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DETERMINATION OF DEVELOPMENTAL PERIODS OF LEAF BEETLE (*OULEMA* SPP.) FOR SHORT-TERM FORECASTING

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Abstract: Two species of leaf beetle (*Oulema* spp.) – *Oulema melanopus* (Linnaeus 1758) and *Oulema gallaeciana* (Heyden 1870) are classified as the pests of cereals of economical importance in Poland. Determination of the optimal period of their control is very difficult due to extended time of laying eggs and brood of larvae. Mass brood of larvae of both species takes place at the time when larvae hatched from first laid eggs reached ca. 4 mm length of both species. Both developmental stages indicate an optimal term of leaf beetle control. To improve short-term forecasting and warning system the data on developmental cycles of both species from an egg to larva (ca. 4 mm size), the studies were carried out in the field trails in the Wielkopolska region and some in an environmental growth chamber.

Key words: warning system, winter wheat, *Oulema gallaeciana*, *Oulema melanopus*, period of developmental cycle

INTRODUCTION

In Poland, besides aphids, the leaf beetles (*Oulema* spp.) and locally the saddle gall midge (*Haplodisplosis equestris*, Wagner) are the most important pests of cereals in Europe. The leaf beetles have been known as the pests of cereals occurring commonly for more than a century. There are two species that can cause severe damage to cereal crops: cereal leaf beetle (*Oulema melanopus*, Linnaeus, 1758) and blue leaf beetle (*Oulema gallaeciana* Heyden 1870) of the *Chrysomelidae* family. Over last twenty years, an rapid of economic importance of cereal pests, including leaf beetles, was locally observed in Poland (Pruszyński and Ruszkowska 1986; Walczak et al. 1987; Walczak 1989, 1990; Kaniuczak 1987, 1993; Ruszkowska et al. 1990). Every year beetles and larvae of *Oulema* spp. damage significantly leaf tissues of cereal leaves (Walczak 1994, 1999; Walczak et al. 1999, 2003), which causes high losses in yields. First and second leaves of plants are mostly inhabited by larvae (ca. 40% of population) (Groll and Wetzel 1984).

To reduce damages caused by these pests it is essential to: (1) select the most effective plant protection products and (2) establish the most optimal time for their application. Properly determined time of chemical treatment determines efficacy of disease and pest control more efficiently than applied dose of pesticide (Jørgensen and Nielsen 1998). Considering these facts, long-time studies were carried out on the *Oulema* spp. biology under controlled conditions as well as in field trials in correlation to climatic factors (Walczak 1998, 1999, 2002) to establish a short-term forecasting of appearance of developmental stages of *Oulema* spp. Chemical treatment at optimal time minimizes damages caused by pests and eliminates unnecessary use of pesticides.

Determination of optimum time for chemical control of *Oulema* spp. is very difficult due to extended time of laying eggs and larval development period. Literature concerning these problems is scanty and mostly refers to influence of abiotic factors on the development of *Oulema* spp. (Ali et al. 1977; Guppy and Harcourt 1978; Groll and Wetzel 1984; Freier et al. 1985). Especially little information is available on modern methods of short-term forecasting for chemical control of these pests.

To obtain information for accurate time of leaf beetle control, investigations on the length of the developmental stages that are necessary for short-term prognosis were performed in a growth chamber and under field conditions.

Based on previous observations of *Oulema* spp. in the Wielkopolska region the following conclusion can be drawn:

a) *O. gallaeciana* beetles occur on the cereal crops later than those of *O. melanopus* (Walczak 1990); nevertheless, both species were in practice controlled simultaneously at the stage of larva of ca. 4 mm length (Walczak 1990);
b) at time of occurrence of larvae of ca. 4 mm length hatched from the first laid eggs of both *Oulema* spp. on cereals corresponds with mass emergence of larvae from mass laid eggs. Both phenomena are presently used in the official recommendation (Zalecenia ochrony roślin 2001) of *Oulema* spp. control (Bubniewicz et al. 1993; Walczak 2002).

There was however need for further improvement of short-term forecasting of *Oulema* spp. by establishing following factors:

1. Length of development period from freshly laid eggs, through stage of larval hatching and reaching ca. 4 mm long, referred herein to as the "studied developmental stage".
2. Length of development period from freshly laid eggs to larval hatching, hereinafter referred to as the "incubation of eggs".
3. Compare the egg and larval development period with temperature and relative air humidity.
4. Establishing "experimental" period (EP) of *Oulema* spp. development time to their size of 4 mm.

