Insect Damage to and Mortality of Seedlings of *Chenopodium album* L. and *Fallopia convolvulus* (L.) Á. Löve

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Abstract

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During 1997–1999, the damage and mortality caused by insect herbivores to pigweed (*Chenopodium album*) and wild buckwheat (*Fallopia convolvulus*) were studied in an early fallow field at Prague-Ruzyně. The highest abundances of *Ch. album* and *F. convolvulus* (83 and 3.5 plants/m^2, resp.) were recorded in 1999, the lowest (11.6 and 0.3 plants/m^2, resp.) in 1998. Mortality was low in 1997 (9.6% and 1.4%, resp.) and 1999 (4.0% and 2.5%, resp.), but high in 1998 (25% and 10%, resp.) due to concurrent drought. In accordance with previous studies on *Thlaspi arvense*, herbivory and concurrent drought may increase the mortality of *Ch. album* and *F. convolvulus* seedlings, and thereby alter the species composition of the weed community during secondary succession.

Keywords: pigweed; *Chenopodium album* L.; wild buckwheat; *Fallopia convolvulus* (L.) Á. Löve; flea beetle; *Phyllotreta* spp.; herbivory; phytophagous insect; secondary succession; fallow

Herbivory on alien plant species has been frequently studied in order to find phytophagous insect species that could be used in biological control (Peterson *et al.* 2005; Lewis *et al.* 2006; Newingham & Callaway 2006). Fewer attempts have been made to quantify the role of phytophagous insects in reducing the spread of native weed species. Several studies related to native weed species have addressed the role of insect herbivory in plant communities during secondary succession, but data are still relatively sparse (Brown & Gange 1992; Schadler *et al.* 2004). Carson and Root (1999) concluded that insect herbivory may represent an important, but overlooked factor operative during early old-field succession. Additionally, Brown and Gange (1992) demonstrated that the composition of successional plant communities, as well as the direction and rate of succession, may be modified by the actions of both above- and below-ground insect herbivores, and that insect herbivory may function as a major determinant of plant community structure and composition. The level of herbivory is influenced by environmental conditions, and great influence has been attributed to weather conditions, primarily levels of rainfall (Shure *et al.* 1998; Staley *et al.* 2007). The effect of insect herbivory and concurrent drought has been discussed previously (Štolcová 2005).

In the present study, seedling emergence, insect injury and mortality of pigweed (*Chenopodium al-*

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bum L.) and wild buckwheat (*Fallopia convolvulus* (L.) Á. Löve) were investigated on an early fallow field. The results were compared with earlier findings on *Thlaspi arvense* L. (Štolcová 2005).

MATERIAL AND METHODS

Experimental area. The experiments were performed at Prague-Ruzyně (50°06'N, 14°15'E, altitude 350 m, annual mean temperature 8.2°C, annual mean precipitation 477.4 mm) in a field used for small plot experiments (brown soil, clay-loam soil). The portion of experimental fallow was situated in the western part of the field, on a gentle slope with southern exposure. Nearly the entire area was surrounded by cover crops (mixed crops, *Phacelia*), except for a section that bordered on a neighbouring experimental area, with no influence on the experimental fallow.

Annual thermal conditions are expressed as degree-days above a 5°C development threshold summed from January 1, and precipitation was summed over a period beginning 7 days before observations started, until they ended. The ratio of precipitation/sum of degree-days was then calculated.

Experimental treatment. The experimental fallow had been established in 1996. Since then, it has been ploughed every year in autumn (November–December) to a medium depth (15–20 cm); harrowed and rolled (to prevent uneven soil compression) in subsequent springs (early April), and then divided into 5 × 5 m plots whose positions were identical each year. Vegetation was then left to develop spontaneously. Eight plots were chosen for the experiment. *Chenopodium album* (pigweed) seedlings were monitored on subplots of 0.25 m^2 that were marked out in three repetitions in each 5 m × 5 m plot. Since there were far fewer seedlings of wild buckwheat, *Fallopia convolvulus*, 9 m^2 of the area of each plot was used instead of small subplots.

