Soil Nematode Community Structure as Affected by Tourism Trampling in Wudalianchi Scenic in Northeast China

Li-Mei Zhang^{1,2}, Xue-Ping Zhang¹ and Li-Min Zhang^{1*}

 ¹Key Laboratory of Remote Sensing Monitoring of Geographic Environment, College of Heilongjiang Province, Harbin Normal University, Harbin - 150025, China.
 ²School of History, Culture and Tourism, Heilongjiang University, Harbin - 150080, China.

(Received: 12 April 2014; accepted: 09 May 2014)

The effect of human trampling on soil nematode community were studied along an increasing distance from the trail of Wudalianchi World Geo-park which is located in Northeast China. It can provide valuable information about the impacts of human disturbances on ecosystem structure. Our study evaluated the abundance, the composition and the ecological indicators of soil nematode communities in three different trampling intensity (severely disturbance, moderately disturbance, slightly disturbance). Soil samples were collected from the depth of 0 cm to 20 cm in 2013. Soil nematode were separated using the Baermann's funnels method, and were identified and counted. Soil pH value, soil moisture, soil bulk density, organic matter, total nitrogen, total phosphorus, available phosphorus content, and available potassium content were measured in topsoil (0-20 cm) from each site. Sixty-one nematode genera were collected during this study. Trampling decreased the abundance of the total nematode and four tropic groups, and affected the frequency of occurrence of some species. Canonical correspondence analysis (CCA) indicated that the soil nematode trophic group distribution related to soil properties closely. Tramping increased soil bulk density, reduced soil moisture content, and decreased soil nutrient supply. Therefore, it lead to changes of soil nematode community. The severely trampling site had the lowest the abundance MI 2-5, EI and SI, and the highest BI and CI, which indicates a serious interference to the environment. Our results show human traffic can affect soil biota significantly in this ecosystem and may alter ecosystem processes. Consequently, soil nematode community analysis may provide useful information for assessing the impact of human foot traffic on soil processes.

Key words: Tourism disturbance, Nematodes, Ecological functions, Community structure.

With the development of tourism industry, activities associated with human recreation (including tourists trampling, vehicle rolling, tourist facilities placement, environmental pollution and so on) have caused soil erosion progressively, vegetation destruction, loss of biodiversity etc.¹⁻². In all kinds of recreational activities, trampling is acknowledged to be the most widespread and it becomes a problem as it represents the major disturbance affecting vegetation and soil surface horizon³. In tourist areas, trail is the region which is most affected by the trampling⁴⁻⁵. Therefore, it becomes a topic of considerable importance for ecological impact study.

Human trampling causes disrupting soil structure partially or totally, reducing porosity and modifying the edaphic microenvironment⁶. Soil fauna is a good indicator for human impact since it inhabits soil surface horizons mainly⁷⁻⁸. For instance, Ayres *et al.*, (2008) found that human trampling reduce the abundance of soil organisms in the McMyrdi dry valleys, Antarctica⁹. Battigelli

^{*} To whom all correspondence should be addressed. Mob.: +86 13945099476; E-mail: zlmihb@163.com

et al. (2004) found that soil compaction causes a change in soil fauna composition¹⁰. Lee *et al.* (2009) indicate a clear negative effect for trampling on the composition of soil arthropods⁶. In these soil organisms, nematode maybe the first choice because they were identifiable, small, common, and easily cultured and propagated¹¹⁻¹². Changes in soil nematode community structures reflect changes in soil microenvironments and so are increasingly used as bioindicators for disturbance of the soil environment because their numbers, taxa and trophic groups may reflect the state of soil ecological processes¹³⁻¹⁷. However, there have little study about tourism impact on soil nematode.

As a result of seven volcanic eruptions in the past 2.1 million years, wudalianchi World Geopark have the most well-preserved intra-continental volcanic in China, and it was nominated as a World Heritage Property in 2010¹⁸. As a national scenic, Wudalianchi have precious aesthetic and scientific value, attracting a large number of domestic and foreign tourists and recuperators. According to statistic provided by the Heilongjiang Provincial Tourism Bureau, tourists increased from 230,000 to 1.25 million during recent years (2002-2012), which increased nearly 11 times. The substantial growth in tourists will lead to the changings in soil environment. It is not clear if these changes would have impact on ecosystem. We take Yaoquan mountain and South Gelagiu mountain of Wudalianchi as study examples. The soil nematode communities at the 0-20 cm depth was investigated along an increasing distance from the trail in study sites revealing the effects of tourism trampling on the soil in 2013. We predicted that (1) The abundance of nematode would decrease with increasing distance from the trail. (2) forest soils from areas with less trampling would have more stable structure of nematode than soils with more trampling. (3) the trampling would change the composition and spatial distribution of nematode. Perhaps the knowledge of trampling impact on the nematode community will assist park managers to perfect tourism planning.

MATERIALSAND METHODS

Description of study area

The study was conducted at the temperate forest in Wudalianchi ($126^{\circ}00' - 126^{\circ}25'$ E, $48^{\circ}30'$, $-48^{\circ}50'$, N) within the ecotone between

J PURE APPL MICROBIO, 8(SPL. EDN.), MAY 2014.

the Great Hinggan Mountains, the Less Hinggan Mountains and the forest steppes of the Songnen Plain. The soil at the study site is classified as volcanic soil and the typical vegetation is the temperate mixed forest, Mongolia oak is the main plant population¹⁸. This area enjoys temperate continental monsoon climate, and it has long cold winters and moderately short warm summers. The annual precipitation is 476.3 mm and concentrate in June-August. The annual temperature is -0.5 °C. The annual frost-free in a year is 121 d and the average annual sunshine duration is 2726 h¹⁹. **Field sampling**

Soil samples at the 0-20 cm depth were taken from three sites along a disturbance gradient with distance at 0 (Severely disturbance, D3), 10 (Moderately disturbance, D2), and 50 (Slightly disturbance, D1) meter from the Yaoquan mountain and South Gelagiu mountain recreational trails with six altitudes. Three replications were random chosen in each site. Each replications was composed of four 5×5 cm² samples. Samples collected from the same location were mixed thoroughly and preserved in a plastic bag. Then a part of soil fresh samples was used to measure soil moisture (MC; by the oven drying method) and soil bulk density (BD; by the cutting ring method), the other part of soil fresh samples were kept at 4°C to analyze soil nematodes, and the remaining samples were air-dried at room temperature and then sieved through a 2 mm screen to meaure soil chemical properties including soil pH (with the use of glass electrode pH meter), total nitrogen content (TN; by the semimicro Kjeldahl method), soil organic matter content (OM; by the potassium dichromate volumetric method), total phosphorus (TP; by the Mo-Sb colorimetry method), available phosphorus content (SP; by the 0.5mol/L NaHCO₂ extraction method), available potassium content (SK; as extracted by ammonium acetate and determined by flame photometry)²⁰. The results are showed in Table 1.

Exraction and identification of soil nematodes

Soil nematodes were separated from 100 g of fresh soil using the Baermann's funnels method and preserved in 4% formaldehyde ²¹⁻²². Collected arthropods were counted and at least 150 nematodes from each sample were indentified to genue level under a inverted compound microscope using the De Nematoden Van Nederland²³. Abundances of nematodes were expressed as

	MC (%)	pН	OM(g/kg)	TN(g/kg)	TP(g/kg)	SP(mg/kg)	SK(mg/kg)	BD (g/cm ³)
D1 D2	35.59±2.69 32.28±2.60	6.66±0.02 6.68±0.02	87.63±3.68 87.29±3.56	5.96±0.28 5.96±0.27	2.47±0.04 2.47±0.03	37±0.02 36±0.02	57.10±0.09 57.18±0.09	1.26±0.04 1.31±0.04
D3	28.86 ± 2.60	6.47 ± 0.02	87.06 ± 3.56	5.88 ± 0.27	2.26 ± 0.03	29±0.02	56.56 ± 0.09	1.34 ± 0.04

Table 1. Soil environment parameters (mean±S.E.) of the three tourism disturbance plots

Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Environment parameters included: MC, soil moisture content; OM, soil organic matter content; TN, total nitrogen content; TP, total phosphorus content; SP, available phosphorus content; SK, available potassium content; BD, soil bulk density.

individuals per 100 g (ind./100 g) of dry soil²⁴. Nematodes were divided into 4 trophic groups according to the feeding habits and life history characteristics¹³: bacterivores (Ba), fungivores (Fu), omnivores-carnivores (Om) and plant parasites (Pp). And according to nematode life history characteristics, nematodes were divided into 6 colonizer-persister (cp) scale²⁵.

Data analysis

Several nematode community indices were calculated: (1) maturity index (MMI); (2) plant parasite maturity index (PPI); (3) soil free-living nematode maturity index (MI); (4) maturity index including cp 2-5 group (MI2-5)²⁵; (5) basal index (BI); (6) channel index (CI); (7) enrichment index (EI); (8) structure index (SI)¹¹; (9) nematode channel ratio (NCR)¹⁴; (10) fungal feeder to bacterial feeder ratio (F/B)²⁶; (11) trophic diversity (TD)²⁷.

Soil Nematode abundances were ln(x + 1) transformed before the statistical analysis to normalize the data and make the variance constant. One-way ANOVA was used to evaluate the effects of disturbance degree on measured ecological indices. Principal component analysis was used to evaluate all soil nematode community structure parameters. Canonical correspondence analysis was used to evaluate to evaluate community structure and main environmental properties under different disturbance degree. All statistical analyses were performed with SPSS and CANOCO software packages, and differences with p < 0.05 were considered statistically significant.

RESULTS

Composition and abundance of soil nematode communities

Sixty-one nematode genera were identified, *Cephalobus* was the dominant species

(which counted more than 10 % of total), counting for 11.54 % of the total individuals. And 80.88 % of the nematode were made up of 29 common groups (which counted 1 to 10 % of total), while 31 rare groups (which counted less than 1 %) counted only 7.58 % (Table 2). The total number of genera was no significant difference in three disturbance degree sites (p > 0.05) (Fig. 1). And the most of genera abundance had no significant difference in three disturbance degree (p > 0.05). However, disturbance degree influences dramatically the abundance of some genera (p < 0.05) (Table 2); for example, the porportional contributions of Teratocephalus and Aphelenchus significant decreased with the increase of tourism disturbance degree, while the porportion of *Eudorylaimus* increased (Table 2). The proportional contributions of some nematode changed only slightly among three disturbance sites; for example, Mesorhabditis (CV = 6.22%). On the contrary, some species changed dramatically. For example, Tenunemellus and Pungentus did not get in D3, Heterodera and Longidorus did not get in D2, and *Rotylenchulus* did not get in D1. *Chrysonemoides* and Microdorylaimus was obtained only in the D3 and D2 respectively (Table 2). .

In this study, the average abundance of nematodes across all sites was 461 individuals per 100 gramme dry soil (ind./100 g dry soil). The total abundance of nematodes was significantly affected by the disturbance degree (p < 0.01) (Fig. 1). D1 had the highest individual abundance (618 ind./100 g dry soil), which was approximately two times greater than D3 (329 ind./100 g dry soil). (Fig. 2).

Functional guilds of soil nematode communities

In this study, significant tourism disturbance effects were observed in the abundance of the trophic groups (Fig. 1). There