MATERIAL AND METHODS

Every year, in spring, usually from the beginning of April, during days when mean, daily air temperature reached ca. 10°C cereal crops were inspected for the presence of *O. melanopus* and *O. gallaeciana* beetles. Adults were collected using an

entomological sweeping net and identified in laboratory to species as: *O. gallaeciana* and *O. melanopus*. Only mating pairs were selected for further study to ensure that females would lay eggs. Three pairs of beetles were placed on winter wheat plants of variety Korweta cultivated in pots under controlled conditions in the growth chamber in the Institute of Plant Protection in Poznań from 1997 to 2001. Another pairs were reared on plants growing netting cages under the field conditions in the Experimental Station of the Institute Winna Góra, in the years 1999–2001.

The temperature range during rearing of *Oulema* spp. in the growth chamber was as follows: in 1997–1998 – 20°C; in 1999–2000 at 16°C and 25°C, while in 2001 at 20°C and 25°C. The other parameters were maintained as follows: relative air humidity of ca. 60%; illumination of 53 000 lux (provided by lamp Sont-T Agro 400W, usually used for experiments in agriculture); night time of 6 h (as in May).

Oulema spp. rearing in the growth chamber and under field conditions began at the same time every year. Observations were done daily and always at the same time. Every day, the progress in development of freshly laid eggs until stage of larvae of length 4 mm was recorded for both species in the both experiments. Only number of eggs from which larvae hatched and reached 4 mm length were taken for statistical analysis.

Two-factorial experiment was carried out in the growth chamber during the same growing season as field observations, to eliminate effect of additional factors. Number of species (*O. gallaeciana* and *O. melanopus*) was the first factor and three different temperatures; 16°C, 20°C, 25°C as the second one. Duration (number of days) of developmental stage of each individual specimen (experimental unit) was registered beginning from time of freshly laid eggs, through larval hatching, until stage of larva length of ca. 4 mm. This entire period was regarded as the length of studied developmental stage. The stage from laid egg to larva hatching was considered as the egg incubation, next period from larva emergence to larval length of ca. 4 mm as the larval development.

The results collected from the growth chamber experiments were compared to the results collected from the field trials.

RESULTS AND DISCUSION

In the growth chamber at 16°C 66 individuals of *O. gallaeciana* and 80 of *O. melanopus* were reared; 85 individuals of *O. gallaeciana* and 116 of *O. melanopus* at 20°C and 110 individuals of *O. gallaeciana* and 131 of *O. melanopus* at temperature of 25°C (Table 1). Under the three ranges of temperature in the growth chamber, an incubation of eggs and growth of larvae of 261 individuals of *O. gallaeciana* and 327 of *O. melanopus* (totally 588) were observed.

Under field conditions the *O. melanopus* specimens appeared earlier on cereal crops and thus oviposition was recorded earlier compared to *O. gallaeciana* occurrence, which was registered several days later. Despite delayed appearance of the beetles of *O. gallaeciana* on cereals, their larvae reached length of 4 mm at the same time as *O. melanopus*.

Experiment on rearing *Oulema* spp. in the cages placed on the winter wheat plants provided an explanation for simultaneous appearance of 4 mm larvae of

Table 1. Number of observed leaf beetles in the growth chamber experiment in 1997–2001

Year	*Oulema gallaeciana*			*Oulema melanopus*			*Oulema* spp.
	temperature			temperature			
	16°C	20°C	25°C	16°C	20°C	25°C	
1997		23			21		44
1998		38			72		110
1999	26		21	168		23	88
2000	40		46	62		50	198
2001		24	43		23	58	148
Sum	66	85	110	80	116	131	
Total		261			327		588
Total			588				

O. gallaeciana and *O. melanopus* under field conditions, despite differences in time of appearance of beetles of both species. The results collected from this survey revealed that developmental stage of *O. gallaeciana* compared to *O. melanopus* was significantly shorter (Table 2).

The developmental stage of *O. melanopus* was on average 3.1 days longer than of *O. gallaeciana* under field conditions. The shortest time of this cycle was 21 days, two days shorter than for *O. melanopus* (23 days). The longest cycle of *O. gallaeciana* lasted 34 days and was by 7 days shorter than of *O. melanopus* (41 days). *O. gallaeciana* accumulated heat needed for egg incubation and growth of larvae in shorter time and despite of later adults' appearance on cereals, larvae of *O. gallaeciana* and *O. melanopus* reached a length of 4 mm at the same time.

Figures 1–3 illustrate the results of studies carried out in the growth chamber and under field conditions: separately for egg incubation period; larval development (from larva hatch until larva length of ca. 4 mm) – called later "studied larval period", and for the whole developmental period of *Oulema* spp.

