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SOME ASPECTS OF INFLUENCE OF PHOTOPERIOD ON MUGA SILKWORM, *ANTHERAEA ASSAMA* WESTWOOD (LEPIDOPTERA : SATURNIIDAE)

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The role of photoperiod on the developmental processes as well as in the induction of pupal diapause in *A. assama* is presented. Photoperiods of short day lengths (of high intensities though slow down developmental rates, are not effective in the induction of pupal diapause, while short-day photoperiods of very low intensities are only effective in inducing diapause in this insect The effect of photoperiod on egg-laying and hatching is also discussed in this study.

INTRODUCTION

Light and temperature are the two important factors for the regulation of developmental processes in insects. The review works of Danilevskii (1961), Beck (1968), Lees (1968), Tyschenko (1977) and Saunders (1982) sufficiently focus these areas. Working on *Antheraea pernyi* and *Antheraea ployphemus*, Mansingh & Smallman (1971) demonstrated that the photoperiodic influence on saturniids would be modified or nullified by temperature. On the other hand, the work of Tyschenko (1977) indicates the qualitative and quantitative importance of photoperiodic action on insects.

The present finding incorporates the action of light and temperature on development, growth, incidence of pupal diapause and oviposition in muga silkworm.

MATERIAL AND METHODS

Cocoons of the normal variety of muga silkworm were collected from local rearers as well as from the Government farm of Khanapara, Assam. Care was taken to avoid inbreeding of the insect, since inbred population seems to be more prone to infection. The wild variety was collected from the forest region of Tura district of Meghalaya in the Cocoon (diapausing) stage.

Rearing of the insect was maintained in light–proof wooden chamber located in an airconditioned room. Each cabinet had a working space of 57 × 68 × 55 cm and was equipped with fluorescent tube/lamp of different wattages wired to externally fitted time–switches. The design of the rearing cabinet has been adopted from the original design of Dr. Goryshin, Leningrad State University. Temperature and humidity in the rearing cabinets were maintained at desired levels. The caterpillars were fed on the levels of *Som (Machilus bombycina)* or *Soalu (Litsaea polyantha)*, as the natural diet. Branches of suitable size of the food plants were first washed in water and subsequently in 0.13% tetracycline hydrochloride to avoid infection. The branches were then kept in bottles containing water. The caterpillars of the respective photoperiods were then transferred into the leaves/branches. The same method was adopted almost every day.

OBSERVATIONS

Rate of development in relation to photoperiod and temperature

Normal veriety of *A. assama* : The rate of development of the normal variety of *A. assama* seems to be photoperiod dependent. Table I shows that the developmental rate of the insect was determined by the photoperiodic regimes; mean duration of time taken by each larval instar as well as by pupal or adult stage was the longest under short photoperiod (L : D 6 : 18) of 15 lux, while it was the shortest under long photoperiod (L : D 16 : 8) of 1000 lux. On the other hand, the length of life–time of each stage in L : D 8 : 16 photoperiod of 800 lux stands between L : D 6 : 18 and 16 : 8 of 15 and 1000 lux, respectively.

