THE EFFECTS OF PHOTOPERIOD ON THE INITIATION OF PUPAL DIAPAUSE IN THE WILD SILKWORM, *ACTIAS LUNA*

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During 1950 and 1951, Tanaka published a series of five papers (reviewed by Lees (1955) and Williams & Adkisson (1964)) demonstrating that photoperiod affects the initiation of diapause in the silkworm, *Antheraea pernyi* Guérin-Méneville. Since I found no literature as to whether photoperiod also affects the larvae of *Actias luna* (Linnaeus), the following experiment was carried out.

A total of 51 *A. luna* ova from Des Moines, Iowa, was obtained from Mr. Duke Downey. The first 13 hatched on June 6, 1966, 22 more hatched on June 7, and by June 8, a total of 40 had hatched. On that date, the larvae were divided among four fish tanks and exposed to 0, 11, 16, or 24 hours of illumination each day. Twelve larvae were put into each of the containers exposed to 11 and 16 hours of light, 8 each were put into the tank exposed to continuous light and the tank exposed to continuous darkness. On June 9, 2 more larvae hatched. One was put in the container with the 16 hour photoperiod, the other in the container exposed to continuous light.

All larvae were fed washed bitternut hickory leaves, stems of which were put through holes in the tops of plastic boxes containing water. The tanks were covered with mosquito netting and kept indoors at a temperature which varied from about 20°C to 30°C. The tanks were cleaned and the larvae were fed at frequent intervals. Each tank received about 50 foot candles of illumination from two 40 watt GE F400W fluorescent cool white lamps hung about four feet above the containers. The 11- and 16-hour photoperiod containers were covered with cardboard boxes at 6:00 P.M. and 11:00 P.M., respectively, and uncovered each morning at 7:00 A.M. The container with continuous darkness was kept covered except for 5-10 minutes each day for observation and feeding purposes.

Richter (1966) and Seeley (1963) state that *A. luna* larvae take 48–50 days from hatching to spinning. My individuals began spinning cocoons after an average of 27 days, and some after no more than 25 days following hatching of the eggs. (Table I). Those exposed to the 16 hour photoperiod took the shortest time, those exposed to the 11 hour photoperiod were second, those in complete illumination were third, and those in complete darkness took the longest time.

After 14 days, each cocoon was put in a container exposed to an 11

TABLE I. DATES OF COMMENCEMENT OF COCOON CONSTRUCTION (LARVAE BEGAN FEEDING JUNE 6–9).

Photoperiod	July 1	2	3	4	5	6	7	8	9	Total
24 hrs	0	2	2	0	0	2	0	0	1	7
16 hrs	4	2	3	0	1	0	0	0	0	10
11 hrs	0	1	3	5	2	0	0	0	0	11
00 hrs	0	0	0	2	0	1	2	2	0	7

hour photoperiod. It was felt that after 14 days, diapause or non-diapause would have been decided and these conditions would allow non-diapause pupae to emerge while preventing the termination of diapause in the others.

As summarized in Table III, all individuals that had been exposed to the 16 hour photoperiod emerged as adult moths within 15–21 days after the spinning date. Those whose larvae had been exposed to continuous illumination emerged from their cocoons in 17–25 days. It was concluded that both of these photoperiods successfully prevent the onset of pupal diapause. By contrast, none of those whose larvae were reared under the 11 hour photoperiod had emerged five months after spinning. All these pupae appear to be in diapause. Of the seven individuals reared in continuous darkness, the first two to spin emerged as adults in 17 days. The other five have not emerged and appear to be in diapause. The data are reported in Tables II and III.

A number of other interesting observations were made:

(1) Collins and Weast (1961) stated that *A. luna* larvae become reddish-brown immediately before spinning. In this experiment, I observed red larvae only in the 11 hour photoperiod, in which all of the pupae entered diapause. Since no red larvae and a number of green spinning larvae were observed in the tanks receiving 16 and 24 hours of illumination, it appears that the larvae turn red only when they are destined to enter diapause as pupae.

