Winslow (1953) found the hatching curves of *H. schachtii*, *H. cruciferarum* and *H. galeopsidis* were similar to that of *H. rostochiensis*. Winslow (1955) obtained similar results for eight species of *Heterodera*. In this experiment, the hatching percentage of *H. glycines* reached the maximum in a relatively short time, probably because the test eggs had been freed from cyst and pre-soaked, and the hatching curves showed sigmoid forms when the cumulative hatch was plotted against arithmetical time (Fig. 3). Fenwick and Widdowson (1959) and Ouden (1963), using *H. rostochiensis*, recognized that the eggs freed from cysts and those contained within cysts showed similar curves for hatching response, although the former respond to the hatching stimulus slightly more rapidly. Fenwick (1951) pointed out that preliminary soaking of cysts in tap water increased their rate of hatching on the subsequent exposure to root diffusate, and that the cysts appeared to hatch earlier when they had been soaked for a longer period. Therefore, it is supposed that the hatching responses of *H. glycines* are generally similar to other species of *Heterodera*.

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Hormonal Control of Larval Coloration in the Common Armyworm, *Leucania separata* Walker

It is well known that aged larvae of the common armyworm, *Leucania separata* Walker, are characterized by large variation in body color. Three color patterns can be principally differentiated; namely white or whitish-yellow spots, different kinds of ground color and black pigments (Fig. 1). When individual larva was reared, the 3rd or older larva results in a pale color in appearance, showing whitish-yellow spots, a pale brown on reddish brown ground color, and small areas with black pigments. When several larvae were reared together, they showed a black color with white spots, intense brown ground color and large areas with black pigments. The black pattern which is considered to be due to melanin deposited in the larval cuticle (I kemoto, 1970) may be divided into five types by external appearance.


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Received September 14, 1970

Fig. 1. Typical color pattern of the common armyworm larva; Dorsal view of a left half of 3rd abdominal segment (5th instar larva) a: white or whitish yellow spot, b: ground color, c: black pigments.
This paper presents an evidence that there is some hormonal function which controls pigmentation of the integument of L. separata larva. In a series of experiments 20 larvae or a single larva per petri dish (9 cm in diameter) were reared to study differential pigmentation.

If a ligature was applied between 2nd and 3rd abdominal segments in the gregarious 4th instar larvae about 24 hrs before molting, the larvae molted to the 5th instar with the part anterior to the ligature colored black-brown and the posterior part light blackish (Fig. 3). It seems likely, therefore, that the pigmentation is controlled by some organ located in the anterior part of larva.

In order to solve this problem, various organs such as brain, suboesophageal ganglion and prothoracic ganglion were removed from the gregarious 4th instar larvae about 24 hours before molting. As shown in Table 1, the 4th instar larvae without the suboesophageal ganglia molted to the 5th instar larvae with a light black color (Fig. 2 Type I—III, Fig. 4). Removal of the brain produced a medium black pigmentation (Fig. 2 Type II—IV), while most of the larvae without the prothoracic ganglia molted to black-brown ones similar to the sham operated (Fig. 2 Type II—V, Fig. 4). Subsequently, the ligature was applied at both 1st and 4th abdominal segments of the gregarious larvae as men-

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**Fig. 2.** A series of black pigmentation pattern observed in 5th instar larvae; Dorsal view of a left half of 3rd abdominal segment; arrow shows median dorsal line.

**Fig. 3.** A 5th instar larva showing black pigmentation in a part anterior to ligature.

**Fig. 4.** Coloration of a gregarious 5th instar larva deprived of suboesophageal ganglion 24 hrs before molting A : a larva operated, B : a larva sham operated.

**Fig. 5.** A gregarious 5th instar larva showing black pigmentation in posterior abdominal part implanted with a suboesophageal ganglion obtained from a gregarious 4th instar larva 24 hrs before molting.

**Fig. 6.** A solitary 5th instar larva showing reddish-brown pigmentation in posterior abdominal part implanted with Br-SG obtained from a gregarious 4th instar larva 24 hours before molting.
Short Communications

Table 1. Effect of Exirpation of Subesophageal Ganglia and Brains on Pigmentation in the Common Armyworm Larvae

<table>
<thead>
<tr>
<th>Ganglion removed</th>
<th>No. of larvae with black pigmentationa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Subesophageal ganglion</td>
<td>5</td>
</tr>
<tr>
<td>Brain</td>
<td>15</td>
</tr>
<tr>
<td>Prothoracic ganglion</td>
<td>4</td>
</tr>
<tr>
<td>Sham operated</td>
<td>1</td>
</tr>
</tbody>
</table>

a see Fig. 2.

From the results above, and the brains or the subesophageal ganglia removed from the same materials, were implanted posterior to the ligature at 4th abdominal segments. It was found that the posterior parts of the larvae which received either subesophageal ganglia or brains showed more blackish pigmentation than the anterior ones which lacked these organs. The implantation of the subesophageal ganglia or the brains definitely induced intense melanin pigmentation as shown in Fig. 5 (5 larvae out of 10 with the brains and 8 out of 10 with the subesophageal ganglia respectively). Thus, it may be reasonable to assume that the brain and especially the subesophageal ganglion are connected with the black pigmentation of the gregarious larvae.

Experiments were also designed to clarify the appearance of coloration in the solitary larvae. The 4th instar solitary larvae were ligatured at the 2nd abdominal segment 24 hrs before molting, and the brain and subesophageal ganglion complexes (Br-SG), obtained from the gregarious larvae or the solitary larvae, were implanted into the posterior parts of the solitary larvae. The isolated abdomens of the solitary larvae provided with the Br-SG from the gregarious larvae turned reddish-brown after molting in 5 larvae out of 5, as did the Br-SG from the solitary in 3 larvae out of 5 (Fig. 6). If the Br-SG from the gregarious larvae was implanted into the anterior parts of the solitary larvae, the resulting 5th instar larvae showed the same coloration as the untreated solitary larvae.

As to the mechanism involved in the development of pigmentation, some investigations have been carried out. Hidaka (1956) working with Papilio xuthus and P. protoxanthes demetrius, and Ohtaki (1960) working with Pieris rapae crucivora have demonstrated that the hormonal factor secreted from the prothoracic ganglion causes brownish coloration of pupal cuticle and further that the prothoracic ganglion is stimulated by the brain, via the nervous commissures, to secrete the factor. On the other hand, Hashiguchi et al. (1965) have suggested that in Bombyx mori the protein or peptide composition secreted from the thoracic ganglia controls black pigmentation. The result obtained from the present experiments has also shown that in the common armyworm some hormonal factor originated from both brain and subesophageal ganglion caused the black and brown pigmentation. Moreover, it has been suggested that in the solitary condition some unknown factor which seems to inhibit the development of reddish-brown pigmentation exists in the anterior part of the larva.

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