$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Genus Gauld D1 D2 D3 mean CV p Genus Guild D1 Pringrobinis Bal 1055 0.31 0.94 0.77 40 ns frip/a 0m3 0.55 Pringrobinis Bal 2.07 2.09 3.49 2.41 18.11 ns Microbolins 0m4 0.55 Acrobeloides Ba2 2.01 1.47 1.38 1.14 4.963 ns Microbolylainus 0m4 0.55 Acrobeloides Ba2 0.11 0.08 0.07 3.49 3.41 3.11 3.44 3.61 mo4 0.55 Cervidations Ba2 1.127 0.15 0.03 0.01 0.03 0.01 0.55 <t< th=""><th></th><th></th><th>:</th><th>ļ</th><th></th><th></th><th></th><th></th><th></th><th>t</th><th>:</th><th>ļ</th><th>ļ</th><th>6</th><th></th><th>ł</th><th></th></t<>			:	ļ						t	:	ļ	ļ	6		ł	
$ \begin{array}{l l l l l l l l l l l l l l l l l l l $	$ \begin{array}{c cccc} Werkender & Bal & 1.68 & 2.28 & 2.13 & 6.22 & 18 & 77 p/a & 0m3 & 0.5 & 0.23 & 0.88 & 0.77 & 16.2 & 0.88 & 0.77 & 16.2 & 0.88 & 0.77 & 16.2 & 0.88 & 0.77 & 0.64 & 0.94 & 0.57 & 0.56 & 0.75 & 0.75 & 0$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	ĞІ БА	snus	Guild	DI	D2	D3	mean	CA	d	Genus	Guild	DI	D2	D3	mean	CV	d
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Й DDI	sorhabditis	Bal	1.68	2.28	2.8	2.13	6.22	ns	Tripyla	Om3	0.6	0.93	0.88	0.77	16.2	ns
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccc} Prixinchus & Bal & 0.08 & 0.05 & 0.1 & 0.07 & 40 & ns & Epidorylamus & 0m4 & 0.08 \\ Acrobeles & Ba2 & 3.01 & 1.47 & 1.58 & 1.74 & 49.63 & ns & Micronchus & 0m4 & 0.05 \\ Acrobeles & Ba2 & 1.14 & 0.89 & 1.58 & 1.17 & 31.01 & ns & Paugerus & 0m4 & 0.05 \\ Acrobeles & Ba2 & 1.13 & 0.13 & 0.11 & 31.01 & ns & Mylonchuins & 0m4 & 0.05 \\ Acrobeles & Ba2 & 1.27 & 0.98 & 1.57 & 1.154 & 43.61 & ss & Micronchus & 0m4 & 0.05 \\ Chromogaster & Ba2 & 0.03 & 0.1 & 0.08 & 0.07 & 38.71 & ns & Tangerus & 0m4 & 1.52 \\ Chromogaster & Ba2 & 1.27 & 0.05 & 0.13 & 0.08 & 0.07 & 38.71 & ns & Tangerus & 0m4 & 0.05 \\ Chromogaster & Ba2 & 1.27 & 0.05 & 0.13 & 0.08 & 0.07 & 38.71 & ns & Tangerus & 0m4 & 0.05 \\ Chromogaster & Ba2 & 1.27 & 0.75 & 1.22 & 1.13 & 1.95 & 44.36 & ns & Micronchus & 0m5 & 0.23 \\ Eucephalobus & Ba2 & 2.15 & 1.36 & 2.31 & 1.95 & 44.33 & s & Disclamus & 0m5 & 0.12 \\ Pressona & Ba2 & 2.15 & 1.36 & 2.31 & 1.95 & 44.31 & ns & Tanunauwa & 0m5 & 0.12 \\ Pressona & Ba2 & 3.52 & 4.43 & 3.17 & 3.74 & 34.99 & ss & Mecolonylamus & 0m5 & 0.12 \\ Prisoneta & Ba2 & 2.14 & 1.66 & 2.5 & 2.21 & 43.11 & ns & Tanunauwa & 0m5 & 0.12 \\ Duttolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.11 & 21.94 & 3.13 & ns & Bacelaanus & 0m5 & 0.12 \\ Prismatoda & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.95 & 1.43 & 1.8 \\ Prismatolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.95 & 1.43 & 1.8 \\ Prismatolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.94 & 1.8 \\ Prismatolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.43 & 1.8 \\ Prismatolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.43 & 1.8 \\ Prismatolaimus & Ba3 & 1.91 & 1.87 & 2.76 & 2.13 & 1.43 & 1.8 \\ Prismatolaimus & Ba3 & 1.92 & 0.44 & 4.56 & 5.36 & 3.34 & 3.15 & 4.17 & ns & Paintentus & Pp2 & 0.14 \\ Aphelenchus & Fu2 & 2.03 & 0.62 & 0.46 & 4.28 & ns & Paintentus & Pp2 & 0.14 \\ Aphelenchus & Fu2 & 2.13 & 2.14 & 4.39 & 3.15 & 4.17 & ns & Paintenchus & Pp2 & 0.12 \\ Diphtheraphora & Fu2 & 2.14 & 4.36 & 5.36 & 3.35 & 4 & 4.75 & ns & Priconetans & Pp2 & 0.12 \\ Diphtheraphora & Fu2 & 0.21 & 0.21 & 0.21 & 0.21 & 0.21 & 0$, Pa	nagrolaimus	Bal	0.55	0.31	0.94	0.57	43.07	ns	Clarkus	Om4	0.57	0.53	0.49	0.54	39.84	ns
RubblisBal2072.093.498.11B.11.011.151.661.561.751.871.87Excrete/endiesBa22.011.471.8711.731.0118.1731.0130.730.961.5418.3ArcobeloidesBa22.011.471.581.7331.0118.8Microfund0.030.030.030.0110.738.8ArcobeloidesBa21.171.1131.0118.8Microfund0.0640.030.030.0110.7313.88.8CervidationsBa20.070.0738.7118.17.11.731.0119.8177.2668.8CervidationsBa21.270.070.0738.7118.1 <i>Microfund</i> 0.060.020.030.01171.43CervidationsBa21.270.770.900.7938.7118.7 <i>Thous</i> 0.060.020.01171.43ElecpholobiesBa21.270.770.910.080.050.050.060.020.030.01ElecpholobiesBa20.770.770.940.770.070.01171.4318.9ElecpholobiesBa20.750.740.740.740.750.070.060.020.030.060.1713.1318.9ElecpholobiesBa21.231.1313.1313.1613.7713.1313.7713.13 <td>$\begin{array}{cccccccccccccccccccccccccccccccccccc$</td> <td>Rhabditis Bal 2.07 2.09 3.49 2.411 ns Eidorylaimus Omd 1.11 Arorbeles Ba2 2.07 2.96 3.42 3.43 3.44 3.65 0.34 0.53 Arorbeles Ba2 1.14 0.89 1.58 1.17 31.01 ns Mytonchulus 0.03 0.37 0.04 0.53 Cervidellus Ba2 1.27 0.9 0.07 0.86 2.05 ns Mytonchulus 0.03 0.25 Eleceptatobus Ba2 1.23 1.13 1.15 1.14 49.61 nms 0.03 0.25 Eleceptatobus Ba2 0.77 0.9 0.97 0.86 2.33 3.43 3.43 3.0 0.12 0.04 0.05 0.12 Eleceptatobus Ba2 1.24 0.35 3.44 1.66 2.5 3.43 3.43 3.13 3.41 ns Porreadimetus 0.05 0.25 E</td> <td>Ъ ЛІС</td> <td>istionchus</td> <td>Bal</td> <td>0.08</td> <td>0.05</td> <td>0.1</td> <td>0.07</td> <td>40</td> <td>ns</td> <td>Epidorylaimus</td> <td>Om4</td> <td>0.81</td> <td>0.38</td> <td>0.5</td> <td>0.6</td> <td>70.46</td> <td>*</td>	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Rhabditis Bal 2.07 2.09 3.49 2.411 ns Eidorylaimus Omd 1.11 Arorbeles Ba2 2.07 2.96 3.42 3.43 3.44 3.65 0.34 0.53 Arorbeles Ba2 1.14 0.89 1.58 1.17 31.01 ns Mytonchulus 0.03 0.37 0.04 0.53 Cervidellus Ba2 1.27 0.9 0.07 0.86 2.05 ns Mytonchulus 0.03 0.25 Eleceptatobus Ba2 1.23 1.13 1.15 1.14 49.61 nms 0.03 0.25 Eleceptatobus Ba2 0.77 0.9 0.97 0.86 2.33 3.43 3.43 3.0 0.12 0.04 0.05 0.12 Eleceptatobus Ba2 1.24 0.35 3.44 1.66 2.5 3.43 3.43 3.13 3.41 ns Porreadimetus 0.05 0.25 E	Ъ ЛІС	istionchus	Bal	0.08	0.05	0.1	0.07	40	ns	Epidorylaimus	Om4	0.81	0.38	0.5	0.6	70.46	*
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{ccccccc} \label{eq:control_control} \mbox{Acrobeles} & Ba2 & 3.67 & 2.96 & 3.42 & 3.39 & 40.78 & ** & Miconchus & 0.03 \\ \mbox{Araplectus} & Ba2 & 1.14 & 0.89 & 1.137 & 11.01 & 18 & Mylorchaltimus & 0.04 & 0.55 \\ \mbox{Cervitellus} & Ba2 & 1.278 & 9.86 & 11.37 & 11.54 & 43.61 & ** & Pungentus & 0.04 & 0.55 \\ \mbox{Cervitellus} & Ba2 & 0.77 & 0.9 & 0.07 & 0.86 & 20.5 & 18 & Mylorchaltimus & 0.06 & 0.25 \\ \mbox{Cervitellus} & Ba2 & 0.77 & 0.9 & 0.07 & 0.86 & 20.5 & 18 & Mylorchalting & 0.06 & 0.25 \\ \mbox{Cervitellus} & Ba2 & 0.77 & 0.9 & 0.07 & 0.86 & 2.05 & 11.3 & Aporedorial and & 0.56 \\ \mbox{Cervitellus} & Ba2 & 1.27 & 0.75 & 1.22 & 1.1 & 4.961 & 18 & Mylorchalting & 0.06 & 0.25 \\ \mbox{Cervitellus} & Ba2 & 2.15 & 1.26 & 6.78 & 8.55 & 34.43 & ** & Longtalorus & 0.05 & 0.25 \\ \mbox{Cervitellus} & Ba2 & 0.76 & 1.51 & 0.34 & 1.01 & 39.41 & 18 & Moredorial & 0.05 & 0.12 \\ \mbox{Columina} & Ba3 & 0.76 & 1.51 & 0.34 & 1.01 & 39.41 & 18 & Roudorytainm & 0.05 & 0.12 \\ \mbox{Columina} & Ba3 & 0.76 & 1.51 & 0.34 & 1.01 & 39.41 & 18 & Roudorytain & 0.05 & 0.12 \\ \mbox{Columina} & Ba3 & 1.38 & 2.16 & 1.51 & 1.24 & 31.9 & 88 & Roudorytain & 0.05 & 0.12 \\ \mbox{Columina} & Ba3 & 1.38 & 2.16 & 1.41 & 1.08 & 88 & 8.15 & 9.41 & 18 & Roudorytain & 0.05 & 0.12 \\ \mbox{Columina} & Ba3 & 1.38 & 2.16 & 1.41 & 1.08 & 88 & Roudorytain & Pp2 & 1.03 \\ \mbox{Achronicalinus} & Ba3 & 1.38 & 2.16 & 2.14 & 1.06 & 2.55 & 3.11 & 4.30 & 8.15 & 8.16 & 2.16 & 1.15 & 0.04 \\ \mbox{Achronicalinus} & Ba3 & 1.38 & 2.04 & 1.66 & 2.15 & 3.17 & 8. & Rautochus & Pp2 & 0.25 \\ \mbox{Achronicalinus} & Ba3 & 1.38 & 2.04 & 1.66 & 2.15 & 3.17 & 8. & Rautochus & Pp2 & 0.25 \\ \mbox{Achronicalinus} & Ba3 & 1.38 & 2.01 & 1.03 & 3.54 & 4.73 & 8. & Rautochus & Pp2 & 0.25 \\ \mbox{Achronicalinus} & Fu2 & 0.5 & 0.3 & 0.66 & 0.46 & 5.36 & 3.15 & 8.8 & Rautochus & Pp2 & 0.25 \\ \mbox{Achronicalinus} & Fu4 & 0.27 & 0.21 & 0.21 & 0.21 & 0.21 & 0.21 & 0.21 & 0.22 & 0.24 \\ \mbox{Achronicalinus} & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & 8. & 10 & 1.99 & 1.25 \\ Ac$	Ъ́г Я	abditis	Bal	2.07	2.09	3.49	2.41	18.17	ns	Eudorylaimus	Om4	1.11	1.5	1.66	1.36	11.79	*
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccc} \hline 5 \ Acrobeloides \ Ba2 \ 2.01 \ 1.47 \ 1.58 \ 1.74 \ 49.63 \ ns \ Microdorylaimus \ Omd \ 0.53 \ Cervidellus \ Ba2 \ 0.17 \ 0.9 \ 0.87 \ 11.57 \ 31.01 \ ns \ Microdorylaimus \ Omd \ 0.52 \ Cervidellus \ Ba2 \ 0.07 \ 0.86 \ 0.97 \ 0.86 \ 20.5 \ Acrobeloides \ Ba2 \ 0.17 \ 0.9 \ 0.97 \ 0.86 \ 20.5 \ Acrobeloides \ Ba2 \ 0.17 \ 0.9 \ 0.97 \ 0.86 \ 20.5 \ Acrobeloides \ Da2 \ 0.07 \ 0.86 \ 0.07 \ 0.87 \ 11.54 \ 43.61 \ ns \ Purgenta \ Omd \ 0.52 \ 0.06 \ 0.07 \ 0.87 \ 0.07 \ 0.05 \ 0.07 \ 0.05 \ 0.05 \ 0.05 \ 0.05 \ 0.05 \ 0.06 \ 0.07 \ 0.05 \ 0.06 \ 0.07 \ 0.06 \ 0.05 \ 0.012 \ $	Ч ОВ	robeles	Ba2	3.67	2.96	3.42	3.39	40.78	*	Miconchus	Om4	0.03	0.01	0.03	0.03	61.54	ns
$ \begin{array}{l l l l l l l l l l l l l l l l l l l $	Autobacture Ba2 11.4 31.01 ns Mytorchulus Omd 0.55 0.57 0.54 30.68 ns Cervitacitus Ba2 11.3 11.3 11.7 31.01 ns Mytorchulus 0.06 0.05 0.57 0.54 30.68 ns Cervitacitus Ba2 0.03 0.01 0.03 0.03 0.01 11.74 ns Cervitacitus Ba2 0.37 0.35 0.33 0.35 0.33 0.36 0.36 0.37 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.36 0.37 0.36 0.35 0.35 0.35 0.35 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37	Anaplectus Ba2 1.14 0.89 1.58 1.17 31.01 ns Mylonchulus 0.03 Ceptadellus Ba2 12.78 9.86 11.37 11.54 4.361 *** Purgentus 0m4 0.05 Cervidellus Ba2 0.77 0.9 0.97 0.86 20.5 ns Aporcelaimellus 0m4 0.05 Chronogaster Ba2 1.27 0.75 1.22 0.75 1.22 0.75 0.22 0.75 0.25 0.8 0.05 <td>$\overline{A}_{\mathcal{C}}$</td> <td>robeloides</td> <td>Ba2</td> <td>2.01</td> <td>1.47</td> <td>1.58</td> <td>1.74</td> <td>49.63</td> <td>ns</td> <td>Microdorylaimu</td> <td>s Om4</td> <td>0</td> <td>0.37</td> <td>0</td> <td>0.11</td> <td>173.58</td> <td>*</td>	$\overline{A}_{\mathcal{C}}$	robeloides	Ba2	2.01	1.47	1.58	1.74	49.63	ns	Microdorylaimu	s Om4	0	0.37	0	0.11	173.58	*
Cerbiachus Ba2 0.17 0.08 0.01 0.03	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	$ \begin{array}{c} \hline \hline$	s An	aplectus	Ba2	1.14	0.89	1.58	1.17	31.01	ns	Mylonchulus	Om4	0.53	0.52	0.57	0.54	30.68	ns
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c cccc} CerviteIns & Ba2 & 0.03 & 0.1 & 0.07 & 38.71 & ns & Thoma. & 0.md & 1.52 & 2.06 & 1.9 & 1.77 & 2063 & s. \\ CerviteIns & Ba2 & 1.77 & 0.75 & 1.23 & 1.13 & 9.03 & 0.05 & 0.03 & 0.03 & 0.01 & 70.11 & 71.31 & ns \\ Euceprosphatohas & Ba2 & 1.77 & 0.75 & 1.23 & 1.34 & 5.5 & 3.43 & s. & Discolumus & 0.m5 & 0.02 & 0.03 & 0.04 & 0.04 & 0.06 & 0.03 & 0.0$	$ \begin{array}{c cccc} Cervidellus & Ba2 & 0.03 & 0.1 & 0.08 & 0.07 & 38.71 & ns \\ Thomus & Apore climetus & Om5 & 0.25 \\ Cervidentobus & Ba2 & 0.77 & 0.9 & 0.97 & 0.86 & 0.5 \\ Heterocephalobus & Ba2 & 1.27 & 1.36 & 2.31 & 1.95 & 44.33 & * \\ Discolarinus & Om5 & 0.08 & 0.07 \\ Heterocephalobus & Ba2 & 1.51 & 1.36 & 2.31 & 1.95 & 44.33 & * \\ Discolarinus & Dm5 & 0.08 & 0.01 \\ Dottomation & Ba3 & 1.91 & 1.87 & 2.13 & 3.74 & 34.99 & ** \\ Long contrast & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Dottomation & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Dottomation & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Dottomation & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Dottomation & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Dottomation & Ba3 & 0.76 & 1.51 & 0.84 & 1.01 & 39.41 & ns \\ Prismatolaimus & Ba3 & 1.38 & 2.14 & 1.66 & 2.5 & 2.21 & 43.13 & ns \\ Dottomation & Ba3 & 1.38 & 2.15 & 1.42 & 1.63 & 32.59 & ** \\ Lerancephalus & Ba3 & 1.38 & 2.15 & 1.42 & 1.63 & 32.59 & ** \\ Aphelenchoides & Fu2 & 1.53 & 0.62 & 0.46 & 0.26 & 0.44 \\ Ahidmus & Ba3 & 1.38 & 2.15 & 1.42 & 1.63 & 32.59 & ** \\ Aphelenchoides & Fu2 & 1.15 & 0.61 & 1.28 & 1.01 & 49.37 & ns \\ Prismatorians & Fu2 & 1.15 & 0.61 & 1.28 & 1.01 & 49.37 & ns \\ Diphtherophora & Fu2 & 1.15 & 0.61 & 1.28 & 1.01 & 49.37 & ns \\ Diphtherophora & Fu2 & 1.15 & 0.61 & 1.28 & 1.01 & 49.37 & ns \\ Diphtherophora & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Prienchuis & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Prienchuis & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Diphtherophora & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencholaimus & Fu4 & 0.27 & 0.21 & 0.21 & 0.24 & 4.75 & ns \\ Priencho$	് (SE	phalobus	Ba2	12.78	9.86	11.37	11.54	43.61	*	Pungentus	Om4	0.06	0.02	0	0.03	126.67	su
