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THE EFFECT OF PHOTOPERIOD ON *COCCINELLA TRANSVERSOGUTTATA* (COLEOPTERA: COCCINELLIDAE)

BY

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Diapause in *Coccinella transversoguttata* can be inhibited by exposing adult females to photoperiod regimens of LD 16 : 8 or 14 : 10 hours. The photoperiod regimen to which the immature instars are exposed has little effect on the diapause status of the adult female.

The purpose of diapause is to synchronize the life cycle of the organism with the seasons (Lees, 1955). Lees indicates that while diapause may be influenced by immediate environmental factors, such as temperature, food supply, and humidity, the length of day is a more consistant indicator of the seasons. Photoperiod, therefore, is probably the primary factor in the initiation of diapause. The stage of the insect sensitive to the photoperiodic induction of diapause and the photoperiod regimen which induces diapause vary from species to species. The photoperiod which induces or inhibits diapause may vary with the latitude.

Coccinellids of the subfamily Coccinellinae with the exception of the tribe Psyllobrini are predaceous (Arnett, 1960). The biology of predaceous Coccinellidae has been reviewed by Hagen (1962) and Hodek (1967). Hodek & Cerkasov (1961) showed that photoperiod, temperature, and food prevent or induce diapause in *Coccinella septempunctata*. McMullen (1967) determined that these factors affect diapause in *Coccinella novemnotata*, and that the adult from emergence to the seventh day of age is sensitive to diapause induction or inhibition. The importance of photoperiod on diapause induction and inhibition has also been studied in *Chilocorus bipustulatus* (Tadmor & Appleb um, 1971), *Chilocorus renipustulatus* (Pantyukhov, 1968) and *Hippodamia tredecimpunctata* (Storch & Vaundell, 1972). Lady beetles are the major predators of potato-infesting aphids in northeastern Maine. *Coccinella transversoguttata* is the largest and usually the most abundant predator in the potato fields. In North America, the subspecies *C. t. richardsoni* Brown prevails. The overwintering adults become active in late May or early June. The adults of the first generation appear in late June or early July, and second generation adults occur in late August. The purpose of the present investigation was to determine the effects of different photoperiods on diapause induction and inhibition in *C. transversoguttata*.

MATERIALS AND METHODS

The lady beetles used in these studies were collected as adults in potato fields in the vicinity of Presque Isle, Maine. Stock cultures of one male and one female were placed in ½ pint ice cream cartons with plastic tops and maintained in an incubator at a temperature of 21 ± 2° and a photoperiod regimen of 16 light : 8 dark (LD 16 : 8) hours. The beetles were fed daily an excess of green peach aphids, *Myzus persicae* (Sulzer). The aphids were reared on Chinese cabbage plants in a greenhouse.