TABLE II. SURVIVAL RATE OF LARVAE AND NUMBER OF DIAPAUSING COCOONS

Photoperiod	Original Number	Number Spinning	Survival %	Number in Diapause	% in Diapause
24 hrs	9	7	78	0	0
16 hrs	13	10	77	0	0
11 hrs	12	11	92	11	100
0 hrs	8	7	88	5	71

TABLE III. PERIOD OF DEVELOPMENT OF NON-DIAPAUSE PUPAE

Complete Light		16 Hr Photoperiod		Complete Darkness	
Date Spun	Days to Hatch	Date Spun	Days to Hatch	Date Spun	Days to Hatch
July 1	19	July 1	16, 17, 18, 18	July 4	17, 17
2	20	2	19, 21		
3	19, 25	3	15, 18, 19		
6	18, 19	5	17		
9	20				
Average	20	Average	18	Average	17

(2) Collins and Weast also state that single brooded cocoons are always brown in color and are usually spun on or near the ground. By contrast, non-diapausing cocoons that emerge in late summer are nearly white and are spun in the leaves. In agreement with Collins and Weast, those cocoons from the 16 and 24 hour photoperiod containers were light colored and were spun mostly among the leaves. As mentioned above, all these developed without diapause. Those from the 11 hour photoperiod were brown and most were spun attached to the fish tank or water container. All these were diapausing pupae. Those given complete darkness were all brown, but most were spun on the leaves.

(3) In the container exposed to complete darkness, the red spots that appeared in the second, third, fourth and fifth instars in the *A. luna* larvae in the other containers, were not present until the fifth instar. Instead, they were a yellowish color in the early stages.

(4) One double cocoon was spun, containing two pupae and no partition between them.

SUMMARY

Tanaka discovered that *Antheraea pernyi* larvae develop without pupal diapause when they are reared under day-lengths longer than 14 hours (early summer), but transform into diapausing pupae when reared under day-lengths of less than 14 hours (late summer and autumn). My experiments show that *Actias luna* larvae also develop without pupal diapause when reared under long day-lengths (16–24 hours), but go into diapause when reared under short day-lengths (11 hours). Tanaka also showed that only 2% of the *A. pernyi* larvae kept in continuous darkness developed into diapause pupae. In my experiment, 71% of the *A. luna* in continuous darkness went into diapause.

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OBSERVATIONS ON *ŒNEIS MACOUNII* (SATYRIDAE) IN MANITOBA AND MINNESOTA

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Referring to the popular reference works, little can be ascertained concerning the bionomics of *Œneis macounii* Edwards. Klots (1951) suggests that it favors grassy Canadian Zone meadows, perhaps wet or boggy ones; Ehrlich & Ehrlich (1961) refer to a northwestward range from northern Michigan and Minnesota; Holland (1931) indicates two localities, Lake Superior's north shore and the eastern base of the Rockies in Alberta; Macy & Shepard (1941) observe that it is found in wooded grasslands near the Nipigon River in Ontario.

It is thought that the field observations of the present authors will increase the published information concerning this species, especially since these observations are somewhat contrary to those previously recorded. Series of *macounii* were collected at widely separated points on June 26, 1966; 13 ♂ ♂ and 15 ♀ ♀ by Masters and Sorensen in Sandilands Provincial Forest, eight miles southeast of Richer in southeast Manitoba; 4 ♂ ♂ and 2 ♀ ♀ by Conway in the vicinity of McNair, Lake County, Minnesota.

The Sandilands colony was located with the help of C. S. Quelch, who knew of it from previous collecting. The locality is a large open jack pine forest near an acid bog. The two sexes possessed different types of flight behavior and habits. The sex of an individual in flight could be determined from a distance even though the sexes are nearly identical in macu-