

# The Metabolic Rate of The Flour Beetle, Tribolium confusum

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The *Tribolium confusum* (flour beetle) is a widely studied organism because it is readily obtainable and representative of a large group of similar organisms. Both *Tribolium confusum* and *Tribolium castaneum* (red flour beetle) are world wide contaminers of flour and bread. For this reason many facts are known about them.[1] The female lays from 300 to 400 eggs per generation 5 or 6 times a year. They reach fertile maturity after approximately 80 days and their life span is 3 years. Therefore, at their optimum temperature of 27°C and humidity of 1–75% they multiply rapidly and soon reach a maximum population density. The adult mean body weight is 2.1 mg. (1.4–3.5). It seemed worthwhile to have more knowledge about the metabolism of *Tribolium* to make possible a more complete understanding of this important beetle. This paper deals with the metabolic rate of *Tribolium confusum* and the effect of temperature upon it.

## Method

The respiration of the flour beetle was measured by the use of typical Warburg respirometry. The Warburg vessel is a small glass receptacle which may be completely sealed and kept in a water bath at constant temperature. By knowing the exact volume of this vessel and the distance which the fluid in the attached manometer moves we may then calculate the exact volume of oxygen removed. From 12 to 36 *Tribolium* were wrapped securely in a porous nylon mesh to restrict their movement within the Warburg vessel but at the same time to allow free respiration. The wrapped group was carefully lowered into the vessel, the center cup was filled with 20% potassium hydroxide to absorb the carbon dioxide, and the system was closed and allowed to equilibrate for 10 minutes. Experiments were carried out at 15°C, 25°C and 37°C.

## Results

In Figure 1 the oxygen consumption of *Tribolium confusum* and also *Tribolium castaneum* at 15°C may be seen. The solid lines are $O_2$ uptake of *confusum* and the dotted lines are *castaneum* uptake. The similarity of *confusum* and *castaneum* is evident. The oxygen uptake of *confusum* increases from 0.069 $\mu$ moles $O_2$ per hour at 15°C to 0.14 $\mu$

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moles $O_2$ per hour with the increase in temperature to 25°C. The $O_2$ uptake of *castaneum* and *confusum* at 37°C is shown. For the *confusum* it increases from 0.14 $\mu$ moles per hour at 25°C to 0.26 $\mu$ moles $O_2$ per hour at 37°C.

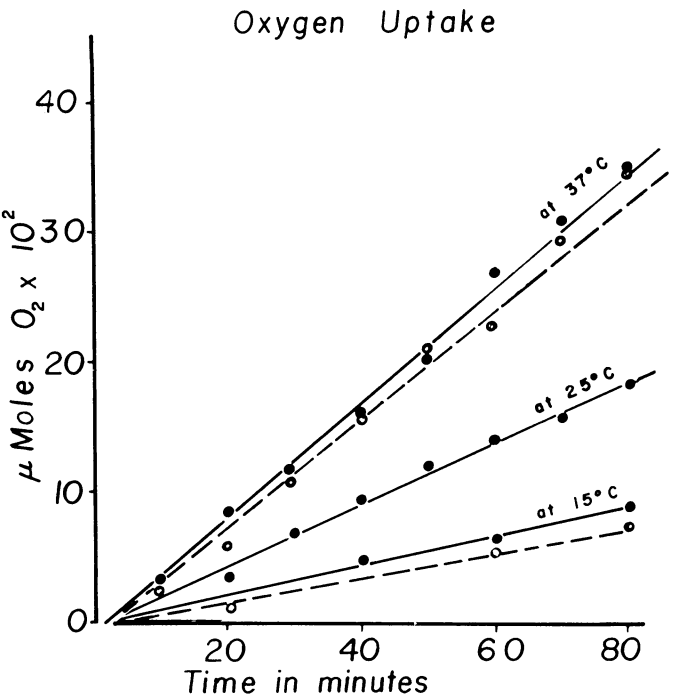


Figure 1. Graph indicating $O_2$ uptake of organisms at the three experimental temperatures. The solid line represents the $O_2$ uptake of **Tribolium confusum** and the dotted line represents the $O_2$ uptake of **Tribolium castaneum**.

## Discussion

It is clear from the data collected that *Tribolium confusum* and *Tribolium castaneum* have essentially the same metabolic rate, as might be expected, owing to their great similarity. The caloric value of these metabolic rates can be calculated. If we assume that the major metabolic substrate to the *Tribolium* is carbohydrate, the reaction

$$1/6\ C_6H_{12}O_6 + O_2 \rightarrow H_2O + CO_2 + 112{,}000\ \mu\text{ cal.}$$

represents the major caloric source. Thus, the metabolic rate at 25°C is 275 $\mu$ cal. per *Tribolium* per min. or 16,500 $\mu$ cal. per hour. The caloric equivalents of the metabolic rates at the various temperatures are:

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|---|---|
| at 15°C | 181.55 |
| at 25°C | 275.31 |
| at 37°C | 490.70 |

in $\mu$ cal./beetle/min. Since the mean weight of a *Tribolium* is 2.1 mg. this amounts to a metabolic rate of .051 $\mu$ moles per mg. per hour. This is, of course, much larger than the caloric rate per unit weight of mammals, but considerably lower than that of bacteria.

From the data of the various temperatures it is possible to determine the $Q_{10}$ ($Q_{10}$ = rate at some temperature, t, divided by the rate at a temperature 10°C higher). For the region 15°–25°C the $Q_{10}$ is 2.4; whereas, in the region 25°–37°C it is 1.8. True $Q_{10}$, calculated on the assumption that the rates are an exponential function of temperature, yields 1.6. A more definitive expression is the Arrhenius temperature coefficient:

$$K_1 = K_0 e^{\frac{U}{2}\frac{(T_1-T_0)}{(T_1 T_0)}}$$

where $K_0$ is the velocity of the reaction at absolute temperature $T_0$, $K_1$ is the velocity at $T_1$, and e is the base of natural logarithms.[2] The approximate value of 2 is taken for the gas constant in the denominator of the exponent of e. In the range 15°–25°C the temperature coefficient is 15,100 cal. and 8,640 cal. for the 25°–37°C range. It is interesting to note that this temperature coefficient for the 25°–37°C range is unusually low for biological processes. This is probably related to the fact that the upper part of this temperature range is also above the optimum temperature for *Tribolium.*

It is hoped that this research can be usefully incorporated into the already vast amount of knowledge, not only about *Tribolium.* but also about Coleoptera metabolism in general to yield a more complete framework for future study.

In conclusion:

1. The metabolic rate of *Tribolium confusum* at 25° C, or approximately its optimum temperature, is 16,500 $\mu$ cal. per *Tribolium* per hour.
2. The temperature coefficient of the metabolism at 15°–25°C is 15,100 cal. and at 25°–37° is 8,640.
3. The metabolic rates of *Tribolium confusum* and *Tribolium castaneum* are essentially the same.

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**References**

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