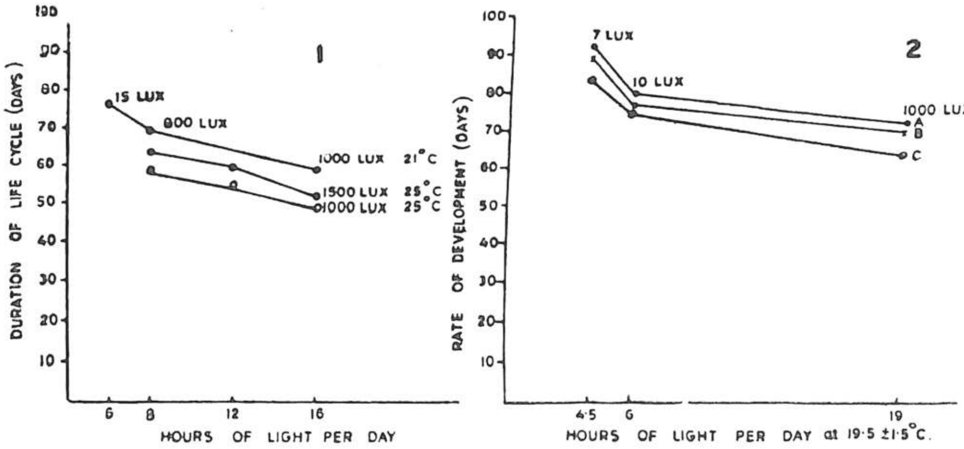
Fig. 1 represents the findings of a series of experiments performed in different photoperiods of various light intensities and at two different temperature conditions so as to recognise the light and temperature relationships in the development of muga silkworm. It is interesting to note that comparison of data obtained from two different temperatures (21 and 25°C) reveals that the duration of life–cycle of the insect maintained in 16 and 8 hr of light of 1000 lux at 25°C was shorter than that of 21°C. This resulted that temperature enhanced the developmental proceses of *A. assama*. It is to be noted that the rate of development of the insect reared in similar photophases of dissimilar intensities, at the same

Table I. Mean duration in days required by each stage of life-cycle of *A. assama* at different regimes and intensities of light at 21 ± 1.5°C.

Photo-period (L : D)	Light intensity (lux)	Instars					Prepupal	Pupal	Adult	
		I	II	III	IV	V			Male	Female
16 : 8	1000	4.17±0.49	5.05±0.47	5.18±0.51	7.24±0.66	15.05±2.66	5.4±0.49	17.18 ±0.78	6±0.32	6±0.83
8 : 16	800	4.32±0.65	5.20±0.67	7.20±1.36	7.43±0.72	15.88±2.13	6±0.63	22.12 ±0.83	6.57 ±0.9	8.09 ±0.79
6 : 18	15	5.18±0.67	5.34±0.62	7.52±0.72	8.72±0.69	19.12±1.87	29.09 ±0.83	7.57 ±0.9	7.57 ±0.9	9±1.26

temperature of 25°C, is not similar. At high intensity (1500 lux) the development was slower than at low intensity (1000 lux).

Wild, semi-wild and normal varieties of *A. assama* : In another series of experiments an attempt was made to ascertain the developmental rate of three different varieties of muga silkworm at similar rearing conditions, the findings of which



Figs. 1–2. **1**. Developmental rate of normal variety of *A. assama*. **2**. Developmental rate of 3 different varieties of *A. assama* (A=Normal, B=Semiwild, C=Wild).

are presented in Fig. 2 The sole objective of these experiments was to induce diapause in the insect of different varieties, mainly in the photophases of low intensity. It has been observed that the rate of development of the wild variety was the fastest, the rate of semi-wild variety was intermediate between that of the wild and normal. In other words, the rate was slowest in the normal variety.

Photoperiodic induction of diapause

Fig. 3 depicts the observations on the incidence of diapause of three varieties of muga silkworm in different conditions. Initially, attempts were made to induce diapause in these varieties of *A. assama* in short (L : D 8 : 16 and 12 : 12) and long-day (L : D 16 : 8) light periods of 1500, 1000 and 800 lux at 21 and 25°C. However, these conditions proved to be ineffective to induce diapause, except that the growth as well as developmental rate was slightly delayed in those short-day photoperiods. Subsequently, the light intensity was reduced to its minimum by using fluorescence bulbs of 15 wattage (Figs. 1, 2 & 3). In doing so, it was realised that short photoperiods of low intensity (L : D 4.5 : 19.5 of 7 lux, 6 : 18 of 15 lux) induced diapuse of varying degrees (durations).

The relation between temperature and photoperiod in diapause induction could not be reported in the present investigations. However, these findings will be reported elsewhere later.

Larval weight and photoperiod

Table II represents the findings relating to the weight of the late 5th instar larvae of the three varieties of *A. assama* reared in 3 photoperiods (L : D 19.5 : 4.5, 6 : 18 and 4.5 : 19.5) at 19±1.5°C. The weight of both male and female sexes was taken separately to know the sex-specificity in different photoperiods. As expected, the larvae of the wild population were heavier than that of the other two populations, except the larvae of the normal variety reared in 4.5 hr photophase where they were slightly heavier than that of the wild and semi-wild varieties.

