Insect Injury and Mortality of Seedlings of Field Penny-Cress (*Thlaspi arvense* L.)

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Abstract

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During 1997–1999 the injury caused by insect herbivors and mortality of plants of field penny-cress (*Thlaspi arvense* L.) was studied on an early fallow field at Prague-Ruzyně. The highest abundance of the weed (102 plants per m^2) was recorded in 1999, the lowest (27 plants/m^2) in 1998. Nearly all plants (100% in 1997 and 1998, 94% in 1999) were injured by flea beetles (*Phyllotreta* spp.). Injury was greatest (> 50%) in younger seedlings. Mortality was low in 1997 (17.1%) and 1999 (15.8%), but high in 1998 (94%) because of concurrent drought. Herbivory and drought may kill a large proportion of seedlings and thus change the composition of the weed community.

Keywords: field penny-cress; *Thlaspi arvense* L.; phytophagous insect; flea beetle; *Phyllotreta* spp.; herbivory; mortality; fallow; secondary succession

Herbivory on alien plant species has been studied to find phytophagous insect species efficient in their biological control (Blossey *et al.* 2001; Burki *et al.* 1997, 2001; Callaway *et al.* 1999, etc.). Less attention has been paid to quantify the role of phytophagous insects in reducing the spread of native plants, mainly noxious weed species. The top-down effects of herbivores in terrestrial communities are considered weak. However, Carson and Root (1999) established that insect herbivory may be an important but overlooked aspect during early old-field succession. There is a continuum in the influence of insect herbivory on plant communities from the more subtle but important effects of herbivory on the fecundity of nonhost species to the devastating influence of outbreaks (Carson & Root 2000).

In this paper seedling emergence, insect injury and mortality of field penny-cress (*Thlaspi arvense* L.) were investigated on an early fallow field. The role of herbivory in secondary succession on an abandoned field is discussed.

MATERIAL AND METHODS

Experimental area. The experiment was performed at Prague-Ruzyně (50°06´N, 14°15´E, altitude 350 m, annual mean temperature 8.2°C,

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precipitation normal 477.4 mm) on a field used for small plot experiments (brown soil, clay-loam soil). The portion of experimental fallow was situated in the western part of this field, on a gentle slope exposed to the south. Nearly the whole area was surrounded by cover crops (mixed crops, phacelia), but a part bordered on a neighbouring experimental area, without any influence on the experimental fallow.

Thermal conditions were expressed as degree-days above 5°C development treshold summed from January 1, precipitation was summed for a period beginning 7 d before observations started until they ended. The ratio of precipitation/sum of degree-days was calculated.

Experimental treatment. The experimental fallow had been established in 1996. Since then it was ploughed every year in the autumn (November–December) to a medium depth (15–20 cm), machine harrowed and rolled (to prevent uneven soil compression) next spring (early April) and then divided into 5 × 5 m plots whose position was identical each year. The weed stands were then left to develop spontaneously. Eight plots were chosen for the experiment; weeds were monitored on subplots of 0.25 m^2 marked out in three repetitions on each 5 × 5 m plot.

Plant species present in the plant community of the experimental plots were: *Amaranthus retroflexus*, *Anagallis arvensis*, *Artemisia vulgaris*, *Capsella bursa-pastoris*, *Chenopodium album*, *Cirsium arvense*, *Convolvulus arvensis*, *Echinochloa crus-galli*, *Elytrigia repens*, *Fallopia convolvulus*, *Galinsoga parviflora*, *G. urticifolia*, *Galium aparine*, *Hyoscyamus niger*, *Lamium amplexicaule*, *L. purpureum*, *Matricaria maritima*, *Medicago lupulina*, *Persicaria lapathifolia*, *Polygonum aviculare*, *Silene noctiflora*, *Sinapis arvensis*, *Solanum nigrum*, *Sonchus arvensis*, *S. asper*, *S. oleraceus*, *Stellaria media*, *Taraxacum officinale*, *Thlaspi arvense*, *Tithymalus helioscopia*, *Trifolium repens*, *Tussilago farfara*, *Urtica urens*, *Veronica persica*, *V. polita* and *Vicia angustifolia*.

Seedling emergence, insect injury and mortality of field penny-cress were monitored between 6–30 May 1997, 21 April–4 June 1998, and 19 April to 31 May 1999. Cumulative numbers of field-penny cress seedlings were recorded in 3–7 d intervals. Seedling abundance was plotted against biological time degree-days above 5°C base temperature summed.

