Population Dynamics of *Chaetocnema tibialis* Illiger and *Phyllotreta vittula* (Redtenbacher) on the Weed *Amaranthus retroflexus* L. and Cultivated *Amaranthus caudatus* L.

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Abstract

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In 1995–1997, the population dynamics of the flea beetles *Chaetocnema tibialis* and *Phyllotreta vittula,* associated with *Amaranthus retroflexus* (wild species) and *Amaranthus caudatus* (cultivated species), were studied at the locality Nitra-Malanta (48°19'N, 18°09'E) in south-western Slovakia. On both plant species, the number of *C. tibialis* adults was usually very low until the beginning of July. During July the number of *C. tibialis* increased, but sooner on cultivated amaranth. An increased number of *C. tibialis* adults was observed on both amaranth species until the middle of September. The results showed that amaranth plants are a very important reservoir of *C. tibialis* during summer. *P. vittula* was a common flea beetle on amaranth during the whole summer, but its numbers never exceeded more than 10 adults per 25 plants. Low temperatures in winter had a negative effect on populations of *C. tibialis* on both amaranth species and also on populations of *P. vittula* on *A. retroflexus*. The lower the precipitation was in July, the higher were the populations of *C. tibialis* on both amaranth species and the populations of *P. vittula* on *A. retroflexus*.

Keywords: *Amaranthus*; flea beetles; *Chaetocnema; Phyllotreta*

Amaranthus retroflexus L. belongs to the 10 most important weeds in Europe (Schroeder *et al.* 1993). Species of the *Amaranthus* genus are troublesome weeds throughout the United States (Coetzer *et al.* 2002) and on other continents (Klister & Kogan 2005; Shaukat & Siddiqui 2005; Nakamoto *et al.* 2006). In addition to the loss caused by competition for nutrients and light (Manojlović 1984; Mikulka & Chodová 1988), it is a secondary host for the European corn borer (Manojlonović 1984) and potential host for other phytophagous insects (Vráblová *et al.* 2000, 2001; Tóthová *et al.* 2003, 2004) or pathogenic microbes (Bürki *et al.* 1997; Ortiz-Ribbing &

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Williams 2006). In Slovakia, *A. caudatus* L., *A. cruentus* L. and *A. hypochondriacus* L. are the most useful species for nutritional and industrial purposes (Debre & Kolenová 1997).

Many species from the family Chrysomelidae (Coleoptera) have been recorded among the insects damaging amaranth species. In Europe (Yugoslavia), *Chaetocnema tibialis* Illiger was found on *Amaranthus hybridus* L. (Nonveiller 1960). Its damage to plants within the families *Amaranthaceae* and *Chenopodiaceae* was confirmed also by Doguet (1994).

In our previous paper (Cagáň *et al.* 2000) we stated that 41.2–97.5% of the flea beetle populations on amaranth consisted of *C. tibialis* and it was found at all localities. It comprised 94.9–99.7% of the flea beetles on cultivated *A. caudatus.* In addition, *Phyllotreta vittula* (Redtenbacher) was present at each locality. All other species occurring on amaranth plants were probably concomitant.

The aim of this study was to determine the population dynamics of *Chaetocnema tibialis* and *Phyllotreta vittula* on wild amaranth, *A. retroflexus* L., and cultivated amaranth, *A. caudatus,* and evaluate the relationship between flea beetle populations and amaranth host plants.

MATERIAL AND METHODS

In 1995–1997, the population dynamics of the flea beetles *Chaetocnema tibialis* and *Phyllotreta vittula* associated with plants of *Amaranthus retroflexus* (wild species) and *Amaranthus caudatus* (cultivated species) were studied at the locality Nitra-Malanta (48°19'N, 18°09'E) in south-western Slovakia.

Insects were collected weekly during the vegetative growth stage (from 3 or 4 weeks after germination) using sweep nets on 3 × 25 randomly chosen plants on each date (Tables 1–4). Plants were bent into and shaken in the sweep net. Collected insects were put to death, sorted and identified.

