OXYGEN CONSUMPTION OF INSECT EGGS.[1]

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Although insect eggs present unique material for studies in metabolism the literature contains comparatively few reports in this interesting field of insect physiology. Bodine (1) has presented data from a study of eggs of Orthoptera which show the velocity of development to increase in direct proportion to increase in temperature within the normal limits of development. This is in accordance with other findings on the effects of temperature on poikilothermos species. This author shows that it is possible to calculate the time of hatching of eggs if previous temperature history is known. Such knowledge of insect pests may lend itself to practical application.

Fink (2) has conducted studies which lead him to conclude that the formative period in the development of eggs of certain insects is dependent upon whether they are deposited upon foliage or in the soil. Data to be presented in this paper tend to disprove the above explanation. For further references to literature in this field see the papers of Bodine and Fink cited above.

Thanks are due Doctor Erma Smith, Professor of Physiology, and other members of the Zoölogy and Entomology staff at Iowa State College, for many helpful suggestions and encouragement throughout the course of this work.

Purpose.

The purpose of this paper is to present briefly a preliminary report of a study of the oxygen consumption during embryonic development of certain insects.

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Methods and Material.

Bodine's modification of Krogh's manometer was used for determining the oxygen intake. Constant temperatures were maintained by use of a Freas electric water bath. The data presented were determined from the eggs of the following insects: Squash bug, *Anasa tristis* De G.; Luna moth, *Tropæa luna* L.; Cecropia moth, *Samia cecropia* L.; and Smartweed borer, *Pyrausta ainsliei* Hein.

The O_2 consumption is expressed in millograms of O_2 per gram live weight (exclusive of shell) per hour. Apparently previous workers have not taken into consideration the weight of the shell. If the weight of the shell be deducted, as it evidently should be, the O_2 consumption curve will be raised from 10 to 30 per cent.

The per cent. of shell at the beginning of incubation for several species of insects was found to be as follows: *A. tristis,* 29.2; *S. cecropia,* 22; *T. luna,* 23.3; and *P. ainsliei,* 31.

Assuming the weight of the egg shell to remain constant throughout the incubation period, the percentage of shell varies directly with changes in the weight of the egg. It is thus evident that changes in the weight of the egg will alter the type of curve representing O_2 consumption. For this reason the weight was determined just prior to each gas determination and calculations made accordingly.

Determinations were made on egg masses as soon as they were deposited and every 12 or 24 hours thereafter, depending on the length of the incubation period, until hatched. Calculations were made according to the formula of Krogh (3).

Temperature.

The effects of temperature upon biological processes are too numerous and too well known to warrant detailed discussion. Numerous investigators have studied the effect of temperature upon the length of the incubation period, but few reports have been found dealing with the effect of temperature upon the rate of metabolism as determined by the oxygen consumption. With this in mind experiments were undertaken to determine the effects of temperature upon embryonic development of insects.

TABLE I.

SHOWING SUMMARY OF DATA ON EFFECTS OF TEMPERATURE ON O_2 CONSUMPTION DURING EMBRYONIC DEVELOPMENTS OF *S. cecropia*.

Temp.	Manner of Calculation.	Total No. of		Millograms of O_2 Used per gram of Live Weight per Hour by Days.								
		Masses.	Eggs.	1	2	3	4	5	6	7	8	9
28	Exclusive of shell	11	534	.345	.359	.500	.615	.632	.684	.860	1.262	1.817
28	Inclusive of shell	11	534	.260	.320	.381	.480	.500	.520	.672	.985	1.420
34	Exclusive of shell	4	213	.347	.415	.550	.653	1.150	1.660	2.560	3.460	
34	Inclusive of shell	4	213	.287	.321	.420	.525	.900	1.302	2.000	2.710	

TABLE II.

SHOWS THE MILLIGRAMS OF O_2 CONSUMED PER GRAM OF LIVE WEIGHT (EXCLUSIVE OF SHELL) PER HOUR.

Name of Insect.	Total No. of										
	Egg Masses.	Eggs.	1	2	3	4	5	6	7	8	9
A. tristis	8	606	.383	.580	.890	.985	1.262	2.000	2.800		
S. cecropia	11	534	.345	.350	.500	.615	.632	.684	.860	1.262	1.817
T. luna	9	501	.397	.410	.421	.650	1.270	2.000	2.800		
P. ainsliei	4	630	1.400	1.500	1.800	2.200	3.000	6.000			

The same eggs were used to make the determinations at both temperatures. After sufficient acclimatization, two to five hours, depending on the size of the animal chamber, the manometer was closed and at the end of two hours the reading was made. In like manner the reading for the next temperature was made and the eggs returned to the incubator at 28 degrees until the next day.

