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# Development of *Cadra cautella* (Walker), *Corcyra cephalonica* (Stainton), and *Plodia interpunctella* (Hübner) (Lepidoptera Pyralidae) on *Triticum monococcum* L., *T. dicoccum* Schrank ex Schübler, and *T. spelta* L.

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## Abstract

Groups of 100 eggs (laid 6-24 hours previously) of *Cadra cautella*, *Corcyra cephalonica*, and *Plodia interpunctella* were reared on 30 g of spikelets or kernels of *Triticum monococcum*, *T. dicoccum*, and *T. spelta* in a conditioned room at 26 ± 1 °C, 70 ± 5 % r.h., and photoperiod 16:8 (L:D). A higher mean number of adults is observed when moths are reared on kernels, except for *C. cephalonica* on *T. monococcum*. The mean developmental time is longer with spikelets except when *P. interpunctella* is reared on *T. monococcum*. A low number of adults of the three species is observed on spikelets of *T. dicoccum* and *T. spelta*. In fact kernels are covered by glumes and inner glumes that hinder larvae feeding. The highest number of adults of *C. cautella* is observed on kernels of *T. dicoccum* (76.5 ± 7.8). Few adults of this species emerge from spikelets of *T. dicoccum* (4.7 ± 0.5) and *T. spelta* (4.5 ± 1.3). The mean developmental time is not significantly different among kernels (from 49.5 to 54.2 days) and among spikelets (from 61.5 to 66 days) of the different species of cereals.

The highest number of *C. cephalonica* adults is observed on kernels and spikelets of *T. monococcum* and on kernels of *T. dicoccum*; numbers are not significantly different (from 78.5 to 79.7 adults). A lower mean number of adults is observed on spikelets of *T. dicoccum* (28.2 ± 1.2) and *T. spelta* (28.5 ± 2) with a longer mean developmental time, 96 ± 0.8 and 112.2 ± 3.2 days respectively. The shortest mean developmental time is observed on kernels of *T. monococcum* (54 ± 1.8). The highest mean number of adults of *P. interpunctella* is observed on kernels of *T. dicoccum* (71 ± 5.5) and of *T. spelta* (70 ± 2.2) with mean developmental times of 42 ± 0.8 and 36.7 ± 0.5 days respectively. Few individuals develop on *T. dicoccum* (5.2 ± 1.3) and *T. spelta* (2.2 ± 1.3) with mean developmental times of 59.2 ± 5.4 and 42.5 ± 0.6 days.

*Key words*: post-harvest moths, development, einkorn, emmer, spelt.

## Introduction

Hulled wheat genotypes grow wild in the Middle East and they are cultivated in the Mediterranean area. These crops have been drastically reduced due to low yield but in these last years they arouse interest for the nutritional composition useful in the processing of dietetical foods (Abdel-Aal et al., 1995; Caballero et al., 2005). The cultivated area in Central and South

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Italy is increasing in marginal areas of high altitude, where its low input requirement and cold resistance make the crop economically viable (Porfiri et al., 1998; Chisci, 2005; Pagnotta et al., 2005).

Extensive references concern the differences in susceptibility of barley, wheat, maize, oat, millet to post-harvest insect pests, mainly Coleoptera and Lepidoptera, but there are few researches on cultivated hulled wheat (Kunike, 1938; Trematerra et al., 1996; Süss et al., 1999; Trematerra et al., 1999; Gentile and Trematerra, 2004).

The development of *Cadra cautella* (Walker), *Corcyra cephalonica* (Stainton), and *Plodia interpunctella* (Hübner) (Lepidoptera Pyralidae) on spikelets and kernels of *Triticum monococcum* L., *T. dicoccum* Shrank ex Schübler, and *T. spelta* L. was investigated.

## Materials and methods

*Cadra cautella*, *Corcyra cephalonica* and *Plodia interpunctella* were reared on spikelets and kernels of *Triticum spelta*, *T. dicoccum*, and *T. monococcum*[1] . Before starting the tests all the substrata were placed in a freezer at a temperature of -20 °C for 45 days in order to eliminate the possible presence of Arthropods.

The moths were reared at the Istituto di Entomologia Agraria, Università degli Studi, Milan, at 26 ± 1 °C, 70 ± 5 % r.h. and photoperiod 16:8 h (Light:Dark). Before the tests the eggs, laid 6-24 hours previously, were observed with a stereomicroscope in order to eliminate those showing evident deformations.

Tests were carried out in environmental conditions like those provided for the rearing.

Groups of 100 eggs in a small plate were placed on 30 g of spikelets or kernels[2] in polystyrene containers, closed with gauze (120 mesh) to provide ventilation, for 5 days. The unhatched eggs were counted with a stereomicroscope. The containers were returned to the conditioned room until the end of post-embryonic development. At emergence, first generation adults were counted daily and removed.

