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# *The Role of the Suboesophageal Ganglion upon the Pupal Diapause of Giant Silkworm, Samia cynthia pryeri*

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**Abstract**

The effect of the transplanted brain or Br-SG complex on the termination of the pupal diapause of cynthia silkworm, *Samia cynthia pryeri,* was investigated in various cases.

Neither the possibility that "diapause factor" was secreted from the suboesophageal ganglion of the diapausing pupa, nor the possibility that something "activating factor" to increase the effect of the transplants was secreted from the suboesophageal ganglion were exhibited in the results of these experiments.

It seems to be explainable that the lesser effect of the transplants on the development of the pupa lacking in Br—SG was derived from the serious injury of the pupa.

## Introduction

It has been clarified by WILLIAMS, C. M. that the pupal diapause of cecropia silkworm, *Hyalophora cecropia,* is induced and kept by the inactivation of secretion of the prothoracic gland, and it is terminated by the reactivation of secretion of the prothoracic gland. Then the activity of the prothoracic gland is under control of the secretory activity of the brain of the pupa. ('46, '47, '48, '52) This is true in the case of the pupal diapause of another cynthia silkworm, *Samia cynthia pryeri.* (FUKUDA, S. '59) In these cases, it is present that the diapause of the pupa is induced by the deficiency of some factor secreted from the brain, and the termination of the diapause is induced by the increase of some facter secreted from the brain. Therefore, it is shown that the existence of the activated brain and the existence of the prothoracic gland are indispensable for the termination of diapause.

Opposing to the opinion of WILLIAMS, C. M., HINTON, H. E. proposed the

different theory on diapause that the diapause was controlled by "diapause factor" secreted from the suboesophageal ganglion of the diapausing insect. ('53, '57)

Regarding to the production of the diapause egg in silkworm, *Bombyx mori*, it is clarified that the "diapause factor" or "diapause hormone" is secreted from the suboesophageal ganglion of the insect which produces diapause egg. (FUKUDA, S. '51, '52, '53 FUKUDA, S. & TAKEUCHI, S. '67, HASEGAWA, K. '52, '63, '64, YAMASHITA, O. & HASAGAWA, K. '64a, '64b, HASEGAWA, K. & YAMASHITA, '65, ISOBE, M., HASEGAWA, K. & GOTO, T. '73)

In the present study, some transplantation experiments of activated brain into the non-chilled pupa from which the brain or Br—SG complex was removed were carried out to investigate the effect of the suboesophageal ganglion of the diapausing pupa.

## Material and Methods

The pupae used for this study were those collected near Matsumoto city in early October 1972. They were stored in an incubator at 26°C. until the use in the study. On late August 1973, 2 pupae out of the 40 pupae which were the rest of the pupae used for experiments developed to imagin, while the 38 pupae were survived in diapausing.

In this study, pupae were divided into the following two groups, the one represented the chilled pupa which was kept for over 10 weeks in a refrigerator at 5°C. until the use, the other represented the non-chilled pupa which was stored in an incubator at 26°C. until the use.

Following experiments were carried out.

(1) The brain of the chilled pupa was transplanted into the 4-th abdominal segment of the intact non-chilled pupa. The transplanted brain was isolated from the chilled pupa on 5-th day of the 26°C. incubation.

(2) The brain was removed from the chilled pupa on 5-th day of the 26°C. incubation.

(3) The brain of the chilled pupa was transplanted into the 4-th abdominal segment of the decerebrated non-chilled pupa.

(4) A brain and suboesophageal ganglion complex of the chilled pupa, (Br+SG)*, was transplanted into a decerebrated non-chilled pupa.

(5) Two (Br+SG)* were transplanted into a decerabrated non-chilled pupa.

(6) The brain-suboesophageal ganglion complex was removed from the non-chilled diapausing pupa.

(7) The brain of the chilled pupa, Br*, was transplanted into the non-chilled diapausing pupa.

(8) The brain of the non-chilled diapausing pupa, Br, was transplanted into

the decerebrated non-chilled diapausing pupa.

(9) The brain-suboesophageal ganglion complex of the non-chilled diapausing pupa, (Br+SG), was transplanted into the non-chilled diapausing pupa.

The treated pupae were reared in an incubator at 26°C. and the effect of the treatment was obsereved. To avoid the pupa to die by desiccation, sterilized distilled water was injected into the pupa occasionally.

## Results

The results of the experiments were presented in table 1. In this table, abbreviations represent as follows. +Br* represents the experiment in which the brain of the chilled pupa isolated on 5-th day of 26°C. incubation was transplanted into the intact non-chilled diapausing pupa. −Br represents the experiment in which the brain was removed from the non-chilled diapausing pupa. −Br+Br* represents the experiment in which the brain of the chilled pupa was transplanted into the decerebrated non-chilled pupa. −Br+(Br+SG)* represents the experiment in which a brain-suboesophageal ganglion complex of the chilled pupa was transplanted into a decerebrated non-chilled pupa. −Br+2 (Br+SG)* represents the experiment in which two Br−SG complexes of chilled pupae were transplanted into a decerebrated non-chilled pupa. −(Br+SG) represents the experiment in which Br−SG complex was removed from the non-chilled pupa. −(Br+SG)+Br* represents the experiment in which the brain of the chilled pupa was transplanted into the non-chilled pupa from which Br−SG complex was removed. −Br+Br represents the experiment in which the brain of the non-chilled pupa was transplanted into the decerebrated non-chilled pupa. −Br+(Br+SG) represents the experiment in which the Br−SG complex of the non-chilled pupa was transplanted into the decerebrated non-chilled pupa.