Climatic data were obtained from the Agrometeorology Station at the Slovak University of Agriculture at Nitra.

The numbers of *C. tibialis* on amaranth plants allowed to compare the populations during each date statistically. Analysis of variance was used to compare the populations of *C. tibialis* during the year. Regression analysis was used to find the relations among climatic data and population levels of both *C. tibialis* and *P. vittula*.

RESULTS

Tables 1 and 2 show the population dynamics of *C. tibialis* on cultivated and weed amaranth in 1995–1997.

Until the beginning of July 1995 the number of *C. tibialis* was very low on both plant species. During July the number of *C. tibialis* increased, but a significant increase was observed earlier on cultivated amaranth (July 17, 1995) than on the wild species (July 31, 1995). On July 24 and July 31, the number of *C. tibialis* adults per 25 cultivated amaranth plants were 207.33 ± 30.05 and 228.00 ± 40.00, respectively, while on weed amaranth it was 57.33 ± 41.87 and 133.00 ± 50.43 on July 24 and July 31, respectively. An increased number of *C. tibialis* adults was observed on both amaranth species until the middle of September.

In 1996, the number of *C. tibialis* on cultivated amaranth significantly increased from the end of June (62.33 ± 19.60 adults per 25 plants on June 25) till the middle of July (July 10) (270.68 ± 8.37). The highest number of *C. tibialis* adults (109.00 ± 41.81 adults per 25 plants) was found on weed amaranth on July 30. In August and September the number of *C. tibialis* was usually higher than 25 adults per 25 plants of both cultivated and weed amaranth.

In 1997, the number of *C. tibialis* was very low on both amaranth species and usually did not reach more than 25 adults per 25 plants.

Tables 3 and 4 show that *P. vittula* was a common flea beetle on *Amaranthus* plants during the whole summer, but its number never exceeded 10 adults per 25 plants. Significant differences between cultivated and weed amaranth were found only in 1995 when the number of *P. vittula* adults was higher on weed amaranth. In this year, only two beetles were found on cultivated amaranth during the whole season. In 1997, a very low number of *P. vittula* adults was observed on both amaranth species.

Correlation coefficients between climatic data and population levels of *C. tibialis* or *P. vittula* adults are shown in Table 3. It shows that low temperatures in winter had a negative effect on populations of *C. tibialis* on both amaranth species and also on populations of *P. vittula* on *A. retroflexus.* The lower the precipitation was in July, the higher were the populations of *C. tibialis* on both amaranth species and of *P. vittula* on *A. retroflexus*.

Table 1. Population dynamics of *Chaetocnema tibialis* Illiger on *Amaranthus caudatus* L. and *Amaranthus retroflexus* L. at Nitra-Malanta (48°19´N, 18°09´E) in 1995–1997

