Forest Gap Size Alters the Functional Diversity of Soil Nematode Communities in Alpine Forest Ecosystems

Ya Shen [1], Wanqin Yang [2], Jian Zhang [1], Zhenfeng Xu [1], Li Zhang [1], Yang Liu [1], Han Li [1], Chengming You [1], Bo Tan [1,*]

[1] Institute of Ecology & Forestry, Sichuan Agricultural University, Forestry Ecological Engineering in Upper Reaches of Yangtze River Key Laboratory of Sichuan Province, Alpine Forest Ecosystem Research Station, Soil and Water Conservation and Desertification Control Key Laboratory of Sichuan Province, Chengdu 611130, China; shenyaella@163.com (Y.S.); sicauzhangjian@163.com (J.Z.); sicauxzf@163.com (Z.X.); zhangli19830116@hotmail.com (L.Z.); sicauliuyang@163.com (Y.L.); hannahlisc@163.com (H.L.); ycmsichuan2009@163.com (C.Y.)

[2] School of Life Science, Taizhou University, Taizhou 318000, China; scyangwq@163.com

* Correspondence: bobotan1984@163.com; Tel.: +86-28-86290957

Supplementary Materials

S1: the detailed description of the soil nematode community indices

Due to the close relationship between soil nematodes and the soil environment and the sensitivity of nematodes to environmental disturbances, soil nematode communities are considered to be indicator organisms that can be used to indicate and reflect the changes in the structure and function of soil food webs[1]. To better determine the biological indicator function of soil nematodes, the researchers used soil nematode community analysis methods to establish various evaluation systems, which became an important tool for evaluating the biological indicator function of nematodes.

In early studies, soil nematode ecological researchers mainly used biodiversity indices to describe the diversity of the soil nematode community, such as the Shannon-Wiener index (H'), Pielou index (J'), dominance index (λ) and Margalef index (SR) [2-4]. These indices are still applied today.

$$H' = -\sum_{i=1}^{S} P_i(InP_i) \quad (1)$$

$$J' = \frac{\mathrm{H}'}{In(S)} \quad (2)$$

$$\mathrm{SR} = \frac{\mathrm{S}-1}{\mathrm{InN}} \quad (3)$$

$$\lambda = \sum {P_i}^2 \quad (4)$$

where N is the number of individuals identified, S is the number of taxa identified, and P_i is the proportion of individuals in the *i*th taxon (a given taxon is regarded as the *i*th taxon).

Moreover, to promote the ecological study of soil nematodes, studies transitioned from nematode community diversity analysis to the evaluation of the ecological function of the soil nematode community and food network. Researchers have gradually developed an ecological index specifically for the analysis of soil nematode communities. For example, food sources are fundamental to trophic interactions and provide the basis for Yeates's definitions of the essential feeding types: bacterivores (Ba), fungivores (Fu), omnivore-predators (OP) and plant-parasites (PP)[5]. Based on the nematode's life strategy, predecessors allocated the known nematodes from colonizers to persisters (r- to K-strategists). The colonizer-persister (cp) scale was distinguished according to the following 5 groups (cp1-cp5), and the definitions came from Bongers et al.[6].

cp1: nematodes with a short generation time that produce many small eggs, resulting in explosive population growth under food-rich conditions.

cp2: nematodes with a short generation time and a high reproduction rate but do not form dauerlarvae. They occur under food-rich as well as food-poor conditions and are very tolerant to pollutants and other disturbances.

cp3: nematodes with characteristics between groups 2 and 4; they have a long generation time and are relatively sensitive to disturbances.

cp4: small dorylaimids and large non-dorylaimids. These nematodes are characterized by a long generation time, permeable cuticle and sensitivity to pollutants. The non-carnivorous nematodes in this group are relatively sessile, whereas carnivorous nematodes have to move.

cp5: large dorylaimid nematodes with a long lifespan and low reproduction rate, which are both likely a corollary of low metabolic activity. These nematodes produce few but large eggs and have low motility. With a permeable cuticle, these nematodes are very sensitive to

pollutants and other disturbances. This group is composed of large dorylaimids: omnivores, predators and plant feeders.

