Soil arthropods associated to the invasive *Senecio inaequidens* compared to the native *S. jacobaea* (Asteraceae)

Valérie VANPARYS[1], Pierre MEERTS[2], Guy JOSENS[3] & Anne-Laure JACQUEMART[1]

[1]Research team in Genetics, Reproduction, Populations, UCL, Louvain-la-Neuve, Belgium. Contact: valerie.vanparys@gmail.com
[2]Laboratoire de Génétique et Ecologie végétales, ULB, Bruxelles, Belgium.
[3]Laboratoire de Systématique et Ecologie animales, ULB, Bruxelles, Belgium.

Introduction

Soil arthropods play a significant role in soil processes (e.g. nutrient cycling). Diversity of soil invertebrates has been shown to positively influence plant diversity (De Deyn et al. 2003). In turn, plant diversity, and even plant species identity, can influence soil communities (Armbrecht et al. 2004, Ayres et al. 2006, Wardle 2006). In the particular case of plant invasions, several authors have shown that some animal groups in the soil can be affected by the change in plant community. For instance, Belnap & Philips (2001) showed that invasion by the annual grass *Bromus tectorum* (western US) decreased the overall abundance of soil invertebrates as well as the species richness of soil arthropods. These changes in soil communities during invasion have been proposed to facilitate the development of invasive plants, creating positive feedbacks (Callaway et al. 2004, Wolfe & Klironomos 2005).

In the present study, the general hypothesis is that *Senecio inaequidens* (Asteraceae), invasive in Europe, and the native *S. jacobaea* (synonym: *Jacobaea vulgaris*) are not associated with the same community of soil arthropods, in terms of abundance, taxonomic assemblage and diversity.

Material and methods

Senecio inaequidens is a perennial chamaephyte native to South Africa, whereas *Senecio jacobaea* is a biennial to perennial hemicryptophyte native to Europe, spending the first year as a rosette (Harper & Wood 1957).

This study was performed in a 25-ha wildland site, situated in Antwerp (51° 14' 36.40'' N, 4° 23' 15.03'' E), northern Belgium. Vegetation was dominated by *S. inaequidens* (present for at least 5 years), *S. jacobaea*, *Festuca rubra, Geranium molle* and *Tanacetum vulgare*. The soil was described as a sandy brown soil. A previous study revealed no difference in soil chemical properties nor in granulometry between invaded and uninvaded patches (Dassonville et al. 2008). There was, however, a higher phytomass and K concentrations in invasive plots.

Soil fauna was sampled in the Antwerp site in 2006 on October 13th. Three distinct zones were chosen, separated by approximately 10 m. The first zone was dominated by *S. inaequidens* (hereafter referred to as I), the second one by *S. jacobaea* (J) and in the third one the density was similar for both species and the soil was more gravelly (M). In each zone, four pairs of plants *S. inaequidens* - *S. jacobaea* were chosen, among the oldest and largest ones. Within a pair, plants were separated by 1.5 m at most. One soil core of 8 cm diameter and 5 cm depth (volume 251 cm³) was extracted, as close as possible to the root crown. A total of 24 samples were taken and placed on a Berlese-Tullgren extractor.

The abundance of soil fauna, i.e. numbers of individuals per sample, was compared between *S. inaequidens* and *S. jacobaea* by an ANOVA for effects of species, zone and their interaction. For the main taxa, the numbers of individuals were compared between the two plant species by Mann-Whitney U tests. A principal components analysis (PCA) was used to extract the axes summarising the community structure of soil samples. These analyses were performed with STATISTICA 7 (Statsoft 2006). In addition, Shannon-Wiener's index (H') was calculated for soil arthropod communities associated to *S. inaequidens* and *S. jacobaea*. A t-test was applied on these data to test for a difference between the two *Senecio* species.

Results

The overall abundance of soil fauna was significantly lower (F= 7.46, p= 0.014) under *S. inaequidens* in comparison with *S. jacobaea,* with respectively 76 ± 62 (or 15,300 individuals m^{-2}) and 186 ± 153 individuals per sample (or 37,000 individuals m^{-2}). This difference was essentially due to the Collembola Arthropleona (Table 1), which were very abundant in *S. jacobaea* samples (19,000 individuals m^{-2}), while they were six fold less abundant in *S. inaequidens* samples (3,500 individuals m^{-2}). Gamasid mites were twice more abundant in *S. jacobaea* samples compared to *S. inaequidens*, but this difference was only marginally significant. None of the other taxa differed significantly in their abundance under the two plant species. Notably, no significant difference was detected in the number of homopteran and heteropteran herbivores (Table 1). The effect of the zone was marginally significant on the abundance of soil fauna, with a tendency of higher densities in the mixed zone (Figure 1). No significant interaction zone*species was detected.