The plant species present in the plant community of the experimental plots included: *Amaranthus retroflexus* L., *Anagallis arvensis* L., *Artemisia vulgaris* L., *Capsella bursa-pastoris* (L.) Med., *Chenopodium album* agg., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Echinochloa crus-galli* (L.) Beauv., *Elytrigia repens* (L.) Desv., *Fallopia convolvulus* (L.) Á. Löve, *Galinsoga parviflora* Cav., *G. quadriradiata* Ruiz *et* Pavón, *Galium aparine* L., *Hyoscyamus niger* L., *Lamium amplexicaule* L., *L. purpureum* L., *Medicago lupulina* L., *Persicaria lapathifolia* (L.) S.F. Gray, *Polygonum aviculare* L., *Silene noctiflora* L., *Sinapis arvensis* L., *Solanum nigrum* L., *Sonchus arvensis* L., *S. asper* (L.) Hill, *S. oleraceus* L., *Stellaria media* (L.) Vill., *Taraxacum sect. Ruderalia* Kirschner, Øllgard *et* Štěpánek, *Thlaspi arvense* L., *Tithymalus helioscopia* (L.) Hill, *Trifolium repens* L., *Tripleurospermum inodorum* (L.) Schultz Bip., *Tussilago farfara* L., *Urtica urens* L., *Veronica persica* Poiret, *V. polita* Fries and *Vicia angustifolia* L.

Seedling emergence, insect damage to and mortality of *Ch. album* were monitored between 6–30 May in 1997, 21 April–29 May in 1998, and 20 April–31 May in 1999. Seedlings of *F. convolvulus* were monitored between 19 May–9 June in 1997, 29 April–14 May in 1998, and 4–31 May in 1999. Cumulative numbers of both pigweed and wild buckwheat seedlings were recorded on average in 3–7 d intervals. Seedling abundance was plotted against biological time degree-days above the 5°C base temperature summed.

The insect damage to *Ch. album* and *F. convolvulus* seedlings was found to be caused by flea beetles (*Phyllotreta* spp.). Additional species of phytophagous entomofauna were not recorded because the damage was typical of that produced by flea beetles.

Insect damage to seedlings was classified into four categories, according to the percentage of leaf area eaten: 1 – no damage, 2 – < 25% , 3 – < 50%, and 4 – > 50% of the leaf area eaten. The damaged plants were counted and evaluated on average in 3–7 days intervals. Cumulative numbers of dead plants were recorded in the same intervals; the mortality rates are expressed as the percent of emerged plants. Data were analysed by linear regression analysis. The botanical nomenclature follows Dostál (1988), Hejný and Slavík (1988, 1990, 1992), Slavík (1995, 1997, 2000) and Slavík and Štěpánková (2004).

RESULTS AND DISCUSSION

Seedling emergence

Observations were initiated after the emergence of weed seedlings; for *Chenopodium album* the dates were 6 May 1997, 21 April 1998 and 20 April 1999, whereas for *Fallopia convolvulus* seedlings

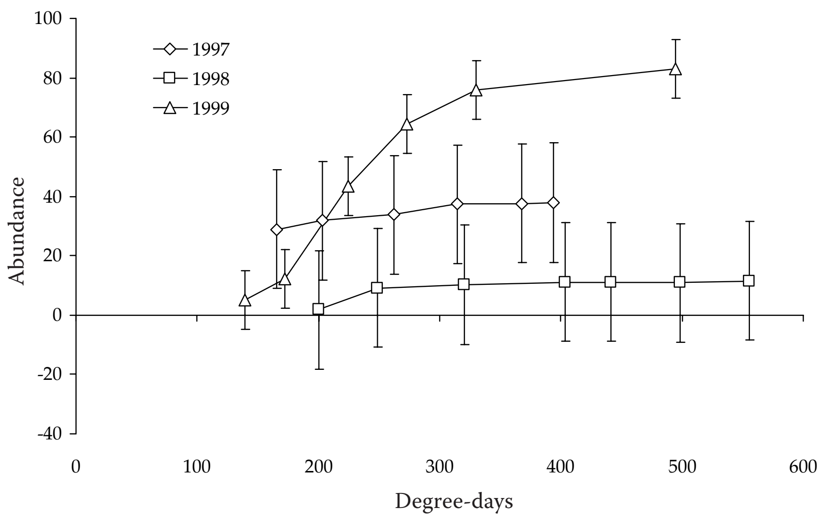


Figure 1. Average (±) seedling abundance of *Chenopodium album* between 1997 and 1999, plotted against the time scale (degree-days above 5°C development threshold from 1 January)

