respiratory quotients obtained for the egg are rather low. However, these quotients are not as low as those of other works which have been reported. Fink (1925) found an initial respiratory quotient of 0.521 for *Anasa tristis*. The initial R. Q. observed for the eggs of the milkweed bug was 0.6019, and an R. Q. of 0.6629 the day the eggs hatched.

No completely satisfactory explanation has as yet been brought forward to explain the occurrence of a quotient lower than 0.7, although it is surmised that the substances oxidized are chiefly fats. Fink (1925, cited from Weinland and Bayliss) suggests that oxygen intake is in some way held back in the organism. It can be shown by the increase of weight that oxygen is actually retained. Another

TABLE II

F VALUES ASSOCIATED WITH THE ANALYSIS OF THE MEASUREMENTS OF OXYGEN CONSUMPTION OF THE INSTARS

Instar	2	3	4	5
1	1.72	0.66	1.17	20.12**
2	....	0.22	5.44*	33.37**
3	....	....	3.36	26.57**
4	....	....	....	10.04**

$F_{0.01} = 6.74$
$F_{0.05} = 3.88$
* Significant at 5% level.
** Significant at 1% level.

way in which this phenomenon might be explained is by the conversion of one type of food into another. When a fat is converted to a carbohydrate more atmospheric oxygen is utilized. The fat is relatively low in oxygen while the carbohydrate is high and thus a large amount of oxygen is utilized without production of carbon dioxide. The reverse is also true, when a fat is formed from a carbohydrate, the excess oxygen of the carbohydrate may be utilized instead of atmospheric oxygen. This would cause a high R. Q.

$$R.\ Q. = \frac{\text{Volume of } CO_2 \text{ given off}}{\text{Volume of } O_2 \text{ consumed}}.$$

Theoretical equations for this process have been worked out. An example (Richardson 1929 quotes Lusk) for the conversion of glucose into a fatty acid, follows:

$$4C_6H_{12}O_6 + O_2 = C_{16}H_{32}O_2 + 8CO_2 + 8H_2O$$

This assumes the conversion of the whole bulk of the glucose into fatty acid, without wastage, other than carbon dioxide and water. The respiratory quotient of the reaction is 8.0, hence it would require only a little conversion to produce a marked effect on the quotient. If the reverse process, the conversion of fat into carbohydrate occurs, it would be expected to have the opposite effect, namely, a fall in the quotient.

The oxygen consumption reaches the maximum in the first instar and declines with each successive molt (Fig. 2). In a statistical analysis it was found the oxygen consumption of the instars is significantly different from each other at a 1% level. An analysis was then made to compare the means by pairs (the mean value of one instar is the same as another). The results are shown in Table II.

From these data we note that the fifth instar differs significantly in oxygen consumption from all others, the fourth and second differ significantly, the first, second, and third seem to be in the same class.

TABLE III

F VALUES ASSOCIATED WITH THE ANALYSIS OF THE MEASUREMENTS OF OXYGEN CONSUMPTION (COMPARISONS MADE DAY BY DAY ON EGGS AND INSTARS)

Source of Variation	Sum of Squares	Deg. of Freedom	Mean Square	F	Significance
			Eggs		
Days	225.330	5	45.066	18.30**	1 $F_{0.001}$ = 3.22
Error	224.118	91	2.462		
		1st Instar			
Days	363.433	4	90.858	11.49**	1 $F_{0.001}$ = 3.72
Error	395.484	50	7.909		
		2nd Instar			
Days	153.641	4	38.410	5.16**	1 $F_{0.01}$ = 3.77
Error	335.078	45	7.446		
		3rd Instar			
Days	99.779	4	24.944	6.79**	1 $F_{0.01}$ = 3.80
Error	154.235	42	3.672		
		4th Instar			
Days	121.329	5	24.265	9.15**	1 $F_{0.01}$ = 3.79
Error	114.079	43	2.653		
		5th Instar			
Days	165.452	8	20.681	7.34**	1 $F_{0.01}$ = 2.77
Error	194.449	69	2.818		

* Significant at 5% level.
** Significant at 1% level.

In another analysis of data it was found within a particular group (egg or instar) the oxygen consumption differed significantly from one day to another. The following results are in Table III.

