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Temporal dynamics of soil nematode community structure under invasive *Ambrosia trifida* and native *Chenopodium serotinum*

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Summary

Temporal dynamics of soil nematode community structure at the depth of 0 – 30 cm was compared under invasive *Ambrosia trifida* and native *Chenopodium serotinum* in an abandoned cropland in Northeast China. The results showed the difference of nematode taxa and dominant genera under *A. trifida* and *C. serotinum* during the study period. *Acrobeloides* and *Paratylenchus* were found to be dominant genera under both *A. trifida* and *C. serotinum*. *Helicotylenchus* prevailed in soil with *C. serotinum*, while *Macroposthonia* was dominant in soil with *A. trifida*. Nematode taxa was higher under *A. trifida* than under *C. serotinum* from June to September. Except in the July, significantly higher numbers of plant-parasites were observed under *A. trifida* than under *C. serotinum* during the study period (P < 0.05). Nematode taxa, Simpson index and structure index were found to be sensitive indicators that detected nematode community structural differences under *A. trifida* and *C. serotinum* during the study period.

Key words: soil nematode; community structure; temporal dynamics; invasive weed; *Ambrosia trifida*; abandoned cropland; *Chenopodium serotinum*

Introduction

Understanding the rapid proliferation of invasive species that are introduced into new regions of the world is one of the most important and difficult problems in ecology (Reinhart & Callway, 2004). Invasive species are a major threat to biodiversity and ecosystem processes in native communities (Rejmanek & Richardson, 1996; van der Putten *et al*., 2005) and it is widely assumed that invasive exotic plants cause a negative impact on native biota (Palmer *et al*., 2004).

Ambrosia trifida, an exotic invasive weed, is wide spread in Northeast China (Wang *et al*., 2005). It usually produces and releases volatile chemicals into the environment and may cause significant costs to agricultural production and public health (Sun *et al*., 2002). Previous studies have focused on the allelopathic potential of *A. trifida* (Wang *et al*., 2005), influence of *A. trifida* on total nematodes (Sun *et al*., 2002) and plant parasitic nematodes (Wang *et al*., 1998). However, little is known about the seasonal distribution of soil nematode community structure in an *A. trifida* habitat. The objectives of this study were to describe the temporal dynamics of soil nematode community structure under invasive *A. trifida* and native *Chenopodium serotinum* in an abandoned cropland in Northeast China.

Material and Methods

This study was conducted at the Shenyang Experimental Station of Ecology (41°31′ N, 123°22′ E), Chinese Academy of Sciences, a Chinese Ecosystem Research Network (CERN) site in the lower reaches of the Liao River plain in Northeast China. The station is located in the continental temperate monsoon zone, with a dry-cold winter and a warm-wet summer. The annual mean temperature is 7.0 – 8.0ºC, annual precipitation averages 650 – 700 mm. The soil at the study site is an aquic brown soil (Liang *et al*., 2005c). Before the establishment of the station in 1989, all land was paddy fields with comparatively homogeneous and sufficient to maize production, and partly remained fallow (abandoned cropland) (Liang *et al*., 2005c). The abandoned cropland (120 m × 80 m) was chosen for the study site, which was dominated by *C. serotinum*, *Conyza canadensis*, *Humulus scandens*, *Metaplexis japonica*. *A. trifida* was invaded in the abandoned cropland. In this study site we selected randomly three communities of *A. trifida* and *C. serotinum*, respectively. Soil samples were collected from the selected communities of *A. trifida* and *C. serotinum* at the depth of 0 – 30 cm from May to September, 2005. Each soil sample comprised 5 cores (5 cm diameter); subsamples were taken from each such bulk sam-

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ple for estimation of nematode abundance. The rainfall and temperature at the study site recorded monthly during the study period (Fig. 1).