they were 19 May 1997, 29 April 1998 and 4 May 1999. Maximum abundance differed between years (Figures 1 and 2), both for *Ch. album* and for *F. convolvulus*, and was highest in 1999 (83 plants/m^2 in *Ch. album* and 3.5 plants/m^2 in *F. convolvulus*). The lowest abundance was found in 1998 (11.6 plants/m^2 in *Ch. album* and 0.3 plants/m^2 in *F. convolvulus*). The numbers of seedlings were correlated with rainfall, which was highest in 1999 (53.6 mm) and lowest in 1998 (13.8 mm) (Figure 3). The low numbers of abundance of pigweed and wild buckwheat plants in 1998 were due to the warm and dry weather in that year.

Insect feeding

The herbivores that damaged pigweed and wild buckwheat as well as other plants (e.g. *Thlaspi arvense*) were flea beetles of the genus *Phyllotreta*. Both populations of *Ch. album* and *F. convolvulus* were attacked beginning at their emergence, particularly in 1998, when the first count found 100% of the plants damaged (Figures 4 and 5).

The maximum intensity of leaf damage was also observed in 1998, when in the *Ch. album* population up to 78% of plants were damaged at levels of 26–50% (category 3 on 21 April), while up to 100% of the *F. convolvulus* seedlings were damaged at > 50% (category 4 on 29 April and 4 May). Later, the proportion of highly damaged plants decreased. The intensity of insect damage was found to be correlated with rainfall. Earlier studies had indicated that drought stress often makes plants more palatable to herbivores and more sensitive to insect damage (Stowe *et al.* 1994). The effect of drought stress on the sensitivity of plants to insect damage has been cited by many authors (e.g. Fox *et al.* 1999)

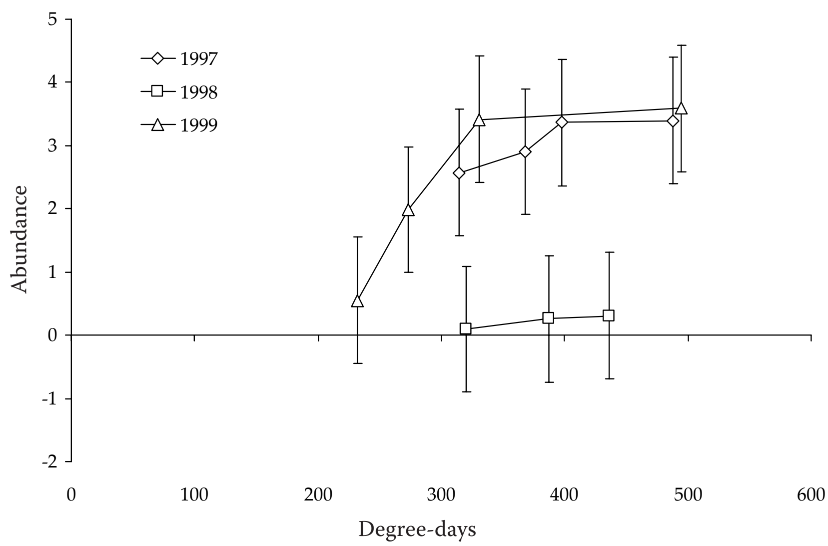


Figure 2. Average (±) seedling abundance of *Fallopia convolvulus* between 1997 and 1999, plotted against the time scale (degree-days above 5°C development threshold from 1 January)

