Ecological Indicators 60 (2016) 310–316

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Using the biomasses of soil nematode taxa as weighting factors for assessing soil food web conditions

Jie Zhao[a,c], Dejun Li[a,c], Shenglei Fu[b], Xunyang He[a,c], Zhiyong Fu[a,c], Wei Zhang[a,c], Kelin Wang[a,c,*]

[a] Key Laboratory of Agro-ecological Processes in Subtropical Region, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha 410125, PR China
[b] Key Laboratory of Vegetation Restoration and Management of Degraded Ecosystems, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, PR China
[c] Huanjiang Observation and Research Station for Karst Ecosystems, Chinese Academy of Sciences, Huanjiang 547100, PR China

ARTICLE INFO

Article history:
Received 30 December 2014
Received in revised form 27 May 2015
Accepted 1 June 2015

Keywords:
Nematodes
Taxonomic level
Weighting factor refinement
Biomass
Community index

ABSTRACT

We propose the use of nematode generic biomasses as weighting factors for calculation of nematode community indices. Three data sets were used to calculate the indices using guild-based weighting (i.e., fixed weighting of nematode guilds) and genus-based weighting (i.e., weighting based on the nematode generic biomasses). The genus-based weighting factors were quadratically correlated with guild-based weighting factors, but the genus-based weighting factors were highly variable within each nematode guild, indicating that important information was likely missing when guild-based weighting was used. Although variation patterns of in the indices in response to management practices and land use were often similar for the two weighting systems, they sometimes differed substantially, and the specific index values frequently differed depending on which weighting system was used. In addition, the absolute values of the indices were frequently found to be different between the two weighting systems. Based on the comparison of indices from the two systems, we found that the genus-based system was complementary rather than superior to the guild-based system. It was suggested that both weighting systems should be used for the calculation of the nematode community indices in a study in order to better distinguish the treatment effects.

1. Introduction

Soil nematodes are one of the most commonly used indicators of soil food web conditions (Bongers and Ferris, 1999; Neher, 2001). This use of nematodes is based on the fact that soil nematodes exhibit differences in food sources and life history strategies and therefore occupy several trophic levels in food webs. Although Yeates et al. (1993) proposed eight trophic groups for soil nematodes, soil nematode taxa are usually assigned to five trophic groups: bacterivores (Ba), fungivores (Fu), plant feeders (Pl), omnivores (Om), and predators (Pr). Another characteristic that makes soil nematodes excellent indicators of soil conditions is that nematode life history strategies might be described with a colonizer–persister (*cp*) scale, with range from 1 (typical *r*-selected taxa) to 5 (typical *K*-selected taxa). Based on their well-documented feeding types and inferred life history strategies (or *cp* scales) (Bongers and Bongers, 1998; Ferris et al., 2001; Yeates et al., 1993), soil nematodes can be grouped into 16 functional guilds (i.e., $Ba_{1\text{-}4}$, $Fu_{2\text{-}4}$, $Pl_{2\text{-}5}$, $Om_{4\text{-}5}$, and $Pr_{3\text{-}5}$). They are considered as basal component (Fu_2, Ba_2), enrichment component (Ba_1) and structure component ($Ba_{3\text{-}4}$, $Fu_{3\text{-}4}$, $Om_{4\text{-}5}$ and $Pr_{3\text{-}5}$) depending on what qualitative conditions in food web each guild indicates.

By weighting these functional guilds, soil nematode community indices (such as enrichment, structure, channel, and bacterivore indices) have been considered useful for assessing soil food web conditions (Ferris et al., 2001). In the formulas used to calculate these four indices, nematode guilds are assigned with different weighting factors. However, these weighting factors for nematode guilds are somewhat arbitrary and require refinement (Ferris et al., 2001). In addition, the responses of many nematode genera to resource enrichment or disturbance did not match their *cp* scale values (Fiscus and Neher, 2002; Korthals et al., 1996; Zhao and Neher, 2013). So far, however, no methodology has been developed to re-assess the *cp* scale and weighting system of nematodes.

* Corresponding author at: Key Laboratory of Agro-ecological Processes in Subtropical Region, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha, Hunan 410125, PR China. Tel.: +86 20 37252631; fax: +86 20 37252615.
E-mail address: kelin@isa.ac.cn (K. Wang).

http://dx.doi.org/10.1016/j.ecolind.2015.06.003
1470-160X/

Table 1
Guild-based weighting factors and average fresh biomasses per individual of the genera of non-plant-feeding nematodes in three studies in southwest and southern China.