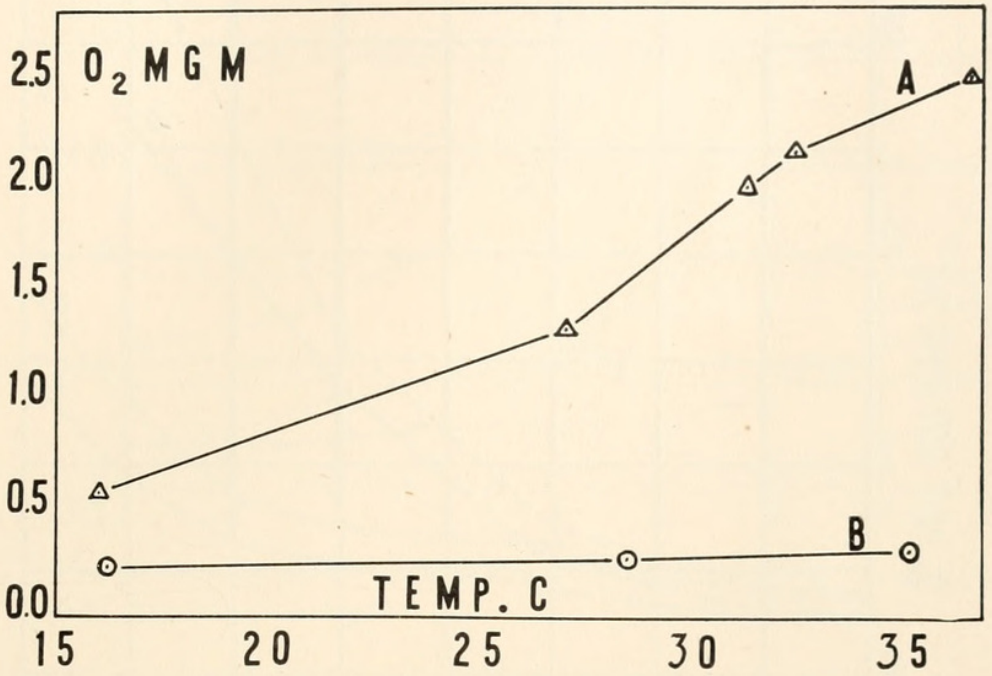

FIG. 1. Showing the effects of temperature on the O_2 consumption of *T. luna* eggs. (*A*) last day of incubation; (*B*) first day of incubation.

The results of these experiments are shown graphically in Fig. 1.

It is observed from Fig. 1 that the effects of temperature on O_2 consumption are very slight during the first day of incubation and very pronounced during the last day. In order to determine the effect of temperature on O_2 consumption during the entire incubation period daily determinations were made on two series of *S. cecropia* eggs at 28 and 34 degrees C. respectively. These results are summarized in Table I. and shown graphically in Fig. 2.

For comparative purposes the eggs of four species of insects were run at 28 degrees C. and the rate of O_2 consumption thus determined is shown graphically in Fig. 3 and summarized in Table II.

Formative Period.

Upon examination of Figs. 2 and 3 we note that during the early part of the incubation period temperature has very little stimulation on the O_2 consumption but as the incubation period

