Parasitoids of Cereal Leaf Beetle, *Oulema gallaeciana* (Heyden, 1879)

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Abstract

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Cereal leaf beetles are serious animal pests of crops in many areas of western and eastern Slovakia. Research was carried out in these areas in order to receive knowledge on occurrence of natural enemies of *Oulema gallaeciana*. We were detecting particular species of parasitoids parasitising *Oulema gallaeciana* and their spreading in particular area. The results showed that dominant parasitoid was *Necremnus leucarthros.* Other parasitoids with bigger proportion on parasitisation were *Pteromalus vibulenus* and *Diplazon* spp. with parasitisation up to 30%. In respect of significant parasitisation of *Oulema gallaeciana* by parasitoid *Necremnus leucarthros*, it would be appropriate to use this species for biological control of cereal leaf beetle.

Keywords: cereal leaf beetle; *Oulema gallaeciana*; parasitoids; *Necremnus leucarthros*; *Pteromalus vibulenus*; crops; temperature; biological control

Cereal leaf beetles are serious animal pests of crops in many growing regions of Slovakia (Gallo & Pekár 2001). Abundances of cereal leaf beetles (CLB) important for growing showed increasing trends in 1976 not only in our country, but also in neighbouring countries (Heyer & Wetzel 1990; Kocourek 1990). Abundances of CLB in the given period were so great that caused large economy losses.

Predators and parasitoids regulate CLB populations. *Oulema gallaeciana*'s parasitoids belong to order Hymenoptera (Šedivý 1995), rarely to order Diptera, namely *Phalacrotophora fasciata* (Fallén 1823) and *Duophoria nigrata*. Pavlov (1981) found the following parasitoids on *Oulema gallaeciana*'s cocoons: *Gelis instabilis* (Foerster 1850), *Lemophagus curtus* Townes 1965, *Bathytrix maculatus* (Hellén 1957) (Hymenoptera, Apocrita, Ichneumonoidea, Ichneumonidae), *Itoplectis alternans* (Gravenhorst 1829) (Hymenoptera, Apocrita, Ichneumonoidea, Ichneumonidae), *I. maculator* (Fabricius 1775), *Scambus annulatus* (Kiss 1924) (Hymenoptera, Apocrita, Ichneumonidea, Ichneumonidae), *Habrocytus* spp., *Eupteromalus* spp., *Trichomalopsis microptera* (Lindeman 1887) (Hymenoptera, Apocrita, Chalcidoidea, Pteromalidae) and *Necremnus leucarthros* (Nees 1834).

The most widespread parasitoid was discovered to be, according to scientific work, *Necremnus*

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leucarthros (Hymenoptera, Apocrita, Chalcidoidea, Eulophidae), parasitising more than 50% cocoons of cereal leaf beetle. Miczulski (1994) found 77% of parasitisation caused by this parasite. In Germany *Necremnus leucarthros* parasitised more than half of the whole populations of CLB (Haeselbarth 1989). Dominant abundance of this parasitoid was discovered also by Horvath and Szabolcs (1992) in experiment lasting from 1985 to 1990. CLB's cocoons parasitisation by this parasite in the Czech Republic varied within 21% to 39%, whereby sex ratio was always in favour of females (Šedivý 1995). Parasitisation caused by this parasitoid was 69.3% in Slovakia (Gallo & Jeloková 2006).

Research in Slovakia showed that *O. gallaeciana*'s cocoons were parasitised apart from *Necremnus leucarthros* also by the following species of parasitoids: *Pteromalus vibulenus* (Walker 1839) (Hymenoptera, Apocrita, Chalcidoidea, Pteromalidae), *Gelis instabilis, Lemophagus curtus, Itoplectis maculator, Diplazon* spp., *Bathytrix maculatus* and *Tetrastichus julis* (Walker 1839) (Hymenoptera, Apocrita, Ichneumonidea, Ichneumonidae). Percentage of parasitisation varied within 34.5 % (1997) up to 83.6% (2000). Total parasitisation of CLB in the western Slovakia region was 56.3%. It was found, that parasitisation in particular years is significantly influenced by a year (Gallo 2000).

Anaphes flavipes (Förster 1841) (Hymenoptera, Apocrita, Chalcidoidea, Mymaridae) parasitises on the cereal leaf beetle's eggs. This egg parasitoid has two generations per year in average. According to Haye (2000), *Anaphes flavipes* is not suitable for classic biological protection, because it is not a specific parasitoid and it requires alternative host for its complete development. However Horvath and Szabolcs (1992) showed that *A. flavipes* was the most effective parasitoid and was engaged in biological control of CLB in Hungary. *A. flavipes* itself is not able to reduce populations of CLB under the threshold of economic harmfulness. Engagement of other parasitoids is effective for control of CLB in growths and this complex of engaged enemies consists of further species of parasitoids of *Diaparsis temporalis, Lemophagus curtus* and *Tetrastichus julis*.