Genus	Guild[d]	Weighting factor[e]	Biomass per individual (μg)	Genus	Guild	Weighting factor	Biomass per individual (μg)
Diploscapter[c]	Ba1	3.2	0.3	*Alaimus*	Ba4	3.2	0.87
Distolabrellus[b]	Ba1	3.2	0.75	*Aphelenchoides*	Fu2	0.8	0.17
Macrolaimus[b]	Ba1	3.2	1.13	*Aphelenchus*	Fu2	0.8	0.26
Panagrolaimus	Ba1	3.2	0.84	*Ditylenchus*	Fu2	0.8	0.47
Protorhabditis	Ba1	3.2	0.41	*Filenchus*	Fu2	0.8	0.09
Pseudodiplogasteroides[b]	Ba1	3.2	0.84	*Psilenchus*	Fu2	0.8	0.45
Rhabditis[b]	Ba1	3.2	8.72	*Seinura*[c]	Fu2	0.8	0.17
Rhabditoides[b]	Ba1	3.2	7.33	*Diphtherophora*	Fu3	1.8	0.6
Rhabditonema	Ba1	3.2	0.2	*Dorylaimellus*	Fu4	3.2	0.3
Acrobeles[a]	Ba2	0.8	0.49	*Leptotylencholaimus*[b]	Fu4	3.2	0.54
Acrobeloides	Ba2	0.8	0.2	*Loncharionema*[b]	Fu4	3.2	1.07
Acrolobus[b]	Ba2	0.8	0.14	*Nimigula*[a]	Fu4	3.2	2.62
Acroukrainicus[b]	Ba2	0.8	0.37	*Tylencholaimellus*	Fu4	3.2	1.09
Cephalobus	Ba2	0.8	0.36	*Tylencholaimus*	Fu4	3.2	0.54
Cervidellus[a]	Ba2	0.8	0.15	*Dorylaimoides*	Fu4	3.2	1.13
Chronogaster[a]	Ba2	0.8	0.23	*Epidorylaimus*	Om4	3.2	1.51
Drilocephalobus	Ba2	0.8	0.1	*Eudorylaimus*	Om4	3.2	3.96
Eucephalobus	Ba2	0.8	0.29	*Microdorylaimus*	Om4	3.2	0.5
Heterocephalobus	Ba2	0.8	0.4	*Prodorylaimus*	Om4	3.2	4.09
Leptolaimus[a]	Ba2	0.8	0.17	*Pungentus*	Om4	3.2	1.75
Paraplectonema[a]	Ba2	0.8	0.51	*Thonus*	Om4	3.2	1.94
Placodira[b]	Ba2	0.8	0.45	*Thornia*	Om4	3.2	0.96
Plectus	Ba2	0.8	0.98	*Chrysonemoides*	Om5	5	0.98
Pseudacrobeles[b]	Ba2	0.8	0.49	*Mesodorylaimus*	Om5	5	5
Steratocephalus[b]	Ba2	0.8	0.08	*Amphibelondira*	Om5	5	2.62
Teratocephalus[b]	Ba2	0.8	0.09	*Tripyla*	Pr3	1.8	3.26
Tylocephalus[a]	Ba2	0.8	0.23	*Trischistoma*	Pr3	1.8	0.75
Wilsonema	Ba2	0.8	0.05	*Tobrilus*[a]	Pr3	1.8	8.38
Eumonhystera[b]	Ba2	0.8	0.22	*Stenonchulus*	Pr3	1.8	0.61
Aphanolaimus[b]	Ba3	1.8	0.43	*Anatonchus*[b]	Pr4	3.2	6.27
Bastiania[b]	Ba3	1.8	0.1	*Coomansus*	Pr4	3.2	4
Cylindrolaimus[b]	Ba3	1.8	0.77	*Iotonchus*	Pr4	3.2	3.99
Metateratocephalus	Ba3	1.8	0.08	*Miconchus*	Pr4	3.2	4
Odontolaimus	Ba3	1.8	0.19	*Clarkus*[b]	Pr4	3.2	1.47
Paraphanolaimus[b]	Ba3	1.8	0.88	*Monochus*	Pr4	3.2	4
Prismatolaimus	Ba3	1.8	0.64	*Mylonchulus*	Pr4	3.2	3.99
Rhabdolaimus	Ba3	1.8	0.09	*Aporcelaimellus*	Pr5	5	10.88
Achromadora	Ba3	1.8	0.31	*Discolaimus*[b]	Pr5	5	0.65
Microlaimus	Ba3	1.8	0.15	*Paractinolaimus*[b]	Pr5	5	10.82

[a] Nematode genus only retrieved from study 1 (data set 1) (Zhao et al., 2014b).
[b] Nematode genus only retrieved from study 2 (data set 2) (Zhao et al., 2014a).
[c] Nematode genus only retrieved from study 3 (data set 3) (Zhao et al., 2011).
[d] Guild designation is the composite of trophic group and cp value: Ba, bacterivore; Fu, fungivore; Pr, predator; Om, omnivore. Trophic group and *cp* value assignment mainly according to Yeates et al. (1993) and Bongers and Bongers (1998), respectively.
[e] Weighting factor of each nematode guild according to Ferris et al. (2001).

The individual biomass, generation time, and fecundity are important aspects of nematode life history strategies and could be useful for developing or improving a weighting system. Among these variables, nematode biomass is perhaps the easiest to determine because it can be calculated based on body length and the greatest body diameter (Andrassy, 1956; Ferris, 2010).

The objectives of the current study were to: (1) develop a new weighting system for nematodes on a fine taxonomic level (i.e., genus level) based on nematode generic biomass, and (2) use existing nematode community data to determine whether the biomasses of soil nematode genera can be used as weighting factors for the calculation of nematode community indices. We calculated soil nematode community indices using two contrasting weighting systems. In one system (designated the guild-based weighting system), weighting was based on nematode guilds according to Ferris et al. (2001). In the other system (designated the genus-based weighting system), weighting was based on the biomasses of nematode genera. We explored how the community indices differed depending on which weighting system was used. We also compared how the indices derived from the two weighting systems responded to specific disturbances and land uses. We hypothesized that the nematode community indices calculated with the genus-based and guild-based systems would be complementary in distinguishing the treatment effects.

2. Materials and methods

2.1. Data collection

Three raw data sets used in this research were obtained from three studies. In study 1, soil nematodes under different management practices (fertilization, cutting frequency and intensity, and irrigation) in hybrid napiergrass (*Pennisetum hydridum*) field were studied (Zhao et al., 2014b). In study 2, the impact of different land use (grassland, shrubland, and forest) on nematode communities was examined (Zhao et al., 2014a). In study 3, soil nematodes under the forest management practices included understory removal and all plants removal were studied (Zhao et al., 2011, 2013); the forest management practices included understory removal and all plants removal. The data from study 1, 2, and 3 are hereafter referred to as data set 1, 2, and 3, respectively.