Insect damage of *Thlaspi arvense* seedlings was caused by flea beetles (*Phyllotreta* spp.). Further species of phytophagous entomofauna were not recorded because the damage was typical of flea beetles.

Insect damage of seedlings was divided into four categories according to the percentage of leaf area eaten: 1 – no injury, 2 – injury < 25%, 3 – < 50% and 4 – > 50% of the leaf area eaten. The damaged plants were counted and evaluated in 3–7 d intervals. Cumulative numbers of dead plants were recorded in the same intervals; the mortality rate was expressed as percent of emerged plants. The botanical nomenclature follows Dostál (1988), Hejný and Slavík (1988, 1990, 1992) and Slavík (1995, 1997, 2000).

RESULTS

Seedling emergence

Observations started after emergence of *Thlaspi arvense* seedlings, on 6 May 1997, 21 April 1998 and 19 April 1999. Maximum abundance differed between years (Figure 1) and was highest in 1999 (102 plants/m^2) and lowest in 1998 (27 plants/m^2). The numbers of seedlings were correlated with rainfall, which also was highest in 1999 (53.6 mm) and lowest in 1998 (7.5 mm) (Figure 2).

Insect feeding

The herbivors that damaged field penny-cress and other plants (*Chenopodium album*, *Fallopia convolvulus*) were flea beetles of the genus *Phyllotreta*. The plants were attacked from emergence on, and already at the second counting 94–100% of them were damaged (Table 1). At this time also the intensity of insect feeding was highest. Maximum leaf damage was observed in 1998 when up to 90% of the plants were damaged at > 50% (category 4 on 27 April). Later on the proportion of highly damaged plants decreased.

Mortality

The proportion of dead plants increased steeply at the beginning of the vegetation period when the plants were in the stage of cotyledons and first leaves. The mortality varied between years

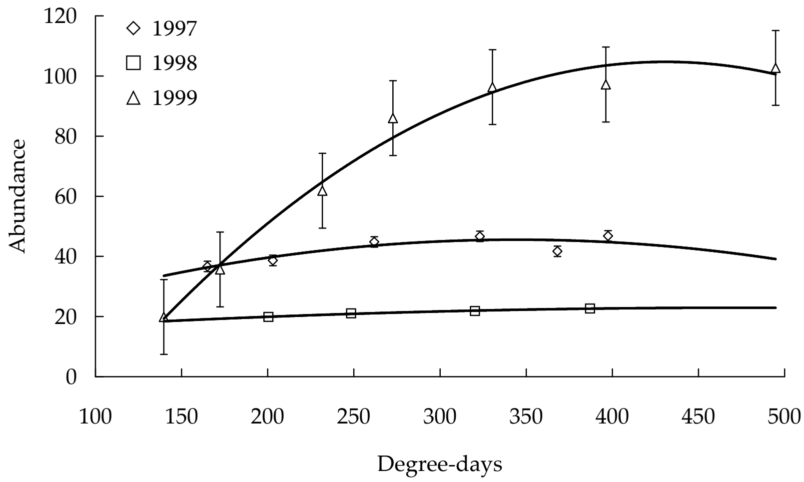

Figure 1. Average (± SE) seedling abundance in 1997 to 1999 plotted against time scale (degree-days above 5°C development treshold from 1 January)

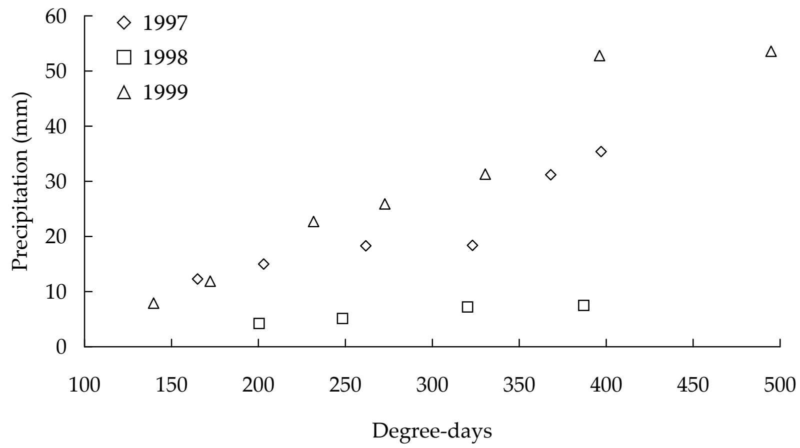

Figure 2. Cumulative precipitation (interval beginning 7 days before start of observations until they ended) in 1997–1999 plotted against time scale (degree-days above 5°C development treshold summed from 1 January)