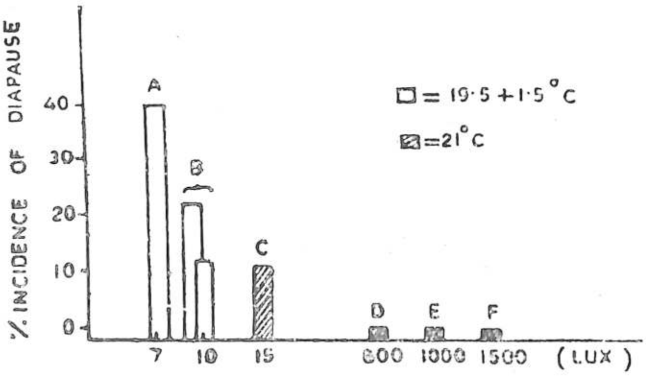


Fig. 3. Diapause incidence in *A. assama* (Hours of light per day : A=4 5 hr, B=6 hr, C=6 hr, D=8 hr, E=8 & 16 hrs. It is to be noted that E & F include both short and long photoperiods).

Photoperiod and egg-laying

The egg-laying capacity of females in long (L : D 16 : 8 of 1000 lux) and short (8 : 16 of 800 lux, 6 : 18 of 15 lux) photoperiods at 21±1.5°C indicates that short-day females in this temperature produced more eggs than the long-day ones (Table III). The observations were supported by the data obtained from another series of experiments done on long (19 5 hr) and short

Table II. Influence of Photoperiod on the weight of 5th instar larvae of 3 varieties of *A. assama* (19±1.5°, RH 70±5%).

Photoperiod	Light intensity (lux)	Variety of *A. assama*	Larval weight (gm)	
			Male	Female
19.5 : 4 5	1000	Wild	12.242	17.359
		Semi-wild	11 562	15.312
		Normal	11.534	12.736
6 : 18	10	Wild	13.080	17.118
4.5 : 19.5	7	Wild	13.762	16.136
		Normal	14.181	19.865

Table III. Influence of photoperiod on egg–laying of *A. assama* (21 ± 1.5°C : RH 65 ± 5%)

Photoperiod (L : D)	Light intensity (lux)	Average No. of eggs laid/female
16 : 8	1000	139.4
8 : 16	800	201.75
6 : 18	15	218.87

Table IV. Effect of photoperiod on incubation and hatchability of eggs of *A. assama* at 19 ± 1.5°C : RH 75 ± 5%

Photo-period (L : D)	Light intensity (lux)	Average No. of eggs laid/female	Incubation period (days)	Hatchability		
				Percentage of eggs hatched	Percentage of eggs developed but remained unhatched	Percentage of eggs undeveloped
19.5 : 4.5	1000	221.06	10–11	100	—	—
6 : 18	10	216.005	13–14	96.58	2.57	0.858
4.5 : 19.5	7	236.00	14–15	81.786	13.214	5.0

photoperiods (6 hr of 10 lux and 4.5 hr of 7 lux) at 19±1.5°C as illustrated in Table IV.

Incubation and hatchability in relation to photoperiod

The photoperiods seem to have a role in the incubation and hatching processes in *A. assama*. The incubation period in long photoperiod (19.5 hr) ranges from 10–11 days, while under 6 and 4.5 hr of light it was between 13–15 days. A similar photoperiodic action could be seen in regard to hatchability of eggs (Table IV). The percentage of hatching was the lowest (81.7 percent) in short photoperiod (4.5 hr) of 7 lux, while in 6 hr light (regime) of 10 lux it was 96.5 percent, but in long photoperiod (19.5 hr) of 1000 lux the hatchability was 100 percent.

DISCUSSION

The findings reported here suggest that growth and development of 5th instar larvae of muga silkworm have a direct relationship with photoperiod, although the effect of temperature cannot be lost sight of.