The longest time of egg incubation of *O. gallaeciana* as well as *O. melanopus* was recorded at temperature of 16°C (Fig. 1). The average time of egg incubation for both species was over 12 days and equal to 12.6 and 12.2 days for *O. gallaeciana* and *O. melanopus*, respectively.

The egg incubation period lasted shorter at 20°C than at 16°C. Average time of egg incubation of *Oulema* spp. did not exceed 8 days and was 7.2 days for *O. gallaeciana* and 7,3 days for *O. melanopus*. The shortest time of egg incubation for

Table 2. Average duration of developmental periods of *Oulema* spp. under field conditions in 1999–2002

Developmental period	*Oulema gallaeciana*			*Oulema melanopus*		
	days			days		
	mean	min.	max.	mean	min.	max.
Incubation of eggs	15.2	12	19	17.0	13	21
Larval development period	13.3	8	19	14.2	7	21
Experimental period of larval development	28.8	21	34	31.9	23	41

O. gallaeciana and *O. melanopus* was recorded at temperature of 25°C and on average did not exceed 6 days with 5,5 days for *O. gallaeciana* and 5.6 days for *O. melanopus*, respectively.

The longest egg incubation period, over 15 days; was observed under field conditions – 15.2 for *O. gallaeciana* and 17 days for *O. melanopus,* respectively.

In conclusion, if air temperature in the growth chamber was lower, egg incubation lasted longer, while under field conditions time of incubation period was the longest and the closest to that measured in the growth chamber at 16°C. Dissimilarity in incubation time between tests carried out in the growth chamber at 16°C and net cages placed in the field resulted from differences in an average day air temperature. The average daily temperature under field condition was an outcome of morning, noon and night temperatures of high fluctuations, while in the growth chamber fluctuations were much lower (±2°C of programmed temperature). Also average values of air humidity were not the same for both the growth chamber and field conditions and equal to 60% and 70%, respectively. It probably effected the period of egg incubation. Moreover, it was found that the average time of egg incubation under field conditions was longer for *O. melanopus* than *O. gallaeciana*. Similar relation was observed between these species reared in the growth chamber at 20°C (Fig. 1).

Studied larval development period of *Oulema* spp. in the growth chamber was on average 13 days (14.3 days for *O. gallaeciana* and 13.4 days for *O. melanopus*) at 16°C and prolonged in comparison to other temperatures (Fig. 2).

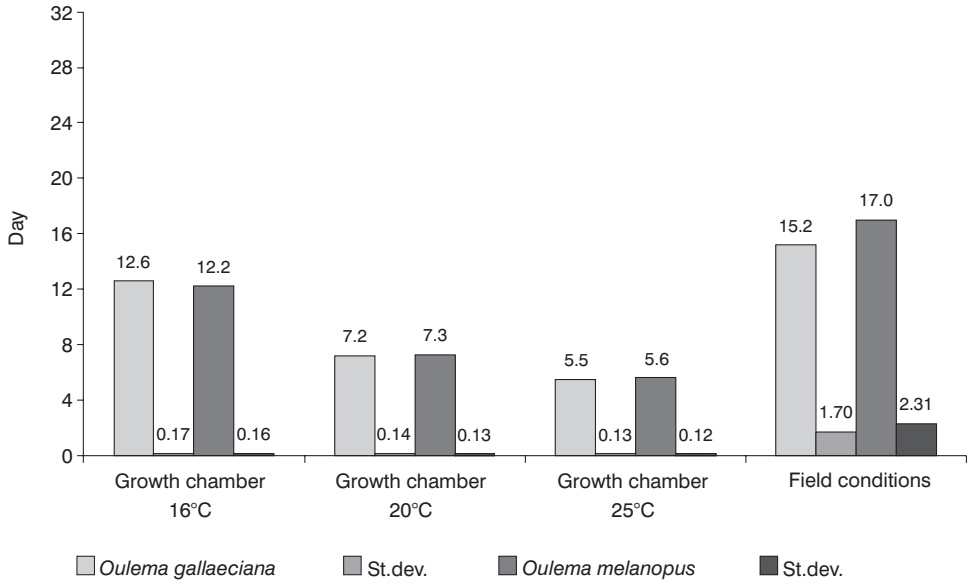

Fig. 1. The average egg incubation time of *Oulema* spp. in the growth chamber and under field conditions

At temperature of 20°C studied larval development period did not exceed on average of 10 days. For *O. gallaeciana* it lasted on average 8.5 days and for *O. melanopus* was 1.1 day longer (average 9.6 days).

