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OCCURRENCE OF PEST SPECIES OF THE GENUS *Oulema* (COLEOPTERA: CHRYSOMELIDAE) IN CEREAL FIELDS IN NORTHERN POLAND

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ABSTRACT

The cereal leaf beetles *Oulema melanopus* L. and *Oulema gallaeciana* Heyden (Chrysomelidae) are common pests in European and North American cereal fields. Here we report infestation rates by *Oulema* spp. and yield loss of winter wheat and barley in Northern Poland (1995 to 1997) and show that both *Oulema* species might be of significant economic importance. *Oulema melanopus* was in all the three study years more abundant than *Oulema gallaeciana.* Larval densities ranged from 22 to 26 larvae per 100 stalks for winter wheat and 29 to 36 larvae per 100 stalks for barley. From these data we estimate yield losses of 0.5 to 4% for winter wheat and 3 to 8% for barley. The significant negative correlation between beetle abundances and the hydrothermic index indicates that higher precipitation and/or lower temperature had a negative effect on the activity of *O. melanopus* and *O. gallaeciana*.

Key words: *Oulema melanopus*, *Oulema gallaeciana*, Chrysomelidae, winter wheat, barley

INTRODUCTION

In Central Europe seven chrysomelid beetles belong to the genus *Oulema*. Two of them, the cereal leaf beetles *Oulema melanopus* L. and *Oulema gallaeciana* Heyden (Chrysomelidae) are pests of various cereals. In recent times, *O. melanopus* has also been introduced in North America and North Africa as well as in the northern and western parts of Asia where they are classified as major pests of cereals, grains and various grasses [1,11].

Morphology, life history and biology of *Oulema melanopus* L. and *Oulema gallaeciana* Heyden are well known [3,5,7,13,16,18,19,20,21,24,25]. Adults hibernate gregariously in protected places such as in field debris, in the crevices of tree bark or inside rolled leaves. The adults become active in the spring, when the temperature reaches 10°C and feed initially on wild grasses. Oviposition begins about 14 days after the emergence of adults. During the next two months each female may lay several hundred eggs. The larvae pass through four instars, each lasting two to three days. Pupation occurs in the soil up to five cm beneath the surface. The species are univoltine. Adults initially continue feeding but become less and less active during summer and early autumn. Feeding of larvae and adults is typically between leaf veins.

In Poland five *Oulema* species occur of which *Oulema melanopus* and *Oulema gallaeciana* are most common. Chrobok and Borowiec [4] distinguished the sixth pest species *O. duftschmidi* (Redt.), although the species status of the latter is still unclear and life history and occurrence patterns are nearly identical to *O. melanopus* [2].

The economic impact of cereal leaf beetles can be significant. Heyer [9] estimated that a single larva of *Oulema* reduces assimilation by about 10%. Massive attack of larvae reduces total assimilation by up to 80% [6] causing losses of about one tonne grain per ha. Larger damage in Polish cereal crops caused by *Oulema* has been observed roughly since 1990 [18].

This raises the question about the status and the causes of higher economic impact of cereal leaf beetles [15,16,17,27]. The present study focuses on the question whether abundances of cereal leaf beetles rose during the last decades. The second aim of this study is to assess damage caused by *Oulema* species; the knowledge of damage rates should help answering the question whether economic thresholds for control activities are reached. The attack reported concerns cereal leaf beetles on winter wheat and barley fields of the Nicolaus Copernicus University agro-ecological station. *Oulema* spp. is shown to have caused yield losses of several percent, rates that demand further investigation the economic importance of *Oulema*.

MATERIAL AND METHODS

The following study was based on field surveys from 1995 to 1997. Two 2-and-35 ha winter wheat ('Kobra' in 1995, 'Mikon' in 1996 and 'Almari' cultivars in 1997) and two 2-and-66 ha barley fields ('Orlik' in 1995, 'Rhodos' in 1996 and 'Krona' cultivars in 1997) of the Agricultural Field Station at Koniczynka and Piwnice near Toruń were sampled for larvae and adult cereal leaf beetles. The fields were treated following standard agricultural practice. No insect pest chemicals were applied. However, the fungicides Alert 375 SC and Cerelux 510 SC and the herbicide Balance 56 WG were used according to standard practice. In both fields samples were taken every 10 days from the beginning of April to the end of the harvesting period (first decade of August; in total 12 sampling sessions for both fields).