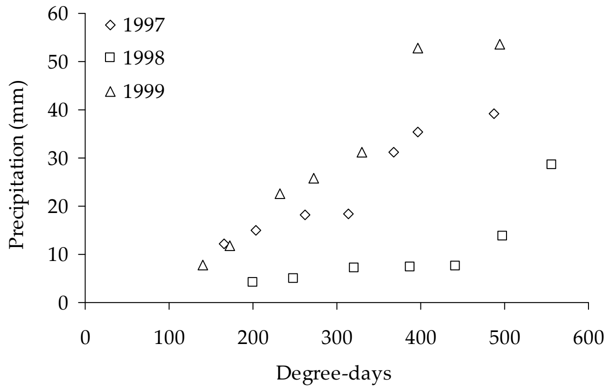
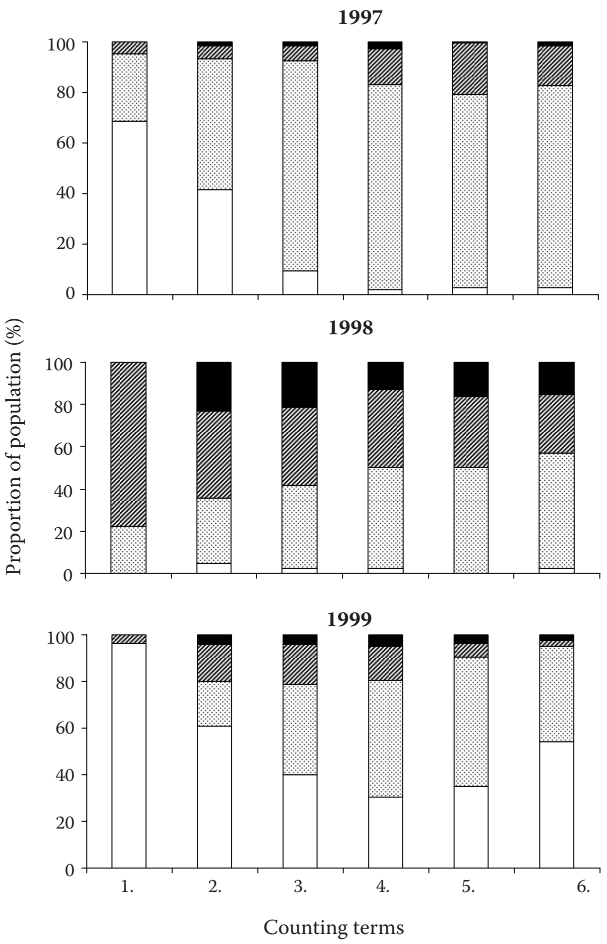


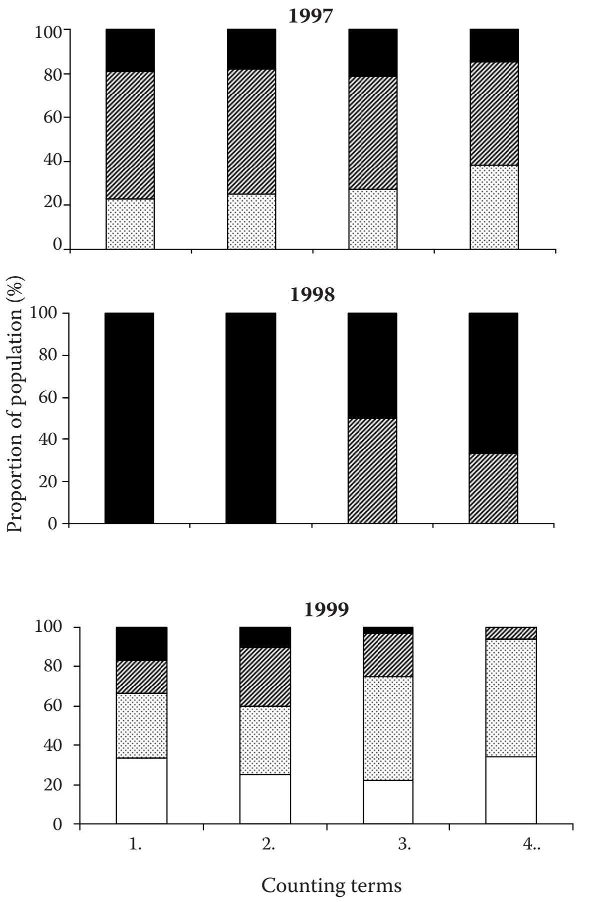
Figure 3. Cumulative precipitation (interval beginning 7 d before the start of observations until they ended) in 1997–1999 plotted against the time scale (degree-days above 5°C development threshold summed from 1 January)