Adult emergence data were corrected for variations in percentage hatch of eggs in order to compare results for the four replicates of the growth of the three species on the substrata. Data were based on 100 hatched eggs. The developmental period was counted from eggs laying to the time when 50 % of the total adults emerged.

Data were subjected to ANOVA and Duncan's multiple range test ($P < 0.05$) (SPSS 10.0 per Windows).

## Results

The differences in development of the three moths on the different substrate are considered in Tables1, 2, 3 and the correlation between mean developmental time and mean number of emerged adults is shown in Figure 1.

A higher mean number of adults is observed when moths are reared on kernels, except for *Corcyra cephalonica* on *Triticum monococcum*. A low number of adults of the three species is noticed on spikelets of *T. dicoccum* and *T. spelta*. Individuals of the three species present a shorter mean time of hatching and a shorter mean developmental time when reared on kernels, except *Plodia interpunctella* that shows the same mean developmental time on spikelets and kernels of *T. monococcum* (Tables 1, 2, 3).

[1] Spikelets and kernels of *T. monococcum*, *T. dicoccum*, and *T. spelta*, all obtained from "Experimental Institute for Cereal Research of S. Angelo Lodigiano (LO) Italy" - Italy, were used in the experiments.

[2] Mean number (± s.e.) in 30g of the diet: *T. monococcum*: spikelets 1098 ± 14, kernels 1586 ± 27; *T. dicoccum* 567 ± 8, 759 ± 9; *T. spelta* 362 ± 10, 741 ± 9). It was observed that sometimes spikelets of *T. dicoccum* and *T. spelta* have only one kernel.

**Table 1.** Mean (± s.d.) of beginning of hatching (d), of developmental time (d), and of emerged adults of *Cadra cautella* on spikelets and kernels of *Triticum monococcum*, *T. dicoccum* and *T. spelta*.

| *Triticum* | | Beginning of hatching (d) | Developmental time (d) | Number of emerged adults |
|---|---|---|---|---|
| *monococcum* | spikelets | 56.0 ± 0.0 ab | 66.0 ± 1.4 a | 39.7 ± 0.5 c |
| | kernels | 46.0 ± 0.8 c | 49.5 ± 1 b | 69.2 ± 1.9 b |
| *dicoccum* | spikelets | 56.7 ± 5.6 ab | 61.5 ± 3.1 a | 4.7 ± 0.5 d |
| | kernels | 47.0 ± 0.0 c | 50.2 ± 0.5 b | 76.5 ± 7.8 a |
| *spelta* | spikelets | 58.2 ± 8.5 a | 65.2 ± 7.4 a | 4.5 ± 1.3 d |
| | kernels | 50.7 ± 0.9 bc | 54.2 ± 0.5 b | 67.5 ± 5.3 b |

Means followed by the same letter are not significantly different (P < 0.05, ANOVA, Duncan's test)

**Table 2.** Mean (± s.d.) of beginning of hatching (d), of developmental time (d), and of emerged adults of *Corcyra cephalonica* on spikelets and kernels of *Triticum monococcum, T. dicoccum,* and *T. spelta*.

| *Triticum* | | Beginning of hatching (d) | Developmental time (d) | Number of emerged adults |
|---|---|---|---|---|
| *monococcum* | spikelets | 50.7 ± 1.5 c | 62.7 ± 0.5 c | 78.5 ± 1.7 a |
| | kernels | 44.0 ± 1.6 d | 54.0 ± 1.8 e | 79.7 ± 3.3 a |
| *dicoccum* | spikelets | 61.7 ± 8.7 b | 96.0 ± 0.8 b | 28.2 ± 1.2 c |
| | kernels | 52.5 ± 0.6 c | 61.0 ± 1.8 c | 78.5 ± 3.7 a |
| *spelta* | spikelets | 82.0 ± 3.2 a | 112.2 ± 3.2 a | 28.5 ± 2 c |
| | kernels | 44.2 ± 0.5 d | 57.2 ± 1.2 d | 64.7 ± 2.7 b |

Means followed by the same letter are not significantly different (P< 0.05, ANOVA, Duncan's test)

**Table 3.** Mean (± s.d.) of beginning of hatching (d), of developmental time (d), and of emerged adults of *Plodia interpunctella* on spikelets and kernels of *Triticum monococcum*, *T. dicoccum* and *T. spelta*.