Adults were sampled by standard sweep net sampling using the method of Ruesink and Haynes [23]. Each sample consisted of 25 hits by the net (∅ 40 cm) taken during walks across both diagonals of one-ha squares in the centre of the fields. Eggs and larvae were counted at the same time as the adults. The counting was based in each case on 100 randomly chosen plants. Eggs and larvae were not classified according to species [18].

Leaf damage caused by the beetles were classified into four classes: class I (up to 10% leaf area damaged), class II (10 to 30% damaged), class III (30 to 60% damaged), class IV (above 60% damaged) [18].

To assess the influence of weather conditions on the populations multiple regressions assuming the following linear model were used:

$$N(t) = b_1 + b_2N(t-1) + b_3T(t) + b_4P(t) \quad (1)$$

where:

N(t) and N(t-1) – abundance data of adults at sampling times t and t-1,
P(t) – denotes mean precipitation during the sampling decade from t-1 to t,
T(t) – mean temperature (data from the University Meteorological Station at Koniczynka)

To compare abundances with climate data, the hydrothermic index [21] was used in the form:

$$HTQ = \frac{P(t)}{T(t)}$$

where:
P(t) – denotes mean precipitation,
T(t) – mean temperature during time period t.
Van Duyn et al. [26] and Ihrig et al. [14] reported relationships between leaf damage by *Oulema* and yield loss and developed a non-linear leaf damage – yield loss relation in the form:

$$YL = 0.37\ LD \quad (2)$$

where:
YL – denotes yield loss,
LD – leaf damage.

Therefore, it is possible to estimate the total yield loss caused by *Oulema* spp. by estimating LD from the damage rates of each class:

$$LD(\%) = (1 - D_{I}Class - D_{II}Class - D_{III}Class - D_{IV}Class) \cdot 100 \quad (3)$$

where:
LD(%) – denotes percent damage,
D – attack rates (from Table 2) and class damage rates per class.

Additionally, yield loss of winter wheat was estimated directly from the number of larvae per stem (LS) using the regression in Schärer [24]:

$$YL = 1.06\text{-}5.56LS \quad (4)$$

The low coefficient of determination ($R^2 = 0.615$) instead makes the estimates less precise than the previous method [24].

RESULTS

Abundances of *O. melanopus* and *O. gallaeciana*

Mean numbers of *O. melanopus* and *O. gallaeciana* did not fluctuate significantly during the study period (Table 1; no pairwise comparison significant at $p(t) < 0.05$). The mean number of adult *O. melanopus* was 16 individuals per sample on barley and 12 individuals at winter wheat. Of *O. gallaeciana* we found in the mean four individuals per sample for both cereals. The mean number of eggs per sample was 26 on barley and 15 on winter wheat, mean larval abundances were 18 on barley and 13 on winter wheat. In 1995 maximum larval densities on winter wheat were 26 per 100 stalks, in 1996, 22 per 100 stalks, and in 1997 23 per 100 stalks. On barley maximum densities were 36 per 100 stalks (1995), 34 per 100 stalks (1996), and 29 per 100 stalks (1997) (data not shown). The data for eggs and larvae indicate a decrease in abundance from 1995 to 1997 although this was statistically not significant. In all years *O. melanopus* had higher abundances in the barley fields.

Table 1. Mean number of imagines of *O. melanopus* and *O. gallaeciana* and of larvae and eggs of both species found during 12 sample sessions (April to August)

Year	Cereal	*O. melanopus*	*O. gallaeciana*	Eggs	Larvae
1995	Barley	21 ± 7	4 ± 1	33 ± 12	19 ± 6
	Wheat	15 ± 4	5 ± 1	19 ± 6	14 ± 4
1996	Barley	14 ± 4	3 ± 1	24 ± 9	20 ± 5
	Wheat	12 ± 3	5 ± 1	16 ± 6	16 ± 4
1997	Barley	13 ± 4	4 ± 1	23 ± 10	14 ± 4
	Wheat	9 ± 3	4 ± 1	11 ± 4	9 ± 3

Errors denote standard errors

Damage caused by *Oulema* spp.

The larvae of *Oulema* spp. damaged between 26 and 57% of all the plants sampled (Table 2). In the mean 17% of plants fell into class I (less than 10% of leaf area damaged), 10% into class II (10 to 30% damaged), 8% into class III (30 to 60% damaged), and again 8% into class IV (more than 60% damaged). In all the three years barley (46 to 57% of leaves damaged) appeared to be more attacked than wheat (26 to 35% of leaves damaged).