The symbols ⫲, ⫲, + and − represent the degree of the development, that the pupa developed to the imago, the imaginal organs were formed partially, the retraction of the skin occurred and no development of the pupa occurred respectively.

It is clearly shown in table 1 that no development of the pupa occurred in both cases, in the one of which the brain was removed from the non-chilled pupa and in the other of which the Br−SG complex was removed from the non-chilled pupa.

When one brain of the chilled pupa isolated on the 5-th day of the 26°C. incubation was transplanted into the intact non-chilled pupa, some of the recipient pupae developed, *i. e.* two pupae developed into imagin, 8 pupae formed imaginal legs and antennae, and 9 pupae developed slightly, while three pupae did not develop.

Table 1 development of the diapausing pupae with various treatments (*Samia cynthia pryeri*)

| treatment | number of pupae | survival period (days) | development +++ | ++ | + | − |
|---|---|---|---|---|---|---|
| +Br* | 22 | 23–100 | 2 | 8 | 9 | 3 |
| −Br | 21 | 28–126 | 0 | 0 | 0 | 21 |
| −Br+Br* | 12 | 29– 78 | 0 | 5 | 4 | 3 |
| −Br+(Br+SG)* | 12 | 36– 83 | 0 | 3 | 2 | 7 |
| −Br+2(Br+SG)* | 8 | 34– 80 | 0 | 2 | 0 | 6 |
| −(Br+SG) | 16 | 24– 83 | 0 | 0 | 0 | 16 |
| −(Br+SG)+Br* | 10 | 29– 87 | 0 | 3 | 2 | 5 |
| −Br+Br | 13 | 29– 75 | 0 | 0 | 0 | 13 |
| −Br+(Br+SG) | 6 | 48– 96 | 0 | 0 | 0 | 6 |

When the brain of the chilled pupa on 5-th day of 26°C. incubation was transplanted into the decerebrated non-chilled pupa, 5 pupae developed partially, 4 pupae developed slightly, while 3 pupae did not develop.

When the brain of the chilled pupa on 5-th day of incubation was transplanted into the non-chilled pupa of which Br−SG was extirpated, 3 pupae out of 10 pupae received the brain developed partially and 2 pupae developed slightly, while 5 pupae did not develop.

From these three experiments, it seems that the possibility of the secretion of a "diapause factor" or "diapause hormone" from either the brain or the suboesophageal ganglion of the diapausing pupa was not supported, for no increase of the effect of the activated brain upon the development occurred in the case that the brain was transplanted into the non-chilled diapausing pupa of which brain or Br−SG was extirpated.

When a Br−SG complex of the chilled pupa on 5-th day of incubation was transplanted into a decerebrated non-chilled pupa, out of the 12 pupae received the complex, 3 pupae developed partially and 2 pupae developed slightly, while 7 pupae did not develop.

When two Br−SG complexes of the chilled pupae on 5-th day of incubation were transplanted into a decerebrated non-chilled pupa, 2 pupae out of the 8 pupae received the complexes developed partially but the rest 6 pupae did not develop.

When a comparison of the results were carried out among the activated brain transplantation experiment, one activated Br−SG complex transplantation experiment and two Br−SG complexes, it seems that no significant difference is present. Therefore, the possibility of something acceleratory effect of suboesophageal ganglion through the nervous connection with the brain upon the

development of the pupa was not proved from these experiments.

## Discussion

It has been clarified by WILLIAMS, C. M. that the termination of the pupal diapause of cecropia silkworm, *Hyalophora cecropia*, was controlled by the secretory activity of the brain through the secretion of ecdysone from the prothoracic gland. He also discovered that the initiation and maintenance of the diapause had not to do with the secretion of some kind of inhibitory factor, but to do with the deficiency of some kind of activating factor in the diapausing pupa. ('46, '47, '52) The similar relation of the brain with the pupal diapause was found by FUKUDA, S. in another giant silkworm, *Samia cynthia pryeri*. ('59)

Opposing to the opinion of WILLIAMS on the role of the brain to the pupal diapause, HINTON, H. E. proposed a different theory on the diapause that the diapause occurred by "diapause factor" secreted from the suboesophageal ganglion of the insect. ('53, '57)

In results of these experiments, it seems that the possibility of the secretion of some "diapause factor" from either the brain or the suboesophageal ganglion of the diapausing pupa is not supported, for no increase of the effect of the transplanted activated brain upon the development was observed in the transplantation experiments to the pupa from which the brain or both brain and suboesophageal ganglion were removed. The results of these experiments consist with those obtained by WILLIAMS, C. M. and by FUKUDA, S.

Regarding to the secretion of "diapause factor" or "diapause hormone" from the suboesophageal ganglion, there are many detailed studies on the production of diapause egg in the silkworm, *Bombyx mori*. (FUKUDA, S. '51, '52, '53, FUKUDA, S. & TAKEUHI, S. '67, HASEGAWA, K. '52, '63, '64, YAMASITA, O. & HASEGAWA, K. '64a, '65b, HASEGAWA, K. & YAMASHITA, O. '65, ISOBE, M., HASEGAWA, K. & GOTO, T. '73) In the pupal diapause of this insect, however, it seems that "diapause factor" or "diapause hormone" is not secreted from the suboesophageal ganglion.

When the effect of the transplantation of the brain of the chilled pupa into the pupa extirpated of its brain was compared with that of the transplantation into the pupa extirpated of its Br–SG, the former appeared to be more effective than the latter. It seems, however, that this difference does not result from the activating effect of the existence of the suboesophageal ganglion, but it results from the inhibitory effect of the more serious injury of the extirpation of the Br–SG.

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