	Year	Date of observation															
Amaranthus caudatus	1995	–	–	19.6.	27.6.	3.7.	8.7.	17.7.	24.7.	31.7.	7.8.	14.8.	20.8.	31.8.	5.9.	13.9.	
	x			5.0	3.3	12.0	54.7	145.3	207.3	228.0	152.0	187.0	171.0	313.3	472.7	140.0	
	*			a	a	a	a	b	bc	c	b	bc	bc	d	e	b	
	1996	4.6.	11.6.	18.6.	25.6.	2.7.	10.7.	16.7.	23.7.	30.7.	6.8.	13.8.	20.8.	27.8.	4.9.	11.9.	18.9.
	x	0.0	31.0	25.0	62.3	283.0	270.7	53.3	65.7	39.7	30.7	35.7	22.3	8.7	8.7	7.7	5.3
	*	–	a	a	a	b	b	a	a	a	a	a	a	a	a	a	a
	1997	–	13.6.	19.6.	26.6.	4.7.	11.7.	17.7.	24.7.	30.7.	7.8.	14.8.	21.8.	28.8.	3.9.	10.9.	19.9.	26.9.
	x		2.7	6.0	21.3	6.3	11.0	2.0	13.3	13.7	8.3	10.0	2.7	19.0	4.3	0.7	2.7	1.7
	*		a	ab	c	ab	abc	a	abc	abc	abc	abc	a	bc	a	a	a	a
Amaranthus retroflexus	1995	–	–	19.6.	27.6.	3.7.	8.7.	17.7.	24.7.	31.7.	7.8.	14.8.	20.8.	31.8.	5.9.	13.9.	
	x			3.0	3.3	11.0	3.0	19.0	57.3	133.0	106.0	197.3	109.0	98.0	74.3	28.0	
	*			a	a	a	a	a	ab	c	bc	d	bc	bc	abc	a	
	1996	4.6.	11.6.	18.6.	25.6.	2.7.	10.7.	16.7.	23.7.	30.7.	6.8.	13.8.	20.8.	27.8.	4.9.	11.9.	18.9.
	x	4.0	11.7	3.0	2.7	2.7	8.3	2.7	14.3	109.0	19.0	33.0	40.7	70.0	24.7	38.0	33.7
	*	a	a	a	a	a	a	a	a	c	ab	ab	ab	bc	ab	ab	ab
	1997	–	13. 6.	19. 6.	26. 6.	4. 7.	11. 7.	17. 7.	24. 7.	30. 7.	7. 8.	14. 8.	21. 8.	28. 8.	3. 9.	10. 9.	19. 9.	26. 9.
	x		3.0	7.7	0.7	3.0	1.7	4.0	2.7	5.3	18.3	14.7	3.0	4.7	2.3	1.0	1.7	0.7
	*		ab	b	a	ab	ab	ab	ab	ab	c	c	ab	ab	ab	ab	ab	a

x – number of adults from 25 plants (average from 3 repetitions)

*Means followed by the same letter within each row are not significantly different (Duncan's multiple range test, $P > 0.05$)

Table 2. Population dynamics of *Phyllotreta vittula* (Redtenbacher) on *Amaranthus caudatus* L. and *Amaranthus retroflexus* L. at Nitra-Malanta (48°19´N, 18°09´E) in 1995–1997

	Year	Date of observation																
Amaranthus caudatus	1995	–	–	19.6.	27.6.	3.7.	8.7.	17.7.	24.7.	31.7.	7.8.	14.8.	20.8.	31.8.	5.9.	13.9.		
	x			0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0		
	SD			0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0		
	1996	4.6.	11.6.	18.6.	25.6.	2.7.	10.7.	16.7.	23.7.	30.7.	6.8.	13.8.	20.8.	27.8.	4.9.	11.9.	18.9.	
	x	0.0	0.3	0.0	0.0	3.3	1.3	1.3	4.0	9.7	0.7	0.3	0.3	0.3	0.3	0.0	0.0	
	SD	0.0	0.5	0.0	0.0	1.3	0.5	0.5	2.8	4.5	0.9	0.5	0.5	0.5	0.5	0.0	0.0	
	1997	–	13.6.	19.6.	26.6.	4.7.	11.7.	17.7.	24.7.	30.7.	7.8.	14.8.	21.8.	28.8.	3.9.	10.9.	19.9.	26.9.
	x		0.0	0.0	0.3	0.7	0.7	0.3	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SD		0.0	0.0	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amaranthus retroflexus	1995	–	–	19.6.	27.6.	3.7.	8.7.	17.7.	24.7.	31.7.	7.8.	14.8.	20.8.	31.8.	5.9.	13.9.		
	x			0.0	1.0	1.3	6.0	2.7	4.3	5.7	2.7	3.0	6.0	6.0	7.7	1.0		
	SD			0.0	0.8	0.5	1.6	1.7	0.5	1.7	2.5	0.8	0.8	2.2	2.4	1.4		
	1996	4.6.	11.6.	18.6.	25.6.	2.7.	10.7.	16.7.	23.7.	30.7.	6.8.	13.8.	20.8.	27.8.	4.9.	11.9.	18.9.	
	x	1.0	0.0	0.0	0.0	2.0	2.0	7.7	6.0	2.0	1.7	0.7	2.7	1.0	1.0	0.7	0.3	
	SD	0.8	0.0	0.0	0.0	0.8	2.2	2.5	2.2	0.8	1.3	0.5	2.4	0.0	0.8	0.5	0.5	
	1997	–	13.6.	19.6.	26.6.	4.7.	11.7.	17.7.	24.7.	30.7.	7.8.	14.8.	21.8.	28.8.	3.9.	10.9.	19.9.	26.9.
	x		0.0	0.0	1.0	0.7	2.7	0.7	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.7	0.0
	SD		0.0	0.0	0.8	0.5	1.3	0.9	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.9	0.0

