Ent. exp. & appl. **34** (1983) 9—12. *Ned. Entomol. Ver. Amsterdam*

SENSITIVITY TO PHOTOPERIOD IN RELATION TO DIAPAUSE IN *SEMIADALIA UNDECIMNOTATA* FEMALES

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Photoperiod has an important role in the regulation of reproductive activity in *Semiadalia undecimnotata*. Despite favourable temperature and food conditions, oviposition was permanently prevented in 10% of ♀♀ and substantially delayed in 86% of ♀♀ at 12 L : 12 D. Short day did not prevent a gradual onset of oviposition after 60.3 days on the average. Fecundity in short-day ♀♀, after such a long pre-oviposition period, was almost twice as high as in long-day females, and also the oviposition rate was substantially higher.

KEY WORDS: Coccinellidae — *Semiadalia undecimnotata* — Oviposition — Fecundity — Pre-oviposition period — Post-oviposition period — Diapause induction, prevention, termination, development — Estivo-hibernation — Aphids.

Adult dormancy in *Semiadalia undecimnotata* (Schneider) is accompanied by migrations to prominent features in the landscape where the beetles stay in large aggregations for 8—9 months in estivo-hibernation (Hodek, 1973). Although several studies on *S. undecimnotata* have been concerned with this phenomenon (last one: Iperti & Hodek, 1976), the factors governing diapause induction are not yet well understood.

In populations from central Europe, short photoperiod (12 L : 12 D) exerts an inhibitory action in the first half of the estivo-hibernation (still in November) (Hodek & Růžička, 1977), but does not affect the reproduction of overwintered adults in spring (Hodek & Růžička, 1977). The importance of nutritive signals for diapause induction has been proven (Iperti & Hodek, 1974; Rolley *et al.*, 1974). The experimental analysis reported here is a first attempt to identify the role of photoperiod in diapause induction.

MATERIAL AND METHODS

The experimental adults were descendants of diapausing insects collected early in August 1979 in estivo-hibernation quarters in SE France (Cousson near Digne) and activated at 25° and 18 L : 6 D. They began to lay eggs late in September and eggs for the experiment were collected in mid-October. Larvae, pupae and adults were exposed to stationary photoperiods, 12 L : 12 D or 18 L : 6 D at 25 ± 1°. Both the larvae and adults were fed with aphids (*Aphis fabae*) reared on young horse bean (*Vicia faba*) seedlings at 18 L : 6 D and 25 ± 1°. The adults were reared in individual pairs in circular boxes (125 ccm). Both series comprised 30 pairs at the beginning of the experiment. One experimental female was lost early in the oviposition period. The aphids were supplied and eggs were counted after 24 and 48 hr, on Mondays after 48 hr. The term diapause is used in the context of with the general definitions given by Beck (1980), with particular characteristics of adult diapause (Hodek, 1983) and with the characteristics of diapause in Coccinellidae (Hodek, 1973).

RESULTS

Pre-oviposition period. Delay in the onset of oviposition was strikingly different with the two photoperiods used (Fig. 1). All ♀♀ oviposited at 18 L : 6 D and the duration of the pre-oviposition period ranged between 4 and 14 days with an average of 7.7 days. Three ♀♀ did not oviposit at 12 L : 12 D; the pre-oviposition period in the other 26 ♀♀ ranged between 5 and 121 days, with an average of 60.3 days.

Oviposition and post-oviposition periods. The average length of the oviposition period was much shorter under long photoperiod, although the range was similar (Table I) and indicated a high variability. The duration of the

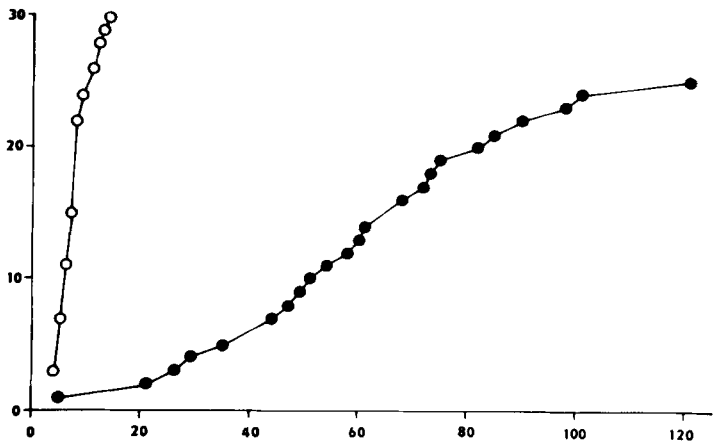

Fig. 1. Duration of pre-oviposition period in *S. undecimnotata* at 25 ± 1°, under 12L : 12D (solid circles) and 18L : 6D (open circles). Ordinate: accumulated number of ovipositing ♀♀. Abscissa: days.