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{ccccc} Chronogener & Ba2 & 0.77 & 0.9 & 0.97 & 0.05 & 0.5 & 0.75 & 0.27 & 0.07 & 0.01 & 71.13 & 0.5 \\ Fleeroce phalobus & Ba2 & 1.27 & 0.75 & 1.22 & 1.1 & 9.61 & 0.8 & 0.55 & 0.08 & 0.03 & 0.03 & 0.01 & 71.13 & 0.5 \\ Fleeroce phalobus & Ba2 & 2.12 & 1.36 & 2.31 & 1.35 & 44.33 & ** & Longianus & 0.05 & 0.05 & 0.05 & 0.05 & 0.05 & 0.05 & 0.01 & 71.13 & 0.05 \\ Fleeroce phalobus & Ba2 & 3.52 & 4.39 & 3.73 & 3.74 & 3.94 & ** & Longianus & 0.05 & 0.12 & 0.06 & 0.09 & 0.06 & 0.05 & $	$ \begin{array}{cccccc} \label{eq:constraints} Chronogaster Ba2 0.77 0.9 0.97 0.86 20.5 ns Aporcelaimellus 0m5 0.23 \\ \mbox{Alexerphalobus Ba2 1.27 0.75 1.22 1.1 9.66 ns Chronome 0m5 0.08 0.28 \\ \mbox{Alexenadora} Ba2 1.27 0.75 1.22 1.1 9.61 ns Chronome 0m5 0.08 0.20 \\ \mbox{Alexenadora} Ba2 1.27 0.76 5.78 8.55 39.48 ** Longidorus 0m5 0.03 0.03 0.03 0.03 0.03 0.01 1.87 2.76 2.1 2.108 ns Parconchium 0m5 0.01 0.01 0.01 1.87 2.76 2.5 2.21 4.3.13 ns Parconchium 0m5 0.03 0.01 0.000 molaimus Ba3 0.76 1.187 2.76 2.5 2.21 4.3.13 ns Parconchium 0m5 0.12 0.000 molaimus Ba3 0.76 1.187 2.76 2.5 2.21 4.3.13 ns Parconchium 0m5 0.12 0.000 molaimus Ba3 0.76 1.187 2.76 2.5 2.21 4.3.13 ns Parconchium 0m5 0.12 0.000 molaimus Ba3 0.76 1.187 2.75 3.11 3.9.41 ns Corparaton 0m5 0.12 0.000 molaimus Ba3 0.76 1.187 2.75 3.11 4.3.13 ns Parconchium Pp2 0.25 0.04 0.000 molaimus Ba3 0.76 1.187 2.75 3.11 4.3.13 ns Parconchium Pp2 0.25 0.04 0.000 molaimus Ba3 0.56 6.57 4.95 8.15 4.17 ns Cophalenchus Pp2 0.25 0.04 0.000 molaimus Ba3 0.56 6.57 4.92 8.8 0.000 0.000 molaimus Pp2 0.25 0.04 0.000 molaimus Ba3 0.56 6.57 4.92 8.8 0.000 0$	С л	rvidellus	Ba2	0.03	0.1	0.08	0.07	38.71	ns	Thomas	Om4	1.52	2.05	1.9	1.77	20.63	*
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{ccccc} Till constraints and the second constraints of the second constant constant of the second constant constant of the second constant consta$	$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	С ЕІ	ronogaster	Ba2	0.77	0.0	0.97	0.86	20.5	ns	Aporcelaimellus	Om5	0.22	0.26	0.36	0.27	12.1	ns
$ \begin{array}{c cccc} \label{eq:constraints} \\ \hline Constraints Ball and Constraints Pp2 0.25 0.29 0.29 0.29 0.27 3.30 ms and Constraints Ball and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Ball and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Ball and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Ball and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.27 0.29 0.27 1.25 1.32.02 * Aphieterchics Ph2 0.3 0.66 6.57 4.32 8 ** Pailenchus Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.29 0.27 1.25 1.22 0.2 ms and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.24 0.05 0.04 0.05 0.42 0.26 0.41 ms and Constraints Pp2 0.25 0.29 0.29 0.27 2.30 ms and Constraints Pp2 0.25 0.29 0.24 0.05 0.20 0.05 0.05 0.23 0.20 0.05 0.05 0.23 0.20 ms and Constraints Pp2 0.25 0.29 0.29 0.20 0.20 0.00 0.00 0.00 0.00$	$ \begin{array}{c cccc} Fit = 0.5 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$ \begin{array}{ccccc} \hline \label{eq:constraint} Hererocephalobus Ba2 2.15 1.36 2.31 1.95 44.33 * Discolatinus Om5 0.05 \\ Plectus Ba2 3.52 4.49 3.17 3.74 3.499 ** Mesodorylatinus Om5 0.12 \\ \hline \end{resolutiont} Ba2 3.52 4.49 3.17 3.74 3.499 ** Mesodorylatinus Om5 0.12 \\ \hline \end{resolutiont} Ba3 1.91 1.87 2.76 2.1 21.08 & n Portonativa Om5 0.12 \\ \hline \end{resolutiont} Ba3 0.76 1.51 0.84 1.01 39.41 ns Parcenchiam Om5 0.12 \\ \hline \end{resolutiont} Ba3 0.76 1.51 0.84 1.01 39.41 ns Parcenchiam Om5 0.12 \\ \hline \end{resolutiont} Ba3 2.44 1.66 2.5 2.21 43.13 ns Baleodorus Pp2 0.25 \\ \hline \end{resolutiont} Ba3 2.44 1.66 2.5 2.21 43.13 ns Baleodorus Pp2 0.25 \\ \hline \end{resolutiont} Ba3 2.44 1.66 2.5 2.51 43.13 ns Parcenchiam Pp2 0.25 \\ \hline \end{resolutiont} Ba3 2.44 1.66 2.5 2.51 43.13 ns Paleotorus Pp2 0.25 \\ \hline \end{resolutiont} Ba3 2.44 1.66 2.5 2.51 43.13 ns Paleotorus Pp2 0.25 \\ \hline \end{resolutiont} Ba3 4.95 4.55 3.11 4.39 51.15 ** Malenchus Pp2 0.25 \\ \hline \end{resolutiont} Ba3 4.95 0.66 6.57 4.92.86 ns Parcelotus Pp2 0.24 \\ \hline \end{resolutiont} Prisenchus Pu2 1.65 5.03 6.6 6.57 4.92.86 ns Parcelotus Pp2 0.25 \\ \hline \end{resolutiont} Prisenchus Pu2 1.15 0.61 1.28 1.01 4.93 ns Pilenchus Pp2 0.25 \\ \hline \end{resolutiont} Prisenchus Pu2 1.65 5.03 6.6 5.7 4.92.8 ** Paleochus Pp2 0.25 \\ \hline \end{resolutiont} Prisenchus Pu2 0.21 0.21 0.21 0.24 47.75 ns Parcelotus Pp3 0.25 \\ \hline \end{resolutiont} Prisenchus Pu3 0.25 \\ \hline \end{resolutiont} Prisenchus Pp3 0.24 \\ \hline \end{resolutiont} Prisenchus Pp3 0.25 \\ \hline \end{resolutiont} Prisenchus $	Er NC	cephalobus	Ba2	1.27	0.75	1.22	1.1	49.61	ns	Chrysonemoides	s Om5	0	0	0.07	0.01	171.43	ns
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Placence Ba2 6.87 12.36 6.73 8.55 3.94 *** Longitorus 0.08 0.0 0.05	Rectas Ba2 6.87 12.36 6.78 8.55 39.48 ** Longidorus Om5 0.08 0.012 0.0	Ϋ́, Η̈́	terocephalobus	Ba2	2.15	1.36	2.31	1.95	44.33	*	Discolaimus	0m5	0.25	0.06	0.42	0.23	65.14	ns
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	A Witsomata Ba2 3.52 4.49 3.17 3.74 3.49 *** Mesodorphium 0.12 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.06 0.09 0.07 0.01 0.01 0.01 0.09 0.06 0.09 0.06 0.09 0.07 0.01 0.09 0.07 0.01 0.09 0.07 0.01 0.01 0.01 0.01 0.09 0.07 0.01 0.09 0.07 0.01 <td>A Wilsonema Ba2 3.52 4.49 3.17 3.74 34.99 ** Mesodorylaimus Om5 0.12 P Bastraina Ba3 0.76 1.51 0.84 1.01 1.87 2.76 2.1 21.08 ns Paraxonchium Om5 0.12 0.13 0.12 0.14 0.15 0.12 0.15 0.12 0.15 0.12 0.14 0.15 0.12 0.15 0.12 0.15 0.12 0.15 0.12 0.14 0.16 1.12 1.10 1.12 1.12 1.12 1.12 <t< td=""><td>Π Μ</td><td>ctus</td><td>Ba2</td><td>6.87</td><td>12.36</td><td>6.78</td><td>8.55</td><td>39.48</td><td>* *</td><td>Longidorus</td><td>0m5</td><td>0.08</td><td>0</td><td>0.05</td><td>0.05</td><td>108.7</td><td>ns</td></t<></td>	A Wilsonema Ba2 3.52 4.49 3.17 3.74 34.99 ** Mesodorylaimus Om5 0.12 P Bastraina Ba3 0.76 1.51 0.84 1.01 1.87 2.76 2.1 21.08 ns Paraxonchium Om5 0.12 0.13 0.12 0.14 0.15 0.12 0.15 0.12 0.15 0.12 0.14 0.15 0.12 0.15 0.12 0.15 0.12 0.15 0.12 0.14 0.16 1.12 1.10 1.12 1.12 1.12 1.12 <t< td=""><td>Π Μ</td><td>ctus</td><td>Ba2</td><td>6.87</td><td>12.36</td><td>6.78</td><td>8.55</td><td>39.48</td><td>* *</td><td>Longidorus</td><td>0m5</td><td>0.08</td><td>0</td><td>0.05</td><td>0.05</td><td>108.7</td><td>ns</td></t<>	Π Μ	ctus	Ba2	6.87	12.36	6.78	8.55	39.48	* *	Longidorus	0m5	0.08	0	0.05	0.05	108.7	ns
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Relation Ba3 1.91 1.87 2.76 2.1 21.08 ns Paraxonchium Om5 0.12 Bastiania Ba3 0.76 1.51 0.84 1.01 39.41 ns Portamanawa Om5 0.12 Pastiania Ba3 0.76 1.51 0.84 1.01 39.41 ns Portamanawa Om5 0.12 Prismatolaimus Ba3 2.44 1.66 2.5 2.21 43.13 ns Portamawa Om5 0.12 Prismatolaimus Ba3 2.44 1.66 2.5 2.21 43.17 ns Portalenchus Pp2 0.02 Rhabolaimus Ba3 2.49 0.5 0.3 0.62 0.45 43.3 51.15 71.05 Rhabolaimus Fu2 7.6 5.03 0.62 0.45 42.86 ms Paratylenchus Pp2 0.04 Aphelenchus Fu2 1.13 3.16 4.33 3.1.5 8.8	AY AY	lsonema	Ba2	3.52	4.49	3.17	3.74	34.99	* *	Mesodorylaimus	s Om5	0.12	0.06	0.09	0.09	68.18	ns
$ \begin{array}{rcccccccccccccccccccccccccccccccccccc$	$ \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	$\overline{\mathbf{F}}$ Bastiania \mathbf{B} 0.76 1.51 0.84 1.01 39.41 \mathbf{ns} $Torumanwa$ 0.05 0.12 0.25 0.12 0.25 0.12 0.25 0.12 0.25 0.12 0.25 0.12 0.25 0.12 0.25 0.21 0.25 0.21 0.25 0.21 0.25 0.21 0.25 0.12 0.25 0.12 0.21 0.25 0.12 0.25 0.21 0.25 0.21	20 20	hromadora	Ba3	1.91	1.87	2.76	2.1	21.08	ns	Paraxonchium	Om5	0.12	0.2	0.19	0.16	17.11	ns
$ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	Odomolaimus Ba3 2.44 1.66 2.5 2.21 43.13 ns Boleadorus Pp2 0.25 0.41 0.19 0.28 45.86 * Prismatolaimus Ba3 8.37 6.74 9.55 8.15 34.17 ns Costlenctus Pp2 0.19 0.29 0.29 0.29 0.27 33.0 ns Rhadolaimus Ba3 1.38 2.15 1.42 1.65 3.13 8.495 8.15 3.11 1.5 0.25 0.24 0.35 0.35 0.65 0.57 1.31 11.15 ns Alaimus Ba4 0.5 0.3 0.62 0.46 42.86 ns Pararylenchus Pp2 1.23 1.23 12.9 13.7 12.5 13.2 13.8 ns Na	Odontolaimus Ba3 2.44 1.66 2.5 2.21 4.3.13 ns Boleodorus Pp2 0.25 Prismatolaimus Ba3 3.37 6.74 9.55 8.15 34.17 ns Boleodorus Pp2 0.25 Prismatolaimus Ba3 8.37 6.74 9.55 8.15 34.17 ns Boleodorus Pp2 0.25 Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Letenchus Pp2 0.10 Rhabdolaimus Ba3 4.95 4.55 3.11 4.39 51.15 ** Malenchus Pp2 0.04 Rhablelenchoides Fu2 1.38 2.04 1.65 2.15 4.92 1.03 7.73 4.92 0.04 Alaimus Fu2 1.21 4.3 5.16 0.24 4.7.5 ns Pp2 0.02 Alaimus Fu2 1.25 0.21 1.25 1.42 1.65	98 914	stiania	Ba3	0.76	1.51	0.84	1.01	39.41	ns	Torumanawa	Om5	0.12	0.09	0.04	0.09	69.05	ns
PrismatolaimusBa3 8.37 6.74 9.55 8.15 34.17 ns $Oxydirus$ $Pp5$ 0.14 0.03 0.09 90.7 ns RhabdolaimusBa3 1.38 2.15 1.42 1.63 32.59 $**$ $Cephalenchus$ $Pp2$ 1.29 1.32 1.213 1.31 1.115 ns RhabdolaimusBa3 4.95 4.55 3.11 4.39 51.15 $**$ $Malenchus$ $Pp2$ 1.29 1.32 1.29 23.45 ns AlaimusBa3 0.5 0.3 0.62 0.46 42.86 ns $Pararylenchus$ $Pp2$ 1.29 1.35 1.29 23.45 ns Aphelenchoides $Fu2$ 1.26 5.03 6.6 6.57 49.28 $**$ $Pararylenchus$ $Pp2$ 0.25 0.29 0.29 0.20 0.27 23.02 s^3 Aphelenchoides $Fu2$ 1.26 5.03 6.6 6.57 49.28 $**$ $ParanylenchusPp22.731.251.25132.02s^4nsAphelenchoidesFu21.655.036.66.5749.23nsParanylenchusPp22.731.251220.020.200.020.071000.02120125124351245512202412212212212212012012012012$	PrismatolaimusBa38.37 6.74 9.55 8.15 34.17 ns $Oxydirus$ $Pp2$ 0.14 0.03 0.08 0.09 90.7 nsRhabdolaimusBa3 1.38 2.15 1.42 1.63 32.59 *** $Lelenchus$ $Pp2$ 1.25 1.29 1.23 1.31 11.15 ns RhabdolaimusBa3 1.38 2.15 1.42 1.63 32.59 *** $Lelenchus$ $Pp2$ 1.25 1.29 1.33 1.31 11.15 ns RhabdolaimusBa3 1.38 2.15 3.11 4.39 51.15 $**$ $Malenchus$ $Pp2$ 1.25 1.29 1.33 1.29 28.45 ns RhabdolaimusBa3 1.55 0.24 0.53 0.64 0.05 0.34 0.05 0.04 0.05 0.04 0.05 90.7 ns RhabdolaimusBa3 1.55 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.23 1.23 1.22 1.20 0.24 1.20 0.24 1.20 0.24 1.20 0.24 1.23 1.22 0.24 1.5 1.23 0.25 0.21 1.23 1.22 0.25 0.21 1.23 1.23 0.24 1.25 1.23 0.22 0.24 1.23 1.23 0.24 1.25 1.23 0.25 0.21 1.23 1.23 1.23 1.23 1.23 1.2	Prismatolaimus Ba3 8.37 6.74 9.55 8.15 34.17 ns Oxydirus Pp2 1.09 Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 $**$ $Cephalenchus$ Pp2 1.25 Rhabdolaimus Ba3 4.95 4.155 3.11 1.63 32.59 $**$ $Coslenchus$ Pp2 1.09 Rhabdelaimus Ba3 4.95 3.11 4.95 3.11 1.65 3.259 $**$ $Palenchus$ $Pp2$ 0.04 Albiner Ba3 0.5 0.66 6.57 49.28 $**$ $Pp2$ 0.02 Aphelenchus Fu2 2.15 0.14 4.95 0.66 6.57 49.28 $**$ $Pp2$ 0.02 Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns $Phalanchus$ $Pp2$ 0.12 Primentus Fu2 <t< td=""><td>õ</td><td>lontolaimus</td><td>Ba3</td><td>2.44</td><td>1.66</td><td>2.5</td><td>2.21</td><td>43.13</td><td>ns</td><td>Boleodorus</td><td>Pp2</td><td>0.25</td><td>0.41</td><td>0.19</td><td>0.28</td><td>45.86</td><td>*</td></t<>	õ	lontolaimus	Ba3	2.44	1.66	2.5	2.21	43.13	ns	Boleodorus	Pp2	0.25	0.41	0.19	0.28	45.86	*
