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Original article

The responses of soil nematode assemblages to disturbance in Liaohe estuary wetlands

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ABSTRACT

To improve the knowledge of nematode communities in the Liaohe estuary, the spatiotemporal variations of free-living nematode communities (density, diversity and trophic structure) in the protected zone (PZ) and the development zone (DZ) were seasonally studied. Soil nematode communities were analysed at the depths of 0–10 and 10–20 cm. The results showed that bacterial feeder nematodes were the most abundant trophic groups in both depths and at both sites. Nematode abundance and plant-parasitic nematodes maturity index/maturity index in the DZ were higher than that in the PZ ($p < 0.05$); trophic diversity, Shannon index, fungivore/bacterivore ratio and Wasilewska index in the PZ were higher than those in the DZ ($p < 0.05$). No significant differences were found in nematode indices between soil layers. Structural equation modelling (SEM) revealed that season, plant biomass and soil properties explained 78% of the variation in soil nematode, and plant biomass controlled nematodes indirectly through affecting soil properties. In general, anthropogenic activities could affect nematode communities, but the degree of influence varied with seasonal change.

1. Introduction

Wetlands are ecotones between water and land experiencing periods of water saturation and anoxia which are missing in forest and many agricultural soils [1]. Wetlands are often relic ecosystems offering refuges for many unique flora and fauna, they are very vulnerable systems affected by nutrient inputs [2]. These areas are important for nature preservation, carbon fixation and can help mitigate global change, they have been called “the kidney of landscape” [3]. Estuarine wetlands represent zones of transition between rivers and pelagic habitats. They are characterized by high biological diversity and the provision of essential ecosystem services to people and the environment.

Nematodes diversity is high amongst the meiobenthos fauna playing a very important role as microbial feeders. They are preyed on by larger animals, transferring important amounts of nutrient and energy through the food web [4–6]. Their abundance and diversity are important to the functioning of both xerarch and aquatic ecosystems. In China, several studies have found nematodes as the dominant group among soil fauna, such as the Sanjiang Plain wetland [7] and Dongting Lake wetland [8]. Further, Wu et al. [9] found that the maturity index (MI) and plant parasitism index (PPI) were sensitive enough for assessing the response of nematode communities to perturbations of the coastal wetland soil.

There are 3848×10^4 hm^2 wetlands in China, among them, coastal wetlands account for about 594×10^4 hm^2 [10]. The Liaohe estuary is Asia’s largest coastal temperate wetland and one of the best preserved estuary ecological regions in the whole world. The estuary is being used for urbanization, consequently many areas are being drained up, while fishing and harvesting have increased in the neighbouring areas. To determine how the ecosystem is responding to these disturbances we investigated the composition of nematode assemblages in disturbed and undisturbed soil of the Liaohe estuary. Our objectives were to examine the effects of disturbance on nematode diversity and community structure. We expect that: a) Disturbance can impact soil properties and plant biomass which affect the soil nematode communities further. b) We predict that seasonal change can also alter nematode assemblage due to the relatively distinct differences between the dry season and the rainy season. c) We hypothesize that nematode index values will be lower in the second layer (10–20 cm in our

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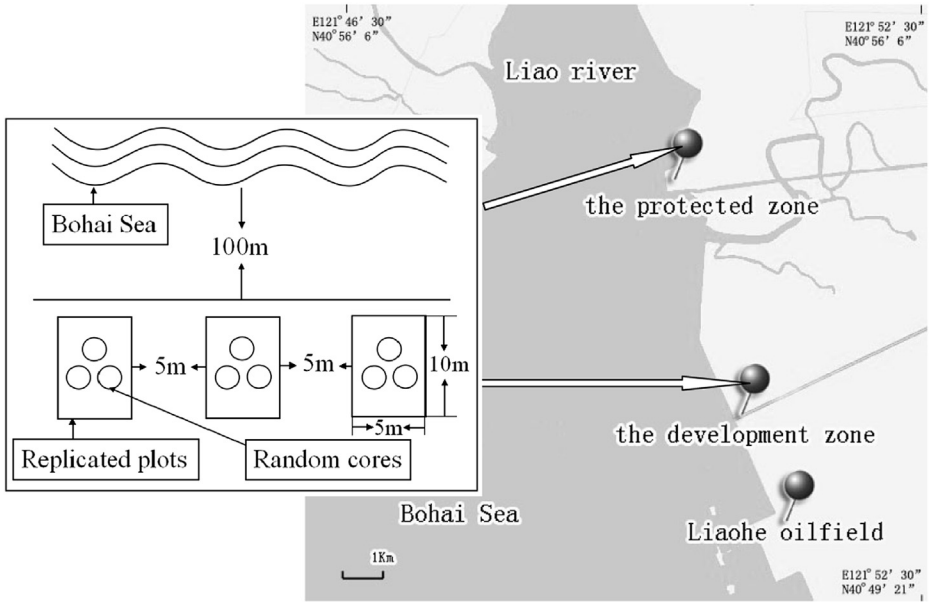