x – number of adults from 25 plants (average from 3 repetitions); SD – standard deviation

Table 3. Correlation coefficients between climatic data and population levels of *Chaetocnema tibialis* Illiger or *Phyllotreta vittula* (Redtenbacher) adults. Sums of adults collected during July and August were correlated to selected climatic data in year

Host plant species	*Amaranthus caudatus* L.		*Amaranthus retroflexus* L.	
Insect species	*C. tibialis*	*P. vittula*	*C. tibialis*	*P. vittula*
T12	0.989453939	0.092406847	0.944850563	0.999929028
T1	0.943906977	–0.37958525	0.989034256	0.89158064
T2	0.339770911	–0.957135	0.509817307	0.211616077
T3	–0.09517158	–0.98904789	0.092849336	–0.22677094
T4	–0.46959984	0.906440943	–0.62656394	–0.34795823
T5	–0.80859952	0.630229512	–0.90444077	–0.72312971
T6	–0.78382118	0.661502984	–0.88620784	–0.69423064
T7	–0.99983369	0.034575401	–0.97874691	–0.993371
T8	0.574845527	–0.84747017	0.717853677	0.460865535
T9	0.546075559	–0.86539805	0.693237548	0.429760349
T4–T6	–0.68956626	0.759618742	–0.81294354	–0.58707821
T7–T9	0.448771725	–0.91609334	0.608119445	0.325882744
P4	0.610428752	0.758738425	0.451372354	0.710386283
P5	0.210543861	0.965105175	0.023829895	0.338739034
P6	0.665026405	–0.78088887	0.793067393	0.559749982
P7	–0.99133304	0.183527762	–0.99840173	–0.96504043
P8	0.902032449	0.383442681	0.805284904	0.951446049
P9	0.917407462	0.34895892	0.805284904	0.962198069
P4–P6	0.6423297	0.731447224	0.487509442	0.738591862
P7–P9	–0.16924006	0.993135469	–0.3507367	–0.03660526

T12 – average daily temperature in December of preceding year; T1…T9 – average daily temperature in January, February, … August of the studied year; T4–T6 – average daily temperature during April–June in studied years (average of 3 moths); T7–T9 – average daily temperature during July–September in studied year (average of 3 months); P4…P9 – sum of precipitation in April, May… August of the studied year; P4–P6 – sum of precipitation in during April–June in studied year; P7–P9 – sum of precipitation during July–September in studied year

DISCUSSION

Pigweeds (*Amaranthus* spp.) are common weeds in sugar beet fields in Slovakia (Černý 1999), and *C. tibialis* is considered to be an important insect pest of sugar beet in central (Pataki 1967) and southern Europe (Stef & Buzinovschi 1982; Neves 1983) and parts of Asia (Yildirim & Ozbek 1992). The same flea beetle species was found on pigweed plants (Cagáň *et al*. 2000). Species composition and abundance of flea beetles (Coleoptera, Chrysomelidae) associated with *Amaranthus retroflexus* were studied in Erzurum province, Turkey. In all localities *C. tibialis* was more abundant than other species. Simple feeding tests in Petri dishes showed that only the Chaetocnema species were actually feeding on leaves of *A. retroflexus* (Aslan *et al*. 2003). In southern regions of the pest occurrence, overwintered adults emerged in early April. The population of these adults peaked in mid-May and declined from the end of May. The adults of the new generation emerged in mid-June. Thus the adults were most numerous in mid-May and again in July–August (Ghadiri 1990, 1992). In