PrismatolaimusBa38.37 6.74 9.55 8.15 34.17 ns <i>Cephalenchus</i> $Pp2$ 0.25 0.29 0.27 23.02 ns RhadolaimusBa3 1.38 2.15 1.42 1.63 32.59 ** <i>Lelenchus</i> $Pp2$ 1.09 1.33 1.31 11.15 ns RhadolaimusBa3 4.95 4.55 3.11 4.39 51.15 $**$ <i>Lelenchus</i> $Pp2$ 1.09 1.35 1.29 2.845 ns AlaimusBa3 4.95 4.55 3.11 4.39 51.15 $**$ <i>Pataenchus</i> $Pp2$ 1.09 0.04 0.05 48 ns AdiamusFu2 7.6 5.03 6.6 6.57 49.28 $**$ <i>Psilenchus</i> $Pp2$ 2.73 1.53 1.23 $1.23.02$ $*8$ ApielenchoidesFu2 7.6 5.03 6.6 6.57 49.28 $**$ <i>Psilenchus</i> $Pp2$ 2.73 1.53 1.23 $1.23.02$ $*8$ ApielenchusFu2 7.6 5.03 6.6 6.57 49.23 2.73 1.53 1.22 2.455 ns ApielenchusFu2 7.6 5.03 6.6 6.57 49.37 ns $7yienchus$ $Pp2$ 2.09 1.00 0.01 0.02 1.05 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 1.25 <	PrismatolaimusBa38.376.749.558.1534.17nsCephalenchusPp20.250.290.2723.02nsRhabdolaimusBa31.382.151.421.6332.59** <i>Lelenchus</i> Pp21.091.31.351.11.15nsRhabdolaimusBa31.382.151.421.6332.59** <i>Lelenchus</i> Pp21.091.351.3523.45nsTeratocephalusBa30.50.30.620.4642.86ns <i>Paaatylenchus</i> Pp21.251.251.322328.45nsAphelenchusFu27.165.030.620.4642.86ns <i>Paaatylenchus</i> Pp22.731.231.231.20nsAphelenchusFu27.150.611.281.0149.37ns <i>Teruneenelus</i> Pp20.040.050.0220nsAphelenchusFu21.150.611.281.0149.37ns <i>Teruneenelus</i> Pp20.040.010.021.20nsDitylenchusFu22.163.044.055.744.35ns <i>Teruneenelus</i> Pp20.040.050.0220nsDitylenchusFu21.150.611.281.0149.37ns <i>Teruneenelus</i> Pp20.040.010.0220nsDitylenchusFu22.163.044.050.21<	Prismatolaimus Ba3 8.37 6.74 9.55 8.15 34.17 ns Cephalenchus Pp2 0.25 Rhabdaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 1.09 Rhabdaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 0.04 Rhabdaimus Ba3 0.5 0.3 0.62 0.44 9.55 ** Malenchus Pp2 0.04 Alaimus Ba4 0.5 0.3 0.62 0.46 42.86 ns Prantylenchus Pp2 0.04 Aphelenchoides Fu2 1.15 0.61 1.28 1.01 49.37 ns Pp1 1.12 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Oxydirus</td> <td>Pp5</td> <td>0.14</td> <td>0.03</td> <td>0.08</td> <td>0.09</td> <td>90.7</td> <td>ns</td>										Oxydirus	Pp5	0.14	0.03	0.08	0.09	90.7	ns
RhadolatimusBa31.382.151.421.6332.59***LelenchusPp21.091.31.731.3111.15nsTeratocephalusBa34.954.553.114.3951.15**MalenchusPp21.251.291.351.2928.45nsTeratocephalusBa30.50.620.4642.86nsMalenchusPp20.040.090.040.0548nsAphelenchoidesFu27.60.330.620.4642.86nsPp22.731.531.232.3228.45nsAphelenchoidesFu27.60.040.620.4642.86nsPp20.040.050.64nsAphelenchusFu21.150.611.281.0149.37nsTytenchusPp21.122.070.591.2912960.4nsDitylenchusFu21.150.611.281.0149.37nsTytenchusPp21.122.070.591.291.262.10nsDitylenchusFu21.150.210.210.210.210.250.290.660.352.20nsDitylenchusFu21.150.611.281.0149.37nsTytenchusPp21.122.070.591.2960.4nsDitylenchusFu25.362.162.10118Heteroderus	RhabdolaimusBa31.382.151.421.633.2.59***CoslenchusPp21.091.31.311.11.15nsTeratocephalusBa31.382.151.421.633.2.59***LelenchusPp21.251.291.331.232.44ssTeratocephalusBa40.50.30.620.4642.86nsParatucesPp21.251.291.332.32.453.3.02**setnsAphelenchusFu27.65.036.66.5749.28**ParatucesPp22.731.231.232.32.27.455nsAphelenchusFu21.167.644.666.5749.37nsTreitunentialusPp22.070.591.291.322.77.455nsDisylenchusFu21.167.644.665.363.04*CriconylenchusPp21.751.222.070.591.291.832.731.29	Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 1.09 Teratocephalus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 1.09 Alaimus Ba3 0.5 0.3 0.62 0.46 42.86 ns Paratylenchus Pp2 2.33 Aphelenchoides Fu2 7.6 5.03 6.6 6.57 49.37 ns Ppactulus Pp2 0.04 Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns Ppicentus Pp2 0.04 Diphtherophora Fu2 1.36 7.37 4.43 5.76 30.04 * Criconemoides Pp2 0.12 Diphtherophora Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.12 Tylenchaimus Fu4 7.64 4.66 5.36 35	P_{I}	ismatolaimus	Ba3	8.37	6.74	9.55	8.15	34.17	ns	Cephalenchus	Pp2	0.25	0.29	0.29	0.27	23.02	ns
RhabdolaimusBa31.382.151.421.6332.59***LelenchusPp21.251.291.351.2928.45nsTeratocephalusBa34.954.553.114.3951.15**MalenchusPp20.040.090.040.0548nsAlaimusBa40.50.30.620.4642.86nsParatylenchusPp22.330.250.511.25132.02*AphelenchoidesFu27.65.030.666.5749.28**PrilenchusPp22.040.090.040.0548nsAphelenchusFu21.150.611.281.0149.37nsTrummenelusPp20.040.0100.02120nsAphelenchusFu21.150.611.281.0149.37nsTrummenelusPp21.122.070.591.2960.4nsDitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.590.511.2960.4nsDitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.590.611.2960.4nsDitylenchusFu21.382.030.040.210.040.010.020.021.200.04nsDitylenchusFu4 </td <td>RhabdolaimusBa31.382.151.421.6332.59***LelenchusPp21.251.291.351.2928.45nsTeravocephalusBa34.954.553.114.3951.15***MalenchusPp20.040.050.040.059.148msTeravocephalusBa34.954.553.114.3951.15***MalenchusPp22.330.250.511.2928.45nsAphelenchusFu22.482.041.655.1551.74**TenumenellusPp22.731.292.332.20nsDipyleinchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.2960.4nsDipyleinchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.291.561.370.210.040.010.021.200.332.02nsDipyleinchusFu21.150.611.281.01nsHelicoylechusPp21.122.070.591.2960.4nsDipyleinchusFu20.210.210.210.210.210.210.210.221.370.270.921.290.921.960.352.090.332.090.310.021.960.352.09<td>Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 0.04 Teratocephalus Ba3 4.95 4.55 3.11 4.39 51.15 ** Malenchus Pp2 0.04 Alaimus Ba4 0.5 0.3 0.62 0.46 42.86 ns Paratylenchus Pp2 0.04 Aphelenchus Fu2 7.6 5.03 6.6 6.57 49.28 ** Pp2 0.04 Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.04 Diphherohus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.02 Tylenchus Fu4 0.27 0.21 0.21 0.24 4.75 ns Tylenchus Pp3 0.15 Tylenchus Fu4 0.21 0.21 0.24 4.75 ns Roylen</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Coslenchus</td><td>Pp2</td><td>1.09</td><td>1.3</td><td>1.73</td><td>1.31</td><td>11.15</td><td>ns</td></td>	RhabdolaimusBa31.382.151.421.6332.59***LelenchusPp21.251.291.351.2928.45nsTeravocephalusBa34.954.553.114.3951.15***MalenchusPp20.040.050.040.059.148msTeravocephalusBa34.954.553.114.3951.15***MalenchusPp22.330.250.511.2928.45nsAphelenchusFu22.482.041.655.1551.74**TenumenellusPp22.731.292.332.20nsDipyleinchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.2960.4nsDipyleinchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.291.561.370.210.040.010.021.200.332.02nsDipyleinchusFu21.150.611.281.01nsHelicoylechusPp21.122.070.591.2960.4nsDipyleinchusFu20.210.210.210.210.210.210.210.221.370.270.921.290.921.960.352.090.332.090.310.021.960.352.09 <td>Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 0.04 Teratocephalus Ba3 4.95 4.55 3.11 4.39 51.15 ** Malenchus Pp2 0.04 Alaimus Ba4 0.5 0.3 0.62 0.46 42.86 ns Paratylenchus Pp2 0.04 Aphelenchus Fu2 7.6 5.03 6.6 6.57 49.28 ** Pp2 0.04 Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.04 Diphherohus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.02 Tylenchus Fu4 0.27 0.21 0.21 0.24 4.75 ns Tylenchus Pp3 0.15 Tylenchus Fu4 0.21 0.21 0.24 4.75 ns Roylen</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Coslenchus</td> <td>Pp2</td> <td>1.09</td> <td>1.3</td> <td>1.73</td> <td>1.31</td> <td>11.15</td> <td>ns</td>	Rhabdolaimus Ba3 1.38 2.15 1.42 1.63 32.59 ** Lelenchus Pp2 0.04 Teratocephalus Ba3 4.95 4.55 3.11 4.39 51.15 ** Malenchus Pp2 0.04 Alaimus Ba4 0.5 0.3 0.62 0.46 42.86 ns Paratylenchus Pp2 0.04 Aphelenchus Fu2 7.6 5.03 6.6 6.57 49.28 ** Pp2 0.04 Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.04 Diphherohus Fu2 1.15 0.61 1.28 1.01 49.37 ns Tylenchus Pp2 0.02 Tylenchus Fu4 0.27 0.21 0.21 0.24 4.75 ns Tylenchus Pp3 0.15 Tylenchus Fu4 0.21 0.21 0.24 4.75 ns Roylen										Coslenchus	Pp2	1.09	1.3	1.73	1.31	11.15	ns
TeratocephalusBa34.954.553.114.3951.15 $**$ MalenchusPp20.040.090.040.0548nsAlaimusBa40.50.30.620.4642.86nsParatylenchusPp22.330.250.511.25132.02 $*$ AphelenchoidesFu27.65.036.66.5749.28 $**$ PsilenchusPp22.731.23274.55nsAphelenchusFu21.150.611.281.0149.37nsTylenchulusPp20.0100.040.0548nsDipylenchusFu21.150.611.281.0149.37nsTylenchulusPp20.0100.040.050.04nsDipylenchusFu25.367.374.435.7639.04*0.0100.060.3522.09nsDipylenchusFu25.367.374.435.7639.04*7.511.251.2960.4nsDipylenchusFu21.150.611.281.0149.37ns <i>Tylenchulus</i> Pp30.030.060.040.050.021.200.050.04nsDipylenchusFu25.367.374.435.7639.04*7.551.2960.4nsDipylenchusFu40.270.290.290.060.050.020.06<	TeratocephalusBa3 4.95 4.55 3.11 4.39 51.15 $**$ <i>Malenchus</i> Pp2 0.04 0.05 4.8 ns AlainusBa4 0.5 0.3 0.62 0.46 42.86 ns <i>Pararylenchus</i> $Pp2$ 2.33 0.25 0.51 1.25 132.02 $*$ AphelenchoidesFu2 7.6 5.03 6.6 6.57 49.28 ns <i>Pyranylenchus</i> $Pp2$ 1.23 1.23 12.75 0.04 0.05 0.02 12.00 ns AphelenchoidesFu2 7.6 5.03 6.6 6.57 49.28 ns <i>Pyranylenchus</i> $Pp2$ 0.04 0.02 0.02 12.02 ns AphelenchosFu2 7.16 5.03 6.6 6.57 49.38 <i>* Prannenellus</i> $Pp2$ 0.04 0.02 12.0 ns <i>Aphelenchus</i> Fu2 1.16 2.116 1.04 49.37 ns <i>Tenunenellus</i> $Pp2$ 0.04 0.02 12.9 ns <i>Diphtherophora</i> Fu2 1.13 0.61 1.28 1.07 0.21 0.21 0.21 0.22	TeratocephalusBa34.954.553.114.3951.15**MalenchusPp20.04AlaimusBa40.50.30.620.4642.86nsParatylenchusPp22.33AphelenchusFu27.65.036.66.5749.28**PsilenchusPp22.73AphelenchusFu27.65.036.66.5749.28**Pp20.04DitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.12PinolusFu21.150.611.281.0149.37nsTylenchusPp20.03DitylenchusFu25.367.374.435.7639.04*CriconemoidesPp30.25DorylaimoidesFu40.270.210.210.2447.75nsHeteroderaPp30.03DiphtherophoraFu44.167.644.665.3635.4*RoylenchusPp30.03ParcholaimusFu40.270.210.210.2447.75nsHeteroderaPp30.03DiphtherophoraFu44.167.644.665.3635.4*RoylenchusPp30.04ParcholaimusFu40.210.210.210.2447.75nsHeteroderaPp30.03DiphtherophoraFu44.167.644.665.3635.4*<	RL	abdolaimus	Ba3	1.38	2.15	1.42	1.63	32.59	* *	Lelenchus	Pp2	1.25	1.29	1.35	1.29	28.45	ns
