TEMPERATURE CHARACTERISTIC FOR LOCOMOTOR ACTIVITY IN TENT CATERPILLARS.

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I.

At different temperatures young tent caterpillars (Malacosoma americanum) were caused to creep vertically upward upon a thin wooden rod (3 mm. diameter) with evenly roughened surface. The rod was 24 cm. long, and the larva began ascent at the bottom; the mid-region of the rod was graduated, so that the time taken to travel 10 cm. could be accurately observed. Simultaneously, the number of "peristaltic" locomotor waves required to cover the 10 cm. distance was obtained by counting the steps of the anal prolegs. In case the initial or the terminal step failed to coincide precisely with the selected graduation mark, an estimate was made of the fractional step involved. The rod and a thermometer were suspended in a large box which also contained an electric heating device controlled with a rheostat. The box was set up in a room having approximately the desired temperature. For higher temperatures a small dark room was used which could be heated electrically. The animals were adapted to the temperature of the experiment until the rate of creeping became constant.

From the observations taken it was possible to compute: (1) the speed of progression; (2) the frequency of abdominal locomotor waves; (3) the mean amplitude of the step taken by the anal prolegs. We desired to consider these quantities in their relations to temperature, and to compare the critical thermal increment of locomotor activity with that found for some homologous activities.

It was found that variation in speed of creeping could be adequately controlled by the temperature, provided animals of the same size were used. Among such individuals, especially if taken from the
same nest, the rate of creeping is very uniform. We have used caterpillars 1.5 to 2.0 cm. long. About 14 individuals were employed in obtaining 180 measurements. The points plotted in Fig. 3 are each the average of 6 or more very closely concordant determinations.

II.

When the mean speeds of creeping at different constant temperatures are considered in terms of the relationship known to be valid for a number of similar instances,

\[ \log \frac{\text{velocity at } T_2}{\text{velocity at } T_1} = \mu \left( \frac{1}{T_1} - \frac{1}{T_2} \right) \]

the graphs of log velocity versus 1/absolute temperature fails to be rectilinear (Fig. 1). No significant value of the critical increment \( \mu \) can be calculated.

This result finds its explanation in the fact that one of the two components determining the speed of vertical ascension is influenced by the temperature in a special way. The act of creeping is begun by a forward movement of the anal prolegs, initiating a peristaltic
body wave coursing cephalad to the anterior margin of the abdomen; simultaneously the anterior thoracic legs begin their progression movements, the wave of leg activity running posteriorly. The abdominal movements may be timed by counting the steps of the anal prolegs. Between 20° and 30° the number of such steps per 10 cm. distance is sensibly constant. Above 30° there is a tendency for the amplitude of the steps to become less, but the available observations are not numerous because creeping is so often irregular at these higher temperatures. Below 20°, however, the amplitude decreases markedly and regularly as the temperature falls (Fig. 2). It is clear that as a consequence the value of the product (amplitude of step) \times (frequency of steps), which is the velocity of progression, will be abnormally lowered at temperatures less than 20° ± (cf. Fig. 1).

The speed of creeping is thus deprived of its possible analytical utility, and it becomes necessary to deal directly with the frequency of the locomotor steps. The shortening of the amplitude of the locomotor wave at lower temperatures may have a physical basis in the physiology of the caterpillar’s musculature, or it may be condi-
tioned by the vertical attitude in these experiments. Tests with horizontal creeping suggest the probability of the former alternative. It is in any case not an artifact due to irregularities of creeping; all instances in which the larva "hesitated" were excluded.

The frequency of the locomotor steps, on the other hand, is very definitely related to the temperature by the Arrhenius equation (Fig. 3). The temperature characteristic, \( \mu \), has the value 12,200 ± 100 calories. At temperatures below 11\( ^\circ \) the frequency tends to be abnormally low, and above 30\( ^\circ \) (a "critical point" in experiments with other insects also (cf. Crozier and Stier, 1924–25)) many larvae do not creep continuously. In a few cases regular locomotion was obtained at temperatures as high as 36\( ^\circ \)C., but the mean frequencies of steps are always lower at these temperatures than the relation given by Fig. 3 would demand.

III.

Various rhythmic neuromuscular activities of arthropods consistently exhibit the temperature characteristic 12,200 (Crozier,
1924-25, a), with which that now obtained for frequency of locomotor movements in tent caterpillars shows satisfactory agreement. Abdominal respiratory movements must be excluded from this category (Crozier and Stier, 1924-25). The coincidence of the present finding with the result in other instances involving activities of arthropods presumably controlled by nerve center discharge substantiates the view that homologous activities may be governed in

![Graph](image_url)

**Fig. 4.** The speed of vertical ascension at any temperature = frequency of steps × mean amplitude of step. The curves for speed and for amplitude are respectively taken directly from the smoothed curves in Figs. 1 and 2, that for frequency from Fig. 3. (One ordinate division = 0.1 on log scale.) Curve 1 is also the resultant of adding the corresponding ordinates of Curves 2 and 3.
chemically similar, or even identical, ways; and that from this stand-
point the classification of quantitative aspects of behavior is possible
upon the basis of the respective critical increments.

The locomotion of the tent caterpillar is especially interesting
because it shows how the analysis of a case in which a velocity (i.e.
of movement) fails to be a simple exponential function of \(1/T^\circ_{\text{abs}}\)
is readily rectified when the mechanism of the process is examined
with sufficient detail. Curves of the general type exemplified by
Fig. 1 have been indicated (Crozier, 1924–25, b) as resulting when
competing processes have a cumulative effect upon the observed
velocity. The creeping of *Malacosoma* provides a kind of model
illustrating this conception (cf. Fig. 4).

**SUMMARY.**

The frequency of abdominal peristaltic locomotor waves in tent
caterpillars during vertical ascension is controlled by the temperature
according to the equation of Arrhenius. The constant \(\mu^\circ\) (tempera-
ture characteristic) has the value 12,200 calories, agreeing quantita-
tively with the value obtained for a number of other (non-respiratory)
rhythmic neuromuscular movements among arthropods.

**CITATIONS.**