The larval development period at 25°C was the shortest and did not exceed 8 days on average. Means for *O. gallaeciana* and *O. melanopus* were 7.1 and 6.4 days, respectively.

Under field conditions duration of larval period was similar to that observed in the growth chamber at temperature of 16°C; e.g. on average 13.3 for *O. gallaeciana* while 14.2 days for *O. melanopus*.

In summary, when air temperature in the growth chamber was lower, the larval period was longer. Duration of the above period in field conditions was the most similar to the values obtained in the growth chamber test conducted at temperature of 16°C. Under field conditions length of larval period of *O. gallaeciana* was shorter than of *O. melanopus* and results from the growth chamber test showed similar correlation with temperature of 20°C. Moreover, it was found that differences in duration of larval period for *Oulema* spp. were larger than differences in the period of egg incubation (Fig. 2).

Developmental cycle of both *O. gallaeciana* and *O. melanopus* was the longest in the growth chamber at 16°C (Fig. 3). At this temperature, average length of developmental cycle of *Oulema* spp. was over 25 days; 26.9 days for *O. gallaeciana* and 25.7 days for *O. melanopus*. At 20°C developmental cycle of *Oulema* spp. did not exceed 17 days on average and was 15.7 days and 16.9 days for *O. gallaeciana* and *O. melanopus*, respectively. Finally, at 25°C developmental cycle did not exceed 13 days; 12.6 days and 11.9 days for *O. gallaeciana* and *O. melanopus*, respectively.

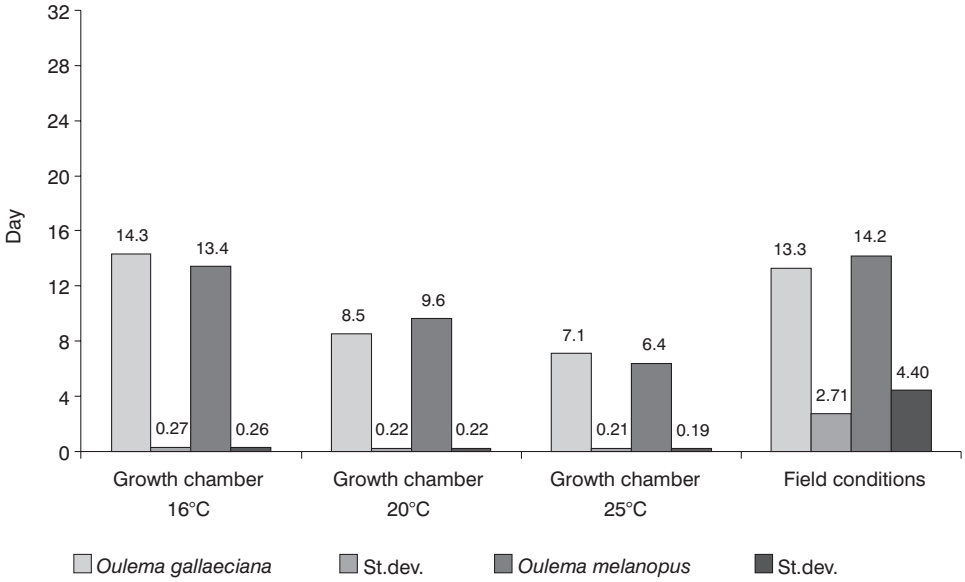

Fig. 2. The average time of larval development period duration of *Oulema* spp. in the growth chamber and in field conditions

Under field conditions the length of developmental cycle of *Oulema* spp. was similar to results obtained in the growth chamber at 16°C. In the cases of *O. gallaeciana* and *O. melanopus* means were 28.8 days and 31.9 days, respectively.

In conclusion, if air temperature in the growth chamber was lower, developmental cycle was longer with, the longest under field conditions, similar to those in the growth chamber at 16°C. Moreover, *O. gallaeciana* developed faster than *O. melanopus*, analogously to the growth chamber at 20°C.

Presented data on egg incubation period at 25°C was similar to results obtained by Ali et al. (1977). Average time of eggs incubation of *O. gallaeciana* at this temperature according to these authors (5.3 days) was similar to values obtained in this investigation (5.5 days). Incubation of eggs of *O. melanopus* according to these authors lasted on average 5.9 days, similarly to the presented herein studies (5.6 days).

According to Ali et al. (1977) at 20°C incubation of eggs for both *Oulema* spp. took on average 1 day longer, 8.3 and 8.5 days for *O. gallaeciana* and *O. melanopus*, respectively.

The results obtained at 16°C in the presented studies can not be compared to those at 15°C giving by Ali et al. (1977).