and was discussed in an earlier study (Štolcová 2005). The ability of plants to compensate for tissue loss due to herbivory when provided with sufficient water and nutrients to support photosynthesis and growth was reported by Joern and Mole (2005) for *Bouteloua gracilis*. The role of regional weather patterns in plant/herbivore interactions in the case of *Fraxinus americana* and *Acer rubrum* seedlings was likewise demonstrated by Meiners *et al.* (2000).



□ category 1 – no damage, ▨ category 2 – damage below 25%, ▦ category 3 – damage 26–50%, ■ category 4 – damage above 50%

Figure 4. Changes in damage to *Chenopodium album* seedlings over time



□ category 1 – no damage, ▨ category 2 – damage below 25%, ▦ category 3 – damage 26–50%, ■ category 4 – damage above 50%

Figure 5. Changes in damage to *Fallopia convolvulus* seedlings over time

Table 1. Results of regression of mortality of *Chenopodium album* and *Fallopia convolvulus* on precipitation/sum of degree-days ratio in 1997–1999

	Coefficient	Standard error	*T* value	Significance	Low 95%	Upper 95%
Const.	28.4509	5.8364	4.8747	0.0000	16.8104	40.0913
Precipitation/sum of degree-days	–160.8939	63.5305	–2.5325	0.0136	–287.6015	–34.1864

Standard error = 25.1563, mean Y = 15.7188, R^2 = 0.0839, $F(1.70)$ = 6.4138

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 addition, in the present study, low abundance and lack of appropriate host plants may also have contributed to increased herbivory and plant mortality.

Mortality

The proportion of dead plants increased steeply at the beginning of the vegetation period, when the plants were at the cotyledon and first leaves stages. The mortality varied between years, and was low in both 1997 (9.6% in *Ch. album* and 1.4% in *F. convolvulus*) and 1999 (4.0% in *Ch. album* and 2.5% in *F. convolvulus*) (Figures 6 and 7).

The highest rates of mortality (25% in *Ch. album* and 10% in *F. convolvulus*) were recorded in 1998. Total mortality both of *Ch. album* and *F. convolvulus* seedlings significantly decreased with increasing rainfall (Table 1 and Figure 8).

The results obtained in this study were compared with earlier results on *Thlaspi arvense* (Štolcová 2005). Under the same conditions, up to 94% of the *T. arvense* population was killed by herbivory due to a concurrent drought in 1998. The mortality rates of *Ch. album* and *F. convolvulus* seedlings were relatively low compared to that of *T. arvense*; the effects of mortality and concurrent drought were also not as pronounced. However, the preferences of phytophagous insects for host plants naturally play a role. *Ch. album* seedlings were more attacked by the flea beetles after practically the entire *T. arvense* population had been eliminated from the weed community; later, *F. convolvulus* was also highly damaged. Although the mortality of *Ch. album* seedlings was higher than that of *F. convolvulus*, flea beetles did exhibit a preference for wild buckwheat plants; starting at emergence, the entire population of *F. convolvulus* seedlings was damaged at > 50% (category 4). Similarly, Dernovici *et al.* (2006) detected damage to sunflower no sooner than *Ambrosia artemisifolia*, the preferred host plant for *Ophraella communa*, had been completely defoliated. Our results may

