EFFECTS OF INVASIVE JAPANESE KNOTWEED ON DIVERSITY AND STRUCTURE OF SOIL NEMATODE COMMUNITIES

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Abstract. In this study we investigated the communities of soil nematodes in the forest habitats invaded and uninvaded by *Fallopia japonica* (Houtt.) Ronse Decr., in Tatra National Park, Slovakia. We found that invasion by *F. japonica* altered nematode communities and their structures. Total nematode abundance, species number and nematode biomass were significantly lower in invaded than uninvaded plots, but species diversity remained unaffected throughout the study. The overall abundance of all nematode trophic groups well represented the negative impact of *F. japonica* invasion on soil food webs, supported by low values of all maturity indices, a structural index and the Jaccard index of faunal similarity. A weighted faunal analysis similarly characterized the food webs of invaded plots as poorly developed or highly disturbed, with bacterial decomposition and a low C/N ratio. Our findings thus suggest that dense plots of knotweed simplify the structural complexity of the soil environment by reducing the richness of plant species, which may have contributed to the negative changes in the structures of the nematode communities.

Introduction

Fallopia japonica (Japanese knotweed) invasions have repeatedly been demonstrated to have a negative impact on the species richness and diversity of native plants [6, 7]. Studies of knotweed invasions, however, rarely address impacts on soil metazoans such as nematodes [2], which are probably the most well-studied group of soil organisms with excellent indicative characteristics [3].

We used soil nematodes as representatives of soil invertebrates since they are considered to the most abundant metazoans that can be found in almost all environments, under diverse climatic conditions and habitats [8].

Soil nematodes utilise plant resources from both litter inputs and root exudates, drive important ecosystems functions and comprise several specific trophic groups, including bacteria, fungi and plant feeding as well as carnivores and omnivores. Therefore, nematodes serve as valuable biological indicators and could provide interesting information on how Japanese knotweed invasion affects soil food webs.

Materials and methods

We established ten independent plots and collected soil core samples for characterizing the nematode communities in ruderal habitats of Tatra National Park invaded (five plots, Fig. 1a - INV) and uninvaded (five plots, Fig. 1b - UNI) by *F. japonica*. The soil samples were randomly collected from the 10-15 cm layer in each plot using a hand spade on 17 June 2017, 2018 and 2019, for a total of 30 samples (five plots × two sites × three sampling years). Extracted nematodes were heat killed, fixed and microscopically identified to the genus level. The evaluation

of nematode communities was based on assignation of nematode species to the trophic groups (bacterivores, fungivores, plant feeders, predators and omnivores) [8]; to the “colonizer-persister (c-p) scale” (1-5) based on their *r* and *k* characteristics [1] and computation of several community indices e.g. the Shannon-Weaver diversity index ($H'spp$) [5], the Jaccard similarity index (J_s) [4], the maturity index (MI) [1] or the enrichment index (EI) [3]. The statistical analyses were performed separately for each plot, and data were compared between the INV plots and the UNI control plots. All nematological data, including the indices, were calculated as means for the individual plots and sampling years. A factorial analysis of variance was used, and means were compared using Tukey's honestly significant difference (HSD) post hoc test ($P<0.05$; $P<0.01$) of the PlotIt program Ver 3.2 (Stat Soft). Data were log-transformed before analysis to improve normality.

Figure 1. Plot invaded (a) and uninvaded (b) by *F. japonica* in the High Tatras

Results and conclusion

The response of the nematode communities to *F. japonica* invasion did not differ among sampling years but differed considerably between the INV and UNI plots. The mean number of species was significantly lower in the INV than in the UNI plots, but species diversity did not differ significantly between the plots (Table 1). Total nematode abundance also differed significantly between the INV and UNI plots (HSD, $P<0.01$; $P<0.05$) (tab. 1). Mean nematode abundance was significantly higher in the UNI than in the INV plots in all sampling years.

Additionally, The HSD test indicated that the establishment of *F. japonica* was negatively associated with all maturity indices (MI, PPI and $\sum MI$), SI and total nematode biomass in the INV plots throughout the study ($P<0.01$; $P<0.05$) (Table 1). The Jaccard index of faunal similarity ranged from 55.8 to 63.2%.

The nematode communities of the INV and UNI plots were represented by all trophic groups. Bacterivores were the most diverse trophic group in the study, followed by plant feeders, omnivores, predators and fungivores.