AlaimusBa4 0.5 0.3 0.62 0.46 42.86 nsParatylenchusPp2 2.33 0.25 0.51 1.25 132.02 *AphelenchoidesFu2 7.6 5.03 6.6 6.57 49.28 ** $Psilenchus$ $Pp2$ 2.73 1.53 1.23 2 74.55 ns AphelenchusFu2 1.15 0.61 1.65 2.15 51.74 * $Tenumenellus$ $Pp2$ 2.73 1.53 1.23 2 74.55 ns DitylenchusFu2 1.15 0.61 1.28 1.01 49.37 ns $Tylenchus$ $Pp2$ 0.04 0.01 0 0.02 120 ns DitylenchusFu2 1.15 0.61 1.28 1.01 49.37 ns $Tylenchus$ $Pp2$ 1.12 2.07 0.59 1.29 60.4 ns DitylenchusFu2 1.15 0.61 1.28 1.01 49.37 ns $Tylenchus$ $Pp2$ 1.12 2.07 0.59 1.29 60.4 ns DiphtherophoraFu2 1.98 2.03 2.66 2.16 21.01 ns $Hetrodera$ $Pp3$ 0.75 0.21 0.02 120 ns DorylaimoidesFu4 0.27 0.21 0.21 0.24 47.75 ns $Hetrodera$ $Pp3$ 0.14 0.16 0.05 0.03 0.02 110 ns DorylaimoidesFu4 </td <td>Atainus Ba4 0.5 0.3 0.62 0.46 42.86 ns Pararylenchus Pp2 2.33 0.25 0.51 1.25 132.02 * Aphelenchus Fu2 7.6 5.03 6.6 6.57 49.28 ** <i>Painenellus</i> Pp2 2.73 1.23 $2.74.55$ ns Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns <i>Tranenellus</i> Pp2 2.77 1.23 $2.74.55$ ns <i>Aphelenchus</i> Fu2 1.15 0.61 1.28 1.01 49.37 ns <i>Tranenellus</i> Pp2 2.07 0.59 129 0.21 0.21 0.21 0.21 0.21 0.27 0.21</td> <td>AlaimusBa4$0.5$$0.3$$0.62$$0.46$$42.86$$ns$Pararylenchus$Pp2$$2.33$AphelenchoidesFu2$7.6$$5.03$$6.6$$6.57$$49.28$$**$$Psilenchus$$Pp2$$2.73$AphelenchusFu2$1.15$$0.61$$1.65$$2.15$$51.74$$*$$Tenunenellus$$Pp2$$2.73$AphelenchusFu2$1.15$$0.61$$1.28$$1.01$$49.37$$ns$$Tylenchus$$Pp2$$1.12$DiphtherophoraFu2$5.36$$7.37$$4.43$$5.76$$39.04$$*$$Criconemoides$$Pp3$$0.25$DorylaimoidesFu4$0.27$$0.21$$0.21$$0.21$$0.24$$47.75$$ns$$Helicorylenchus$$Pp3$$0.35$DorylaimoidesFu4$4.16$$7.64$$4.66$$5.36$$35.4$$*$$Roylenchus$$Pp3$$0.24$DorylaimusFu4$0.27$$0.21$$0.21$$0.24$$47.75$$ns$<math>Helicorylenchus$Pp3$$0.24$DorylaimusFu4$4.16$$7.64$$4.66$$5.36$$35.4$$*$<math>Roylenchus$Pp3$$0.24$DorylaimusFu4$0.21$$0.21$$0.21$$0.21$$0.21$<math>Dorylainor$Pp3$$0.25$DorylaimusFu4$4.16$$7.64$$4.66$$5.36$$35.4$$*$<math>Roylenchus$Pp3$$0.24$DorylainusFu4$0.21$</math></math></math></math></td> <td>Te</td> <td>ratocephalus</td> <td>Ba3</td> <td>4.95</td> <td>4.55</td> <td>3.11</td> <td>4.39</td> <td>51.15</td> <td>* *</td> <td>Malenchus</td> <td>Pp2</td> <td>0.04</td> <td>0.09</td> <td>0.04</td> <td>0.05</td> <td>48</td> <td>ns</td>	Atainus Ba4 0.5 0.3 0.62 0.46 42.86 ns Pararylenchus Pp2 2.33 0.25 0.51 1.25 132.02 * Aphelenchus Fu2 7.6 5.03 6.6 6.57 49.28 ** <i>Painenellus</i> Pp2 2.73 1.23 $2.74.55$ ns Aphelenchus Fu2 1.15 0.61 1.28 1.01 49.37 ns <i>Tranenellus</i> Pp2 2.77 1.23 $2.74.55$ ns <i>Aphelenchus</i> Fu2 1.15 0.61 1.28 1.01 49.37 ns <i>Tranenellus</i> Pp2 2.07 0.59 129 0.21 0.21 0.21 0.21 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21 0.27 0.21	AlaimusBa4 0.5 0.3 0.62 0.46 42.86 ns Pararylenchus $Pp2$ 2.33 AphelenchoidesFu2 7.6 5.03 6.6 6.57 49.28 $**$ $Psilenchus$ $Pp2$ 2.73 AphelenchusFu2 1.15 0.61 1.65 2.15 51.74 $*$ $Tenunenellus$ $Pp2$ 2.73 AphelenchusFu2 1.15 0.61 1.28 1.01 49.37 ns $Tylenchus$ $Pp2$ 1.12 DiphtherophoraFu2 5.36 7.37 4.43 5.76 39.04 $*$ $Criconemoides$ $Pp3$ 0.25 DorylaimoidesFu4 0.27 0.21 0.21 0.21 0.24 47.75 ns $Helicorylenchus$ $Pp3$ 0.35 DorylaimoidesFu4 4.16 7.64 4.66 5.36 35.4 $*$ $Roylenchus$ $Pp3$ 0.24 DorylaimusFu4 0.27 0.21 0.21 0.24 47.75 ns $HelicorylenchusPp30.24DorylaimusFu44.167.644.665.3635.4*RoylenchusPp30.24DorylaimusFu40.210.210.210.210.21DorylainorPp30.25DorylaimusFu44.167.644.665.3635.4*RoylenchusPp30.24DorylainusFu40.21$	Te	ratocephalus	Ba3	4.95	4.55	3.11	4.39	51.15	* *	Malenchus	Pp2	0.04	0.09	0.04	0.05	48	ns
AphelenchoidesFu27.65.036.66.5749.28**PsilenchusPp22.731.531.23274.55nsAphelenchusFu22.482.041.652.1551.74*TenumenellusPp20.040.0100.02120nsDitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.2960.4nsTilenchusFu25.367.374.435.7639.04*CriconemoidesPp30.250.290.60.3522.09nsDiphtherophoraFu31.982.032.662.1621.01nsHelicotylenchusPp30.730.010.02150nsDorylaimoidesFu40.270.210.210.2447.75nsHeteroderaPp30.030.010.02150nsDorylaimoidesFu44.167.644.665.3635.4*RotylenchulusPp30.040.010.02170nsTylencholaimusFu40.270.210.210.2447.75nsHeteroderaPp30.060.320.3760.92*TylencholaimusFu44.167.644.665.3635.4*RotylenchulusPp40.010.060.02100nsTrichodorusPp40.010.04	AphelenchoidesFu27.65.036.66.5749.28***PsilenchusPp22.731.531.23274.55nsDitylenchusFu22.482.041.652.1551.74*TenumenellusPp20.040.0100.02120nsDitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.2960.4nsDitylenchusFu25.367.374.435.7639.04*CriconenoidesPp30.050.030.050.352.03nsDorylainoidesFu40.270.210.210.2447.75nsHetrodrausPp30.040.160.02150nsDorylainoidesFu40.270.662.161.049.050.030.02110nsDorylainoidesFu40.270.610.010.02120nsNsNsDorylainoidesFu40.270.662.165.3635.4*RoylenchulusPp30.040.160.050.02150nsDorylainoidesFu40.270.610.270.060.420.2468.14nsNsTrichodorusPp40.010.060.060.060.060.050.02100nsParableRepresendencePp40.010.040.160.0	AphelenchoidesFu27.65.036.66.5749.28***PsilenchusPp22.73AphelenchusFu22.482.041.652.1551.74*TenunenellusPp20.04DitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.12FilenchusFu25.367.374.435.7639.04*CriconemoidesPp30.25DiphtherophoraFu31.982.032.662.1621.01nsHelicotylenchusPp30.03DorylaimoidesFu40.270.210.210.2447.75nsHeteroderaPp30.03DorylaimoidesFu44.167.644.665.3635.4*RoylenchusPp30.04DorylaimuusFu40.270.210.210.210.2447.75nsHeteroderaPp30.04DorylaimuusFu44.167.644.665.3635.4*RoylenchusPp30.04DorylaimusFu40.210.210.210.210.2447.75nsHeteroderaPp30.02DorylaimuusFu44.167.644.665.3635.4*RoylenchusPp30.04DiphtherophoraPp40.210.210.210.210.210.210.210.21DiptusFueFue7.644.665	AI_{i}	aimus	Ba4	0.5	0.3	0.62	0.46	42.86	ns	Paratylenchus	Pp2	2.33	0.25	0.51	1.25	132.02	*
AphelenchusFu2 2.48 2.04 1.65 2.15 51.74 *Tenumenellus $Pp2$ 0.04 0.01 0 0.02 120 ns DisylenchusFu2 1.15 0.61 1.28 1.01 49.37 ns $Tylenchus$ $Pp2$ 1.12 2.07 0.59 1.29 60.4 ns DisylenchusFu2 5.36 7.37 4.43 5.76 39.04 * $Criconemoides$ $Pp3$ 0.25 0.29 0.6 0.35 22.09 ns DiphtherophoraFu2 1.98 2.03 2.66 2.16 21.01 ns $HelicotylenchusPp30.750.290.60.3522.09nsDorylaimoidesFu40.270.210.210.2447.75nsHelicotylenchusPp30.0300.010.02110nsDorylaimoidesFu44.167.644.665.3635.4*RotylenchulusPp30.060.320.330.02110nsTylencholaimusFu44.167.644.665.3635.4*RotylenchulusPp40.270.060.320.330.02110nsTylencholaimusFu44.167.644.665.3635.4*RotylenchulusPp40.270.060.020.020.37$	Aphelenchus Fu2 2.48 2.04 1.65 2.15 51.74 * Tenumenellus Pp2 0.01 0 0.02 120 ns Ditylenchus Fu2 5.36 7.37 4.43 5.76 39.04 * Criconenoides Pp2 1.12 2.07 0.59 1.29 60.4 ns Pilenchus Fu2 5.36 7.37 4.43 5.76 39.04 * Criconenoides Pp3 0.03 0.06 0.35 22.09 ns Diphtherophora Fu2 5.36 7.37 4.43 5.76 39.04 * Criconenoides Pp3 0.01 0.02 1.96 23.73 69.9 * 7.75 ns Phalecoylenchus Pp3 0 0.01 0.02 1.96 1.95 ns Phane	AphelenchusFu22.482.041.652.1551.74*Tenumenellus $Pp2$ 0.04DitylenchusFu21.150.611.281.0149.37nsTylenchus $Pp2$ 1.12FilenchusFu25.367.374.435.7639.04*Criconemoides $Pp3$ 0.25DiphtherophoraFu21.982.032.662.1621.01ns <i>Helicotylenchus</i> $Pp3$ 0.03DiphtherophoraFu40.270.210.210.2447.75ns <i>Helicotylenchus</i> $Pp3$ 0.03DiphtherophoraFu44.167.644.665.3635.4* <i>Roylenchus</i> $Pp3$ 0.04DiphtherophoraFu44.167.644.665.3635.4* <i>Roylenchus</i> $Pp3$ 0.04DiphtherophoraFu40.270.210.210.2447.75ns <i>Heterodera</i> $Pp3$ 0.04DiphtherophoraFu44.167.644.665.3635.4* <i>Roylenchus</i> $Pp3$ 0.04DiphtherophoraFu40.210.210.2447.75ns <i>Heterodera</i> $Pp3$ 0.03DiphtherophoraFu40.217.644.665.3635.4* <i>Roylenchus</i> $Pp3$ 0.04DiphtherophoraFu40.217.644.665.3635.4* <i>Roylenchus</i> $Pp3$ 0.04DiphtherophoraFu6 <td>Ap</td> <td>helenchoides</td> <td>Fu2</td> <td>7.6</td> <td>5.03</td> <td>6.6</td> <td>6.57</td> <td>49.28</td> <td>* *</td> <td>Psilenchus</td> <td>Pp2</td> <td>2.73</td> <td>1.53</td> <td>1.23</td> <td>0</td> <td>74.55</td> <td>ns</td>	Ap	helenchoides	Fu2	7.6	5.03	6.6	6.57	49.28	* *	Psilenchus	Pp2	2.73	1.53	1.23	0	74.55	ns
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	DitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.122.070.591.2960.4nsFilenchusFu25.367.374.435.7639.04*CriconemoidesPp30.250.290.60.3522.09nsDiphtherophoraFu25.367.374.435.7639.04*CriconemoidesPp30.250.290.60.3522.09nsDorylainoidesFu40.270.210.210.210.2447.75nsHeteroderaPp30.0300.010.02110nsDorylainoidesFu44.167.644.665.3635.4*RoylenchutsPp30.040.010.02110nsTylencholainusFu44.167.644.665.3635.4*RoylenchutsPp30.010.050.030.02110nsTylencholainusFu40.160.270.210.210.2447.75nsHeteroderaPp30.040.160.620.3760.92*TylencholainusFu44.167.644.665.3635.4*RoylenchusPp40.270.060.420.2468.14nsTylencholainusFu40.110.010.020.060.420.2468.14nsTylencholainusFu40.210.06	DitylenchusFu21.150.611.281.0149.37nsTylenchusPp21.12FilenchusFu25.367.374.435.7639.04*CriconemoidesPp30.25DiphtherophoraFu31.982.032.662.1621.01nsHelicotylenchusPp30.03DiphtherophoraFu40.270.210.210.2447.75nsHelicotylenchusPp30.03DorylaimoidesFu44.167.644.665.3635.4*RoylenchuusPp30.04DiphtherophoraFu44.167.644.665.3635.4*RoylenchusPp30.04DiphtherophoraFu44.167.644.665.3635.4*RoylenchusPp30.04DiphtherophoraFu40.210.210.210.210.2447.75nsHeteroderaPp30.04DiphtherophorusFu44.167.644.665.3635.4*RoylenchusPp30.04DiphtherophorusPuPuPuPuPuPuPuPuPuDiphtherophorusPuPuPuPuPuPuPuPuDiphtherophorusPuPuPuPuPuPuPuPuDiphtherophorusPuPuPuPuPuPuPuPuPuPuDiphtherophorus <td>A_{I}</td> <td>helenchus</td> <td>Fu2</td> <td>2.48</td> <td>2.04</td> <td>1.65</td> <td>2.15</td> <td>51.74</td> <td>*</td> <td>Tenunemellus</td> <td>Pp2</td> <td>0.04</td> <td>0.01</td> <td>0</td> <td>0.02</td> <td>120</td> <td>ns</td>	A_{I}	helenchus	Fu2	2.48	2.04	1.65	2.15	51.74	*	Tenunemellus	Pp2	0.04	0.01	0	0.02	120	ns
FilenchusFu2 5.36 7.37 4.43 5.76 39.04 $*$ $Criconemoides$ $Pp3$ 0.25 0.29 0.6 0.35 22.09 ns DiphtherophoraFu3 1.98 2.03 2.66 2.16 21.01 ns $Helicotylenchus$ $Pp3$ 1.75 1.53 2.91 1.96 24.73 ns DorylaimoidesFu4 0.27 0.21 0.21 0.24 47.75 ns $Hererodera$ $Pp3$ 0.03 0 0.01 0.02 150 ns TylencholaimusFu4 4.16 7.64 4.66 5.36 35.4 $*$ $Rotylenchulus$ $Pp3$ 0.05 0.03 0.02 110 ns TylencholaimusFu4 4.16 7.64 4.66 5.36 35.4 $*$ $Rotylenchulus$ $Pp3$ 0.44 0.16 0.52 0.37 60.92 $*$ Longidorella $Pp4$ 0.27 0.06 0.42 0.24 68.14 ns Trichodorus $Pp4$ 0.01 0.04 0.16 0.06 85.19 ns Trichodorus $Pp4$ 0.01 0.04 0.16 0.06 85.19 ns the number of groups 58 58 61 ns 61 ns	Filenchus Fu 5.36 7.37 4.43 5.76 39.04 * Criconemoides Pp3 0.25 0.29 0.6 0.35 22.09 ns Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicorylenchus Pp3 0.25 0.29 0.6 0.35 24.73 ns Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 0.02 110 ns Dorylaimoides Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.01 0.02 10 ns Informas Fud 196 24.73 ns Dorylaimoides Fud 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.01 0.02 10.01 0.02 110 ns Informas Fud 10.6 0.24 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.01 0.01 0.02 <t< td=""><td>FilenchusFu2$5.36$$7.37$$4.43$$5.76$$39.04$*Criconemoides$Pp3$$0.25$DiphtherophoraFu3$1.98$$2.03$$2.66$$2.16$$21.01$$ns$<i>Helicotylenchus</i>$Pp3$$0.03$DorylaimoidesFu4$0.27$$0.21$$0.21$$0.24$$47.75$$ns$<i>Heterodera</i>$Pp3$$0.03$TylencholaimusFu4$4.16$$7.64$$4.66$$5.36$$35.4$*<i>Roxylenchus</i>$Pp3$$0.04$TylencholaimusFu4$4.16$$7.64$$4.66$$5.36$$35.4$*<i>Roxylenchus</i>$Pp3$$0.04$DisturbanceFu4$4.16$$7.64$$4.66$$5.36$$35.4$*<i>Roxylenchus</i>$Pp3$$0.04$DisturbanceFu4$4.16$$7.64$$4.66$$5.36$$35.4$*<i>Roxylenchus</i>$Pp3$$0.04$DisturbanceFu4$0.21$$0.21$$0.24$$47.75$$ns$<i>Roxylenchus</i>$Pp3$$0.04$DisturbanceFu4$0.21$$1.64$$7.64$$4.66$$5.36$$35.4$*<i>Roxylenchus</i>$Pp4$$0.27$DisturbanceEuclidealDisturbanceEuclidealDisturbance$Pp4$$0.21$DisturbanceEuclidealDisturbanceSudversion$Pp4$$0.21$DisturbanceEuclidealDisturbanceSudversion$Pp4$$0.21$DisturbanceEuclidealDisturban</td><td>D^{i}</td><td>tylenchus</td><td>Fu2</td><td>1.15</td><td>0.61</td><td>1.28</td><td>1.01</td><td>49.37</td><td>ns</td><td>Tylenchus</td><td>Pp2</td><td>1.12</td><td>2.07</td><td>0.59</td><td>1.29</td><td>60.4</td><td>ns</td></t<>	FilenchusFu2 5.36 7.37 4.43 5.76 39.04 *Criconemoides $Pp3$ 0.25 DiphtherophoraFu3 1.98 2.03 2.66 2.16 21.01 ns <i>Helicotylenchus</i> $Pp3$ 0.03 DorylaimoidesFu4 0.27 0.21 0.21 0.24 47.75 ns <i>Heterodera</i> $Pp3$ 0.03 TylencholaimusFu4 4.16 7.64 4.66 5.36 35.4 * <i>Roxylenchus</i> $Pp3$ 0.04 TylencholaimusFu4 4.16 7.64 4.66 5.36 35.4 * <i>Roxylenchus</i> $Pp3$ 0.04 DisturbanceFu4 4.16 7.64 4.66 5.36 35.4 * <i>Roxylenchus</i> $Pp3$ 0.04 DisturbanceFu4 4.16 7.64 4.66 5.36 35.4 * <i>Roxylenchus</i> $Pp3$ 0.04 DisturbanceFu4 0.21 0.21 0.24 47.75 ns <i>Roxylenchus</i> $Pp3$ 0.04 DisturbanceFu4 0.21 1.64 7.64 4.66 5.36 35.4 * <i>Roxylenchus</i> $Pp4$ 0.27 DisturbanceEuclidealDisturbanceEuclidealDisturbance $Pp4$ 0.21 DisturbanceEuclidealDisturbanceSudversion $Pp4$ 0.21 DisturbanceEuclidealDisturbanceSudversion $Pp4$ 0.21 DisturbanceEuclidealDisturban	D^{i}	tylenchus	Fu2	1.15	0.61	1.28	1.01	49.37	ns	Tylenchus	Pp2	1.12	2.07	0.59	1.29	60.4	ns
Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicotylenchus $Pp3$ 1.75 1.53 2.91 1.96 24.73 ns Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera $Pp3$ 0.03 0 0.01 0.02 150 ns Dorylaimoides Fu4 0.27 0.21 0.24 47.75 ns Heterodera $Pp3$ 0.03 0.01 0.02 110 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 $*$ Roylenchulus $Pp3$ 0.04 0.16 0.22 0.37 60.92 $*$ Tongidorella $Pp4$ 0.27 0.06 0.42 0.24 68.14 ns Trichodorus $Pp4$ 0.01 0.06 0.06 85.19 ns Trichodorus 58 58 61 ns 16 $number$ 16 10.01 </td <td>Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicorylenchus Pp3 1.75 1.53 2.91 1.96 24.73 ns Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 0.01 0.02 150 ns Dorylaimoides Fu4 0.27 0.21 0.24 47.75 ns Heterodera Pp3 0 0.01 0.02 110 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 $*$ Roylenchulus Pp3 0 0.01 0.02 110 ns Tricholaimus Fu4 0.16 0.66 0.42 0.24 6192 $*$ Insultance plas Pp4 0.27 0.06 0.42 0.06 85.19 ns Trichodorus Pp4 0.27 0.06 0.42 0.06 86.14 ns Trichodorus Pp4 0.27 0.06 0.42 <t< td=""><td>Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicotylenchus Pp3 1.75 Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 Pp4 0.27 Trichodorus Pp4 0.02 Trichodorus Pp4 0.11 Trichodorus Pp4 0.01 Disturbance plantpance plantpance plantpance plantpance sturbance sturfanct fudict</td><td>Fi</td><td>enchus</td><td>Fu2</td><td>5.36</td><td>7.37</td><td>4.43</td><td>5.76</td><td>39.04</td><td>*</td><td>Criconemoides</td><td>Pp3</td><td>0.25</td><td>0.29</td><td>0.6</td><td>0.35</td><td>22.09</td><td>ns</td></t<></td>	Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicorylenchus Pp3 1.75 1.53 2.91 1.96 24.73 ns Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 0.01 0.02 150 ns Dorylaimoides Fu4 0.27 0.21 0.24 47.75 ns Heterodera Pp3 0 0.01 0.02 110 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 $*$ Roylenchulus Pp3 0 0.01 0.02 110 ns Tricholaimus Fu4 0.16 0.66 0.42 0.24 6192 $*$ Insultance plas Pp4 0.27 0.06 0.42 0.06 85.19 ns Trichodorus Pp4 0.27 0.06 0.42 0.06 86.14 ns Trichodorus Pp4 0.27 0.06 0.42 <t< td=""><td>Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicotylenchus Pp3 1.75 Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 Pp4 0.27 Trichodorus Pp4 0.02 Trichodorus Pp4 0.11 Trichodorus Pp4 0.01 Disturbance plantpance plantpance plantpance plantpance sturbance sturfanct fudict</td><td>Fi</td><td>enchus</td><td>Fu2</td><td>5.36</td><td>7.37</td><td>4.43</td><td>5.76</td><td>39.04</td><td>*</td><td>Criconemoides</td><td>Pp3</td><td>0.25</td><td>0.29</td><td>0.6</td><td>0.35</td><td>22.09</td><td>ns</td></t<>	Diphtherophora Fu3 1.98 2.03 2.66 2.16 21.01 ns Helicotylenchus Pp3 1.75 Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 4.16 7.64 4.66 5.36 35.4 * Roylenchulus Pp3 0.04 Openations Fu4 Pp4 0.27 Trichodorus Pp4 0.02 Trichodorus Pp4 0.11 Trichodorus Pp4 0.01 Disturbance plantpance plantpance plantpance plantpance sturbance sturfanct fudict	Fi	enchus	Fu2	5.36	7.37	4.43	5.76	39.04	*	Criconemoides	Pp3	0.25	0.29	0.6	0.35	22.09	ns
Dorylaimoides Fu4 0.27 0.21 0.24 47.75 ns Heterodera Pp3 0.03 0 0.01 0.02 150 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Rotylenchulus Pp3 0 0.05 0.03 0.02 110 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Rotylenchulus Pp3 0 0.16 0.27 0.03 0.02 110 ns Longidorella Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns the number of groups 58 58 61 ns	Dorylaimoides Fu4 0.27 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.21 0.02 150 ns Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 $*$ $Roylenchulus$ $Pp3$ 0.01 0.02 110 ns Tylencholaimus Fu4 0.16 0.52 0.37 60.92 $*$ Trichodorus Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.27 0.06 0.42 0.24 68.14 ns Instrubance $Pp4$ 0.27 0.06 0.42 0.24 68.14 ns Instrubance $Pp4$ 0.27 0.06 0.42 0.26 610 ns Instrubance $Pp4$ 0.01 0.06 0.42 0.24 68.14 ns Instrubance $Pp4$ 0.01	Dorylaimoides Fu4 0.27 0.21 0.21 0.24 47.75 ns Heterodera Pp3 0.03 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Ronylenchulus Pp3 0 0.44 Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Ronylenchulus Pp3 0 0.44 Trichodorus Pp4 0.27 7.64 4.66 5.36 35.4 * Ronylenchulus Pp3 0 0.44 Disturbance Examplementus Pp4 0.27 0.21 17nchodorus Pp4 0.21 Trichodorus Pp4 0.01 Trichodorus Pp4 0.01 Disturbance plot inturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild c 58 Disturbance Plot fungivore; Om - omnivores. Pp - plant parasites. Numbers following the letters indic (1900) CV (= mean/S D) is the creeficient of variation n indicate the effects of disturbance on the senera abundance	Ĩ	phtherophora	Fu3	1.98	2.03	2.66	2.16	21.01	ns	Helicotylenchus	Pp3	1.75	1.53	2.91	1.96	24.73	ns
Tylencholainus Fu4 4.16 7.64 4.66 5.36 35.4 * Raylenchulus Pp3 0 0.05 0.03 0.02 110 ns Scutylenchus Pp3 0.44 0.16 0.52 0.37 60.92 * Longidorella Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns the number of groups 58 58 61 18	Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Roxylenchulus Pp3 0 0.05 0.03 0.02 110 ns Scurylenchalus Pp3 0.44 0.16 0.52 0.37 60.92 * Scurylenchalus Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.66 85.19 ns the number of groups 58 58 61 conditions for a severely disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild designation is the composite of feeding habit and cp value: Ba – bacterivore; Fu – fungivore; Om – onnivores: Pp – plant parasites. Numbers following the letters indicate the cp value of each taxon based on Bongers (1990) CV (= mearS D) is the coefficient of variation or indicate the effects of disturbance device on the event a bundence ** $n < 0.01$; $n < 0.05$, $n < 0.05$, $n < 0.05$ moderately disturbance site; D3, severely disturbance device on the event a bundence ** $n < 0.01$; $n < 0.05$, $n < 0.05$, $n < 0.05$ moderately $n > 0.05$.	Tylencholaimus Fu4 4.16 7.64 4.66 5.36 35.4 * Rotylenchulus Pp3 0.44 27 Scurylenchus Pp3 0.44 0.27 77/dorlar Pp4 0.27 26 Trichodorus Pp4 0.27 77/dorlar Pp4 0.27 27 Trichodorus Pp4 0.01 101 100 101 101 28 Disturbance Disturbance ster 101	D	rrylaimoides	Fu4	0.27	0.21	0.21	0.24	47.75	ns	Heterodera	Pp3	0.03	0	0.01	0.02	150	ns
Scutylenchus Pp3 0.44 0.16 0.52 0.37 60.92 * Longidorella Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns the number of groups 58 58 61 ns	Scutylenchus Pp3 0.44 0.16 0.52 0.37 60.92 * Longidorella Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.66 85.19 ns Ibiturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. 0.01 0.04 0.16 0.06 85.19 ns Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. 0.01 0.04 0.16 0.06 85.8 61 Disturbance plots included: D1, slightly disturbance site; D3, severely disturbance site. D3, severely disturbance site. D3, severely disturbance site. 0.01d designation is the composite of feeding habit and cp value: B3 D3 D4 D3 D4 D3 D4 D3 D4	Scutylenchus Pp3 0.44 Longidorella Pp4 0.27 Trichodorus Pp4 0.01 Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site; C0, severely disturbance site; D3, severely disturbance site; C0, severely disturbance site; D3, severely disturbance site; C10000, CV (= mean/SD) is the coefficient of variation. nindicate the effects of disturbance deteres on the senera abundance	Ľ	lencholaimus	Fu4	4.16	7.64	4.66	5.36	35.4	*	Rotylenchulus	Pp3	0	0.05	0.03	0.02	110	ns
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Longidorella Pp4 0.27 0.06 0.42 0.24 68.14 ns Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Calld designation is the composite of feeding habit and cp value: Ba – bacterivore; Fu – fungivore; Om - omnivores: Pp - plant parasites. Numbers following the letters indicate the cp value of each taxon based on Bongers (1900) CV (= mear/S D) is the coefficient of variation p indicate the effects of disturbance device on the centra abundance ** p < 0.01: * p < 0.05: ns – no significantly	Longidorella Pp4 0.27 Trichodorus Pp4 0.01 Trichodorus Pp4 0.01 Insturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site; D3, severely disturbance site; D3, severely disturbance site. Guild c Cp value: Ba - bacterivore: Fu - fungivore; Om - omnivores-carnivores; Pp - plant parasites. Numbers following the letters indic (1900) CV (= mean/S D) is the coefficient of variation. n indicate the effects of disturbance deree on the senera abundance										Scutylenchus	Pp3	0.44	0.16	0.52	0.37	60.92	*
Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns the number of groups 58 58 51 61	Trichodorus Pp4 0.01 0.04 0.16 0.06 85.19 ns Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site.	Trichodorus Pp4 0.01 Trichodorus Pp4 0.01 Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild c 58 cp value: Ba - bacterivore; Fu - fungivore; Om - omnivores-carnivores; Pp - plant parasites. Numbers following the letters indic 61900. CV (= mean/S D) is the coefficient of variation n indicate the effects of disturbance deree on the genera abundance										Longidorella	Pp4	0.27	0.06	0.42	0.24	68.14	ns
the number of groups 58 58 61	Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild designation is the composite of feeding habit and cp value: Ba – bacterivore; Fu – fungivore; Om - omnivores; Pp - plant parasites. Numbers following the letters indicate the cp value of each taxon based on Bongers (1900) CV (= mear/S D) is the coefficient of variation p indicate the effects of disturbance device on the centra abundance $** p < 0.01$: $* p < 0.05$: $n = -no$ sionificantly	Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild c cp value: Ba – bacterivore; Fu – fungivore; Om - omnivores; Pp - plant parasites. Numbers following the letters indic (1900) CV (= mean/S D) is the coefficient of variation n indicate the effects of disturbance deree on the genera abundance										Trichodorus	Pp4	0.01	0.04	0.16	0.06	85.19	ns
	Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild designation is the composite of feeding habit and cp value: Ba – bacterivore; Fu – fungivore; Om - omnivores; Pp - plant parasites. Numbers following the letters indicate the cp value of each taxon based on Bongers (1900) CV (= mean/S D) is the coefficient of variation p indicate the effects of disturbance degree on the genera abundance. ** $p < 0.01$: * $p < 0.05$: ns – no significantly	Disturbance plots included: D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site. Guild c cp value: Ba – bacterivore; Fu – fungivore; Om - omnivores; Pp - plant parasites. Numbers following the letters indic (1900) CV (= mean/S D) is the coefficient of variation n indicate the effects of disturbance destree on the genera abundance										the number of gi	roups	58	58	58	61		
	(1900) CV (= mean/S D) is the coefficient of variation p indicate the effects of disturbance degree on the genera abundance ** $p < 0.01$; * $p < 0.05$; $n_s = n_0$ significantly	(1900) CV ℓ = mean/S D) is the coefficient of variation <i>n</i> indicate the effects of disturbance degree on the genera abundance	cb	value: Ba – bact	erivore; Fu	u – fungivore	; Om - om	nivores-can	nivores; Pp	- plant ps	urasites.	Numbers followin	ig the lette	srs indicate	the cp va	ulue of eac	ch taxon b	ased on	Bongers
cp value: Ba - bacterivore: Fu - functivore: Om - omnivores. Pp - plant parasites. Numbers following the letters indicate the cp value of each taxon based on Bongers	11770h OT I = IIIOUIDDD D I I UD VOULUUU VI I MINNOU VI VUVUV VIV VIV VUVUVV VI VUVUVVVV VU VIV POUVU VV VUVUVUVVI VV VVVI VV VUVUVUVVI VV VVVI VV VVVVI VV VVVVI VV VVVVI VVVVVV	$\frac{1}{1} = 1 + 1 +$	-5	90). CV (= mea	an/S.D.) is	the coefficie	ent of varia	ation. p ind	icate the ef	fects of d	isturbaı	nce degree on the	genera ab	undance. *	** n < 0.0	1: * $p < 0$	0.05: ns -	- no sioni	ficantly