Taxonomic richness was similar between *S. inaequidens* and *S. jacobaea* (Table 1). However, the Shannon diversity index was lower for *S. jacobaea* (H=1.54 and evenness = 0.52) than for *S. inaequidens* (H= 1.96 and evenness = 0.71) and this difference was highly significant (T-test: t=-10.19, p<0.001). The PCA revealed no distinct pattern between *S. inaequidens* and *S. jacobaea* in the soil arthropod communities (Figure 2).

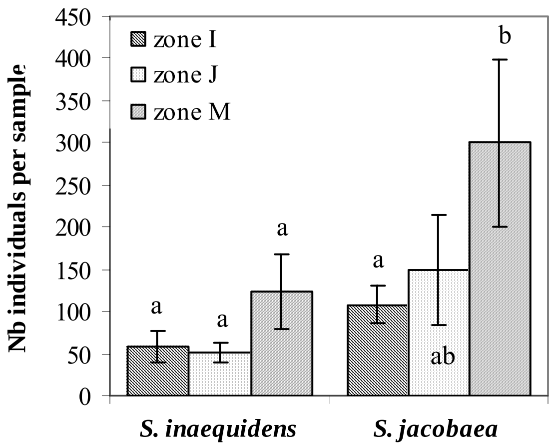

Figure 1. Abundance of soil fauna expressed as the number of individuals per soil sample collected under S. inaequidens and S. jacobaea in the three sampled zones in the site of Antwerp: vegetation dominated by S. inaequidens (I), S. jacobaea (J) and mixed zone with similar density of the two species (M). Error bars denote standard errors and different letters indicate significant difference.

*Table 1. Abundance of soil fauna expressed as the total number of individuals (N) for each identified taxon in soil samples collected under S. inaequidens and S. jacobaea (12 samples per species) and percentage of the total number of individuals (%). Feeding groups: herbivore (H), microbivore-mycophagous (M), predator (P), honeydew (*), saprophagous (S), undetermined or diverse (?). Numbers in brackets are the minima and maxima per sample. Mann-Whitney U tests for difference between the two plant species (for taxa present in more than half the samples): * and $^{+}$ indicate respectively significant ($p<0.05$) and marginally significant ($p<0.07$) differences between S. inaequidens and S. jacobaea.*

		S. inaequidens		*S. jacobaea*		Species effect
Taxon	Food	N	%	N	%	Z
Diplopoda	S	2 (0-1)	0.22	3 (0-1)	0.13	
Chilopoda	P	6 (0-3)	0.65	9 (0-4)	0.40	
Symphyla	S	0	0	1	0.04	
Aranea	P	4 (0-2)	0.43	3 (0-1)	0.13	
Acari Gamasida	P	289 (2-64)	31.1	564 (11-158)	25.1	1,85^{+}
Acari Oribatida	M, S	94 (0-18)	10.1	91(0-19)	4.06	-0,03
Acari non determined		13 (0-8)	1.40	18 (0-10)	0.80	0,00
Isopoda	M, S	52 (0-9)	5.59	64 (0-14)	2.85	0,84
Protura	M, S	0	0	1	0.04	
Collembola Arthrop.	M	210 (2-94)	22.6	1121 (0-429)	50.0	2,22*
Collembola Symphy.	M	130 (1-25)	14.0	147 (1-35)	6.55	0,32
Thysanoptera (thrips)	?	6 (0-2)	0.65	12 (0-4)	0.53	
Hymenoptera (ant)	P*	4 (0-2)	0.43	2 (0-1)	0.09	
Heteroptera (Tingidae)	H	3 (0-1)	0.32	5 (0-2)	0.22	
Homoptera	H	66 (0-38)	7.10	118 (0-42)	5.26	0,53
Coleoptera adult	?	11 (0-3)	1.18	9 (0-2)	0.40	0,73
larva	?	11 (0-3)	1.18	34 (0-10)	1.52	0,19
Diptera adult	?	5 (0-4)	0.54	4 (0-2)	0.18	0,69
larva	?	6 (0-2)	0.65	8 (0-3)	0.36	
Lepidoptera (larva)	H	0	0	1	0.04	
Non determined		13 (0-6)	1.40	20 (0-13)	0.89	
Total		**925 (25-245)**		**2235 (42-551)**		
Number of taxa		**16**		**19**		