The total abundance of all trophic groups was generally lower in the INV than the UNI plots throughout the study (tab. 2)

Table 1. Mean total nematode abundance, species number, ecological and functional indices associated with knotweed invaded and uninvaded sites during study period (n=5)

	Uninvaded	Invaded	Significance HSD test
2017			
Nematode abundance	1093.3±114.5	484.9±64.2	**1
Number of species	48.4±3.6	39.0±1.9	*
Species diversity index (H'spp)	3.14±0.09	3.11±0.05	--
Maturity index	2.26±0.15	1.97±0.14	**
Plant parasitic index	2.58±0.10	2.18±0.17	**
Summ maturity index	2.34±0.14	2.06±0.13	*
Enrichment Index	69.9±8.6	66.7±5.1	--
Structure Index	67.5±2.1	42.5±11.3	**
Channel index	16.7±6.7	13.7±6.6	--
Total nematode biomass (mg)	3.44±0.96	0.94±0.32	**
Jaccard index of similarity (%)	63.2		
2018			
Nematode abundance	1171.5±157.9	492.9±205.2	*
Number of species	39.6±2.7	32.2±2.0	*
Species diversity index (H'spp)	3.08±0.08	2.91±0.11	--
Maturity index	2.24±0.17	2.02±0.05	*
Plant parasitic index	2.65±0.18	2.21±0.11	**
Summ maturity index	2.33±0.13	2.15±0.14	*
Enrichment Index	73.3±4.5	69.9±5.4	--
Structure Index	68.3±8.5	52.6±5.7	*
Channel index	15.5±7.3	7.05±5.1	--
Total nematode biomass (mg)	3.79±1.42	1.11±0.51	**
Jaccard index of similarity (%)	55.8		
2019			
Nematode abundance	924.8±90.5	507.4±86.6	*
Number of species	48.8±3.7	38.0±4.2	--
Species diversity index (H'spp)	3.27±0.14	3.05±0.10	--
Maturity index	2.30±0.13	1.99±0.08	**
Plant parasitic index	2.64±0.08	2.15±0.24	*
Summ maturity index	2.37±0.10	2.10±0.19	--
Enrichment Index	68.4±4.2	69.6±9.3	--
Structure Index	67.5±6.4	49.8±11.8	*
Channel index	16.6±2.7	12.9±7.2	--
Total nematode biomass (mg)	3.20±2.70	1.15±0.46	**
Jaccard index of similarity (%)	56.1		

In conclusion, our study found that *F. japonica* invasion had a negative impact on the native plant communities and on the structure of soil nematode communities during the three years of our study. The impact of knotweed on these communities did not differ among sampling years, indicating a persistent disturbance of the ecosystem and soil food webs in comparison to the uninvaded control plots. Overall nematode abundance and nematode biomass were significantly lower in invaded than in uninvaded plots, a weighted faunal analysis characterized the food webs of invaded plots as poorly developed or highly disturbed with prevailed bacterial decomposition pathway.

Table 2. Mean total abundance of nematode trophic groups associated with knotweed invaded and uninvaded sites during study period (n=5)

	Uninvaded	Invaded	Significance HSD test
2017			
Bacterial feeders	2504.9±345.2	1329.8±159.2	**1
Predators	183.0±35.9	61.0±29.9	*
Fungal feeders	420.5±111.3	292.1±88.7	--
Omnivores	550.6±126.7	172.2±53.8	**
Plant feeders	1807.7±428.8	569.7±188.4	**
2018			
Bacterial feeders	2787.4±259.7	1307.2±199.5	**
Predators	231.1±59.7	134.9±31.7	*
Fungal feeders	681.3±156.7	116.3±47.6	**
Omnivores	498.1±121.0	184.2±36.4	**
Plant feeders	1659.8±321.5	721.9±166.6	**
2019			
Bacterial feeders	2187.2±108.6	1455.8±161.7	*
Predators	215.5±44.4	103.0±26.6	*
Fungal feeders	455.9±91.4	164.3±60.5	*
Omnivores	438.8±124.9	212.2±99.2	*
Plant feeders	1325.3±333.9	727.4±88.7	**

(1) Different from uninvaded control according the Tukey's (HSD) post hoc test (* for $P < 0.05$; ** for $P < 0.01$).

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