Fig. 1. Diagrammatic illustration of sampling strategy.

study) than in the top layer (0–10 cm), because of unfavourable anaerobic conditions.

2. Material and methods

2.1. Study area

The Liaohe estuary wetland (40°45′–41°10′N, 121°30′–122°00′E) is located in the west of Panjin, China. The landform belongs to alluvial–diluvial delta and the terrain is low-lying and flat. The climate is warm temperate monsoon, mean annual temperature is about 8.3 °C, annual precipitation and evaporation are approximately 623 mm and 1.67 × 10^3 mm respectively. Precipitation occurs mainly in summer with the highest amount in July.

The whole Liaohe estuary wetland is about 3000 km^2, but only 1280 km^2 are national nature reserve established by Chinese government in 1988, so the Liaohe estuary wetland contains both protected and unprotected zones (Fig. 1).

2.2. Sampling sites

Protected zone (PZ): PZ is situated at the northeast of the Bohai Sea Gulf and located within the marsh of Liaohe Delta. It is the best-preserved wetland in China characterized by a unique type of vegetation, the most common plant is *Suaeda salsa*.

Development zone (DZ): Zhaoquanhe Developing Zone is about 5 km north from the PZ and 3 km south from the Liaohe oil field, and the sampling site is surrounded by wasteland and fishpond. This area is being built into a scenic spot and the infrastructure is under construction. The most dominant vegetation in this area is *S. salsa* followed by *Phragmites australis*, all the plants are growing without fertilization.

2.3. Sampling strategy

Nematodes were sampled in spring (May), summer (July) and autumn (October) of 2012. Sampling sites were parallel to the coastal line and 100 m from it. Soil samples were collected randomly as three independent replicates, each one was spaced 5 m apart and at depths of 0–10 cm and 10–20 cm. For each replicate, three random cores were combined to form one composite sample. Each sample was placed in an individual plastic bag and sealed. All samples were kept at 4 °C for biological and chemical analysis.

Nematodes were extracted from a 100 g (fresh weight) soil by a modified cotton-wool filter method [11]. All nematodes in each sample were counted and identified to genus level using light microscope, according to Jairajpuri and Ahmad (1992) [12] and Bongers (1994) [13].

Subsamples were used for other analyses: 20 g was dried to a constant weight at 105 °C for 8 h for soil moisture. Total salinity (TS) was measured using a conductivity meter (WTW, Germany) and pH was measured using an electronic pH meter (soil:water 1:2.5, model SevenGo™ pH-SG2). Total phosphorus (TP), total nitrogen (TN) and organic matter (OM) were determined by fused sodium hydroxide-Mo-Sb colorimetry method, semi-micro Kjeldahl method and the potassium dichromate external heating method respectively [14].

2.4. Ecological indices and statistical analysis

The classification of trophic groups (bacterivores Ba, fungivores Fu, plant parasites H, omnivores-predators OP) was based on feeding habits or stoma and esophageal morphology [15]. Nematode families were assigned a c–p value from 1 to 5 based upon whether they were fast or slow reproducers [16,17].

The following nematode community indices were calculated: Fungivore/bacterivore ratio (f/b); trophic diversity (TD) = $1/\sum pi^2$, where pi is the proportion of the trophic group i in the nematode community [18]; Shannon index (H′) = pi (ln pi), where pi is the frequency of taxon i in a sample [19]; plant-parasitic nematodes maturity index/maturity index (PPI/MI) = $\Sigma vipi$, where vi is the c–p value for free-living (plant parasitic) nematodes assigned by Bongers [16] to the i-th nematode genus and pi is the proportion of the genus in the nematode community [20]; Wasilewska index (WI) = $(f + b)/pp$, where f is the number of fungivore, b is the number of bacterivore and pp is the number of plant feeder and structure index (SI) [21,22] were calculated.