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INSENSITIVITY TO PHOTOPERIOD AFTER DIAPAUSE IN *SEMIADALIA UNDECIMNOTATA* [*COL. COCCINELLIDAE*]

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To check the sensitivity to photoperiod in *Semiadalia undecimnotata* SCHNEIDER the beetles were transferred to laboratory short day (12 L: 12 D) and long day (18 L : 6 D) both during diapause (mid-November) and after diapause (in mid-May, when most females were still in their hibernation quarters and when the outdoor photoperiod was 16 hr 40 min.).

After diapause, most parameters of reproductive activity (fecundity, oviposition intensity, duration of pre- and post-oviposition periods) were identical at both photoperiods, indicating thus insensitivity to photoperiod. Only the incidence and duration of ovipositional arrests were higher under short-day conditions.

In the middle of diapause the sensitivity to photoperiod was still high, so that reproduction was inhibited under short day and 20°-24°C.

According to the conception of diapause termination it is generally assumed that post-diapause insects are indifferent to photoperiodic treatments. As contradictory results were found in the Heteropteran *Aelia acuminata* (HODEK, 1971) and in the Neuropteran *Chrysopa carnea* (HODEK & HONEK, 1976), we checked the sensitivity to photoperiod after diapause also in *Semiadalia undecimnotata* (SCHNEIDER).

MATERIAL AND METHODS

S. undecimnotata has a very long period of inactivity during aestivo-hibernation. This phenomenon was described in detail in previous papers and in a book (HODEK, 1973).

The adults of *S. undecimnotata* were collected in their hibernation quarter on the top of a volcanic hill near Louny (approx. 50 km northwest of Prague) on 16th May and 11th November 1974. In autumn we collected 10 females and 10 males for a comparative preliminary experiment checking the photoperiodic sensitivity during diapause. The spring sample (35 pairs) was collected after the onset of spring dispersal. This was indicated by the uneven sexual index : the sample contained only 26 % of males, which leave the hibernation quarter earlier than females. The experiments started on the day after collection. The coccinellids were confined in pairs in glass containers (100 cc) covered with nylon. They were provided with aphids (*Acyrthosiphon pisum* HARRIS) and drinking water. The aphids were supplied in surplus on seedlings of horse bean plants, *Vicia faba* L., which were inserted in a small tube fixed by a piece of plastic material. The rearing cells were examined and food was supplied daily (exceptionally after 2 days). The eggs were counted and removed with a fine

brush moistened with water. Hatching of eggs was checked. Despite an excess of aphids the coccinellids regularly fed on their own eggs. The remains of eaten eggs were included in the recorded number of eggs laid. When one adult died the pair was completed by a surviving beetle from other pairs.

Series of pairs of coccinellids were held in each of 2 incubators with different photoperiods. One group was exposed to short day (12 L : 12 D). The other group was kept under long day (18 L : 6 D). The photoperiodic regimen was maintained by a clock and two 40 W bulbs in each incubator. Due to the heat of bulbs, the temperature ranged during 24 hours between 20°C and 24°C in the "short-day" incubator, and between 21°C and 24.5°C in the "long-day" incubator.

RESULTS

Sensitivity to photoperiod after diapause

The beetles began to oviposit rather early under both light regimens (table 1). Only one female from the short-day series had a long pre-oviposition period of 38 days. Both the mean and median values indicate no difference between either series. The females mostly died soon after the end of the oviposition period. There is only a negligible difference in the duration of the post-oviposition period between long-day and short-day females.

The oviposition period (table 1) and the overall longevity of females were longer under short-day than under long-day conditions. During their longer life the short-day females laid also more eggs. Their fecundity was 14 % higher than the fecundity in long-day controls. Oviposition rate was, however, the same in both series (table 1).