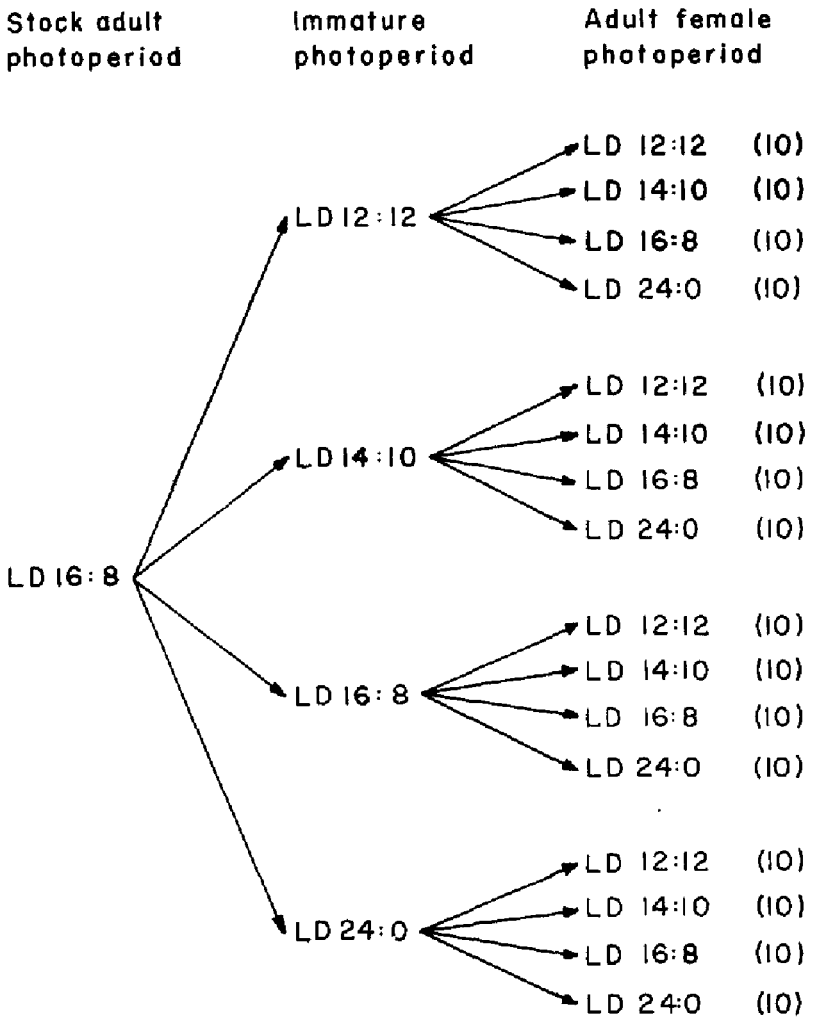

Fig. 1. Experimental procedure. Numbers in parentheses indicate the number of females tested in each replicate.

The experimental design was the same as used to study the effects of photoperiod on *Hippodamia tredecimpunctata* (Storch & Vaundell, 1972). The immature forms and adults were exposed to four photoperiod regimens; LD 16 : 8 (long day), LD 14 : 10 (intermediate day), LD 12 : 12 (short day), and 24 : 0 (continuous day) (Fig. 1). Larval and adult beetles were fed an excess of aphids daily. Eggs were collected each morning from the stock cultures and placed in the immature photoperiod regimen. Upon hatching the larvae were placed in 10-dram vials. Newly emerged adult females were placed in ½ pint cartons with plastic tops in the adult photoperiod regimen. After 10 days females were paired with adult males which had been reared in LD 16 : 8 immature and adult photoperiods. Eggs were collected each day and the numbers recorded for 20 days. Dead females were replaced by others reared under the same conditions. Each treatment was replicated three times.

Oviposition was used as the criterion to indicate the non-diapause condition. The females from one replicate were fixed in alcoholic Bouin's solution for dissection of the ovaries. The chi-square test was used to determine significant differences between the number of females ovipositing in each treatment. Differences in the total number of eggs deposited, the total number of days of oviposition, and the daily number of eggs per female for each treatment were compared by means of Duncan's Multiple Range Test. The student's *t* test was used to determine significant differences in the rate of larval development, length of the pupal stage, and number of females dying during the oviposition period for each treatment.

RESULTS AND DISCUSSION

The photoperiod to which the adults are exposed is responsible for diapause induction or inhibition (Table I). A significantly greater number of females oviposit when exposed to an adult photoperiod of LD 16 : 8 than when exposed to an adult photoperiod of LD 12 : 12. These data are in agreement with data for *Coccinella novemnotata* (McMullen, 1967), *C. septempunctata* (Hodek & Cerkasov, 1961), *Chilocorus bipustulatus* (Tadmor & Applebaum, 1971), *C. renipustulatus* (Pantyukhov, 1968), and *Hippodamia tredecimpunctata* (Storch & Vaundell, 1972). The immature photoperiod regimen has little effect in inducing or preventing diapause in adult females. Within a given adult photoperiod regimen, however, more adult females entered diapause when they were exposed to short day immature photoperiods. Beetles exposed to continuous day immature photoperiods reacted similarly. Continuous day adult photoperiods did not prevent a significant number of adults from entering diapause. The critical photoperiod for diapause induction or inhibition is probably between 13 and 14 hours of light per day in north-eastern Maine. The ovaries which were examined from diapausing females did not contain mature ova.

