

ECOLOGY, BEHAVIOR AND BIONOMICS**Food Availability and Larval Density Affect Ovarian Development in *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae)**MARINA CASTELO BRANCO¹ and ALEXANDER G. GATEHOUSE²¹Centro Nacional de Pesquisa de Hortaliças/Embrapa, Caixa postal 218, 70.359-970, Brasília, D.F, Brazil. e-mail: marina@cnph.embrapa.br²University of Wales, School of Biological Sciences, Brambell Building, Bangor, Gwynedd, LL57 2UW, United Kingdom.

An. Soc. Entomol. Brasil 28(4): 611-616 (1999)Disponibilidade de Alimentos e Densidade de Larvas que Afetam o Desenvolvimento Ovariano de *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae)

RESUMO - Foi investigado o efeito da densidade populacional e idade da planta no desenvolvimento ovariano da traça-das-crucíferas (*Plutella xylostella* L.). Em testes realizados em placas de Petri, a densidade de larvas por disco de folhas de repolho afetou o desenvolvimento ovariano. Quando a densidade foi de sete ou 14 larvas/disco de repolho, a maior parte das fêmeas possuíam ovários maduros na emergência. Quando esta densidade foi de 28 larvas/disco de folha, a maior parte das fêmeas possuíam ovários imaturos na emergência. Não houve efeito da idade da planta sobre o desenvolvimento ovariano. Quando larvas da traça-das-crucíferas foram criadas sobre plantas de repolho de idades de dois e quatro meses, com densidade de 30-35 larvas/planta, mais de 94% das fêmeas possuíam ovários maduros na emergência. Foi sugerido que a densidade populacional exerce um importante efeito sobre o desenvolvimento ovariano da traça-das-crucíferas. Como migrações de insetos geralmente ocorrem quando os ovários das fêmeas estão imaturos, em campo, fêmeas com potencial migratório deverão ocorrer apenas quando a densidade for superior a 30 larvas/planta.

PALAVRAS-CHAVE: Insecta, traça-das-crucíferas, desenvolvimento ovariano, migração.

ABSTRACT – The effect of Diamondback Moth (*Plutella xylostella* L.) population density and plant age on the rate of ovarian development was investigated. In tests carried out in Petri dishes, the density of larvae/leaf disk affected the rate of ovarian development. A high proportion of moths from larvae reared on leaf disks from two or four-month-old spring cabbage at a density of seven or 14 larvae/leaf disk were mature at emergence. But moths reared at the same type of plant at a density of 28 larvae/leaf disk were largely immature at emergence. When the larvae were reared at a density of 30 larvae/plant on two or four-month-old spring cabbage plants, a high proportion of females were ma-

ture at emergence. Crowding has an important effect on the rate of ovarian development in Diamondback Moth with possible consequences for the migratory potential of moths, as insect migration generally occurs when the ovaries of the females are immature. The density of moths necessary to increase the proportion of immature females in the field is probably higher than 30 larvae/plant.

KEY WORDS: Insecta, Diamondback Moth, ovarian development, migration.

The rate of ovarian development of insects can be influenced by environmental conditions. Hiller & Thorsteinson (1969) and McDonald and Cole (1991) reared respectively larvae of Diamondback Moth (*Plutella xylostella*) (DBM) and *Mythimna convecta* (Walker) (Lepidoptera: Noctuidae) individually and in groups in the laboratory. They found that the large majority of moths developing from larvae reared individually were mature at emergence but moths reared in groups were immature at emergence. It was suggested that a crowded environment affected the response and noted that, when environmental conditions were favourable, few females were immature at emergence.

It has been suggested that migration in most migratory insects occurs when females are immature (Johnson 1969). Coombs *et al.* (1993) deployed light traps at heights of 40–50 m on the edge of an escarpment in a National Park in Australia. *Helicoverpa armigera* (Hübner) and *H. punctigera* (Lepidoptera: Noctuidae) were caught in these traps during migratory flight and more than 88% of the females were immature. Rankin *et al.* (1994) evaluated the stage of ovarian development in *Anthonomus grandis* (Boheman) (Coleoptera: Curculionidae) and observed that insects with undeveloped or partially developed ovaries were the most likely to make long flights, i.e. migrate.

Migration in insects can be obligatory (occurs every generation) or facultative (occurs occasionally). Facultative migration occurs when environmental conditions such as lack of food, changes in photoperiod or crowding indicate that the habitat will be unfavourable for the development of the insects' offspring (Southwood 1962, 1971, Johnson 1969, Gate-

house & Zhang 1995).

The objective of this work was to evaluate the effect of population density and host age plant on the rate of ovarian development of DBM in order to obtain indications of the factors that could induce migration in the insect.

Materials and Methods

Population. The population used in this experiment was collected in the Brasília, D.C. (Brazil), in January 1994. The rearing procedures were described elsewhere (Castelo Branco & Gatehouse 1997).