Table 2. Mean damage rates (percent of leaves damaged) caused by *Oulema* spp. according to the damage classes I to IV

Year	Cereal	Damage class				Sum
		I	II	III	IV	
1995	Barley	20	14	12	11	57
	Wheat	17	8	5	5	35
1996	Barley	21	13	11	9	54
	Wheat	13	9	7	5	34
1997	Barley	19	8	9	11	47
	Wheat	11	6	4	5	26

Table 3 shows respective computations of damage rates (eq. 3) for each year and each cereal using mean (5, 15, 45, and 80%) and minimum class damage rates (0, 10, 30, and 60%). Separate estimates were used for mean and minimum damage rates because the distribution of actual damage might not be symmetrical around the means. Barley suffered between 3 and 8% yield loss due to damage caused by *Oulema* spp. For wheat the damage was lower and we estimate only about 0.5 to 3% yield loss. Loss rates did not significantly differ during the study period. The regression of Schärer (1994) (eq. 4) resulted in consistently lower estimates of damage than the method of van Duyn et al. [26] (eq. 2).

Table 3. Damage caused by larvae of *Oulema* spp. Data give percent leaves damaged (assimilation loss) and estimated yield loss (eq. 2) in the three study years (in total 300 stalks of each field checked during the whole season)

Year	Cereal	Mean damage rates		Minimum damage rates		Yield loss % (eq. 4)
		Damage %	Yield loss % (eq. 2)	Damage %	Yield loss % (eq. 2)	
1995	Barley	17	3	13	7	
	Wheat	8	3	5	2	0.8
1996	Barley	15	7	10	5	
	Wheat	9	4	6	3	0.7
1997	Barley	15	8	10	5	
	Wheat	7	3	5	2	0.5

Mean and minimum damage rates refer to the damage classes I to IV. In the *mean* case 5, 15, 45 and 80% of leaf damage per class was assumed; in the *minimum* case 0, 10, 30, and 60% leaf damage per class were taken

Influence of weather conditions on populations of *Oulema* spp.

Seasonal changes in abundances of the imagines of *Oulema melanopus* and *Oulema gallaeciana* (Fig. 1) were in no case attributable to the climate variables precipitation and temperature (Table 4). There were also no correlations detectable across seasonal abundances and the value of the hydrothermic index (1996: $r = -0.19$, $p = 0.55$; 1997: $r = 0.05$, $p = 0.89$). From this one can conclude that within seasonal variation in abundance of the beetles was not significantly influenced by weather conditions.

Table 4. Multiple regression of larval densities N(t) at 12 sample dates as dependent and larval densities of the previous sample N(t-1), temperature(t), and precipitation(t) for 1996 and 1997 (for 1995 no full meteorological data set was available) (model of eq. 1)

Specification	BETA	Standard Error BETA	B	Standard Error B	p
1996					
Constant			0.04	0.16	0.79
N(t-1)	0.70	0.31	0.70	0.31	0.06
Temperature	-0.03	0.30	0.00	0.01	0.93
Precipitation	-0.02	0.28	0.00	0.00	0.95
1997					
Constant			13.72	29.88	0.66
N(t-1)	0.03	0.29	0.27	2.54	0.92
Temperature(t)	-0.09	0.28	-0.24	0.76	0.76
Precipitation(t)	0.75	0.29	0.75	0.29	0.04

Temperature and precipitation were mean values during the sampling period t-1 to t. Both regression coefficients were not significant at the 5% error level: 1996: $R^2 = 0.25$; p = 0.18; 1997: $R^2 = 0.35$; p = 0.12

Fig. 1. Phenology of *Oulema melanopus* and *O. gallaeciana* in the wheat and barley fields studied
A. Fractions of total numbers of adults of both species caught
B. Fractions of total numbers of larvae (I to IV instars) of both species caught

