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Photoperiodic Induction of Aestivation in the Stink Bug *Picromerus bidens* (Heteroptera, Pentatomidae). A Preliminary Report

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Abstract—Nymphal growth and reproduction of predatory bug Picromerus bidens were studied under laboratory conditions of constant temperature (+23°C, +1°C) and two constant photoperiods (long day, 20L : 4D and short day, 12L : 12D). No difference was found in nymphal growth. All females from the short-day regime began oviposition in 16.4 + 2.33 days after adult moult. Reproduction continued up to females' death (about a month after their emergence). But females from the long-day delayed oviposition. Only 2 of 21 females laid eggs before the end of the experiment (35th day of adult life). The long-day delay of oviposition is considered an aestivation (summer diapause or oligopause). Probably, in nature early winged females enter aestivation in the beginning of summer and start oviposition in August–September when days become shorter. Later winged females begin reproduction without any delay.

Picromerus bidens L. (Pentatomidae) is a predatory bug widely spread in the Palearctic and unpremeditatedly introduced in North America. Throughout both the natural and adventive species area, it mainly occupies humid and shaded forests; though sunny and opened forest edges, meadows, and gardens with diverse vegetation can become its habitat as well (Puchkov, 1961; Javahery, 1986; Lariviere and Larochelle, 1989). *P. bidens* is a wide polyphagous species that preys on glabrous moving larvae and sometimes adults of many orders of insects (Puchkov, 1961; Lariviere and Larochelle, 1989).

The seasonal cycle of the species is usually considered univoltine with an obligatory egg diapause, which can be seldom found among pentatomids (Leston, 1955 and others). But the question is not quite clear. According to the literature, there are several registrations of active individual adults in early spring (Schumacher, 1910–1911; Butler, 1923—cited after Leston, 1955). Our studies of the collection of the Zoological Institute (Russian Academy of Sciences, St. Petersburg) confirmed registrations of *P. bidens* adults in different regions from April to May. Recently, M. -C. Lariviere and A. Larochelle (1989) supposed a parallel co-existence in nature of two independent seasonal cycles: a primary cycle with egg hibernation and a secondary one with hibernation of adults that had not been reproductively active. If the egg diapause is obligatory and prolonged cold exposure is required for egg reactivation (as is typical of winter diapause), the nymphs would hatch from the eggs laid by overwintered adults in spring after the next winter only (cold exposure), rather than in the same spring.

Uncommonness of the species' seasonal cycle gave rise to detailed laboratory research. It is a common knowledge that the diapause is usually strictly related to a species-specific stage, and photoperiod and temperature are the most important factors which control its induction in insects. While studying the seasonal cycle of *P. bidens*, it was necessary to evaluate the possibility of diapause formation in different stages of the species ontogenesis (egg and adult) and reveal the conditions which suppress development (delay in nymph hatching in the case of egg diapause, and absence of oviposition in the case of adult one) probably considered prospective physiological rest.

Egg-batches of *P. bidens* from Moscow laboratory population were put at my disposal by Dr. O. G. Volkov (Institute of Plant Quarantine, Moscow). Nymphs hatched after cold reactivation from these batches were used in the experiment.

Insects were kept in plastic Petri dishes 100 mm in diameter, the lids of which were provided with 50-mm diameter openings for aeration, covered by gauze. Caterpillars of *Galleria melonella* served as main food for nymphs and then for adults of the bug. *Tradescantia propagules* in small test tubes with water and moist cotton pads were always available for insects. The food was replaced every two days. The density of the nymphs was kept at 20–30 per dish for I and II instars

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Nymphal and preoviposition development of females of *P. bidens*

Characteristics	Photoperiodic conditions	
	D12 : 12	D 20 : 4
Temperature during the period of nymphal development, °C		
mean	+23.0	+22.5
range	(22.2...23.9)	(21.5...23.0)
Duration of nymphal development ($X \pm S_x$)*, days	35.6 ± 0.66	35.9 ± 0.61
Duration of preoviposition period, days		
mean ($K \pm S_x$)	16.4 ± 2.33	
range	(11...22)	
Number of egg-batches laid by one female		
mean ($K \pm S_x$)	3.5 ± 0.45	
range	(1...7)	
Number of females in the experiment	16	21

*In all cases the arithmetic means are reliable at the 99.9% confidence level (*t*—test).

and then was reduced to 4–5 per dish for the final (V) instar. Winged bugs were paired off (male and female). Zigzag-folded paper was served as a substratum for egg-laying.