Experimental design. Tests in Petri dishes: larvae of DBM were reared on 4.5 cm diameter leaf disks of spring cabbage cv. January King at densities of seven, 14 and 28 larvae per disk, using leaves from cabbages which were two and four-month-old. Eight, four and two replications per density were used in order to obtain the same number of larvae (56). The leaf disks were changed when approximately 90% of the area had been eaten. Females were killed in a freezer within 15 h of emergence and were dissected under a binocular at three times magnification. A solution of 0.09% NaCl was coloured with neutral red until it was light pink (Sokolova 1994). The females were placed in the solution, the terminal part of the abdomen was pulled out and the ovary exposed. When exposed in this procedure the chorionated eggs turned yellow. The stage of ovarian development was assessed using the following scale (Han 1988):

Grade 0: ovarioles short and empty;

Grade 1: ovarioles longer with the appearance of red spot-like oocytes inside;

Grade 2: these spots developed into red, rectangular oocytes;

Grade 3: oocytes further developed with one or more chorionated yellow eggs at the base of the ovarioles;

Grade 4: fully developed yellow eggs are present at the base of the ovarioles and have moved into the lateral or common oviducts.

Tests on plants: fifty-five eggs of DBM were placed per plant. Two categories of plants, cabbage with two and four-month-old, with three replications were used. The larvae pupated on the leaves and, at this stage, they were collected and placed in a 9.0 cm diameter Petri dish until the emergence of the adults. When this occurred, the same procedure described above was used.

Analysis: In order to analyse the influence of the several rearing procedures on the rate of ovarian development of DBM, the females were grouped as immature (grades 0, 1 and 2) or mature (grades 3 and 4).

The results from females reared in Petri dishes of different ages and with different densities were analysed using χ^2 in a 3x2 contingency table (Zar 1984), while the results from females reared on plants were analysed using a two tailed Fisher Exact Test as expected values were less than five (Zar 1984).

Results and Discussion

The number of females that emerged from Petri dishes treatments were between 20-28. More than 80% of the moths that emerged from larvae reared at densities of seven or 14 larvae/leaf disk on two or four month-old cabbage were mature at emergence (grades 3 and 4) (Fig. 1A and B). However at a density of 28 larvae/leaf disk, 40 and 25% of the females were mature at emergence when the larvae were reared on two and four-month-old cabbage respectively (Fig. 1A and B). Analysis of the contingency table showed that the rate of ovarian development was significantly af-

ected by larval density on two month ($\chi^2 = 41.53$, $df=2$, $p < 0.05$) or four month cabbage ($\chi^2 = 27.26$, $df=2$, $p < 0.05$). Analysis of the contingency table also showed that the rate of ovarian development was independent of the age of the plant when a density of 28 larvae/leaf disk was used ($\chi^2 = 0.44$, $df=2$, $p > 0.05$). Finally, the analysis using a two tailed Fisher Exact Test showed that the rate of ovarian development in DBM was independent of the age of the plants at density of seven ($p > 0.05$) and 14 ($p > 0.05$) larvae/leaf disk.

According to Southwood (1962, 1971) environmental factors that predict the onset of unsatisfactory conditions, such as crowding or reduced availability or quality of food, may cause a delay in sexual maturation. The effect of crowding in delaying sexual maturation was observed by McDonald & Cole (1991) when rearing *Mythimna convecta* (Walker) (Lepidoptera: Noctuidae) at high densities. The delay in sexual maturation could induce emigration from unfavourable habitats. Evidence obtained in this work suggests that the rate of reproduction development in DBM females is influenced by larval density but not by plant age. A high proportion of females reared on spring cabbage at high densities (28 larvae per disk) (Fig. 1A and B) emerged with immature ovaries indicating extended pre-reproductive periods which may provide time for pre-reproductive migration. These results suggest the hypothesis that migration could occur when population levels, and, therefore, densities, are high. The same hypothesis was suggested by Hiller & Thorsteinson (1969).

In order to simulate the density that could induce migration, a test was carried out in laboratory on two and four month-old plants. Forty and 45 females emerged from the two and four month-old-cabbage respectively. The results showed that independent of plant age, more than 94% of the females were mature at emergence (grades 3 and 4) (Fig. 2) and that the two tailed Fisher Exact Test showed no effect of plant age. The small number of immature females at emergence indicated that few individuals were likely to have the po-