Discussion

Although there was an overall tendency for smaller populations of soil arthropods under *S. inaequidens* compared to *S. jacobaea*, only one taxon was significantly affected by *S. inaequidens*, Collembola Arthropleona (and to a lesser extent, acari Gamasid). Since collembolans mostly feed on fungi (Briones et al. 1999), their lower abundance under *S. inaequidens* might be due to antifungal properties of this species (Loizzo et al. 2004). Differences between *S. inaequidens* and *S. jacobaea* in plant productivity, root biomass and architecture (De Jong & van der Meijden 2000, Garcia-Serrano et al. 2005) might also explain these results.

Surprisingly, diversity was higher under *S. inaequidens*, as a result of greater evenness. The difference in Collembola Arthropleona abundance is responsible for this result. Few authors have measured the effect of invasive plants on soil diversity but both positive (on bacteria: Duda et al. 2004) and negative effects are documented (on arthropods: Gratton & Denno 2005).

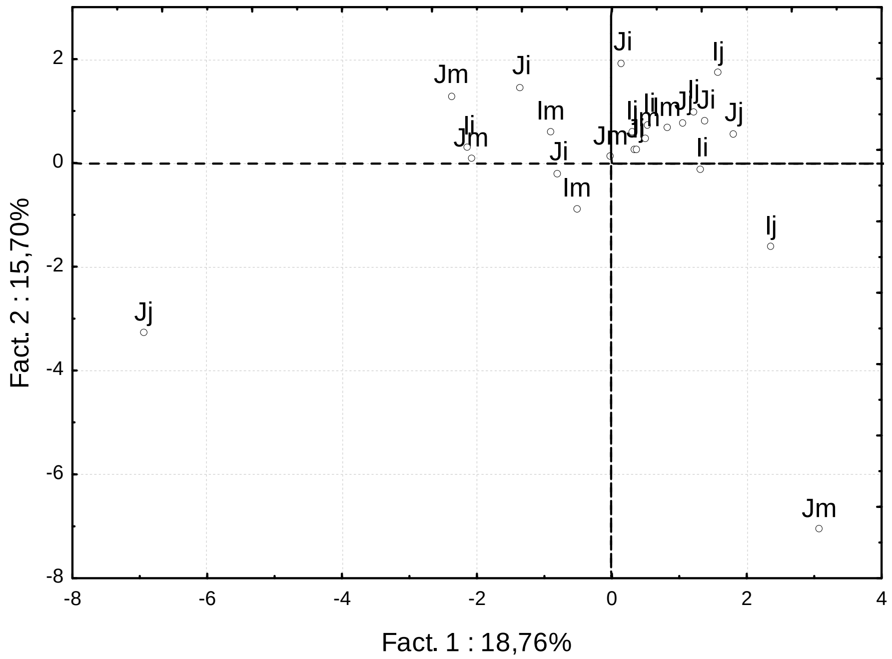

Figure 2. Results of the PCA for the abundance of the different taxa in soil samples for S. inaequidens and S. jacobaea: projection of taxa (A) and samples (B). Labels of samples mention the plant species (J for S. jacobaea or I for S. inaequidens), the sample No (1 to 12) and the zone (i, j or m).

As lower abundance and higher diversity of arthropods were found under *S. inaequidens*, the possible impacts of the invasion by *S. inaequidens* are difficult to assess. Our study needs to be repeated in other sites, as the response of soil arthropods may differ between sites (Yeates & Williams 2001).

In conclusion, this study showed that *S. inaequidens* and *S. jacobaea* were associated with similar soil arthropod assemblages, but that arthropod abundance was lower under *S. inaequidens*, whereas the diversity was higher, essentially due to collembolans Arthropleona. Further studies should focus on verifying this result in other sites with contrasting soil characteristics. Finally, more thorough identifications may help to understand our results.

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