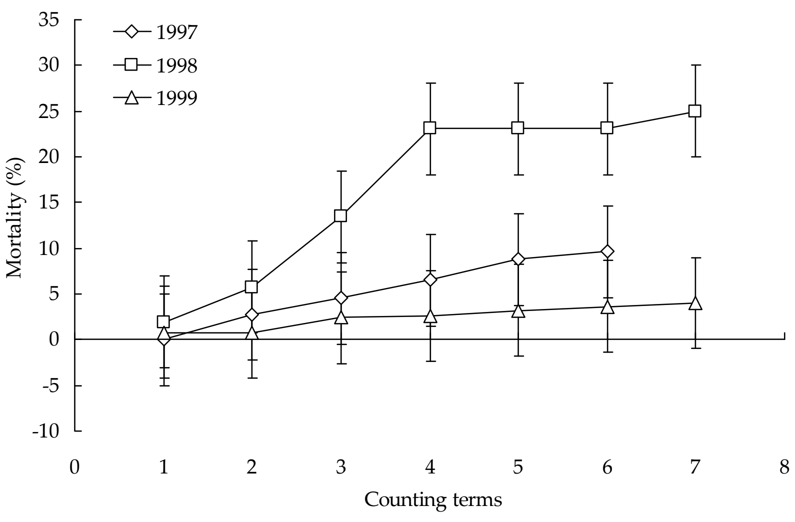


Figure 6. Cumulative proportion of seedlings of *Chenopodium album* killed by insect damage up to particular counts

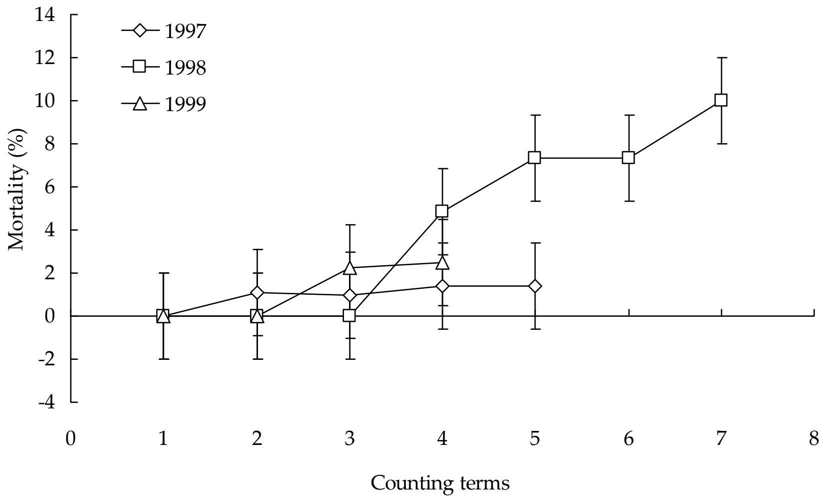


Figure 7. Cumulative proportion of seedlings of *Fallopia convolvulus* killed by insect damage up to particular counts

indicate that under environmental stress and in the absence of specific host plants, even less appropriate host plants may be attacked by herbivores and highly damaged.

Although the mortality rates of C*h. album* and *F. convolvulus* seedlings were not as pronounced compared to *T. arvense*, the total mortality was found to reach a significant level. Thus, a large proportion of weed seedlings may be eliminated from the weed community over the course of a few years. Moreover, considerable fractions of weed populations may experience reduced vitality due to heavy insect injury. Our results confirm previous findings that herbivory and concurrent drought may eliminate a large proportion of seedlings from the weed community and therefore may induce changes in secondary succession.

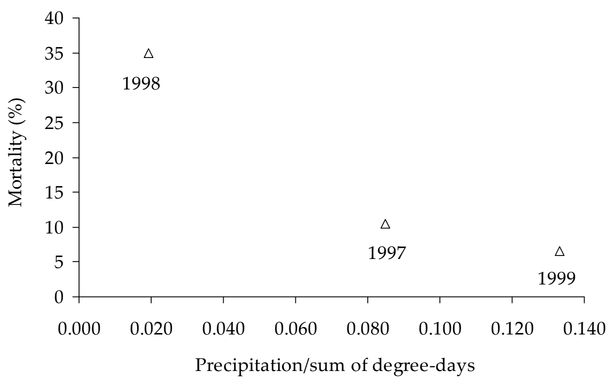


Figure 8. Total mortality of *Chenopodium album* and *Fallopia convolvulus* in the 1997–1999 period, plotted against the ratio of precipitation/sum of degree-days

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