Under short days, 9 females (26 %) stopped egg-laying and resumed after a delay of variable duration. In 6 females, this arrest of oviposition lasted 3-5 days, in 1 female 9 days and in another 36 days. The 9th female was very aberrant : its 3 oviposition periods (of 18, 25 and 30 days) were separated by intervals lasting 32 and 45 days. This female thus resumed oviposition on 1st October, whereas the last of other short-day females died on 23 August. Under long days, only 2 females (6 %) had short inter-ovipositional arrests of 4 and 5 days. If the average duration of inter-ovipositional arrest (longer than 2 days) is calculated for the whole samples, the difference is quite marked (table 1) : 0.3 days for long-day females and 4.2 days for short-day females (or at least 2.0 days, if the aberrant female is excluded).

During the 1st 8 weeks of experiment, the daily rate of oviposition was in most cases higher under long-day conditions. Only exceptionally was the oviposition intensity higher under short days, or identical under both light regimens. At the end of experiment, when long-day females were senescent and some had died, the situation was reversed.

Whereas there was a significant difference between the longevity of females under the 2 photoperiods, this was not so with males. Male longevity under different photoperiodic regimens was identical and it exceeded the female longevity (RUZICKA & HODEK, in prep.).

Sensitivity to photoperiod in diapause

In both series of this preliminary check coccinellid survival was poor and the experiment was discontinued after 5 weeks.

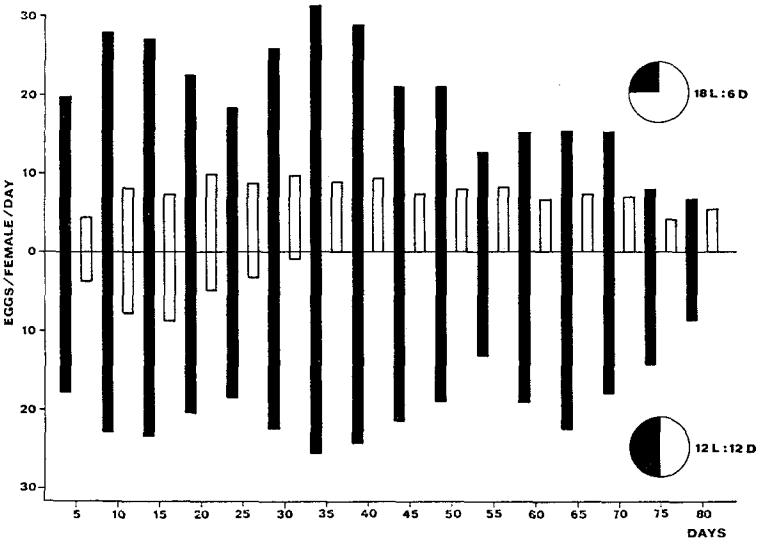

FIG. 1. Oviposition rate after diapause in *Semiadalia undecimnotata* and *Aelia acuminata* under long- and short - day conditions (see also table 1).

Each value represents daily average of oviposition rate for a period of 5 days. Solid columns : *S. undecimnotata*, open columns : *A. acuminata*. Under short days, the females of *A. acuminata* stop laying eggs, but live longer than under long days (HODEK, 1971 b).

Four females died soon after transfer to long-day conditions; their mean survival was 9.3 (8-14) days. The other six females oviposited; their mean pre-oviposition period was 24.2 (16-36) days. The median value was 21 days.

Under short-day conditions four females died after 12.3 (7-19) days but in contrast to the long-day group, none of the remaining six oviposited.

CONCLUSIONS AND DISCUSSION

In the middle of diapause (early November), the females of *S. undecimnotata* are still highly sensitive to photoperiod. If a moderately high temperature is used for activation (20°-24.5°C in our experiments), no oviposition starts within 5 weeks under 12 L : 12 D in contrast to activation of all females under 18 L : 6 D. This response may be modified by using higher temperatures, as was shown by IPERTI & HODEK (1976) who achieved oviposition of *S. undecimnotata* at 30°C even under short days in September.

The effect of photoperiod on flight development of *Coleomegilla maculata* (*Coccinellidae*) has a similar tendency. Short days exert a depressing effect on flight development early in winter, but later this effect disappears (SOLBRECK, 1974).