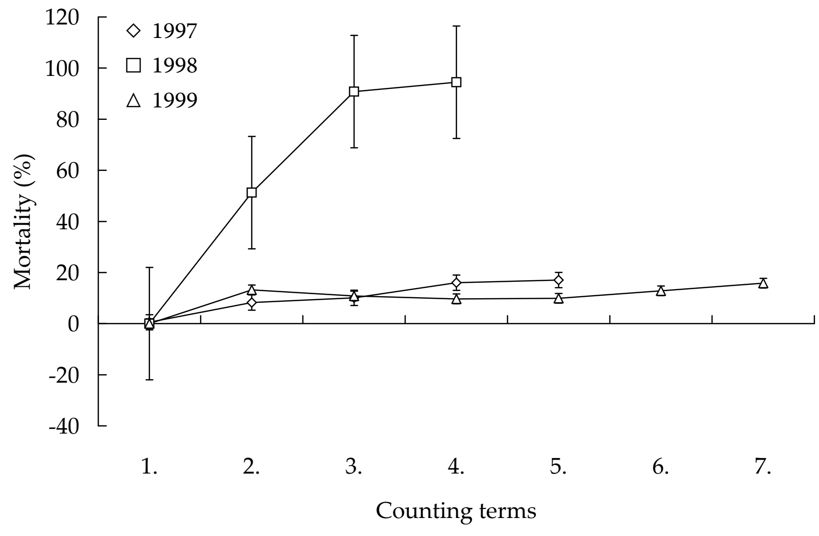

Figure 3. Cumulative proportion of seedlings killed by insect damage up to particular counts (see Table 1)

Table 1. Changes in damage to *Thlaspi arvense* seedlings over time. Total number of seedlings (*N*) and percent of plants in categories of damage

Year	Count	Date	*N* (plants/m²)	Percent leaf area consumed			
				0% (category1)	1–25% (category 2)	26–50% (category 3)	> 50% (category 4)
1997	1.	6.5.	36.5	2.7	37.0	32.1	28.2
	2.	12.5.	35.5	1.4	34.6	49.3	14.6
	3.	16.5.	40.1	0.0	28.2	51.1	20.7
	4.	19.5.	39.8	0.8	23.9	52.0	23.4
	5.	26.5.	39.3	1.8	52.9	40.7	4.6
	6.	30.5.	38.9	1.8	68.1	25.7	4.4
1998	1.	21.4.	25.5	23.1	24.7	23.1	29.0
	2.	27.4.	13.2	4.5	3.0	3.0	89.4
	3.	4.5.	2.5	8.0	8.0	8.0	76.0
	4.	11.5.	1.5	0.0	0.0	13.3	86.7
1999	1.	19.4.	19.8	73.2	19.2	4.0	3.5
	2.	26.4.	30.9	5.8	10.4	42.7	41.1
	3.	4.5.	55.2	13.0	25.7	37.1	24.1
	4.	10.5.	77.3	25.9	46.3	21.7	6.1
	5.	17.5.	86.3	33.3	56.0	7.0	3.8
	6.	24.5.	84.7	36.0	57.9	2.6	3.5
	7.	31.5.	86.2	88.4	10.1	0.3	1.2

