15. The Control of Growth and Development in Bombyx mori. XXXVI

Larval-Larval and Larval-Pupal Apolysis, Especially on a Hormonal Antagonistic Balance

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It was shown an antagonistic action between juvenile hormone (JH) and molting hormone (MH) (Morohoshi 1972, XV). A similar view was expressed by Masner and Hangortner (1973) in vivo experiments with the German cockroach. This concept has been asserted by Morohoshi since 1957 and supported by several investigators in vitro experiments (Congote et al. 1969, Lezzi et al. 1969, Laufer et al. 1970). This study deals with antagonism between JH and MH.

Materials and methods. Eggs resulting from bivoltine hybrids between J. 106 and Daizo were incubated at 17°C in the dark condition (L-series) and at 25°C in the light condition (H-series). The application of JH into the larval skin was performed in the 5th-instar-larvae at the level of 15 µg/1 μl per gr.

Results. 1. Appearance of extra molted larvae in early (Lme), intermediate (+Lm) and late (Lm) maturing strains following the JH-application. Recently Komori (1976) showed extra molting which occurred earlier in the female larvae having the sex-linked recessive early maturing gene (Lme) than in the female ones carrying the dominant late maturing gene (Lm) (Table I (1)). The frequency of extra molted larvae in the 96-hr-old 5th-instar-female larvae following the JH-application was most in the Lme-larvae, medium in the +Lm-larvae and least in the Lm-larvae.

2. Appearance of extra molted larvae in the L- and H-series following the JH-application. Extra molted larvae were produced earlier in the L-series-larvae than in the H-series-larvae after the JH-application (Table I (2)).

Discussion. In the last 5th larval instar the secretion of JH ceases at the early stage, while the secretion of MH rises with age after the 3rd day. A similar hormonal sequence has been induced in younger larvae either by decapitation or by allatectomy. Under such
hormonal environmental conditions, larvae naturally induce larval-pupal (L-P) apolysis. The L-P apolysis was changed into L-L apolysis by applying JH, MH or BH (brain hormone). The L-L apolysis as well as L-P apolysis are controlled by the presence or absence of JH in haemolymph, while the timing of apolysis is determined by the titer of JH or MH. The time (hour) needed to prepare for pupal ecdysis usually exceeds that of larval ones.

Fig. 1(1) illustrates L-L apolysis following the application of JH (Morohoshi et al. 1975: XXV), and Fig. 1(2) shows the difference

Table I. Frequency of extra molted larvae following the application of JH under various conditions

| Condition | JH-applied 5th-instar-stage (hr) |
|-----------|---------------------------------|
|           | 48    | 72    | 96    | 120   | Control (%) |
| (1) Crossing form (gene constitution) (from Komori 1976) |         |       |       |       |             |
| C. 108×Mysore (+Lm×Lme/Lme) | ♀45   | 89    | 100   | 0     | 0         |
| Mysore×C. 108 (Lme×+Lm/+Lm) | ♀0    | 26    | 80    | 0     | 0         |
| E. 16×C. 108 (Lm×+Lm/+Lm) | ♀0    | 21    | 47    | 0     | 0         |
| C. 108×E. 16 (+Lm×Lm/Lm) | ♀0    | 28    | 75    | 0     | 0         |
| (2) Condition of incubation |       |       |       |       |             |
| 17°C in darkness | ♀0    | 0     | 65    | 0     | 0         |
| 25°C in light | ♀0    | 0     | 75    | 0     | 0         |

Fig. 1. Larval-pupal (L-P) and larval-larval (L-L) apolysis by application of JH, MH and BH. △: JH, ▼: MH.
by strains on the induction of L-L apolysis with the application of JH (Komori 1976). Fig. 1(3) shows L-L apolysis by the application of MH (Morohoshi et al. 1969) or BH (Kobayashi et al. 1973). The L-L apolysis after the implantation of the brain-corpora allata (Br-CA) complex into the 4th-instar-larvae 24 hours after decapitation is illustrated in Fig. 1(4).

The amount of BH in haemolymph seems to determine the period of L-L or L-P apolysis in the final larval instar (Fig. 2, Rep. XXVII, XXIX and XXXV). The higher titer of BH induced the higher frequency of L-L apolysis and the quicker period of apolysis. These results were quite in accord with Kobayashi's results (1973) in which extracted BH was injected into decapitated 4th-instar-larvae.

The secretion of JH in the 5th-instar-larvae ceased on the 3rd day. When much JH would be applied to larvae, they may induce extra larval ecdysis. Even if insects would be young, they could be pupated following the cease of JH-secretion. Thus, two hormones (JH and MH) show an antagonistic action upon protein-metabolic tissues or organs such as body wall, silk glands or ovaries. The JH acts as a larva-maintaining (growth) hormone, whereas the MH serves as a pupation-promoting (development) hormone. However, the function of JH on ecdysed types is always superior to that of MH.

When the MH-titer in haemolymph is constant, the length of each instar is controlled by the amount of JH: under a sufficient amount of JH, the length of each instar becomes long. When the JH-titer is constant, the length of each instar is controlled by the amount of MH: a sufficient amount of MH induces a short larval
instar. Under a poor amount of JH and rich amount of MH, the length of each instar becomes shortened to a considerable extent.

The larvae carrying the sex-linked early maturing gene (\(Lm^e\)) release more BH than those carrying the sex-linked late maturing gene (\(Lm\)). The CA activity of the larvae of the former type is strongly inhibited by more BH introduced or stored in the CA while the PG (prothoracic gland) activity is strongly promoted by the BH released into haemolymph from the CA. The JH induces the delay of larval development (Rep. XVI) with the inhibition of protein synthesis (Rep. VII–IX). The MH induces the acceleration of larval development (Rep. XIII) with the promotion of protein synthesis (Kobayashi et al. 1971). The JH and MH are clearly antagonistic hormones.

The change of molt-numbers at earlier larval instars is well explained by this antagonistic action between JH and MH. Tetramolting groups segregating some trimolters in the L-series accelerate molting cycles more than tetramolting groups segregating no trimolters in the H-series. Some larvae out of accelerated normal tetramolters in the L-series delay molting cycles at earlier larval instars and they become trimolters. When much BH is produced in the L-series-larvae, a lower titer of JH and a higher titer of MH result in haemolymph. This feature induces the acceleration of molting cycles. The delay of the molting cycle in appeared trimolters may be controlled by a higher titer of JH and a lower titer of MH due to the acceleration of larval development.

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