Nematodes were extracted from 100 g (fresh weight) of soil from each sample using sugar flotation and centrifugation (Hua *et al*., 2006; Liu *et al*., 2006), the nematode abundance was expressed per 100 g dry weight soil (Liang *et al*., 2005a). All extracted nematodes in each sample were counted and identified to genus level using an inverted compound microscope. The classification of trophic groups

Table 1. The proportion (%) of nematode genera and trophic groups under *A. trifida* and *C. serotinum*

Genus	*C. serotinum*					*A. trifida*				
	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep
Bacterivores	**24.0**	**35.7**	**36.9**	**38.3**	**28.0**	**19.1**	**30.3**	**31.0**	**24.0***	**20.5**
Acrobeles	1.0	2.5	3.3	2.0	1.9	0.9	5.5	1.6	1.7	3.5
Acrobeloides	17.0	16.8	22.3	22.8	19.6	9.3	7.4*	20.8	9.4*	10.9
Alaimus	0.0	0.1	0.0	0.0	0.0	0.0	0.9	0.2	0.3	0.0
Chiloplacus	2.1	8.0	5.3	4.6	2.6	3.7	2.9	4.2	4.1	2.0
Eumonhystera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Hetercephalobus	0.4	0.2	0.2	1.0	2.1	0.0	0.1	0.8	0.5	1.4
Mesorhabditis	0.0	1.0	0.4	3.2	0.2	0.0	2.8	1.7	1.8	1.1
Metateratocephalus	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Microlaimus	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Panagrolaimus	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.3	0.1
Plectus	0.0	0.0	0.2	0.2	0.0	0.2	0.3	0.0	0.1	0.0
Prismatolaimus	2.4	0.0	0.7	0.8	0.6	0.0*	1.0*	0.0	0.4	0.4
Protorhabditis	1.1	6.9	4.5	3.6	1.0	5.0	9.0	1.5	5.2	1.1
Rhabditophanes	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Fungivores	**3.3**	**4.1**	**2.9**	**2.3**	**2.1**	**2.9**	**4.4**	**2.7**	**2.6**	**4.7**
Aphelenchoides	0.0	0.0	0.0	0.4	0.4	0.5	0.2	0.5	0.3	0.2
Aphelenchus	1.8	3.7	2.3	1.4	0.6	1.6	1.4	0.9	1.3	1.1
Diphtherophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Ditylenchus	0.0	0.4	0.0	0.0	0.0	0.0	0.9	0.0	0.3	0.2
Tylencholaimus	1.5	0.0	0.6	0.5	1.1	0.8	1.9*	1.3	0.7	2.5
Plant parasites	**69.2**	**55.9**	**59.6**	**58.4**	**68.8**	**74.8**	**62.1**	**64.6**	**72.1***	**72.7**
Boleodorus	0.1	0.3	0.5	1.3	2.3	0.6	0.0	2.5	1.0	0.1
Coslenchus	0.1	0.4	0.0	0.8	0.1	0.0	0.6	0.0	0.3	0.3
Filenchus	1.7	3.2	3.2	1.4	6.1	2.5	4.5	1.2	2.1	2.6
Helicotylenchus	33.3	7.4	1.1	15.5	32.2	4.5*	9.0	7.8	8.9	4.7*
Heterodera	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Macroposthonia	1.4	9.4	9.5	6.4	4.6	3.3	5.9	26.0*	25.9*	7.3
Paratylenchus	31.1	34.4	45.3	32.9	22.5	63.9*	41.3	26.6*	33.8	53.1*
Pratylenchus	1.4	0.4	0.0	0.1	0.9	0.0	0.1	0.2	0.1	4.2
Psilenchus	0.1	0.4	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.4
Rotylenchus	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Ominivores/predators	**3.5**	**4.3**	**0.6**	**1.0**	**1.1**	**3.2**	**3.2**	**1.7**	**1.3**	**2.1**
Aporcelaimellus	0.9	2.6	0.1	0.8	0.1	0.6	0.5	0.6	0.5	0.2
Dorylaimellus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Dorylaimoides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Epidorylaimus	0.7	0.0	0.2	0.2	0.2	0.5	1.3	0.0	0.0	0.3
Eudorylaimus	0.1	0.9	0.0	0.0	0.0	0.7	0.1*	0.0	0.2	0.0
Microdorylaimus	1.6	0.4	0.3	0.0	0.4	0.6	0.8	0.6	0.1	0.2
Mononchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Nygolaimus	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.1
Thonus	0.1	0.4	0.0	0.0	0.4	0.5	0.5	0.3	0.2	0.9
Torumanawa	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* denote differences in the proportions of nematode genera and trophic groups between *A. trifida* and *C. serotinum* at $P < 0.05$ level

was assigned to: (1) bacterivores; (2) fungivores; (3) plant-parasites; and (4) omnivores-predators, based on known feeding habitats or stoma and esophageal morphology (Yeates *et al*., 1993; Renčo, 2002; Liang *et al*., 2005a; Hua *et al*., 2006; Liu *et al*., 2006).