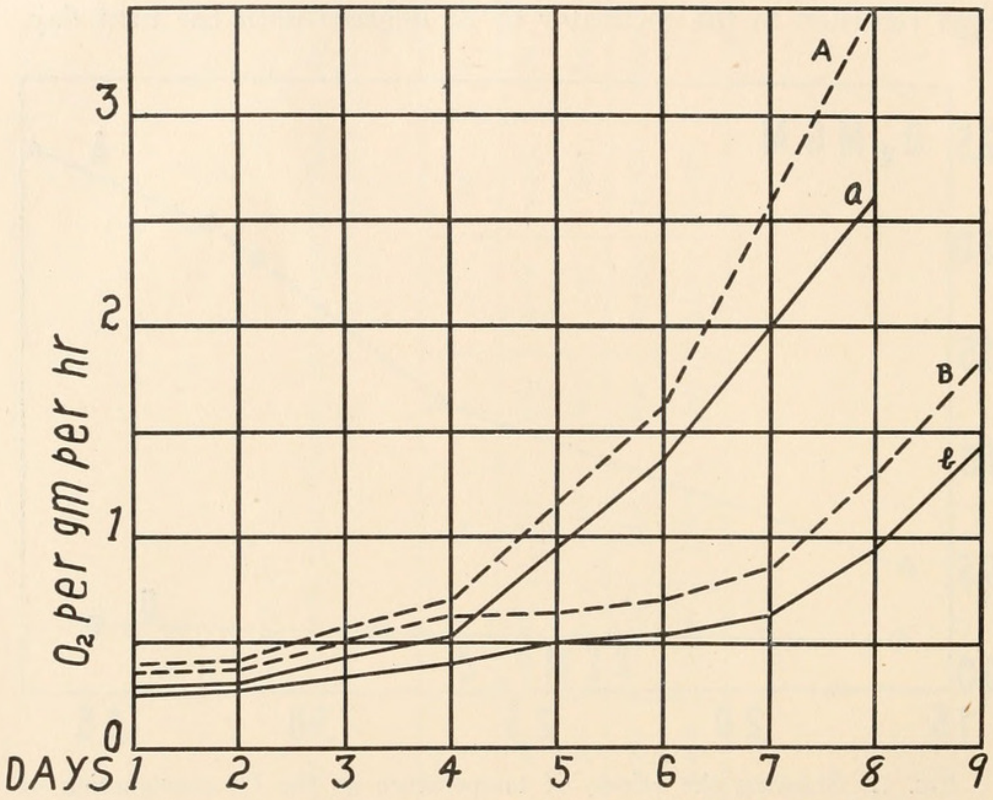

Fig. 2. Shows the effects of temperature on O_2 consumption during the entire incubation period of *S. cecropia*. (*A*) exclusive of shell 34° C., (*a*) same as above but including shell; (*B*) exclusive of shell 28° C., (*b*) same as above, but including shell.

progresses its effects become pronounced. This is in accord with and substantiates the existing theory which states *that during early embryonic development there is a formative period during which metabolic activity is comparatively low and only influenced slightly by environmental changes.* Mention has been made, above, of the explanation offered by Fink for the variation in the length of this formative period among different species of insects. In the case of *S. cecropia* and *T. luna,* both species laying eggs on foliage, the formative period is somewhat lengthened. This is contrary to Fink's explanation. Data presented in this paper shows the length of the incubation period to be a greater

factor in determining the length of the formative period than the type of place where the eggs chance to be deposited. Fig. 3

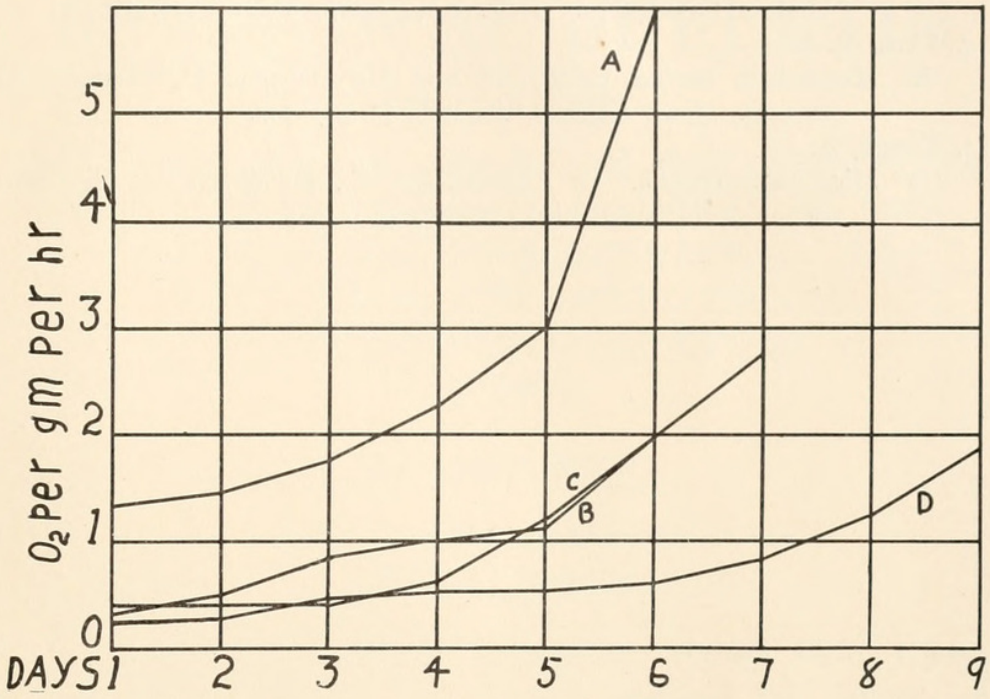

FIG. 3. O_2 consumption of eggs of (*A*) *P. ainsliei*, (*B*) *A. tristis*, (*C*) *T. luna*, and (*D*) *S. cecropia*.

bears out this explanation. A study of Fink's curves will show that they too substantiate the explanation here offered.

SUMMARY.

From a preliminary study of the factors accompanying and influencing metabolism as determined by the O_2 consumption during embryonic development made on four species of insects the following conclusions are drawn:

I. The weight of the egg shell is an important factor and should be taken into consideration.

II. The effects of temperature are not as pronounced during the formative period as during the period of late incubation.

III. The explanation offered for the variation in the length of the formative period is the length of the incubation period and not the place where the eggs chance to be laid as has been suggested.

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