After hibernation the females of *S. undecimnotata* lack sensitivity to photoperiod almost completely by mid-May. All parameters of reproductive activity, as fecundity, oviposition rate (fig. 1), duration of the pre-oviposition and post-oviposition periods, were similar both under 12 L : 12 D and 18 L : 6 D. This indicates that the shortening of photophase by 4 3/4 h on transfer from the field had no inhibitive function. (The length of natural photophase at our latitude is 16 h 40 min on 15th May.).

TABLE 1

Reproduction in Semiadalia undecimnotata *after diapause under two photoperiods* (a)

Photoperiod	n	Pre-oviposition period (days) mean (range)	median	Arrest of oviposition (days) mean (range)	n	Post-oviposition period (days) mean (range)	Fecundity (eggs/♀) mean (range)	Rate of oviposition (eggs/♀/day) mean (range)	median
18 L : 6 D	33	9.8 (7—16)	10	0.3 (0—5)	2	0.2 (0—2)	914 (19-2258)	17.5 (1.5—30.9)	18.0
12 L : 12 D	35	11.0 (7-38)	10	4.2 (0-77)	9	0.7 (0-12)	1046 (151-2228)	17.4 (2.6—30.9)	18.3
	34 (b)	10.2 (b) (7-14)	10	2.0 (b) (0-36)	8 (b)				

(a) The beetles were collected in their hibernation quarters 16 May 1974 and reared as individual pairs. *Acyrthosiphon pisum* in surplus was given as food.

(b) One aberrant female was excluded from the calculation of the mean value.

The only measurable difference between animals reared under the 2 regimens was the higher occurrence of inter-ovipositional arrests under short day (table 1). As is explained under Material and Methods, the temperature was slightly higher in the incubator with long-day conditions than under short days. Although the photoperiod appeared responsible for the principal difference found, an additive effect of the difference in temperature is not excluded.

Compared with other insects studied by the same method, the neutral response to photoperiod after diapause is similar in *S. undecimnotata* to that of *Pyrrhocoris apterus* (HODEK, 1968, 1971 a). It has been supposed that terminaison of diapause is always accompanied by such a loss of photoperiodic response (DANILEVSKII & SHELDESHOVA, 1968; DE WILDE, 1969; WILLIAMS, 1969; ZASLAVSKII & BOGDANOVA, 1965). In contrast, we found high sensitivity to photoperiod in *Aelia acuminata* (HODEK, 1971 b), and in *Chrysopa carnea* (HODEK & HONEK, 1976).

The two migratory species were, however, under unequal conditions. While *A. acuminata* adults were collected soon after their migration from hibernation quarters to wheat fields (on 20th May), *S. undecimnotata* beetles were collected before spring migration when still in the hibernation quarter. The physiological state of diapausing adults is definitely changed by migration (JOHNSON, 1969) and this might contribute to some extent to the different photoperiodic response of both insects.

The adaptive function of different photoperiodic responses of *A. acuminata* and *S. undecimnotata* could be in their unequal longevity: the higher longevity of *A. acuminata* makes a 2nd hibernation of the same individual quite possible. Then the sensitivity to daylength would enable the photoperiodic induction of the 2nd diapause. In *S. undecimnotata*, a regular 2nd induction of diapause is not probable.

RÉSUMÉ

Non sensibilité à la photopériode après la diapause
chez *Semiadalia undecimnotata* [*Col.* : *Coccinellidae*]

Au cours de ce travail on a cherché à établir la sensibilité à la photopériode chez *Semiadalia undecimnotata* SCHNEIDER. Les insectes furent récoltés sur les lieux d'estivo-hibernation pendant (mi-novembre) et après la diapause (mi-mai) et placés au laboratoire sous une photopériode courte (12 J : 12 N) ou longue (18 J : 6 N).

Après la diapause, la plupart des caractères de l'activité reproductrice (fécondité, intensité de l'oviposition, durée des périodes des pré- et post-oviposition) sont identiques sous les 2 photopériodes et montrent une insensibilité des insectes à la photopériode. Seulement les arrêts de l'oviposition sont sensiblement plus fréquents et plus allongés sous la photopériode courte.

Au milieu de la diapause, la sensibilité à la photopériode est encore assez élevée et empêche la ponte sous une photopériode courte et à 20°-24°C.

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