Experiment was performed in chambers in which both photoperiod and temperature were controlled (Braun and Goryshin, 1978). Regimes of constant photoperiods 12 h (short day, 12L : 12D) and 20 h (long day, 20L : 4D) were used. The light intensity in the chambers of 180 to 250 lx was provided by 20 W fluorescent lamps. Deviations from the preset temperature (+23°C) were no more than 1°C.

The duration of nymphal development was the same for two alternative photoperiodic regimes (see table). Long-day conditions neither accelerated, nor retarded nymphal growth, though such a quantitative control over growth rate was known in many bug species (Saulich and Musolin, 1996).

The response to day-length displayed itself during the reproduction period. In the short-day regime all successfully winged females began to lay eggs. The oviposition period was, on the average, 16.4 days. The next egg-batches were laid in 2–12 days, and each female laid, on the average, 3.5 batches. Females were reproductively active and laid eggs until their death (the imaginal life of female ranged between 17 and 53 days with an average of 31 days).

The experiment was finished at 35th day from the average date of female adult moult. By that time, most of short-day females died and the mean preoviposition period (16.4 days) was exceeded in duration twice. During that period, only 2 of 21 long-day females began oviposition; and preoviposition period amounted to 24 and 28 days, respectively. Only 4 long-day females died and none of them had developed eggs in ovarioles by the day of their death (25th–33rd days of their adult life). All of them had more or less developed fat body.

Ten egg-batches laid by females in the experiment were then kept under room conditions for 45 days. Thirty days after oviposition only one nymph hatched from all the batches. All other eggs were considered diapausing.

It can be stated that long-day conditions induce physiological rest in adults of *P. bidens*. Taking into consideration the obligatory egg diapause and appearance of young adults in nature in June-July, the physiological rest revealed in the experiment is aestivation—“a summer rest aimed at avoiding summer overheating and its attendant adverse environmental conditions (water deficiency, starvation, etc.)” (Ushatinskaya, 1987). Aestivation as a prospective rest is widely present in different orders of insects in tropics, as well as in temperate and arid zones (Masaki, 1980; Ushatinskaya, 1987).

In the most pronounced cases of aestivation, insects stop feeding and its vital activity, and most of physiological and biochemical processes are suppressed.

Sometimes deep changes occur, such as reduction of tissues and groups of cells (e.g., reduction of total gut dimensions, epithelial cytoplasm, and musculature in alfalfa weevil, *Hypera postica*: Tombes and Marganian, 1967).

However, aestivation, as well as winter diapause, can manifest itself in a less intensively suppressed state, namely, oligopause (Ushatinskaya, 1973, 1987). For instance, in the Neotropical cassidine beetle, *Chelymorpha alternans*, short day (12L : 12D) induced reproductive oligopause which was judged from the absence of egg-laying. When day was longer (13L : 11D), physiological rest was not induced (Pullin and Knight, 1992). In our experiment, aestivating bugs continued to move and eat (by visual observation the food consumption was reduced, but did not cease at all). Sometimes copulation took place. No special behavioral responses were observed.

Ecological meaning of the aestivation (summer diapause) in *P. bidens* is not quite clear. In nature, adults appear when the day-length is approaching its maximal value. It is probable that in early winged adults long day induces aestivation, which terminates (spontaneously or in response to short or shortening day) in late summer. Just at this time, in August–September, females begin to lay diapausing eggs in Moscow Region (O. G. Volkov, pers. comm.).

Determination of summer diapause characteristics (threshold of photoperiodic response inducing this state, termination, reversibility of the response, ecological significance and the role in seasonal cycle) is the subject for further research.

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