The average duration of larval stage in the growth chamber at 20°C was longer for *O. melanopus* than for *O. gallaeciana*. However, there is no possibility to compare these results with those of the authors cited above because they observed development of complete larval development, up to pupa stage, while the presented studies ceased at stage of larva of 4 mm long.

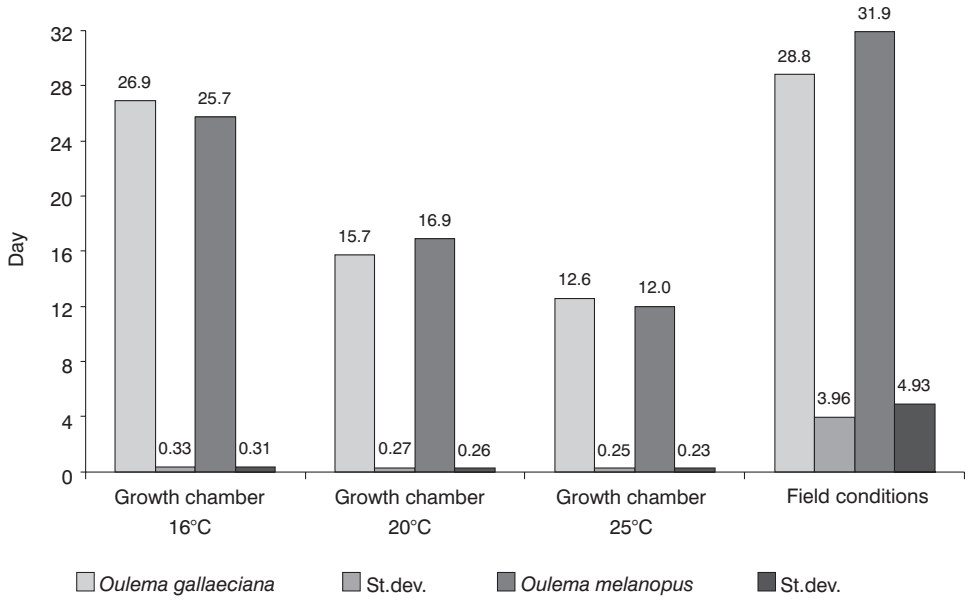

Fig. 3. Mean duration of developmental cycle of *Oulema* spp. in the growth chamber and under field conditions

Authors cited above noticed differences between the species in duration of pupa stage. In presented here studies differences in duration of developmental stage were observed in both growth chamber and field trials and referred to larval the development up to 4 mm of length.

At 20°C, *Oulema* spp. reacted similarly, regarding larval period, to field conditions. Less sensitive to temperature fluctuations *O. gallaeciana* developed in field conditions shorter cumulating less energy then *O. melanopus*. Shorter period of development of *O. gallaeciana* was noticed also in the growth chamber at 20°C.

CONCLUSIONS

1. The lengths of developmental periods both of eggs and larvae of two studied species of *Oulema* depended on air temperature and humidity.
2. There were differences in duration of larval period of *O. gallaeciana* comparing to *O. melanopus* under field conditions and in the growth chamber at 20°C.
3. Collected data can be valuable for further investigations on the influence of climatic conditions on the length of developmental stages using linear and curvilinear multinomial regression.

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POLISH SUMMARY

BADANIA NAD OKREŚLENIEM DŁUGOŚCI CYKLI ROZWOJOWYCH SKRZYPIONEK (*OULEMA* SPP.)

W Polsce ważnymi gospodarczo szkodnikami zbóż są między innymi dwa gatunki skrzypionek (*Oulema* spp.). – *Oulema melanopus* (Linnaeus 1758) i *Oulema gallaeciana* (Heyden 1870). Ze względu na rozciągnięte w czasie składanie przez nie jaj i wyląg larw określenie optymalnego terminu ich zwalczania nie jest łatwe. W czasie, kiedy na plantacjach zbóż obserwowane są larwy obu gatunków *Oulema* spp. wielkości około 4 mm z najwcześniej złożonych jaj, jednocześnie następuje masowy wyląg larw z masowo składanych jaj. Oba stadia rozwojowe sygnalizują optymalny termin zwalczania obu gatunków *Oulema* spp. W rejonie Wielkopolski przeprowadzono w fitotronie i w warunkach polowych badania, w wyniku których dla potrzeb doskonalenia prognozowania krótkoterminowego określono długości cykli rozwojowych obu gatunków O*ulema* spp. od świeżo złożonego jaja do osiągnięcia przez larwy wielkości około 4 mm.