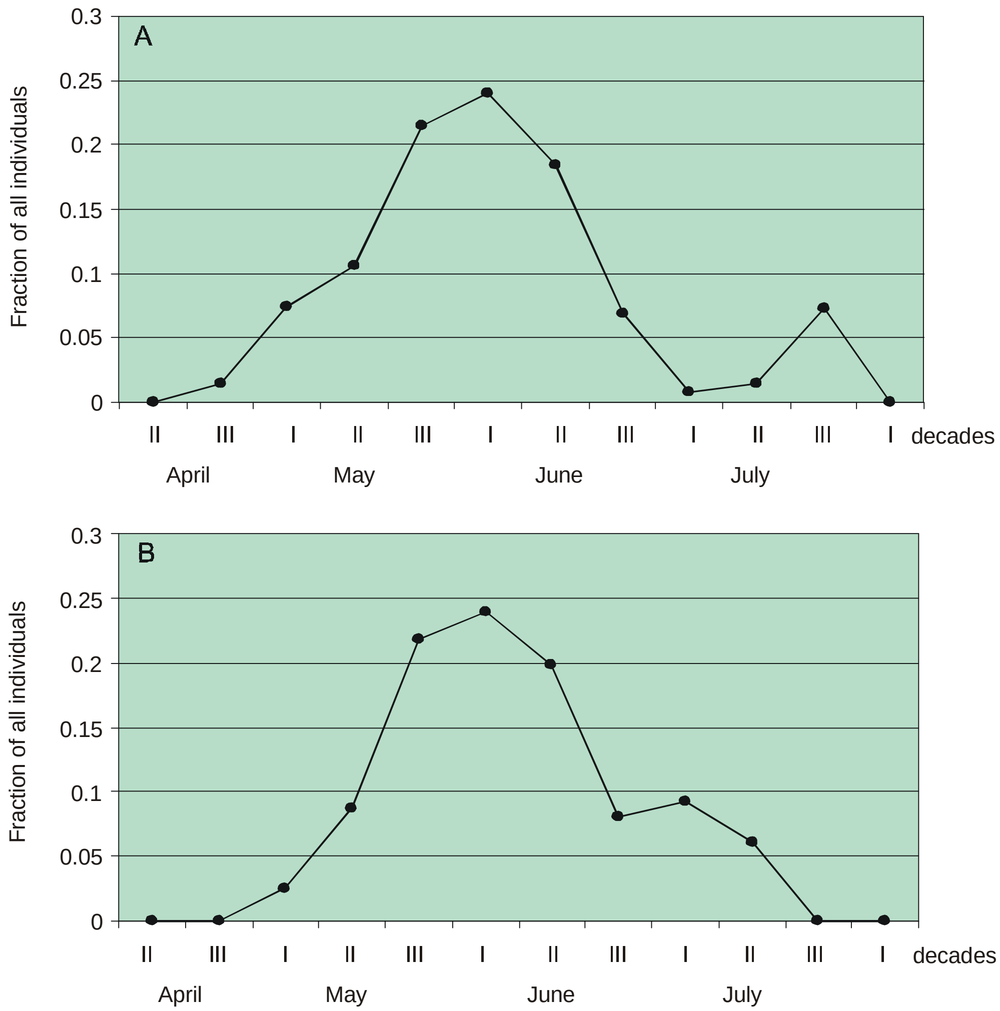
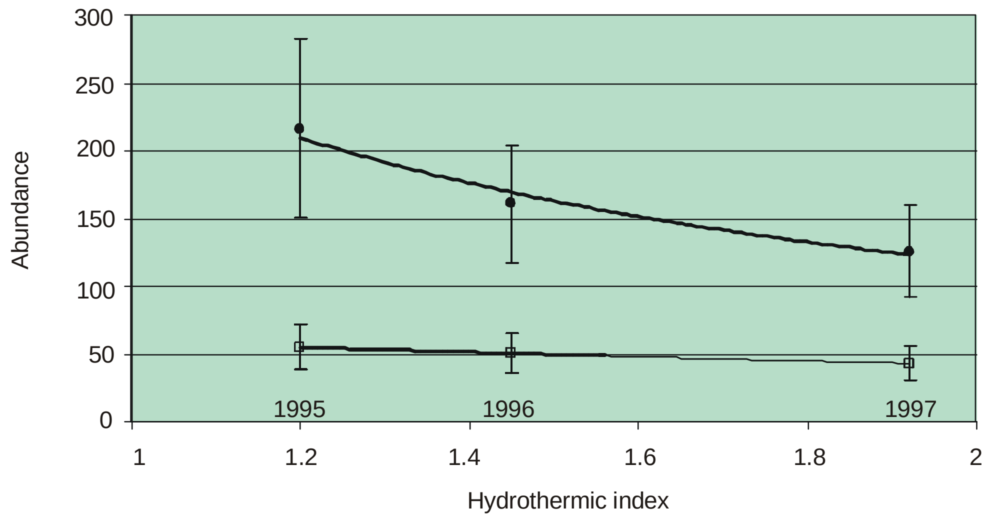


Fig. 2. Plot of total numbers of imagines of *O. melanopus* (full circles) and *O. gallaeciana* (open squares) sampled against mean hydrothermic indices (eq. 2) in 1995, 1996, and 1997. Error bars denote standard errors



A plot of abundances of both beetle species against the hydrothermic index (Fig. 2), however, indicates that the HTQ was negatively correlated with beetle abundance. This implies that higher precipitation and / or lower temperature had a negative effect on the activity of *O. melanopus* and *O. gallaeciana*.