MATERIALS AND METHODS

Monitoring CLB and their parasitoids was carried out in two locations of Slovakia – Nitra in western Slovakia and Zvolen in central Slovakia. In order to detect presence of egg parasitoid of *Oulema*, monitoring of *Oulema* eggs was carried out since 17. 4. until 11. 5. 2007 at intervals of week on both locations. Eggs were collected together with leafs where they were situated. They were carried in closed sacs into laboratory in Department of Plant Protection (hereinafter referred to as "DPP"). Then particular eggs were carried into tubes and left at room temperature until brood of CLB's larvae or detecting of egg parasitoid. In order to determine specific composition of parasitoid species of *Oulema gallaeciana* ears and leafs of grains were picked up with foamy cocoon of *Oulema gallaeciana*. They were cut off, collected and inserted into paper bags and carried into DPP. All cocoons from ears and leafs were unsticked. Each cocoon separately was inserted into small tube. All tubes were stored in laboratory at room temperature. After brood of parasitoids or non-parasitoid cocoons after brood of CLB, particular species of parasitoids, their abundance were identified, as well as parasitisation percentage in particular areas was determined. Parasitoids were identified on the basis of morphological signs according to keys and verified on UK Bratislava by RNDr. J. Lukáš. Climatic data were submitted from meteorological stations in monitored areas. Results were subject to mathematical-statistical analysis through the software Statistica.

RESULTS AND DISCUSSION

Collections of CLB from the Nitra area

CLB cocoons were monitored in Nitra during 2000–2007. Analysis of collected cocoons showed spectrum of parasitoids parasitising *Oulema gallaeciana*. The following species of parasitoids were collected in the area of Nitra: *Necremnus leucarthros*, *Diplazon* spp., *Pteromalus vibulenus* and *Lemophagus curtus* were found during the whole period of research. *Gelis instabilis*, *Bathythrix maculatus, Bathyplectes curculionis* (Thomson 1887) and *Tetrastichus julis* parasitoids were found only in several years.

The most widespread parasitoid for the whole monitored period was *Necremnus leucarthros*. Parasitisation by this parasitoid varied within the period of 25.5% (2007) to 83.6% (2000). First drop in occurrence was in 2002, when the parasitisation was only 50%, however the parasitisation grew up

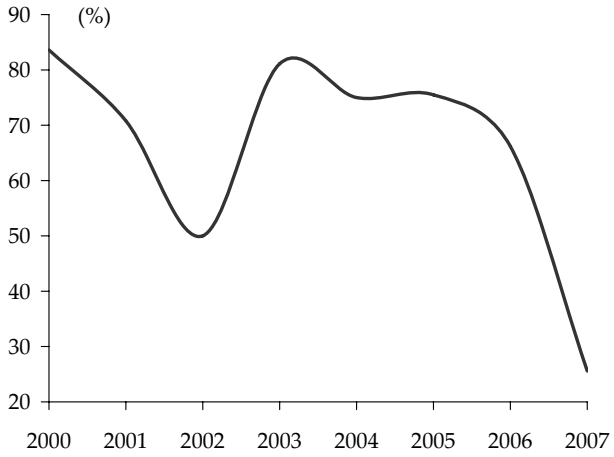

Figure 1. Parasitisation by *Necremnus leucarthros* during 2000–2007 in Nitra

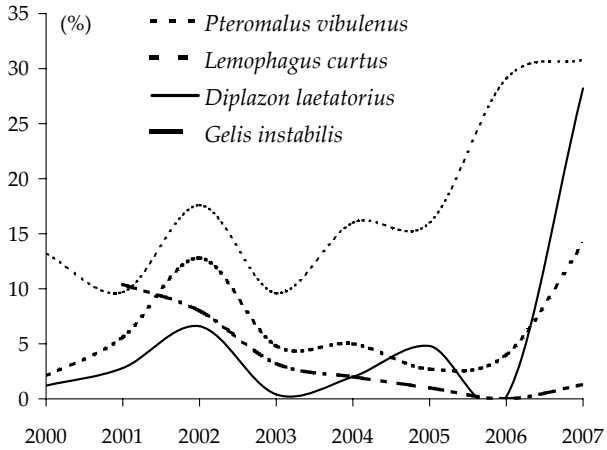

Figure 2. Parasitisation by other parasitoids found 2000–2007 in Nitra

in the next years. The most significant drop was in 2007, when *Necremnus leucarthros* parasitised only 25.6% of CLB's cocoons (Figure 1).