ZHANG et al.: STUDY OF SOIL NEMATODE COMMUNITY STRUCTURE

436

were similar patterns between the abundance of trophic groups and the total nematodes. Except fungivore, which highest in D2, the abundance of three trophic groups including bacterivores, plant



ui, degrees of freedom, p<0.05, p<0.01.

Fig. 1. F-values from one-way ANOVA analysis of disturb degree (df=2) on the total nematodes abundances (TA), the total nematodes groups (TG), abundances of trophic groups (Ba, bacteriophages; Fu, fungivores; Om, omnivores-carnivores; Pp, plant parasites), cp group (cp scale : colonizer-persister scale 1-5), and nematode ecological indices (F/B, ratio of fungivores to bacterivores; TD, trophic diversity index; NCR, nematode channel ratio; MMI, maturity index; PPI, plant parasite maturity index; MI, soil free-living nematode maturity index; MI 2-5, maturity index including cp 2-5 group; BI, basal index; CI, channel index; EI, enrichment index; SI, structure index; Σ F, comprehensive index).



Fig. 2. Abundances (ind./100 g dry soil) of total nematodes and their trophic groups (Ba, bacterivores; Fu, fungivores; Pp, plant parastites; Om, omnivores-carnivores) in different tourism disturbance plots (D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site). Different lowercase letters indicate a significant difference (p < 0.05).

parasites, and omnivore was significant higher in D1 than in D2, and D3 (Fig. 2). Among three disturbance sites, bacterivores was predominant with higher relative abundance (> 50%), while omnivore-carnivores had the lowest percentage (<8%). Tourism disturbance increased the relative abundance of bacterivores and omnivore-carnivores. The fungivores and plant parasites had the highest percentage in D2 and D1, respectively. However, no significant differences of the proportions of trophic groups were found among all disturbance sites (p > 0.05) (Fig. 3a).

Among three disturbance degree sites, the relative abundance of cp2 group was highest, followed by cp3 group, cp4 group, cp1 group, and cp5 group. Tourism disturbance increased the relative abundance of cp1 group and decreased that of cp2 group. The highest relative abundance of cp3 and cp5 was in D3 and lowest in D2, while that of cp4 was highest in D2 and lowest in D1. As the trophic groups, the proportions of cp groups had no significant differences among all disturbance sites (p > 0.05) (Fig. 3b).



Fig. 3. Proportion of nematode tropic groups (a) and cp group (b) under different tourism disturbance plots (D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site). Ba, bacterivores; Fu, fungivores; Pp, plant parastites; Om, omnivores-carnivores; cp scale : colonizer-persister scale 1-5.

Community indices of soil nematode communities

One-way ANOVA was used to analyze the community index of soil nematode. No statistically significant effects were observed in the case of MI, MMI, EI, SI, CI, F/B, NCR, and TD due to tourism pressure, while PPI, MI2-5, and BI index were significantly different (p < 0.05) (Fig. 1). MI2-5 index showed the same trend as total nematodes abundance which was significantly decreaded by

J PURE APPL MICROBIO, 8(SPL. EDN.), MAY 2014.

toursim disturbance (2.82 in D3 and 5.25 in D1) contrary to the PPI and SR index. BI index had the highest value in D3 (44.41), and lowest in D1 (26.73) (Fig. 4).

The principal component analysis of the community index indicated that the first principal component (f1) accounted for 40.86 %, the second

principal component (f2) 28.59 %, and the third principal component (f3) 27.48% of variance. The three principal components accounted for most of the total variance (96.93 %) (Fig. 5). The ordination diagram (Fig. 5) based on the loading plots of PCA for soil nematode community structure parameters indicated that the total nematode abundance and



Fig. 4. Nematode community indicts under different tourism disturbance polts (D1, slightly disturbance site; D2, moderately disturbance site; D3, severely disturbance site). MI, soil free-living nematode maturity index; PPI, plant parasite maturity index; MMI, maturity index; MI 2-5, maturity index including cp 2-5 group; EI, enrichment index; SI, structure index; BI, basal index; CI, channel index; F/B, ratio of fungivores to bacterivores; NCR, nematode channel ratio; TD, trophic diversity index; \pounds F, comprehensive index. Different lowercase letters indicate a significant difference (p < 0.05)



Fig. 5. The loading plots of PCA for soil nematode community structure parameters. MI 2-5, maturity index including cp 2-5 group; SI, structure index; BI, basal index; F/B, ratio of fungivores to bacterivores; NCR, nematode channel ratio; TA, the total nematodes abundances



Fig. 6. Canonical correspondence analysis (CCA) between nematode trophic groups and soil environmental parameters. MC, soil moisture content; OM, soil organic matter content; TN, total nitrogen content; TP, total phosphorus content; SP, available phosphorus content; SK, available potassium content; BD, soil bulk density. Ba, bacterivores; Fu, fungivores; Pp, plant parastites; Om, omnivores-carnivores; numbers following the trophic groups indicate the cp values.