In an analysis of the measurements on the zero age group (and the same for other age groups) in Table IV, it was found that the means in the one and three day age group do not differ significantly from each other. Comparing these results with the table above we can infer that there is less variability within the one day and three day age group than there is among the other age groups of the same instar.

TABLE IV

F VALUES ASSOCIATED WITH THE ANALYSIS OF THE MEASUREMENTS OF OXYGEN CONSUMPTION (COMPARISONS MADE ON THE DIFFERENT AGE GROUPS OF INSTARS)

Source of Variation	Sum of Squares	Deg. of Freedom	Mean Square	F	Significance
		0 Day			
Instar	287.137	4	71.784	10.78**	1 $F_{0.01}$ = 3.72
Error	333.013	50	6.660		
		1st Day			
Instar	65.549	4	16.887	2.20	5 $F_{0.01}$ = 2.61
Error	307.027	40	7.675		
		2nd Day			
Instar	180.183	4	45.045	10.98**	1 $F_{0.01}$ = 3.81
Error	168.145	41	4.101		
		3rd Day			
Instar	37.545	4	9.386	2.17	5 $F_{0.01}$ = 2.60
Error	185.678	43	4.318		
		4th Day			
Instar	220.532	4	55.133	16.18**	1 $F_{0.01}$ = 3.86
Error	129.443	38	3.406		

* Significant at 5% level.
** Significant at 1% level.

In the comparison of the male and female adults for oxygen consumption, results showed that virgin females consumed more oxygen than males. The following are the results of the statistical analysis of the measurements showing this difference:

Mean of Male	Mean of Female	$X_F - X_M$	N_M	N_F	X^2_M	X^2_F
7.648	9.204	+1.556	205	200	13,216.585	18,747.272

$t = 7.072$** $t_{0.01} = 2.588$

** Significant at 1% level.

A statistical analysis was made on the respiration quotients which showed in general there was no significant difference in all comparisons made, that is, among the instars, between the same age group of the instars and between the males and females. In all probability the respiratory quotient is not as discriminatory a measurement statistically as the oxygen consumption measurement since it is in itself composed of two variables.

Fig. 2 shows the R. Q. beginning with the egg and ending with the adult. The R. Q. starts low in the egg, rises rapidly by the first instar; it then levels off with only a slight rise with the succeeding instars. After reaching the adult stage the R. Q. lowers somewhat and remains fairly constant until death.

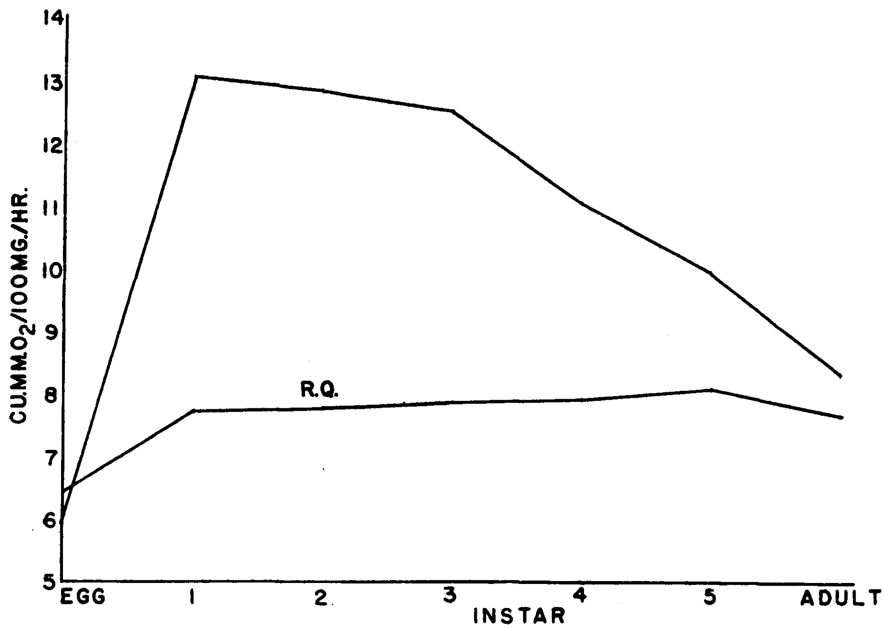

FIG. 2. The oxygen consumption reaches the maximum in the first instar and declines with each successive molt.

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DID YOU KNOW?