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Photoperiodic sensitivity in adults of *Aelia fieberi* (Heteroptera: Pentatomidae)

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Ecophysiology, photoperiodic response, adult diapause, *Aelia fieberi*

Abstract. Photoperiodic sensitivity was examined in adults of a bivoltine bug, *Aelia fieberi* Scott, by exposing insects to long-day or short-day conditions at 25°C. The adult diapause of *A. fieberi* is facultative, induced by short-day photoperiod. Adults reared from eggs under long-day conditions began to lay eggs, whereas those reared under short-day conditions entered diapause. Both nondiapause and diapause adults were sensitive to photoperiod. The adults of the first and the second generation collected from the field were also sensitive to photoperiod. However, after overwintering, adults did not show photoperiodic sensitivity.

INTRODUCTION

Many insects entering adult diapause to overwinter lose photoperiodic sensitivity during autumn and winter, and photoperiod plays no role in starting oviposition in spring (Hodek, 1983; Tauber et al., 1986). Some of these species, however, regain the photoperiodic sensitivity after a period of postdiapause oviposition (e.g., Hodek, 1971, 1977; Numata, 1987; Ikeda-Kikue & Numata, 1992). Among them, *Aelia acuminata* (Heteroptera: Pentatomidae) shows a particular mechanism: Adults of this species lose and resume photoperiodic response intermittently, and may repeat alternation of oviposition and diapause under short-day conditions (Hodek, 1979).

A congeneric species, *Aelia fieberi*, produces two generations a year in Japan and overwinters as adults (Kobayashi, 1960). The question whether the intermittent character of photoperiodic response is common between two *Aelia* species leads us to the present study. First, we confirmed that *A. fieberi* also has an adult diapause. Then, we examined the photoperiodic sensitivity in adults of *A. fieberi* reared from eggs in the laboratory and those collected from the field in various times of the year.

MATERIAL AND METHODS

Adults of *A. fieberi* of first and second generations were collected after overwintering from a field in Osaka City (34°41′N, 135°31′E), Japan in 1991–1993. These adults were reared on wheat grains and water, as single male and female pairs in plastic cups (60 ml) under long-day (16L : 8D) or short-day (12L : 12D) conditions at 25 ± 1°C. Some of these adults were dissected and the diapause status was judged by the criteria used for another pentatomid bug, *Eurydema rugosa* (Numata & Yamamoto, 1990): Females without mature eggs or vitellogenic oocytes in the ovarioles and males without secretory fluid in the ectodermal sac of the accessory gland were judged to be in diapause.

The progeny of the field collected adults were reared on wheat grains and water from eggs under long-day or short-day condition at 25°C. The initial density of nymphs was 12 per cup. After adult emergence, the insects were reared as single male and female pairs. Fifteen days after emergence, some of these adults were dissected and their diapause status was determined. Some adults were transferred to the contrasting photoperiodic condition 15 days after emergence. The mortality and oviposition of adults were recorded daily.

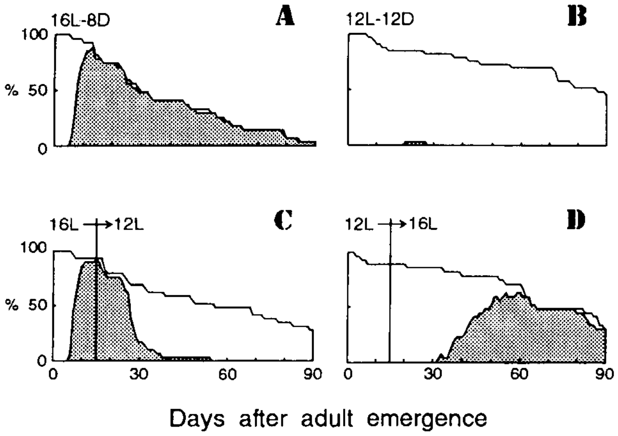

Fig. 1. Effect of photoperiod on the oviposition of *Aelia fieberi* reared in the laboratory from eggs (25°C). Shaded areas, ovipositing females; open areas, non-ovipositing females. n = 27–33.

RESULTS

Photoperiodic sensitivity of adults raised in the laboratory

Adults reared from eggs under long-day conditions started oviposition early after emergence and continued until death (Fig. 1A), although the results more than 90 days after adult emergence are not shown in the figure. We dissected 26 males and 25 females reared under long-day conditions 15 days after emergence and all these adults were reproductive. However, when kept continuously under short-day conditions, most adults never laid eggs (Fig. 1B). We dissected 29 males and 26 females reared under short-day conditions 15 days after emergence and all these adults were in diapause. When transferred from long-day to short-day conditions, they stopped oviposition, and entered diapause, and never resumed oviposition (Fig. 1C). When transferred from short-day to long-day conditions, they began to lay eggs (Fig. 1D).

Photoperiodic sensitivity of adults collected from the field

Adults of the first generation were collected from 18 to 20 July 1991 and 1993. Most adults had already started oviposition before collection. Under long-day conditions, the females continued oviposition until death (Fig. 2A), although the results more than 90 days after collection are not shown in the figure. Under short-day conditions, the females stopped oviposition and entered diapause (Fig. 2B). Thus, the adults of the first generation can respond to short-day conditions by entering diapause.

Then adults of the second generation before overwintering were collected from 21 August to 5 September 1993. Under long-day conditions, most females began to lay eggs (Fig. 2C), whereas under short-day conditions most females never laid eggs and eventually died (Fig. 2D) and the latter were considered as diapausing. Thus, the adults of the second generation before overwintering can respond to long-day conditions to terminate diapause.