Nematode taxonomic and functional diversity was analysed by the following approaches: Simpson index was calculated to determine effects of plant species on nematode taxonomic diversity (De Deyn *et al*., 2004); Nematode taxa consisted of genera (De Deyn *et al*., 2004). The structure index (SI), enrichment index (EI) and channel index (CI) were indicators for soil food web structure and condition (indicating functional diversity) (Ferris *et al*., 2001; De Deyn *et al*., 2004; Liang *et al*., 2005b); they are calculated according to the method of Ferris *et al*. (2001), and the colonizer-persister (cp) values for taxa are adopted from Bongers (1990) and Bongers and Bongers (1998).

All the data were subjected to statistical analysis of variance (ANOVA) in the SPSS statistical package. Differences with $P < 0.05$ were considered significant.

Results

Altogether 39 genera of nematodes were identified in our investigation (Tab. 1). *Acrobeloides* and *Paratylenchus* were found to be dominant genera under *A. trifida* and *C. serotinum*. *Helicotylenchus* prevailed in soil with *C. serotinum*, while *Macroposthonia* was dominant in soil with *A. trifida*.

Plant parasitic nematodes were the most dominant trophic group under both *A. trifida* and *C. serotinum*, followed by bacterivores, fungivores and omnivores-predators were rare in our investigation. Significant plant species effects were found in the numbers of different trophic groups (Tab. 2). Except in the July, significantly higher numbers of plant-parasites were observed under *A. trifida* than under *C. serotinum* during the study period ($P < 0.05$). Similar results were also found in the numbers of omnivore-predators in August and September, and the numbers of bacterivores in May, respectively ($P < 0.05$).

In the present study, significant plant species and sampling month effects were found in the taxonomic diversity indices (Taxa and Simpson index) and the structural index (Tab. 3). The enrichment index was only sensitive to different sampling month ($P < 0.01$). But only structural in-

Table 2. Abundance of nematode trophic groups under *A. trifida* and *C. serotinum* (numbers per 100 g dry soil)

Sampling month		BF	FF	PP	OP
May	*A. trifida*	296a	41a	1193a	44a
	C. serotinum	226a	28a	758b	43a
Jun	*A. trifida*	226a	34a	468a	23a
	C. serotinum	106b	13a	181b	14a
Jul	*A. trifida*	196a	16a	397a	6a
	C. serotinum	172a	12a	304a	4a
Aug	*A. trifida*	274a	37a	1032a	21a
	C. serotinum	242a	16a	366b	5b
Sep	*A. trifida*	178a	50a	677a	18a
	C. serotinum	132a	10a	438b	5b
Repeated measures ANOVA		P-values			
Plant species		0.03	<0.01	<0.01	0.01
Month		0.01	ns	<0.01	<0.01
Plant species × month		ns	ns	0.01	ns

Explanations: BF – bacterivores; FF – fungivores; PP – plant parasites; OP – omnivores-predators; ns – no singnificant. Different letters denote divterences between *A. trifida* and *C. serotinum* at $P < 0.05$ level.

Tab. 3. Functional and taxonomic nematode diversity under *A. trifida* and *C. serotinum*

Sampling month		Taxonomic diversity		Functional diversity		
		Taxa	Simpson	SI	EI	CI
May	*A. trifida*	9a	0.48a	54a	44a	24a
	C. serotinum	11a	0.41a	53a	20a	60a
Jun	*A. trifida*	13a	0.28a	70a	61a	7a
	C. serotinum	11a	0.23a	51a	49a	24a
Jul	*A. trifida*	9a	0.27a	33a	27a	29a
	C. serotinum	9a	0.32a	38a	42a	28a
Aug	*A. trifida*	12a	0.33a	51a	56a	13a
	C. serotinum	10a	0.30a	29b	34a	24a
Sep	*A. trifida*	11a	0.40a	51a	27a	21a
	C. serotinum	10a	0.28a	32b	16a	17a
Repeated measures ANOVA		P-values				
Plant species		0.03	0.04	0.02	ns	ns
Month		0.01	<0.01	<0.01	<0.01	ns
Plant species × month		ns	ns	ns	ns	ns