TABLE I

Comparison of reproductive activity of S. undecimnotata *reared at 25 ± 1° and 12L : 12D or 18L : 6D*

Photophase	n		Duration of period of oviposition			Fecundity
			pre-ov. (days)	ov. (days)	post-ov. (days)	(eggs/♀)
12L	25	aver.	60.3	38.5	2.7	823.6
		med.	61	39	3	789
		range	5—121	7—78	1—9	35—2277
18L	30	aver.	7.7	25.5	2.9	454.5
		med.	7.5	23	3	414
		range	4—14	4—71	1—7	65—1284

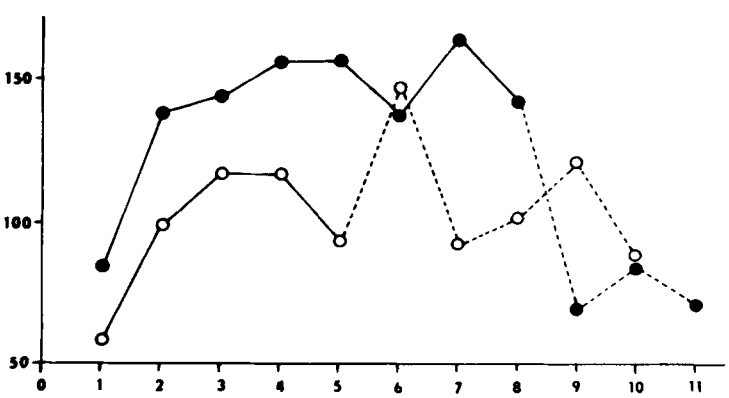

Fig. 2. Oviposition rate in *S. undecimnotata* at 25 ± 1°, under 12L : 12D (solid circles) and 18L : 6D (open circles). Ordinate: average number of eggs/♀/week. Abscissa: weeks of oviposition. Dotted line: fewer than 10 ♀♀. Oviposition by individual ♀♀ aligned for an uniform start.

post-oviposition period was very similar with both photoperiods.

Fecundity and oviposition rate. Fecundity at the short day was almost twice the value achieved under long-day conditions (Table I). This was caused not only by shorter duration of the oviposition period — also the oviposition rate was substantially higher during the short day (Fig. 2).

DISCUSSION

Prevention and induction of diapause. Although the experimental design (constant high temperature, stationary short photoperiod, laboratory-reared prey) simulates natural conditions rather crudely, a comparison of the short-day experiment with the long-day control gives unambiguous evidence of the important role of photoperiod in the regulation of diapause in *S. undecimnotata*. In only one experimental ♀ was the pre-oviposition period similar to controls (5 days). Reproduction was significantly inhibited in all the other experimental ♀♀, favourable temperature and nutrition notwithstanding. Oviposition was permanently prevented in 10% of experimental ♀♀, in 86% it was delayed by various intervals but it always differed significantly from the control. Also in 4 experimental females with a relatively short pre-oviposition period (21—35 days) the beginning of oviposition was much more delayed than in the "latest" control females (14 days) (Fig. 1).

The onset of adult diapause in *S. undecimnotata* thus appears to be facultative, being easily prevented if environmental conditions are maintained in the "stimulatory" (non-diapause) range. Although the experiment was not designed to discriminate between the roles of individual factors (photoperiod, temperature, nutrition) in diapause induction, the inhibition or considerable delay of reproductive activity in 96% of experimental females (reared at non-diapause temperature and nutrition) indicates that these two factors play a secondary role, while photoperiod has a major function.

Under natural conditions, the inductive effects of short photoperiod are evidently reinforced in *S. undecimnotata* by nutritive signals (Iperti & Hodek, 1974; Rolley *et al.*, 1974) and probably also by a switch to migratory behaviour.

Termination of diapause. The diapause-promoting photoperiod combined with a relatively high constant temperature did not prevent the onset of reproduction in at least 86% of females, i.e. it enabled both gradual termination of diapause and post-diapause development. The mechanism of photoperiodic regulation of reproduction thus resembles that occurring in e.g. *Metaseiulus occidentalis* (Hoy, 1975), *Psylla pyri* (Nguyen, 1975), *P. pyricola* (McMullen & Jong, 1976), *Aleyrodes brassicae* (Iheagwam, 1977), *Aelia acuminata* (Hodek, 1979) and *Oniscus asellus* (McQueen & Steel, 1980).

With the exception of two females, oviposition was not interrupted by ovipositional arrests, so that the recurrent photoperiodic response (discovered in Aelia acuminata, Hodek, 1971, 1983) does not seem to play role in the life-cycle of *S. undecimnotata.*

Diapause development and fecundity. The values of all reproductive parameters were substantially higher under short-day conditions. This may seem surprising considering the accelerating effect of the long day on the onset of oviposition (Fig. 1). In contrast to *Coccinella septempunctata* (Hodek & Růžička, 1979), *S. undecimnotata* has been found insensitive to photoperiod after the end of hibernation in central Europa, and fecundity was even slightly higher under short day (Hodek & Růžička, 1977). The difference found here can hardly be ascribed to a direct action of the photoperiod. It might be speculated that under 18 L : 6 D the "precocious" photoperiodic activation within a week does not stimulate the neuroendocrine mechanism of reproductive activity in a similarly adequate way as the long pre-oviposition period (average of 60 days) during a diapause-promoting photoperiod.

RÉSUMÉ

Sensibilité photopériodique des femelles de Semiadalia undecimnotata *en pré-diapause et en diapause*

La photopériode joue un rôle important dans la régulation de la reproduction chez *Semiadalia undecimnotata* (Schneider). Malgré les conditions favorables de température et de nourriture, les jours courts (12L : 12D) empêchent définitivement l'oviposition chez 10% des femelles et la retardent considérablement chez 86% d'entre elles. Par contre, cette photopériode n'inhibe pas le commencement graduel de l'oviposition après un délai moyen de 60.3 jours. Après cette longue pré-oviposition, la fécondité des femelles exposées aux jours courts s'avère presque le double de celle enregistrée avec des individus soumis aux jours longs (18L : 6D); de même l'intensité d'oviposition se situe à un niveau sensiblement plus élevé.

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Accepted: March 31, 1983