The parasitisation by *N. leucarthros* over the monitored years was at average 63% (Table 1). Our results correspond to those of other authors (Haeselbarth 1989; Horvath & Szabolcs 1992; Miczulski 1994; Šedivý 1995; Gallo 1997; Gallo & Jeloková 2006), according to which this species was the most widespread CLB's parasitoid. The results of the said authors showed that 25 individuals of this parasitoid can brood out of one cocoon, whereby in our experiment there were only 17 individuals brooded out of one cocoon. In the majority of cases, females outnumbered males. In our experiments for the period of 2000–2007 the sex index of brooded parasitoids was 0.66 (Table 1). Sex index for monitored period was 1:1.74 at average. Šedivý (1995) and Gallo (2000) reached the same results in their work.

Another parasitoid occurring over the whole monitored period was *Pteromalus vibulenus.* Occurrence of this parasitoid had fluctuating trend, in 2006 it reached 29.1% and maximum of 30.8% was reached in 2007. The lowest parasitisation was in 2003, namely 9.6% (Figure 2). The results of Šedivý (1995) showed index in favour of males, which does not correspond to our results, where

Table 1. Parasitism of cocoons of cereal leaf beetle collected in Nitra and Zvolen areas during the study, including ratio of sexes and sexual index of *Necremnus leucarthros*

Year	Number of cocoons	Number of cocoons parasitised		Parasitism by all spp. (%)	*Necremnus leucarthros*	
		total	by *Necremnus leucarthros*		sexual ratio M:F93.2	sexual index
2000	529	493	412		1:2.20	0.69
2001	205	144	102	70.2	1:1.50	0.60
2002	390	289	144	74.0	1:1.86	0.65
2003	272	249	202	91.5	1:2.06	0.67
2004	413	257	193	62.2	1:1.87	0.65
2005	452	294	222	65.0	1:3.10	0.65
2006	473	151	100	34.6	1:2.40	0.67
2007	516	78	20	25.5	1:2.67	0.73
Average	402	264	174	63.2	1:2.20	0.66

Table 2. Analysis of variance of relationship between temperature in May and percent of parasitisation

Source	Sum of squares	Df	Mean square	*F*-ratio	*P*-value
Model	13.7633	1	13.7633	11.76	**0.0187**
Residual	5.85324	5	1.17065		
Total (corrrelation)	19.6165	6			

sex index was in favour of females over the whole period of monitoring.

Lemophagus curtus is solitary endoparasite of small larvae of CLB. According to Dysart *et al.* (1973), this species can have several generations a year, which was not discovered in our research. Šedivý 1(995) informed that this parasitoid exists in the areas of wheat grown for two consecutive years, which was not confirmed in our experiments. Also with this parasitoid, the first maximum of 6.6% was shown in 2002 and significant growth was found in 2007, when parasitisation reached 14% (Figure 2).

The level of parasitisation by *Diplazon* spp. ranged widely. It increased most up to 2007 in the Nitra area when parasitisation was 28%, the highest by this parasitoid during the study.

Also *Gelis instabilis* occurred over the whole period apart from 2000 and 2006. In 2001–2003 also *Bathythrix maculatus*, *Bathyplectes curculionis* and *Tetrastichus julis* occurred. Percentage of parasitisation of these *Oulema gallaeciana*'s parasitoids was low and varied up to 1%.

First significant maximum of the most parasitoids was detected in 2002 (Figure 2). The occurrence of parasitoids varied over the next years and further significant maximum was in 2007 with all parasitoids. Only *Necremnus leucarthros* had low proportion on parasitisation of CLB in 2002 (50%); its trend was slightly decreasing in the next years and its occurrence dropped to 25.5% in 2007 (Figure 1).

Furthermore, dependence between the temperature and parasitisation was monitored in Nitra. Statistically proven relation between the temperature in May and percentage of parasitisation was detected ($0.0187 < 0.05$) at 95% significance level (Table 2). The highest values of the temperatures were reached in May; the biggest parasitisation was in the given year. We did not found influence of the temperature in May on species composition of *Oulema gallaeciana* parasitoids in our experiments.

Collections of CLB from the Zvolen area

In 2006 and 2007 the occurrence of parasitoids in Zvolen area was monitored. The same species of parasitoids in CLB cocoons occurred in Zvolen as in Nitra (Table 3). There were *Necremnus leucarthros*, *Pteromalus vibulenus*, *Lemophagus curtus*, *Diplazon* spp. and *Gelis instabilis*. *N. leucarthros* had the biggest abundance in Zvolen – 81.4% (2006) and 66.4% (2007). The second biggest abundance of 22.7% was that of *Pteromalus vibulenus.* With this parasitoid, females outnumbered males, which was difference compared to Šedivý (1995). All other discovered parasitoids had increasing percentage of parasitisation.