The effects of photoperiod on the growth and development have been shown in several species of insects. The pioneering works of Geyspits (1953) and Danilveskii (1961) showed that short photoperiods slowed down the development processes, while long photoperiods accelerated them. The present results on muga silkworm obtained in various photoperiodic conditions are consistent with that of many other insects.

On the other hand, the difference in the rate of development of the 3 varieties of muga silkworm (wild, semi-wild and normal) is quite conceivable. Since the wild variety was collected from the natural condition, it still retained its natural vigour even after being exposed to different laboratory conditions, and, therefore, developed at the fastest rate as against semi-wild and normal varieties. The hybrid vigour of the semi-wild type occupied an intermediate position between the wild and normal varieties.

The incubation period of the eggs was distinctly dependent on photoperiod (Table IV). The rate of hatching of the eggs also seemed to depend on photoperiod. However, it appears to be difficult to provide any explanations as to why a sizeable number of eggs failed to hatch in short-day photoperiods (4.5 and 6 hr) of low intensity of light.

While Chaudhuri (1970) made an unconfirmed report that pupal diapause occurs in muga silkworm, Tyschenko (personal communication) is of the opinion that it is a non-diapausing insect.

Fig. 3 shows that short-day photoperiod of high intensity were of no consequence in the induction of diapause in this insect. By contrast, short photoperiods of very low intensity could induce diapause. Long day-lengths of both high and low intensities were of no effect in diapause induction (Unpublished data). The reason of incidence of small percentage of pupal diapause in this insect could not be provided in this study.

While emphasizing the influence of photoperiod in terms of intensity, the role of temperature in the induction of pupal diapause in muga silkworm cannot be ruled out. However, the works of Danilevskii (1968) on 20 insect species demonstrated that photoperiod was the main factor in the induction of diapause. Inspite of its dominant role, the threshold of photoperiodic reaction could be changed by temperature level.

Assumption can therefore be made that the prevalence of low intensity of light accompanied by dense forest and low temperature during winter months beginning from mid-October to late February in the foot-hill regions of Assam and Meghalaya States cause the incidence of pupal diapause in the wild variety of this insect. It seems that the intraspecific difference in the adaptive mechanism between the wild and normal varieties of muga silkworm might, therefore, be the result of the climatic zones the species inhabit. Similar observations were also made by Danilevskii (1968) and Danilevskii & Kuznetsova (1968) on 2 varieties of *Pieris rapae*. According to them, these local races did differ in the threshold of photoperiodic reaction. It is therefore, not surprising to find that the wild population undergoes diapause in this locality, whereas the normal one does not do it in the plains of Assam.

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REFERENCES

BECK, S D. 1968. Insect Photoperiodism, Academic Press, New York.

CHOUDHURI, S. N. 1970 *ERI, MUGA, PAT.* Assam Science Society (in Assamese)

DANILEVSKII, A. S 1961. Photoperiodism and Seasonal Development of Insects English Translation, 1965. Oliver & Boyd, Edinburgh, London.

1968 The system of ecological adaptations of insects to the seasonal climate. XIII *Int. Entomol. Conf.*, Moscow. Reproduced in "Problems of Photoperiodism and Diapause of Insects". Leningrad University (in Russian). pp. 15–25.

DANILEVSKII, A. S. & KUZNETSOVA, I. A. 1968. The intraspecific adaptations of insects to the climatic zonation. In "Photoperiodic Adaptations of Insects and Ticks". Leningrad University (in Russian). pp. 3–51.

GEYSPITS, K. P. 1953. Reaction of univoltine lepidopterans in continuous day-lengths. *Entomol. Obzr.* **33** : 17–31 (in Russian).

LEES, A. D. 1968. Photoper iodismin insects. In "Photophysiology" Academic Press New York. pp. 47–137.

MANSINGH, A. & SMALLMAN, B. N. 1971. The influence of temperature on the photoperiodic regulation of diapause in saturniids. *J. Insect Physiol.* **17** : 1735–1739.

SAUNDERS, D. S. 1982. Insect Clock, Pergamon Press. pp. 137–192.

TYSCHENKO, V. P. 1977. Physiology of Photoperiodism in Insects. Published by "Science" Leningrad (in Russian).