We dissected 19 female adults after overwintering from 6 to 23 April 1992 and all were still in diapause. Adults collected from 25 March to 9 April 1992 were transferred to long-day or short-day conditions in the laboratory. Under both photoperiodic conditions, females started oviposition and continued it until death (Fig. 2E, F).

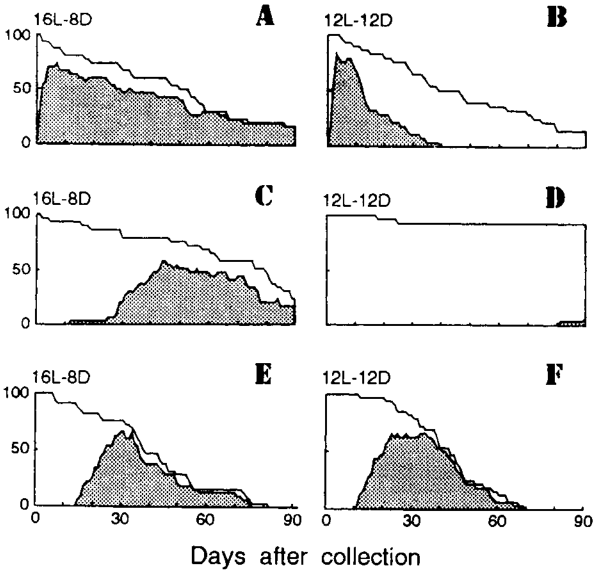

Fig. 2. Effect of photoperiod on the oviposition of *Aelia fieberi* collected from the field (25°C). Adults were collected in mid-July (A, B), from late August to early September (C, D), or from late March to early April (E, F). Shaded areas, ovipositing females; open areas, non-ovipositing females. n = 28–32.

DISCUSSION

A. fieberi shows a facultative adult diapause, and photoperiod controls its induction and termination. In the field, adults of the first and second generations did not enter and entered diapause, respectively. Adults of both generations were sensitive to photoperiod, and they maintained their sensitivity until death when reared at constant 25°C in the laboratory. However, the adults after overwintering were not sensitive to photoperiod. They should belong to the second generation from the previous year, since *A. fieberi* produces two generations a year (Kobayashi, 1960). Therefore, they had lost photoperiodic sensitivity during overwintering. Both the diapause adults collected in autumn and those reared in the laboratory did not lay eggs when kept continuously under short-day conditions at 25°C. Therefore it was the exposure to outdoor conditions during overwintering which promoted diapause development and removed the photoperiodic sensitivity.

Photoperiodic sensitivity after diapause termination under natural conditions varies among species, even if we restrict the examples to phytophagous heteropterans with overwintering adult diapause. 1) *Cletus punctiger* (Coreidae) and *Anasa tristis* (Coreidae) retain photoperiodic sensitivity throughout autumn, winter and spring (Ito, 1988; Nechols, 1988; Fielding, 1989). 2) *Pyrrhocoris apterus* (Pyrrhocoridae) and *Eurygaster maura* (Scutelleridae) lose photoperiodic sensitivity during autumn and winter irreversibly and never resume it after overwintering (Hodek, 1977; Hodek & Hodková, 1992). Hodek (1983) used a preliminary term "*Pyrrhocoris*-type" response. 3) *A. acuminata* loses photoperiodic sensitivity during autumn and winter, but regains it after a period of postdiapause oviposition (Hodek, 1971, 1977). Hodek (1979) called this type of response the recurrent photoperiodic response. In contrast, adults of *A. fieberi* lost photoperiodic sensitivity irreversibly during overwintering and continued postdiapause oviposition until death, both under long-day and short-day conditions. Thus, *A. fieberi* does not have a recurrent photoperiodic response but shows a *Pyrrhocoris*-type response, even though it is closely related to *A. acuminata* systematically.

The photoperiodic responses shown by *C. punctiger* and *A. tristis* have a different ecological significance from the other two types, since long-day photoperiod in spring is a major cue for initiating postdiapause oviposition. Although Hodek (1976) emphasized the difference between the photoperiodic response in *P. apterus* and that in *A. acuminata*, these two types are extremes of a continuous range: some individuals of *Dolycoris baccarum* (Pentatomidae), *Riptortus clavatus* (Alydidae), and *E. rugosa* show a *Pyrrhocoris*-type response and others show a recurrent photoperiodic response (Hodek, 1977; Numata, 1987; Ikeda-Kikue & Numata, 1992). Even in *P. apterus* itself, a small proportion of individuals may resume photoperiodic sensitivity (Hodek, 1974). Furthermore, a species with a typical *Pyrrhocoris*-type response and a species with a typical recurrent photoperiodic response exist within a single genus, *Aelia*.

In central Europe, *A. acuminata* has a univoltine life cycle, and adults of this species are long-lived and show high reproductive potential. Moreover, some adults most probably enter a second diapause in nature (Hodek, 1976). The recurrent photoperiodic response is essential for an insect that enters diapause more than once in its life (Hodek & Hodková, 1992). In Japan, however, the period suitable for reproduction of *A. fieberi* is long enough to produce two complete generations a year and adults after overwintering die before summer. As the life cycle of *A. fieberi* in Japan is quite different from that of *A. acuminata* in Europe, a mechanism for regaining photoperiodic sensitivity is useless for *A. fieberi*. The two types of post-diapause photoperiodic response are evidently adaptive mechanisms which evolve under the pressure of ecological conditions.

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