Central Europe the adults of *C. tibialis* appeared towards the end of April and fed on sugar beet plants (Watzl 1950; Schäufele 1982). In the same region, mating of *C. tibialis* occurred in May (Watzl 1950). The usual time for sowing of sugar beets is the end of March, the temperature required for germination is 5°C, and after one month (end of April) the plants have three to four leaves (Bajči *et al.* 1997). *Amaranthus* spp. germinate at temperatures higher than 10°C. In Slovakia, germination usually starts between the end of April and the beginning of May (Húska *et al.* 1997). Thus, at the end of April there are well-developed plants of sugar beet, germinated *Amaranthus* plants and feeding adults of flea beetles. These adults influence the development of young amaranth plants. If they feed on wild amaranth they can be considered to be a biological control agent, but if they feed on cultivated amaranth, they are a pest. According to our results, the new generation of *C. tibialis* in Slovakia occurred in July and it was very numerous on wild amaranth (*A. retroflexus*) until autumn. It seems that wild amaranth plants are a very important reservoir of *C. tibialis*. Even so, *C. tibialis* has more host plant species, including *Beta vulgaris* L., *Spinacea oleracea, Atriplex* spp. L., *Chenopodium* spp. L., *Sinapis arvensis* L. and others (Watzl 1950; Nonveiller 1960; 1978; Gurjeva & Kryzsanovskij 1965; Pataki 1967; Warchałowski 1978).

Our observations confirmed that *Phyllotreta vittula* is a flea beetle common on both *A. retroflexus* and *A. caudatus*. It is known as a pest of cereals (Naibo 1974; Sekulić *et al.* 1989; Kurppa 1990; Szoeke 1997) and has been recorded on *Brassicaceae, Beta* spp. and *Sinapis arvensis* (Naibo 1974; Hurej *et al.* 1997). Although *P. vittula* probably prefers cereals, it seems that it can be found on many other host plant species. It is known that females of *P. vittula* oviposit in the soil in May, the larvae develop in June on the roots of various plants, giving rise to new adults at the end of June to beginning of July. These undergo both aestivation and hibernation before being able to oviposit in the following year (Naibo 1974). In Hungary, young adults of the new generation appeared in August and moved to overwintering sites by the end of October (Vig 1998). A regression model of flight activity in both generations was established, based on the sum of day-degrees above the temperature threshold for flight of six *Phyllotreta* species (10.2°C) by Kocourek *et al.* (2002). These authors showed that the onset of flight activity of adults of the overwintering generation in spring started at 30 day-degrees, and that of the adults of the summer generation at 280 day-degrees. According to our results it seems that adults of the second generation occurred in July since in June only very low numbers of adults were found. That date corresponds to a degree-day level of more than 400°C, but if calculated that the first adults emerged sooner it would correspond to the data of Kocourek *et al.* (2002).

In 1997, compared to the previous 2 years, very low numbers of both flea beetle species were observed. Correlation coefficients calculated from 1995–1997 results show that populations of both species on *A. retroflexus* and the population of *P. vittula* on *A. retroflexus* were negatively influenced by wet conditions in July. Our results showed further that cold temperatures in December or January influenced the population dynamics of flea beetles. In colder countries like Sweden, weather was an important factor in determining the population size of flea beetles. After successive mild winters the population of chrysomelid beetles was high (Rufelt 1993). The population was reduced following a cold, wet summer (Ekbom 1991).

Our results still leave open the question what is more important for population development of flea beetles: wet conditions in summer or a cold winter. It seems that both are important.

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