TABLE I

Effects of photoperiod on number of females ovipositing

Photoperiod treatment (larval/adult) (light : dark/light : dark)	No. of females tested	No. of females ovipositing	Test of significance at 0.05 level*
14 : 10/16 : 8	30	28	a
16 : 8 /16 : 8	30	24	ab
12 : 12/16 : 8	30	18	bc
24 : 0 /16 : 8	30	15	cd
12 : 12/24 : 0	30	14	cd
14 : 10/24 : 0	30	14	cd
16 : 8 /14 : 10	30	14	cd
14 : 10/14 : 10	30	10	de
24 : 0 /14 : 10	30	9	de
12 : 12/14 : 10	30	9	de
16 : 8 /12 : 12	30	6	e
24 : 0 /24 : 0	30	5	ef
16 : 8 /24 : 0	30	5	ef
14 : 10/12 : 12	30	1	fg
24 : 0 /12 : 12	30	0	g
12 : 12/12 : 12	30	0	g

* Differences between treatments were tested with the chi-square test. Two or more treatments sharing a common letter are not significantly different.

The number of eggs per female per day (Table II) did not differ significantly at the 5% level when tested with the Duncan's Multiple Range Test. Females exposed to a LD 16 : 8 adult photoperiod oviposited twice as often in the 20-day observation period as females exposed to a LD 14 : 10 photoperiod (Table II). The number of females which died during the oviposition period varied from one to six for a particular treatment. The student's *t* test indicated that there were no significant differences between deaths for a particular treatment.

The photoperiod regimen during the larval stages did not influence the rate of larval development. The same relationship was determined for *C. novemnotata* (McMullen, 1967), *C. septempunctata* (Hodek, 1958), and *H. tredecimpunctata* (Storch & Vaundell, 1972).

C. transversoguttata and *H. tredecimpunctata* are two native species of coccinellids which might be employed for control of potato-infesting aphids in Maine. These two species constituted about 95% of the coccinellid predators found in potato fields on the Aroostook Farm each year from 1955 to 1969 (Shands *et al.*, 1972). The percentage of each species varied from year to year. The efficiency of these coccinellids in capturing aphids has not been determined. Of these two species, *H. tredecimpunctata* can be reared more efficiently. When reared under the same conditions of photoperiod, temperature, and food, the *H. tredecimpunctata* females deposited twice as many eggs, twice as frequently as *C. transversoguttata* females in the 20-day observation period (Storch & Vaundell,

TABLE II

Rate of oviposition at different photoperiods

Photoperiod treatment (larval/adult) (light : dark/light : dark)	Total no. of eggs deposited	Total no. of days of oviposition	Daily rate of eggs deposited
12 : 12/16 : 8	3405 (18)	146	23.32
14 : 10/16 : 8	4228 (28)	173	24.44
16 : 8 /16 : 8	3828 (24)	173	22.13
24 : 0 /16 : 8	3534 (15)	118	29.95
12 : 12/14 : 10	1049 (9)	53	19.79
14 : 10/14 : 10	1863 (10)	76	24.51
16 : 8 /14 : 10	912 (14)	50	18.24
24 : 0 /14 : 10	1403 (9)	52	26.98
12 : 12/12 : 12	0 (0)	0	—
14 : 10/12 : 12	79 (1)	4	19.75
16 : 8 /12 : 12	353 (6)	24	14.71
24 : 0 /12 : 12	0 (0)	0	—
12 : 12/24 : 0	1905 (14)	82	23.23
14 : 10/24 : 0	1398 (14)	62	22.55
16 : 8 /24 : 0	380 (5)	21	18.10
24 : 0 /24 : 0	1262 (5)	48	26.29

Numbers in parentheses indicate the number of females which oviposited.

1972). If native species of coccinellids are to be supplemented by laboratory-reared beetles, *H. tredecimpunctata* can be cultured more economically.

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RÉSUMÉ

L'INFLUENCE DE LA PHOTOPÉRIODE SUR COCCINELLA TRANSVERSOGUTTATA *(COLEOPTERA : COCCINELLIDAE)*

Coccinella transversoguttata est un des plus importants prédateurs des Pucerons de la pomme de terre dans l'État du Maine (U.S.A.). C'est la photopériode à laquelle les adultes sont soumis qui conditionne la diapause imaginale de cet insecte : une photopériode jour/nuit de 16 : 8 heures empêche la diapause, alors qu'une photopériode jour/nuit de 12 : 12 heures déclenche la diapause. Un éclairement permanent n'a pas d'effet significatif sur l'inhibition de la diapause. La photopériode à laquelle sont soumis les œufs, les larves et les nymphes n'a guère d'effet sur la diapause des adultes. La photopériode n'a pas non plus d'influence sur le développement larvaire ni sur la mortalité des larves ou des adultes.

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