96. *Hormonal Control of Molting and Pupation in the Silkworm.*

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In a previous paper (Fukuda, 1940) it has been shown that the prothoracic gland of the silkworm is an organ of internal secretion which releases into the blood its active principles responsible for the onset of pupation. Furthermore, I have recently obtained some evidences showing that the molting in the silkworm larva is also controlled by hormones secreted by the prothoracic gland.

Material and methods.

The 4th instar silkworms of Japanese bivoltine race called "Syōhaku" were used in the experiments.¹⁾ In the 4th instar larvae, the feeding period at 23–25.5° C is on an average 129 hours. The age of the silkworms was calculated from the time they begin to take food after previous molting.

Two series of experiments were made: (1) decapitation of the larvae by a ligature at the level between head and prothorax and (2) ligaturing the larvae behind prothoracic segment either (A) at the level between mesothoracic and metathoracic segments or (B) at the level between gonadal and postgonadal segments.

Results.

1. Pupation and molting in decapitated silkworms.

Neither pupation nor molting occurred in the larvae decapitated at 30 or 50 hours of age.

But as is shown in Table 1, some of the silkworms decapitated between 60 and 90 hours underwent a precocious pupation without

TABLE 1.
Decapitation of 4th instar silkworms at different ages.

AGE AT OPERATION IN HOURS	NO. OF SILKWORMS DECAPI- TATED	NO. OF SILKWORMS PUPATED	NO. OF SILKWORMS MOLTED	NO. OF SILKWORMS REMAINED AS LARVAE
50	50	0	0	50
60	50	3	0	47
70	50	6	2	42
80	50	21	3	26
90	50	8	21	21
100	50	0	40	10
110	50	0	48	2

1) Normally the silkworm pupates at the 5th molting.

preceding larval molting resulting small headless pupae (Fig. 1, f).

However the larval molting (Fig. 1, e) also took place in some silkworms decapitated at the ages older than 70 hours, and the later the larvae were operated the more numerous were the molted ones. The time of onset of molting in the decapitated larvae was almost the same with that in the unoperated controls.

2. Molting in silkworms ligatured behind the prothoracic segment.

In every case neither part of the larvae was able to pupate. However, larval molting took place in some cases. Table 2 gives the combined results obtained from the groups A and B.

TABLE 2.

Ligation of 4th instar silkworms behind prothoracic segment at different ages (Combined results from groups A and B).

AGE AT OPERATION IN HOURS	NO. OF SILKWORMS LIGATURED	ANTERIOR PART ALONE MOLTED	BOTH PARTS MOLTED	NEITHER PART MOLTED
50	100	0	0	100
60	100	0	0	100
70	100	7	0	93
80	100	31	0	69
90	100	53	21	26
100	100	28	57	15
110	100	0	100	0

Fig. 1 (natural size). a, b Silkworms ligatured at level between mesothoracic and metathoracic segments at 90 hours of age. a Both parts have molted. b Anterior part alone has molted. c, d Silkworms ligatured at level between gonadal and postgonadal segments at 90 hours of age. c Both parts have molted. d Anterior part alone has molted. e Decapitated silkworm molted. Operation at 90 hours of age. f Pupa obtained from silkworm decapitated at 80 hours of age.

The larval molting occurred in the anterior parts of some larvae ligatured at the ages older than 70 hours, while in the posterior parts the molting took place only in the larvae operated at the ages older than 90 hours (Fig. 1, a-d).

There was no marked delay in the onset of molting in either part of the larvae as compared with that in the unoperated controls. The larval parts not molted at normal time always remained as such until death.

Discussion and Conclusion.

The occurrence of precocious pupation in the larvae decapitated during the 4th instar seems to indicate that something may be present in the head of the silkworms of this age which controls the onset of molting and its removal induces a sudden pupation. The only organs which seem to be of importance in this respect are the corpora allata, since it has already been found that their extirpation at a certain time in the 4th instar silkworm larvae brings about a precocious pupation without preceding larval molting (Bounhiol, 1937; Kin 1939; Fukuda, unpublished).

It should be mentioned that the molting takes place in the decapitated silkworms and in the anterior parts including the first two thoracic segments of the ligatured silkworms if the operations are performed at the ages older than 70 hours. On the other hand, in the posterior parts excluding the thoracic segments the molting is only possible when the larvae are ligatured at the ages older than 90 hours. This may show that there is an organ in the thoracic segments which plays some rôle in the onset of molting by pouring its product into the blood between 70 and 90 hours of age. The organs which seem responsible here are the prothoracic glands.

The larval molting in silkworms and probably also in other lepidopterous larvae may be induced by two different hormones discharged in succession into the blood from the corpora allata and the prothoracic glands. On the other hand, for the onset of pupation only the hormone from the prothoracic gland may be necessary. The precocious pupation following the removal of the corpora allata or the decapitation performed prior to a certain age, *i. e.*, about 90 hours, may be due to the exclusion of the hormone of the corpora allata and the operated larvae affected by the hormone of the prothoracic glands alone undergo pupation without preceding larval molting.

It is highly probable that in the last instar larvae the corpora allata have lost their endocrine activity and the prothoracic glands alone seem to become active. It has already been observed that in the last instar silkworms neither extirpation of the corpora allata (Kin, 1939) nor decapitation (Fukuda, unpublished) can bring about noticeable acceleration of the pupation time.

The rôle played by the corpora allata and the prothoracic gland for the inception of molting and pupation in the silkworm have also been demonstrated in my experiments of the transplantation of the

larval skin, which will shortly be published elsewhere. But suffice it to mention here that when a piece of skin taken from a last instar larva at the beginning of its cocoon formation was transplanted into the body cavity of a silkworm at about the middle of the 4th instar, the transplanted skin underwent a pupal molting simultaneously with the larval molting of the host. On the contrary if similar transplantation of the skin was made into a younger 4th instar larva the larval molting took place in the transplanted skin at the molting of the host.

According to Piepho (1940) in *Galleria mellonella* the transplantation of the corpora allata of young larvae into a last instar larva has brought about excessive larval molting. He has attributed this to the pupation-inhibiting effect of the transplanted corpora allata. However, this explanation seems to have missed the point judging from the above-mentioned results of my experiments.

Literature.

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