The same species of parasitoids were found in cocoons of CLB in Nitra and Zvolen. *Necremnus leucarthros* had the biggest average share on parasitisation of cocoons of *Oulema gallaeciana*, namely 45.9% in Nitra and 73.9% in Zvolen. Our results were the same as those of other authors (Horvath & Szabolcs 1992; Haeselbarth 1989; Gallo 2005), according to which this parasitoid was the most widespread *Oulema gallaeciana*'s parasitoid. Abundance of parasitoid *Pteromalus vibulenus* was almost the same in both locations (Figure 3).

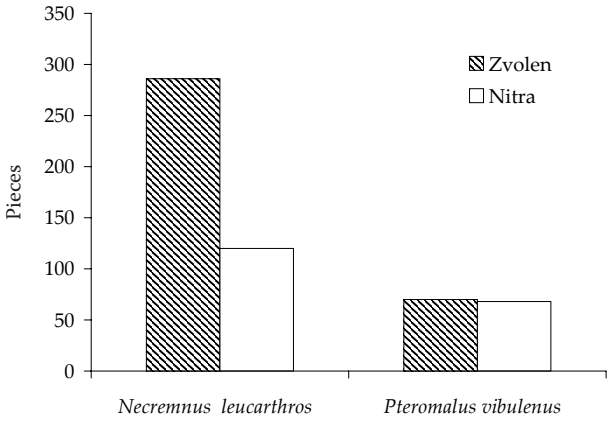

Figure 3. Numbers of *Necremnus leucarthros* and *Pteromalus vibulenus* found in Nitra and Zvolen during 2006–2007

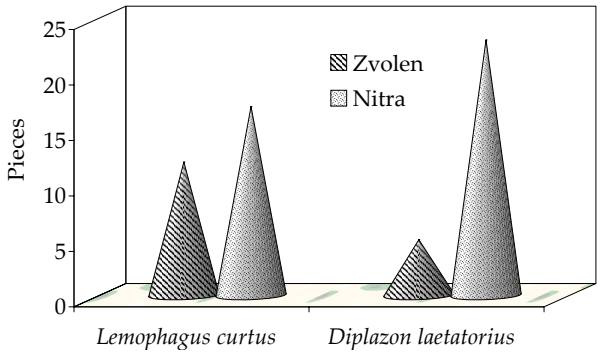

Figure 4. Numbers of *Lemophagus curtus* and *Diplazon* spp. found in Nitra and Zvolen during 2006–2007

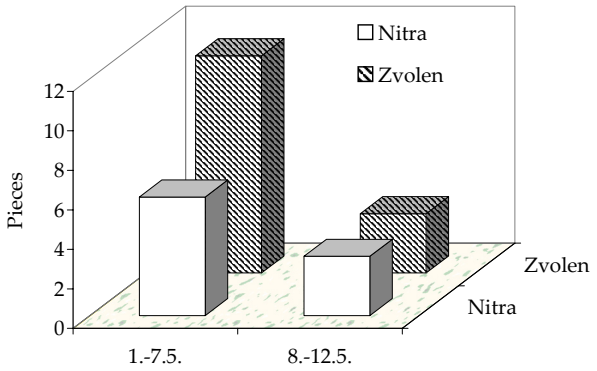

Figure 5. Occurrence of *Anaphes flavipes* in Nitra and Zvolen in 2007

Table 3. Percent of parasitisation by species found in Zvolen and Nitra in 2006–2007

Species		Zvolen		Nitra	
		2006	2007	2006	2007
1.	*Necremnus leucarthros*	81.4	66.4	66.2	25.6
2.	*Pteromalus vibulenus*	16.6	22.7	29.1	30.8
3.	*Lemophagus curtus*	1.2	7.0	4.0	14.1
4.	*Diplazon* spp.	0.8	2.3	0.7	28.2
5.	*Gelis instabilis*	–	1.6	–	1.3

Parasitoids *Lemophagus curtus* and *Diplazon* spp. had in both localities low abundance, parasitisation was in average of 3.2–5.2%. For both species several parasitoids were found in locality of Nitra (Figure 4). Our results were similar to the results of other studies (Gallo 2000; Gallo & Jeloková 2006).

Egg parasitoids in Nitra and Zvolen

Research was extended by monitoring of egg parasitoid of *Anaphes flavipes.* Parasitoid *A. flavipes* was not found in eggs collected in April. The parasitoid was found in both localities in May. Total number of parasitoids was very small. Several individuals were from location of Zvolen, namely 14 pieces. Only 9 pieces of parasitoids were from Nitra. The most of eggs were parasitised from collections from the beginning of May, which means, that eggs were parasitised on the last days of April and first days of May (Figure 5). Our results are the same as results of Dysart *et al*. (1973), according to which parasitised eggs of CLB occurred in May.

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