MI2-5 index had very high loading on f1, so f1 mainly explained the two factors, f2 mainly explained the F/B and NCR indexes, and f3 mainly explained the SI and BI indexes. According to the component score coefficient of the soil nematode community structure parameters (Fig. 5), Σ F index, which indicated the communities structure score comprehensively, was calculated. The Σ F index was highest in D1, followed by D2 and D3 (Fig. 4). This regular pattern was similar to that of the MI2-5 and the abundance of total nematode, as illustrated in Fig. 2 & 4. The Σ F index was significant differences among three disturbance sites (Fig. 1).

Correlations of soil nematode functional guilds and community indices with soil chemical properties

As canonical correspondence analysis (CCA) of the abundance of the functional guild and the date for environmental variables including pH, BD, OM, TN, TP, SK, SP and MC in three disturbance degree sites indicated the eigenvalues of the first axis and the second axis were 0.011 and 0.008. The first axis explained 52.4% of cumulative variance of the species data and 88.8% of the species-environment relationships. The first axis, which reflected pH of the soil, and the second axis, which reflected OM, TN, TP, SP, and SK could be illustrated by the measured environmental variables. This figure revealed the relation between the distribution of species and the environment (Fig. 6). For example, the functional guilds Ba1, Pp4 mainly appeared in areas with high bulk density, while Fu2, Pp2, and Pp5, mainly appeared in areas with high TN, OM, TP, SP, and SK.

DISCUSSION

In all kinds of recreational areas, trampling is acknowledged to be the most widespread impact³. Trampling caused soil compression, which led to a increased soil bulk density and reduced soil moisture centent. Recreational stress also changed nutrient supply in the soil (Table 1). These changes might exert a direct or indirect influence on nematode populations and community structure.

Responses of the abundance of nematodes

The current experiment on the impact of trampling on nematodes had revealed that

trampling affected the total abundance of nematodes which declined progressively with the distance from trail. Numbers of nematodes extracted from D1 and D3 ranged from 628 to 329 ind./100 g dry soil (Fig. 2). This result is similar to those reported by Darby et al. (2010) ²⁸in desert soils and Ayres et al. (2008)9 in Antarctica. Wall et al. $(2002)^{29}$ found the soil from areas with loose, porous and higher soil organic matter had greater nematode density. The foot traffic caused soil compression and the increment in soil bulk density which caused a reduction in the soil moisture and soil porosity. And recreational stress also reduced the amount of the nutrient supply (Table 1). All of these are well explained the decreasing abundance of nematode along the increasing distance from the trails. And the abundance of the trophic groups are similar with the total nematodes. According to Light and MacConaill (2011)³⁰, nematodes might not reproduce in trampled areas or they could migrate elsewhere if food choices became limited. Meanwhile, disturbance degree influences dramatacally the abundance of some genera (Table 2). Some species were not adaptable to different environments and lived only in specific heterogeneitic environments. This suggests that the limited adaptability groups of soil nematode can reflect the differences between environments and can be an important indicator to reflect variations in environments. As there are many kinds of soil nematode and their distributions are very complicated, additional long-term research should investigate to clarify their use as environmental indicators.

Responses of the community structure of nematodes

In this study, bacterivores had the highest ratio among four trophic groups (Fig. 3a) and the F/B values was low (0.22-0.34) (Fig. 4). The results mean that the organic material is mainly decomposed by the bacteria. The decomposition rate of the bacteria-based food web is rapider than fungal-based food web¹¹. The result differs from previously reported studies which showed that fungivores were the dominant trophic group in Changbai mountain³¹. The differences are primarily due to the soil pH in the current study (6.47-6.68) being higher than that in Changbai mountain (4.12-5.82). Yeates (1996)³² found a lower soil pH is favorable for fungi. Additionally, The percent of

soil nematode trophic groups was no significant changed because of trampling (Fig. 3a), indicating that the tourism interference don't change the structure of soil nematode trophic groups.

We predicted that a clear effect of trampling on the percentage of soil nematode trophic groups should be found, but this has not been investigated. According to CCA sorting, the distribution of soil nematode trophic groups were apparently related to the pH and soil nutrients. Trampling did not form a dramatic change of environmental nutrient supply in this study (Table 1). It may be the reason for the result.

Responses of the ecological indices of nematodes

The cp2 group which have a tolerant of adverse conditions and wide ecologial amplitude were predominant with higher relative abundance (Fig. 3b), indicating the soil food web in Wudalianchi scenic is stressed mainly because of trampling and other artificial disturbances¹¹. MI 2-5 gives a much better response to disturbances than MI and MMI in the stressed soil community ³³, which are similar to our results (Fig. 1, 4). The values of MI 2-5 significantly reduced with the increasing foot traffic (Fig. 4).

In the present study, the values of EI decreased and the values of CI increased with the trampling intensity (Fig. 4). EI values reflect food web response to availability of resources and CI values indicate the predominant decomposition pathways¹¹, the obtained results indicated that the trampling decreased the food resources for the food web. Higher EI and lower CI suggest more enriched condition of soil food web and greater bacterial activity in D1³⁴.

SI can be used to assess the response to disturbance. The values of SI decreased with the trampling intensity, lowest SI in D3 suggest the direct impact of foot traffic on the environment (Fig. 4). In D1, the value of EI was less than 50 and the value of SI was greater than 50, which suggested a undisturb environment. While in D3, the value of EI and SI were less than 50,which showed that the environment had suffered severe interference and caused degradation of the food web¹¹.

The value of BI significantly increased from D1 to D3 significantly. A high BI would indicate poor ecosystem health³⁵. Thus, EI, BI, SI and CI appear to be most valuable as indicators for the

J PURE APPL MICROBIO, 8(SPL. EDN.), MAY 2014.

effects of trampling on nematode suppression. However, BI and SI may be more suitable as general indicators for the health status of a soil, since CI can be high in highly disturbed agro-ecosystems as well as in undisturbed natural ecosystems. A high BI would indicate poor ecosystem health, while a high SI would indicate a well-regulated, healthy ecosystem³⁵.

It can be concluded from present study that foot traffic can have negative effects on soil ecosystem. The highest tramping intensity change soil properties, such as increasing soil bulk density, reducing soil moisture content, and decreasing nutrient supply. Then, it lead to disturbance and changes in the ecological functions of nematode. Recreational stress decreased the abundance of soil nematode, the values of MI 2-5, EI and SI, while it increased BI and CI, which indicates a disturbed and poor nutrient soil food web undergoing bacterial decomposition. Soil nematode community analysis may provide useful information for assessing the impact of human foot traffic on soil processes.

ACKNOWLEDGMENTS

The project was financially supported by the National Natural Science Foundation of China (41101048, 41371072), Postdoctoral Science Foundation of China (2013M541407), Postdoctoral Science Foundation of Heilongjiang Province (LBH-Z13130) and Program for the Science and Technology Innovation Team in Universities and Colleges of Heilongjiang Province.

REFERENCES

- Lucas-Borja M.E., Bastida F., Moreno J.L., Nicolás C., Andres M., López F.R., Del Cerro A. The effects of human trampling on the microbiological properties of soil and vegetation in mediterranean mountain areas. *Land Degrad. Develop*, 2011; 22: 383-394.
- Schlacher T.A., Nielsen T., Weston M.A. Human recreation alters behaviour profiles of nonbreeding birds on open-coast sandy shores. *Estuar. Coast. Shelf S.*, 2013; 118: 31-42.
- Roovers P., Dumont B., Gulinck H., Hermy M. Recreationists' perceived obstruction of field and shrub layer vegetation. *Urban For: Urban Gree.*, 2006; 4: 47-53.

- Hall C.N., Kuss F.R. Vegetation alteration along trails in Shenandoah National Park, Virginia. *Biol. Conserv.*, 1989; 48: 211-227.
- Hill W., Pickering C.M. Vegetation associated with different walking track types in the Kosciuszko alpine area, *Australia. J. Environ. Manage*, 2006; **78**: 24-34.
- 6. Lee Y.F., Kuo Y.M., Lu S.S., Chen D.Y., Jean H.J., Chao J.T. Trampling, litter removal, and variations in the composition and relative abundance of aoil arthropods in a subtropical hardwood forest. *Zool. Stud.*, 2009; **48:** 162-173.
- Brown P.J., Taylor R.B. Effects of trampling by humans on animals inhabiting coralline algal turf in the rocky intertidal. *J. Exp. Mar. Biol. Ecol.*, 1999; 235: 45-53.
- 8. Fredes N.A., Martínez P.A., Bernava Laborde V., Osterrieth M.L. Microarthropods as indicators of anthropic disturbance in entisols in a recreational area of Miramar, Argentina. *CI. Suelo*, 2009; **27:** 89-101.
- Ayres E., Nkem J.N., Wall D.H., Adams B.J., Barrett J.E., Broos E.J., Virginia R.A. Effects of human trampling on populations of soil fauna in the McMurdo Dry Valleys, Antarctica. *Conserv. Biol.*, 2008; 22: 1544-1551.
- Battigelli J.P., Spence J.R., Langor D.W., Berch S.M. Short-term impact of forest soil compaction and organic matter removal on soil mesofauna density and oribatid mite diversity. *Can. J. Forest. Res.*, 2004; **34**: 1136-1149.
- 11. Ferris H., Bongers T., De Goede R.G.M. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. *Appl. Soil Ecol.*, 2001; **18**: 13-29.
- 12. Pen-Mouratov S., Ginzburg O., Whitford W.G., Steinberger Y. Forest fire modifies soil free-Living nematode communities in the Biriya woodland of northern Israel. *Zool. Stud.*, 2012; **51:** 1018-1026.
- Yeates G.W., Bongers T., de Goede R.G.M., Freckman D.W., Georgieva S.S. Feeding habits in soil nematode families and genera—an outline for soil ecologists. *J. Nematol.*, 1993; 25: 315-331.
- Yeates G.W. Nematodes as soil indicators: functional and biodiversity aspects. *Biol Fertil. Soils*, 2003; 37: 199-210.
- Tomar V.V.S., Zhang X.K., Li Q., Jiang Y., Liang W.J. Distribution of soil nematode communities along a section of Shen-Ha highway. *Helminthologia*, 2009; 46: 241-246.
- Pen-Mouratov S., Shukurov N., Steinberger Y. Soil free-living nematodes as indicators of both industrial pollution and livestock activity in

Central Asia. Ecol. Indic., 2010; 10: 955-967.

- Neher D.A. Role of nematodes in soil health and their use as indicators. J. Nematol, 2001; 33: 161–168.
- Zhou Z.Q., Xu L.J., Zhang Y.H., Xia C.M., Li H.G., Liu T., Ma K.P. An analysis of the ecological value of Wudalianchi, Heilongjiang Province, China. *Biodiversity Science*, 2011; 19: 63-70. (in Chinese with English abstract)
- Huang Q.Y., Yan Z.Y., Wang J.F., Zhang R.T., HW Ni. Study on spermatophyte diversity in Wudalianchi. *Advanced Materials Research*, 2013; **726**: 4442-4445.
- Lu R.K. Analytical methods of soil and agrochemistry. Beijing: China Agricultural Science and Technology Press. 2000. (in Chinese)
- 21. Viglierchio D.R., Schmitt R.V. On the methodology of nematode extraction from field samples: Baermann funnel modifications. *J. Nematol.*, 1983; **15:** 438-444.
- Tomar V.V.S., Baniyamuddin M.D., Ahmad W. Community structure of soil inhabiting nematodes in a mango orchard at Aligarh, India. *Int. J. Nematol.*, 2006; 16: 89-101.
- Bongers T. De Nematoden Van Nederland. 2nd edition. Vormgeving en technische realisatie: Uitgeverij Pirola, Schoorl, Netherlands. 1994.
- Liang W.J., Zhong S., Hua J.F., Cao C.Y., Jiang Y. Nematode faunal response to grassland degradation in Horqin Sandy Land. *Pedosphere*, 2007; **17:** 611-618.
- Bongers T. The maturity index: an ecological measure of environmental disturbance based on nematode species composition. *Oecologia*, 1990; 83: 14-19.
- Twinn D.C.: Nematodes. In: Biology of plant litter decomposition (Dickinson CH, Pugh GJF, eds.). London: Academic Press, 1974; pp 421-465.
- Heip C., Herman P.M.J., Soetaert K. Data processing, evaluation and analysis. In: Introduction to the study of Meiofauna (Higgins RP, Thiel H, eds.). Washington. D. C.: Smithsonian Institution Press, 1988; pp 197-231
- Darby B.J., Neher D.A., Belnap J. Impact of biological soil crusts and desert plants on soil microfaunal community composition. *Plant Soil*, 2010; **328:** 421-431.
- Wall J.W., Skene K.R., Neilson R. Nematode community and trophic structure along a sand dune succession. *Biol Fert Soils*, 2002; **35:** 293-301.
- Light M.H.S., MacConaill M.C. Potential impact of insect herbivores on orchid conservation. *Eur J Environ Sci.*, 2011; 1: 115-

J PURE APPL MICROBIO, 8(SPL. EDN.), MAY 2014.

ZHANG et al.: STUDY OF SOIL NEMATODE COMMUNITY STRUCTURE

124.

442

- Environ., 2004; 320: 131-143.
- Zhang M., Liang W.J., Zhang X.K. Soil nematode abundance and diversity in different forest types at Changbai Mountain, China. *Zool. Stud.*, 2012; **51:** 619-626.
- 32. Yeates G.W. Diversity of nematode faunae under three vegetation types on a pallic soil in Otago, New Zealand. *New Zeal J. Zool.*, 1996; **23:** 401-407.
- Nagy P., Bakonyi G., Bongers T., Kadar I., Fabian M., Kiss I. Effects of microelements on soil nematode assemblages seven years after contaminating an agricultural field. *Sci. Total*
- Liang W.J., Lou Y.L., Li Q., Zhong S., Zhang X.K., Wang J.K. Nematode faunal response to long-term application of nitrogen fertilizer and organic manure in Northeast China. *Soil Biol. Biochem.*, 2009; **41**: 883-890.
- 35. Berkelmans R., Ferris H., Tenuta M., Van Bruggen A.H.C. Effects of long-term crop management on nematode trophic levels other than plant feeders disappear after 1 year of disruptive soil management. *Appl. Soil Ecol.*, 2003; **23**: 223-235.