DISCUSSION

In the last two decades cereal leaf beetles became significant pests of cereal crops. In North America, where *Oulema melanopus* was first observed in 1962, yield loss of infested fields reached 10 to 20%, regionally up to 30% [14,22,26]. However, in northern regions of the continent infestation by *Oulema* was still negligible, mainly due to unfavourable weather conditions (later onset of spring and drought). For instance, the recent survey program in Washington State [12] reported for 2000 to 2002 mean infestation rates of 13 to 126 (mean 88) larvae per 100 stalks. These infestation rates imply yield losses of about 2 to 4%. In Europe higher abundances of *Oulema melanopus* were observed since the 1980s [15,18] caused by the intensification of industrial food production and the prevalence of large monocultures. Additionally, climate change (warmer winter and early onset of spring) seems to favour beetle survival and development. Schärer [24] summarized our knowledge about damage caused by *Oulema* spp. For Switzerland he reported mean infestation rates of wheat below 1 larvae or egg per stalk. Heyer & Wetzel [10] instead reported infestation rates of two to five larvae per stalk in Eastern Germany's winter wheat fields.

25 years ago Miczulski [19,20] reported for Poland very low infestation rates of less than 1% by *Oulema* species. Recently, Wenda-Piesik and Piesik [27] found infestation rates of about 13% for wheat and 27% for barley in experimental agricultural fields in Northern Poland. The rates reported here are very similar. Both are 10 to 33 times higher (Table 1) than the earlier data of Miczulski [19, 20] and show how abundances of *Oulema* at least in some parts of Northern Poland increased during the last 25 years. This increase surely calls for further investigation about the causes and the future impact of cereal leaf beetles on cereal crop production in Central Europe. Wenda-Piesik and Piesik [27] established damage thresholds of 0.25 larvae per stalk above which control activities should be profitable. For Switzerland Schärer [24] instead argued for an economic threshold of 0.45 to 1.4 larvae per stalk (depended on the cultivar). The infestation rates reported here for winter wheat are still below these damage thresholds whereas the infestation on barley ranges just above the threshold given by Wenda-Piesik and Piesik [27]. However, our results clearly call for detailed survey programs for both cereals to establish whether abundances of both beetle species actually rise.

No significant correlation was found between seasonal beetle abundances and mean precipitation and temperature. Fig. 2 in turn shows a negative correlation between the hydrothermic index and annual cereal leaf beetle abundance. Such a relationship has already been observed earlier [21,24]. It implies that higher temperature and/or lower precipitation favour the development and activity of *Oulema* species. Therefore the earlier onset of spring and the relatively high spring temperature during the last two decades might at least in part be responsible for the increasing abundance of the cereal leaf beetles. This hypothesis is corroborated by the fact that the beetles increase in abundances in North America and in Europe, a fact that implies a common driver for this trend. With that in mind cereal leaf beetles might be an indicator taxon for climatic change. This possibility calls for more detailed surveys of *Oulema* abundances throughout Europe.

CONCLUSIONS

1. *Oulema* populations in Northern Poland can cause significant damage to barley and winter wheat. Larval densities ranged from 22 to 26 larvae per 100 stalks for winter wheat and 29 to 36 larvae per 100 stalks for barley. These rates still appear to be below established thresholds for profitable control activities.
2. Yield losses were estimated from 0.5 to 4% for winter wheat and 3 to 8% for barley.
3. Seasonal variation in abundance of the beetles was not significantly influenced by weather conditions. However annual abundances correlated negatively with the hydrothermic index. This indicates that higher temperature and / or lower precipitation favour the development and activity of *Oulema* species. From this one can argue that the earlier onset of spring and the relatively high spring temperature during the last two decades might, at least in part, have been responsible for the increasing abundance of the cereal leaf beetles in Poland.

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