| *Triticum* | | Beginning of hatching (d) | Developmental time (d) | Number of emerged adults |
|---|---|---|---|---|
| *monococcum* | spikelets | 40.0 ± 1.1 c | 46.2 ± 1.5 b | 48.5 ± 5.0 c |
| | kernels | 44.0 ± 1.1 b | 46.2 ± 1.2 b | 63.2 ± 2.7 b |
| *dicoccum* | spikelets | 50.2 ± 4.8 a | 59.2 ± 5.4 a | 5.2 ± 1.3 d |
| | kernels | 37.2 ± 0.5 c | 42.0 ± 0.8 c | 71.0 ± 5.5 a |
| *spelta* | spikelets | 42.5 ± 0.6 b | 42.5 ± 0.6 c | 2.2 ± 1.3 d |
| | kernels | 33.2 ± 0.5 d | 36.7 ± 0.5 d | 70.0 ± 2.2 a |

Means followed by the same letter are not significantly different (P < 0.05, ANOVA, Duncan's test)

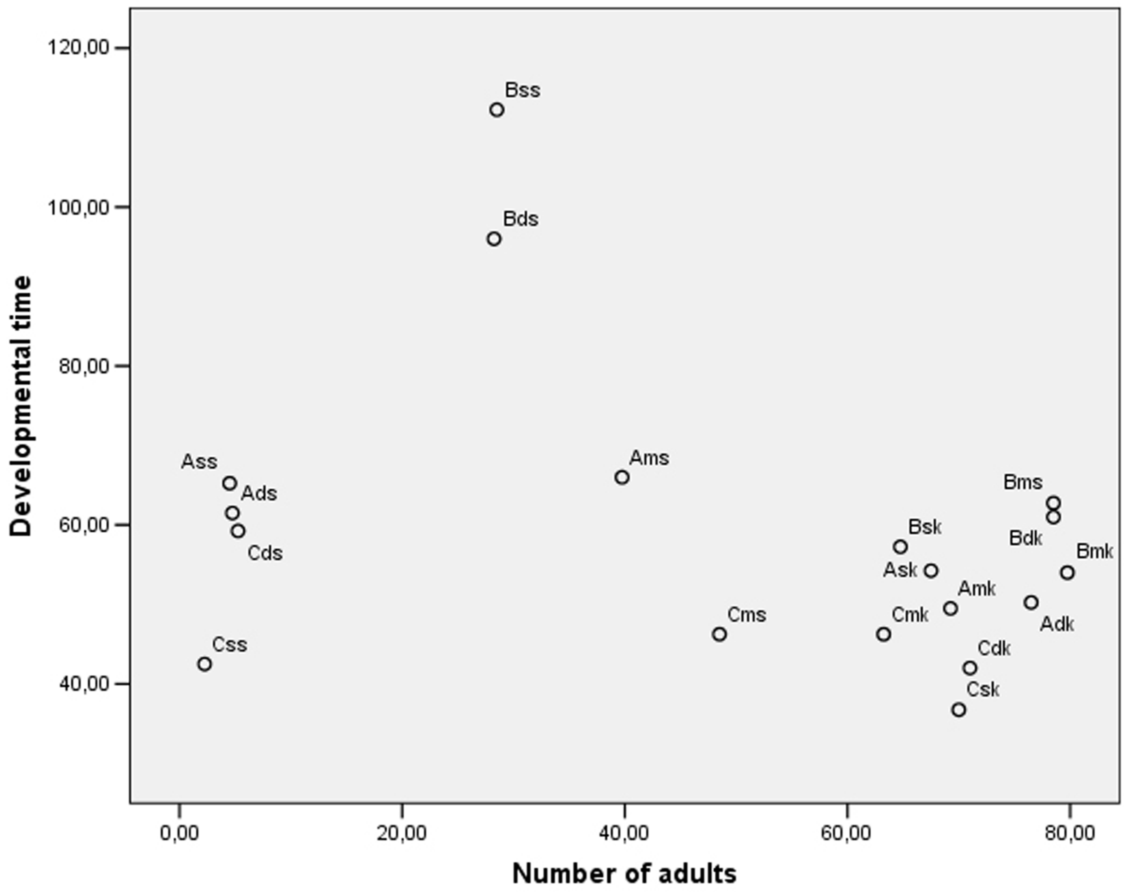


**Figure 1.** Scatter graphic of susceptibility of hulled wheat genotypes in relation to mean number of emerged adults and mean developmental time (days) of *Cadra cautella* (Walker), *Corcyra cephalonica* (Stainton), and *Plodia interpunctella* (Hübner).

The highest number of adults of *Cadra cautella* is recorded on kernels of *T. dicoccum* (76.5 ± 7.8). Few adults of this species emerge from spikelets of *T. dicoccum* (4.7 ± 0.5) and *T. spelta* (4.5 ± 1.3) (Table 1). The mean developmental time is not significantly different among spikelets (from 61.5 ± 3.1 to 66 ± 1.4 days) and kernels (from 49.5 ± 1 to 54.2 ± 0.5 days) among the different species of cereals.