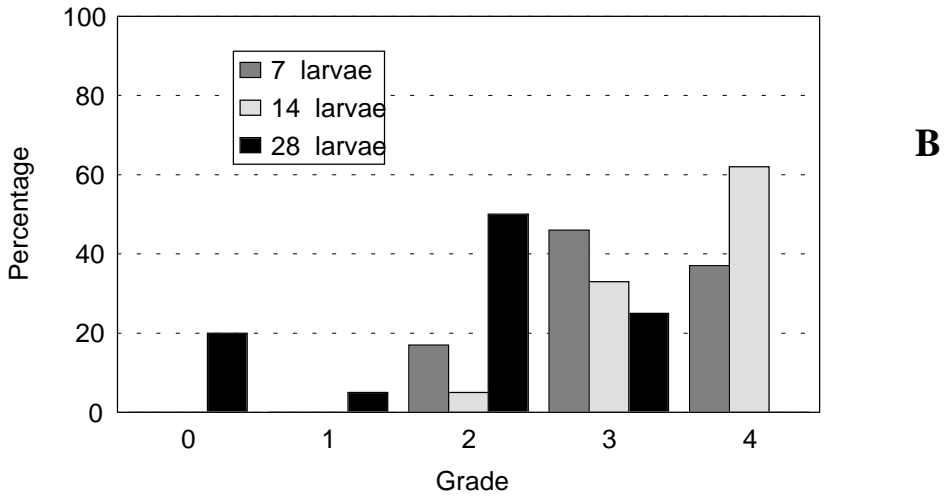
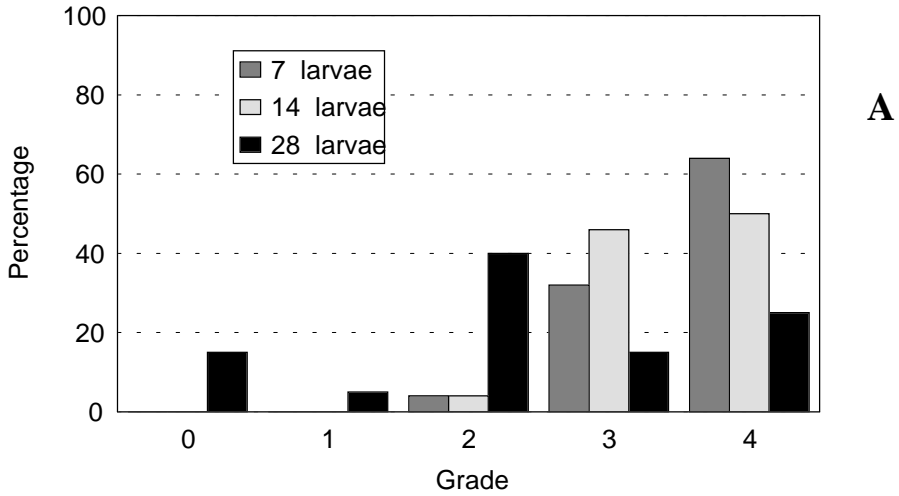


Figure 1: Ovarian development of Diamondback Moth at emergence when reared on Spring cabbage two (A) and four-month-old (B) at densities of seven, fourteen and twenty-eight larvae/leaf disk. Grades 0 (ovarioles short and empty) to 4(fully developed eggs are present at the base of ovarioles and have moved into the lateral or common oviducts) refer to ovarian development.

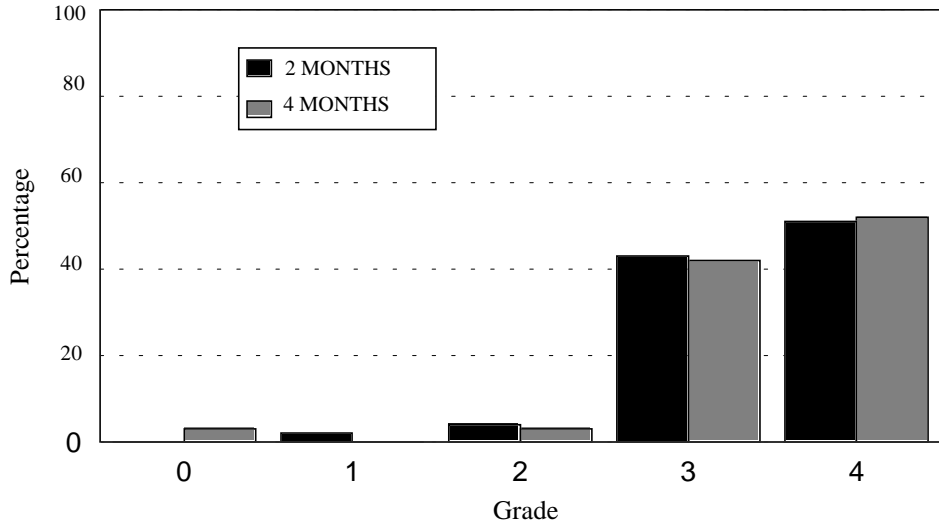


Figure 2: Ovarian development of Diamondback Moth at emergence when reared on two and four-month-old Spring cabbage at a density of 30 larvae/plant. Grades 0 (ovarioles short and empty) to 4 (fully developed eggs are present at the base of ovarioles and have moved into the lateral or common oviducts) refer to ovarian development.

tential to migrate. In the field, higher densities than those to increase the proportion of females that emerge immature may be necessary.

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