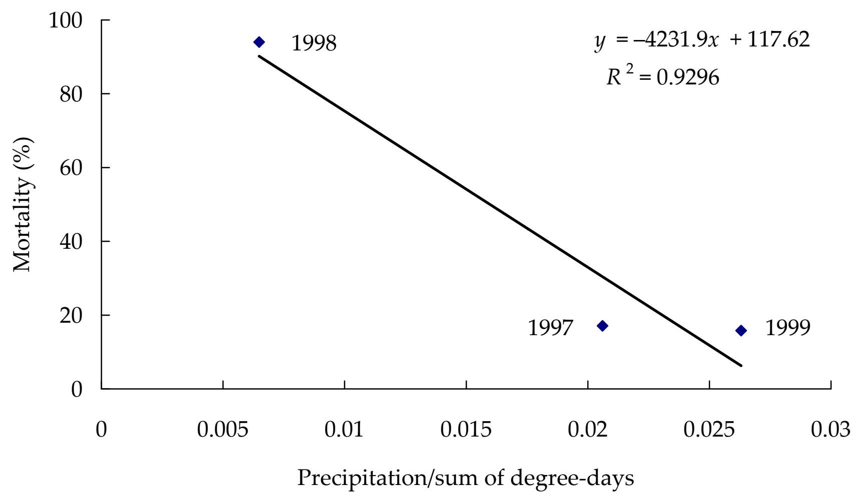

Figure 4. Mortality of *Thlaspi arvense* in 1997–1999 plotted against ratio of precipitation/sum of degree-days (for explanation see Material and Methods)

and was low in 1997 (17.1%) and 1999 (15.8%) (Figure 3). The highest mortality (94%) was recorded in 1998. Mortality decreased with increasing rainfall (Figure 4).

DISCUSSION

In this study the intensity of insect damage was correlated with rainfall. Earlier studies had indicated that drought stress often makes plants more sensitive to insect damage. Its effects may increase herbivory because of an increasing concentration of foliar nutrients and soluble carbohydrates (Stowe *et al.* 1994). Herbivory may be also influenced by other host plants nearby, e.g. by a crop of rape attracting *Phyllotreta* populations and thus decreasing herbivory on weeds.

In this study the major differences in *Thlaspi arvense* abundance were correlated with drought. The low emergence of field penny-cress plants in 1998 was caused by warm and dry weather. The emerged seedlings were then stressed by drought which might increase palatability for *Phyllotreta* and result in greater herbivory. A similar increase of herbivory on plants under drought stress was found on flowers and capsules of *Hypericum perforatum* (Fox *et al.* 1999) and seeds of *Picris hieracioides* (Escarré *et al.* 1999). Moreover, herbivory might be increased also by the low number of host plants, thus increasing the herbivore pressure on emerged seedlings.

Even in years with relatively low mortality, e.g. 1997 and 1999, it eliminated 16–17% of the field penny-cress population. Moreover, early herbivory may reduce the vitality of plants that have survived the seedling stage. Although herbivore damage of field penny-cress usually appears low, in some years it may become an important mortality factor in natural populations.

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Abstrakt

Štolcová J. (2005): **Poškození fytofágním hmyzem a mortalita vzcházejících rostlin penízku rolního** (*Thlaspi arvense* L.). Plant Protect. Sci., **41**: 21–26.

V letech 1997–1999 bylo v jarním období na raném úhoru sledováno vzcházení, požer fytofágním hmyzem a mortalita vzcházejících rostlin penízku rolního (*Thlaspi arvense* L.). Termín, rychlost vzcházení a velikost populací vzcházejících rostlin sledovaného druhu vykazovaly značné ročníkové rozdíly. Nejvyšší průměrné hodnoty abundance (102 ks/m^2) byly zaznamenány v roce 1999, nejnižší hodnoty (27 ks/m^2) byly zjištěny v roce 1998. Ve všech sledovaných letech byla požerem fytofágním hmyzem s různou intenzitou poškozována téměř celá populace vzešlých penízků (100 % v letech 1997 a 1998, 94 % v roce 1999). Nejvýznamnějším herbivorem byli dřepčíci (*Phyllotreta* spp.). Vzcházející rostliny penízku byly atakovány nejvíce v nejranějších fázích vývoje. Nejvyšší podíl v kategorii poškození nad 50 % a nejvyšší přírůstky počtu uhynulých rostlin penízku rolního byly zjištěny právě na začátku vegetace. Mortalita penízku v letech 1997 a 1999 za sledované období dosahovala téměř pětiny populace vzešlých penízků (17,1 a 15,8 % resp.). Výjimku představovaly výsledky dosažené v roce 1998, kdy při značném deficitu srážek v časném jarním období a při malé abundanci populace vzešlých penízků dosahovala mortalita až 94 %. Dosažené výsledky v uvedených podmínkách naznačily, že herbivorie v interakci s přetrvávajícím stresem prostředí se může významněji podílet na změnách ve složení plevelového společenstva během sekundární sukcese na úhoru.

Klíčová slova: penízek rolní; *Thlaspi arvense* L.; fytofágní hmyz; dřepčík; *Phyllotreta* spp.; herbivorie; mortalita; úhor; sekundární sukcese

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