Based on the c-p groups, an index for describing the diversity of life history of nematodes is proposed, such as the maturity index (MI, MI2–5, ∑MI and PPI/MI).

$$\mathrm{M}I(\sum \mathrm{MI}, \mathrm{MI2-5}, \text{and PPI}) = \sum_{i=1}^{n} cp_i \,.\, p_i \quad (5)$$

where n is the number of taxa in the sample, cp_i is the c-p value of soil nematodes to the *i*th taxon, and P_i is the proportion of individuals in the *i*th taxon[1,3,7,8];

A formula for characterizing the functional structure of the soil nematode community was obtained by combining the trophic and c-p groups. The structure index (SI), enrichment index (EI) and channel index (CI) were functional diversity ecological indices to be used to assess the soil quality.

$$\mathrm{SI} = 100 \times (s/(s+b)) \quad (6)$$

$$\mathrm{EI} = 100 \times (e/(e+b)) \quad (7)$$

$$\mathrm{CI} = 100 \times (0.8Fu_2/(0.8Fu_2 + 3.2Ba_1)) \quad (8)$$

The b component is calculated as $\sum k_b\, n_b$, where the k_b values are the weightings assigned to the guilds that indicate the basal characteristics of the food web ($0.8Ba_2$, $0.8Fu_2$), and the n_b values are the abundances of nematodes in those guilds; the *e* and *s* components are calculated similarly, and the k_b values are calculated using the guilds indicating enrichment ($3.2Ba_1$, $0.8Fu_2$) and structure ($1.8Fu_3$, $1.8Ba_3$, $3.2Fu_4$, $3.2Ba_4$, and 3.2OP)[9].

According to the calculated EI and SI, the nematode fauna can be divided into four quadrants A, B, C, and D, where the values of EI and SI vary from 0 to 100. When EI is greater than 50 but SI is less than 50 (A quadrant), the soil nutrient status is good but the degree of disturbance is high, and the food web is subject to a certain degree of disturbance. When both EI and SI are greater than 50 (B quadrant), the soil nutrient condition is improved, the degree of disturbance is small, and the food web is stable and mature. When EI is less than 50 but SI is greater than 50 (C quadrant), the soil nutrient condition is poor but the degree of disturbance is small, and the food web is in a structured state. When both EI and SI are less than 50 (D quadrant), the soil nutrient condition is poor and the degree of disturbance is the highest, which causes stress to the environment and degrades the food web. And this table 1 and figure 1 from Ferris et al.[9].

Table1 Inferred condition of the soil food web and its environment based on weighted nematode faunal analysis [a].

General diagnosis	Quadrat A	Quadrat B	Quadrat C	Quadrat D
Disturbance	High	Low to moderate	Undisturbed	Stressed
Enrichment	N-enriched	N-enriched	Moderate	Depleted
Decomposition channels	Bacterial	Balanced	Fungal	Fungal
C:N ratio	Low	Low	Moderate to high	High
Food web condition	Disturbed	Maturing	Structured	Degraded

a Quadrats refer to faunal ordination in the faunal profile (Fig. 1).

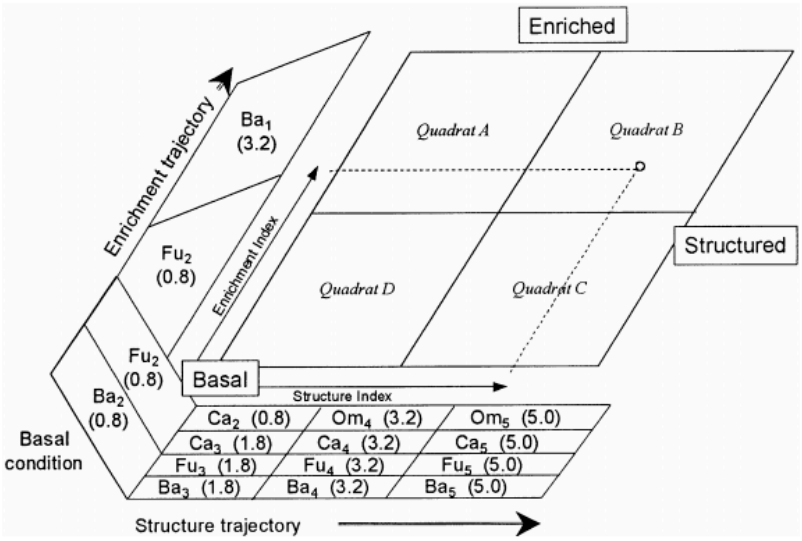

Fig. 1. Functional guilds of soil nematodes characterized by feeding habit (trophic group) and by life history characteristics expressed along a colonizer–persister (cp) scale (after Bongers and Bongers, 1998). Indicator guilds of soil food web condition (basal, structured, enriched) are designated and weightings of the guilds along the structure and enrichment trajectories are provided, for determination of the enrichment index (EI) and structure index (SI) of the food web.

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