SHORT COMMUNICATIONS

Respiratory Rates of Green and Black Larvae of the Armyworm, *Leucania separata* (Lepidoptera: Noctuidae)\(^1\)

Working on the migratory locust, *Locusta migratoria*, BUTLER and INNES (1936) found high respiratory rates in the nymphs and adults of phase *gregaria* as compared with those of phase *solitaria*. GARDINER (1958) obtained similar results with the desert locust, *Schistocerca gregaria*, and also found that the nymphs of phase *solitaria*, reared for 7 days under crowded conditions, began to show a higher respiratory rate than those of the same phase reared in isolation.

The armyworm, *Leucania separata*, has been known to show continuous polymorphism which resembles to the phase of locusts, that is, isolated larvae of this species are pale green or pale brown in body colour but crowded larvae are black, and both types differ markedly in behaviour, development and resistance to environmental stresses (IWAO, 1962). Differences in the respiratory rate in relation to the body colour of *Leucania* larvae is reported in the present paper.

Adults obtained by mass-rearing for one to several generations from original stocks collected in Chiba, near Tokyo, were allowed to oviposit on papers in the laboratory. The first instar larvae from an egg-mass were reared in a group till the completion of the first ecdysis. Then, some larvae were reared in isolation but others were reared in groups of 30 individuals, in petri-dishes, 115 mm in diameter and 30 mm in height, under 16 hr illumination of a fluorescent lamp and at a constant temperature of 28°C. Enough amounts of *Zea mays* leaves were renewed everyday. Several larvae died in some batches of 30 individuals, but the batches in which more than 25 individuals survived at the time of measurement were used. The CO\(_2\) output was measured on the 2nd or 3rd day after each ecdysis. At the 2nd and 3rd instar stages there was no clear difference in colour between individuals reared in isolation and in crowds, and the measurement was made only for crowded larvae. Colour polymorphism became apparent at the later instars, however. No black individual was found in the isolated rearing. In group rearing most individuals were moderately black but some were pale green or intermediate in colour. The isolated pale, crowded black and crowded pale larvae were determined for their CO\(_2\) output, but the individuals having intermediate colours were excluded from the test.

The respiratory rate was represented by CO\(_2\) output which was measured by a Beckman Infrared Analyzer IR 215. The insect (10 individuals for the 2nd instar and 1 individual for the later instar stages) was put into a plastic respiration chamber, 120 ml for the 2nd to 4th instar and 570 ml for the 5th and 6th instar larvae, and the air inside the chamber (including the chamber and the detector-cell) was completely replaced with CO\(_2\)-free air (O\(_2\) : 20.4%, N\(_2\) : 79.6%). Then, the air in the circuit was isolated from the atmosphere and forced to rotate slowly by a pump. The concentration of CO\(_2\) accumulating in the circuit could be read immediately. The measurement was made for 1 hr and the cases where test animals crawled during the measurement were excluded from the data. Temperature in the respiration chamber was kept at 27.5±0.5°C or 30.0±0.5°C using a water-bath.

Such an insect as *Locusta migratoria* shows abnormally high respiratory rate during several hours after introduction into the chamber (e.g. MATSUMOTO, unpublished), but in *Leucania* larvae such an abnormally high respiratory rate disappeared for several minutes (this time was required for the replacement of air) and thereafter a rectilinear increase of CO\(_2\) concentration was observed. Harmful effects of the accumulation of CO\(_2\) could also be neglected because we ceased the measurement before the CO\(_2\) concentration reached 300 ppm.

Fig. 1 shows the relationship between the CO\(_2\) output in mm\(^3\) per larva per hr (R) and the live body weight in mg (W). It can be seen from this figure that the crowded-black larvae gave large value of CO\(_2\) output as compared with the isolated-(pale)green larvae at the 5th and 6th instar stages. Regression equation for crowded-black larvae calculated from data on the 2nd to the 6th instar larvae is

\[
\log R = 0.06 + 0.95 \log W
\]

\(^1\) Appl. Ent. Zool. 4 (2) : 100—101 (1969)
and the equation for isolated-green larvae calculated from data on the 4th to 6th instar larvae is
\[ \log R = 0.41 + 0.74 \log W. \]

![Graph showing CO2 output vs. live body weight](image)

Fig. 1. Respiration-weight relationship of crowded-black (solid circle) and isolated-green (hollow circle) larvae of *Leucania separata* at 27.5°C.

Differences in the respiratory rate between crowded-black and isolated-green larvae were more clear when CO2 outputs per mg live body weight were compared (Table 1). The difference between colour types was highly significant at the 5th and 6th instar. This fact suggests that the respiratory rate of the crowded-black larvae is higher than that of the isolated-green larvae as seen in locusts.

As mentioned above, a few pale green larvae appeared among crowded larvae. All of these crowded-green larvae were used for CO2 measurement, the results of which are shown in the bottom part of Table 1. The CO2 output per mg live body weight of the crowded-green larvae was significantly lower than that of crowded-black larvae and not significantly different from that of isolated-green larvae. This suggests that the respiratory rate of the 5th and 6th instar larvae of *Leucania separata* changes when the crowding effect exceeds a threshold which is indicated by the melanization of body colour. Crowded-green larvae seem to be less affected physiologically by crowding despite the fact that they have been reared with larvae which show remarkable melanization.

<table>
<thead>
<tr>
<th>Series 1. 27.5 ± 0.5°C</th>
<th>Instar</th>
<th>Isolated larvae (green)</th>
<th>Crowded larvae (black)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>1.60(20)</td>
<td>1.43(30)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.96 (7)</td>
<td>0.94 (7)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.57 (5)</td>
<td>0.88 (7)</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.67(24)</td>
<td>0.91(21)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series 2. 30.0 ± 0.5°C</th>
<th>Instar</th>
<th>Isolated larvae (green)</th>
<th>Crowded larvae (black)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>1.48(7)</td>
<td>1.68(7)*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(green) 1.25(5)</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses mean the number of individuals.

*** Difference is significant at 0.001 level.

* Difference is significant at 0.05 level.

REFERENCES


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