Explanations: SI – structure index; EI – enrichment index; CI – channel index; ns – no significant. Different letters denote differences between *A. trifida* and *C. serotinum* at $P < 0.05$ level

dex showed differences in the August and September, with higher values found under the *A. trifida* ($P < 0.05$).
The temporal fluctuations of temperature and rainfall in the study site were showed in fig.1. During the study period, the average temperature fluctuated slightly from 13.8ºC in May to 19.3ºC in July. The mean rainfall varied from 38.8 mm to 182.5 mm, with the lowest in the September and the highest in the May. Significant correlation was only found between the numbers of fungivores and the rainfall ($r = -0.936$, $P < 0.05$).

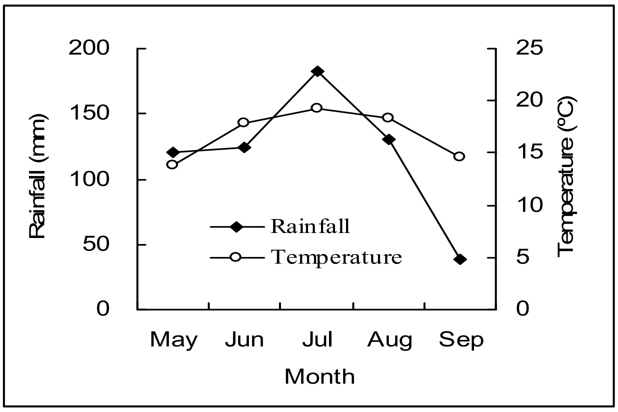

Fig. 1 Temporal fluctuations in rainfall and temperature at the study site during the study period

Discussion

The results showed the difference of nematode taxa and dominant genera under exotic *A. trifida* and native *C. serotinum* during the study period. Nematode taxa reflect biodiversity of soil habitat (Ou *et al*., 2005). In this study, the number of nematode genera was higher under *A. trifida* than under *C. serotinum* from June to September, 2005. This observation agrees with that of Yeates and Williams (2001) for a soil under the invasive weed *Tradescantia fluminensis* in New Zealand. *Helicotylenchus* prevailed in soil with *C. serotinum*, while *Macroposthonia* was dominant in soil with *A. trifida*. This is probably caused partially by differences in root exudates from *C. serotinum* and *A. trifida* (Wang *et al*., 1998).
There are some differences in soil nematode community structure under *C. serotinum* and *A. trifida*. Soil nematode communities under *A. trifida* were characterized by a high proportion of plant parasites (69.3 %), while those under *C. serotinum* dominated by plant parasites (62.4 %) and bacterivores (32.6 %). Our results were partially consistent with the findings of Van der Putten *et al*. (2005) that *A. arenaria* did not have more root-feeding nematode taxa in its natural range than in three out of four introduced regions. In our study, the relative higher abundance of bacterivores under *C. serotinum* might reveal that soil nematode community structure were changed due to the invasion of *A. trifida*, the abundance of plant-parasites showed more obvious response to the plant species than other trophic groups which partially consist with the results of De Deyn *et al*. (2004) that the abundances of the lower trophic consumers level were more affected than the higher trophic levels under different plant species. The different nematode communities under different plant species may have been due to low plant quality or plant defence compounds in the roots (Bardgett & Wardle 2003; Van der Putten 2003), and the variation of nematode community composition might indirectly influence the soil processes.
Although plant species affected nematode abundance and community structure, we did not observe significant effects of plant species on the taxonomic diversity and indices of EI and CI in each sampling month. Only SI index showed differences in the August and September. The higher numbers of omnivore-predators could contribute to the higher values of SI which might indicate a complex community structure with many linkages in the food web under *A. trifida*.
Invasion of plants into new territories may greatly affect aboveground-belowground feedbacks, especially when the invading species has vastly different physiological traits from the native flora (Wardle *et al*., 2004). In the longer term these feedbacks can also involve the effect of the invader on the quantity and quality of resource inputs to soil and on decomposer organisms and the processes they drive (Ehrenfeld, 2003). Future studies may need to determine the effect of exotic *A. trifida* on nutrient cycling in abandoned cropland ecosystems.

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