The highest number of *C. cephalonica* adults (Table 2) is registered on spikelets and kernels of *T. monococcum* and on kernels of *T. dicoccum*; means are not significantly different (from 78.5 ± 1.7 to 79.7 ± 3.3 adults). A lower mean number of adults is observed on spikelets of *T. dicoccum* (28.2 ± 1.2) and *T. spelta* (28.5 ± 2) with a longer mean developmental time, 96 ± 0.8 and 112.2 ± 3.2 days respectively. The shortest mean developmental time is observed on kernels of *T. monococcum* (54 ± 1.8).

The highest mean number of adults of *P. interpunctella* (Table 3) is recorded on kernels of *T. dicoccum* (71 ± 5.5) and of *T. spelta* (70 ± 2.2) with mean developmental times of 42 ± 0.8 and 36.7 ± 0.5 days respectively. Few individuals of *P. interpunctella* develop on spikelets of *T. dicoccum* (5.2 ± 1.3) and *T. spelta* (2.2 ± 1.3) with mean developmental times of 59.2 ± 5.4 and 42.5 ± 0.6 days.

A scatter graphic (Figure 1), correlating the mean developmental time and the mean number of emerged adults, allows some considerations on the susceptibility of spikelets and kernels of cultivated hulled wheats to the attack of the three moths. All the moth species show a similar behaviour on the kernels of the three hulled wheats and *C. cephalonica* also on spikelets of *T. monococcum*, with a mean number of emerged adults included between 63 and 79, and a mean developmental time included between 36 and 62 days. The mean number of adults of *P. interpunctella* and *C. cautella*, on spikelets of *T. dicoccum* and *T. spelta*, is between 2 and 5 and the mean developmental time between 42 and 61 days; while the same species on spikelets of *T. monococcum* present a higher number of adults (39-48) but a mean developmental time (46 and 66 days) almost analogous to what observed on the other hulled wheats. The same mean number of adults of *C. cephalonica* (28) is recorded on spikelets of *T. dicoccum* and *T. spelta*, but with a higher mean developmental time (96-112 days) compared to the one observed on spikelets of *T. monococcum*.

## Discussion

*Corcyra cephalonica* presents a higher mean number of emerged adults on spikelets compared to the other two moth species, due to the considerable ability to pierce glumes and inner glumes. First instar larvae of this species in fact show a higher ability to pierce compared to larvae of *Plodia interpunctella* and *Cadra cautella* as observed by Cline (1978) on different kinds of materials. Abdel-Rahman (1971) observed that *P. interpunctella* is unable to reach the germ region when kernels are on the maize cob.

All the three species of moths have a higher mean number of adults on spikelets of *Triticum monococcum* that presents less tough glumes and inner glumes compared to spikelets of *T. dicoccum* and *T. spelta*.

Larvae, in order to reach the kernel, pierce laterally or apically the spikelets. Larvae of *P. interpunctella* (Madrid and Sinha, 1982) and *C. cautella* (Mookherjee et al., 1969) need a greater quantity of proteins and fats compared to *C. cephalonica* (Sodhi, 1992), but not always they reach the germ, placed at the base of the kernel and protected by glumes and inner glumes. Few individuals reach the adult stage, and in a longer time compared to what observed on kernels, because of inadequate nutritional supply. Nutritional deficiency causes a lower number of emerged adults and a longer developmental time (Dang e Pant, 1965).

*T. monococcum* is classified super soft, in fact kernels during processing easily broken, *T. spelta* is soft while *T. dicoccum* is hard, but, as the larvae of these moths have efficient mandibles, there is no correlation between the number of emerged adults and kernel hardness. Besides the hulled wheats present a similar mean nutritional composition (Abdel-Aal et al., 1995; Balint et al., 2001; Løje et al., 2003) although *T. spelta* has a high vitamins content (Jacquot et al., 1960; Winzeler and Ruegger, 1990) and *T. monococcum* has a high proteins content (D'Egidio et al., 1993; D'Egidio and Vallega, 1994).

There are no significant differences in the mean number of adults of *C. cephalonica* on spikelets and on kernels of *T. monococcum*. Some Authors (Acevedo and Avilés, 1984; Osman, 1986) observed that this moth prefers broken and dehusked kernels.

## Conclusion

Spikelets of *Triticum monococcum* , as glumes and inner glumes are less resistant compared to spikelets of *T. dicoccum* and *T. spelta*, are more susceptible to the attack of *Cadra cautella*, *Corcyra cephalonica* and *Plodia interpunctella*. *C. cephalonica* can develop on spikelets even if it presents a longer mean developmental time compared to the one observed on kernels.

Kernels of the three hulled wheats allow the development of a high number of individuals of *C. cautella*, *C. cephalonica* and *P. interpunctella* in a short period of time.

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