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Distribution and population dynamics of soil nematodes in a tropical forest ecosystem from Sambalpur, India

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Abstract. An ecological study on soil nematodes was made in a tropical deciduous forest ecosystem. Seventeen species of nematodes were identified of which *Rotylenchus* sp. was the dominant plant parasitic form and *Acrobeloides* sp. was the dominant microbivore species. The mean annual importance value for the miscellaneous feeders, plant parasites, microbivores and predators were 57·5, 22·5, 12·6 and 7·4 respectively. The Shannon index of general diversity was maximum during February (1·73) and minimum during June (1·41). Nematodes were distributed in clusters resulting in so called pocket effect. Of the total nematodes 88·4% occurred in the top 10 cm soil during the peak period of density and the microbivores were more frequent in the top 5 cm soil due to the litter layer. Total nematode density ranged from $15{\cdot}1 \times 10^4/m^2$ (May) to $66{\cdot}1 \times 10^4/m^2$ (November). Monthly mean nematode biomass was $18{\cdot}86 \pm 8{\cdot}36$ mg dry wt/m^2. Temperature, soil organic carbon and soil total nitrogen apparently played an important role in regulating the nematode population.

Keywords. Soil nematode; forest ecosystem; importance value; diversity; organic carbon; nitrogen.

1. Introduction

Nematodes are an important consumer group in the decomposer subsystem of many ecosystems. Wasilewska (1970, 1971) in Poland, Yeates (1972, 1973) in Denmark and Johnson *et al* (1972, 1973, 1974) in USA have studied the soil nematodes in the forest ecosystems. However, knowledge on the ecology of soil nematodes from the forest ecosystems of India is non-existent. The results presented here on the diversity, distribution, population dynamics and biomass of soil nematodes of a tropical forest ecosystem in relation with climatic and soil factors are the first of its nature from India.

2. Study site

The study site forms part of Ushakothi National Wild Life Sanctuary located 60 km north-east of Sambalpur University Campus. The dominant tree in the forest site was *Shorea robusta* Gaertn. and during the rainy season there was a thick growth of seasonal plants like *Croton sparsiflorus* Morung., *Euphorbia hirta* L. and *Hygropilla spinosa* T. Anders etc. The soil was sandy clay loam and the pH was 5·82 in the top 10 cm soil.

The area experiences 3 seasons (rainy, winter and summer). The annual rainfall being 1290 mm of which 88% rain fell during the rainy season. The minimum air temperature varied from 10°C (December) to 45°C (May). The average relative humidity was minimum during April (46%) and maximum during August (84%). The soil moisture ranged from 3·5% (May) to 18·8% (August).

3. Methods

At the study site a plot of 121 m^2 in area was taken. Mostly samples were collected from December 1980 to March 1982. Each month 7 sample units were taken and divided into 5 subsamples: 0–5, 5–10, 10–15, 15–20 and 20–30 cm soil layers. The samples, each 10 cm^2 in area × 30 cm deep, were selected at random on a 1 × 1 m grid.

For extraction of soil nematodes, about 250 cm^3 of soil for each subsample was processed by Cobb's (1918) wet screening and then by modified Baermann funnel technique (Southey 1970). Senapati and Dash (1976) had observed that 90% of the total soil nematodes were recovered by this method. Mishra and Dash (1981) also had followed this method while studying the soil nematodes of the rice field and pasture of Sambalpur. Samples were kept for 24 h on the funnel. Nematodes recovered were classified into 4 ecological feeding groups (Banage 1963): (i) Plant parasites (PP), (ii) microbivores (MR), (iii) miscellaneous feeders (MS) comprising Dorylaimida-food varied and largely unknown, and (iv) predators (PR) mostly Mononchidae. Each month, after counting, the nematodes were fixed with hot FA 4:10. For the identification and biomass estimation permanent mounts were made from the fixed nematodes by glycerol ethanol method (Southey 1970). Total numbers of all the trophic groups/m^2 were calculated by taking all the subsamples of each layer into account. Maximum body width and length were measured for the biomass calculation as per Andrassy (1956). To assess the relationship of soil nematodes with soil nutrients, the total organic matter and total nitrogen content of all the soil samples were estimated respectively by muffle furnace method (Paine 1971; Reiners and Reiners 1972) and micro-kjeldahl method (Jackson 1973).

4. Results

4.1 *Diversity*

Table 1 shows the species diversity of the study site. *Rotylenchus* sp. was the dominant plant parasitic form found in every sample. *Hoplolaimus seinhorsti* Luc and *Hemicycliophora oostenbrinki* Luc were sometimes found in deeper soil layers in the rainy and winter seasons. Other plant parasitic species were seen occasionally.

The microbivores were very large in number and *Acrobeloides* sp. was dominant occurring in every sample decreasing with depth. Other microbivore species were mainly found in the upper soil layers. The miscellaneous feeders were abundant throughout the year and 6 species were identified. The predators were very few in number.

The importance value (IV) of the nematode trophic groups were calculated by the formula;

$$IV = \frac{Wa}{Wt} \times 100,$$

Table 1. Species diversity in the study site.

Nematode trophic group	
Plant parasitic forms	*Rotylenchus* sp. *Hemicycliophora oostenbrinki* Luc *Hemicriconemoides cocophilus* (Loos) Chitwood and Birchfield *Hoplolaimus seinhorstii* Luc *Orientylus* sp.
Microbivores	*Acrobeloides* sp. *Cephalobus* sp. *Acrobeles* sp.
Miscellaneous feeders	*Alimus* sp. *Dorylaimus* sp. *Eudorylaimus* sp. *Aporcelaimus* sp.
Predators	*Mylonchulus mulveyi* Jairajpuri *Mononchus dentatatus* Cobb *Coomansus indicus* Jairajpuri and Khan *Mononchus papillatus* Bastian *Nygolaimus* sp.

where Wa is the dry weight of a trophic group and Wt is the dry weight of all the trophic groups in the sampling plot.

The mean annual importance values of the miscellaneous feeders, plant parasites, microbivores and predators were 57·5, 22·5, 12·6 and 7·4 respectively.

The index of general diversity ($\bar{H}$) for nematodes were computed (Shannon and Weaver 1949). The index of diversity ranged from 1·41 (June) to 1·73 (February) indicating peak diversity in fauna in February.

4.2 *Distribution*

The cluster analysis (Norton 1978) during the period of maximum and minimum population density from various sampling plots showed that nematodes were aggregated than distributed uniformly or randomly (figure 1).

The plant parasites were abundant in the 0–15 cm layer only in winter. The microbivores were most abundant in the 0–5 cm soil layer and less in number below 5 cm throughout the year. The miscellaneous feeders were larger in size but decreased in number with the increase of depth or season.

The nematode population per m^2 for each month and for each soil layer are shown in figure 2. The nematode population ranged from 7·3 to 44·4 × $10^4/m^2$ in 0–5 cm soil layer, 3·8 to 14·4 × $10^4/m^2$ in 5–10 cm soil layer, 1·5 to 7·2 × $10^4/m^2$ in 10–15 cm soil layer, 0·8 to 4·1 × $10^4/m^2$ in 15–20 cm soil layer and 0·6 to 3·7 × $10^4/m^2$ in 20–30 cm soil layer. This indicated the decrease of total nematode numbers with increase of soil depth. The nematodes were mainly distributed in the upper 10 cm soil layer in all the seasons being 88 and 81% of the total nematodes during the maximum (November) and minimum (May) density of the year respectively. The mean annual nematode density was 3·6 times more in the 0–10 cm soil layer than the 10–30 cm soil layer.

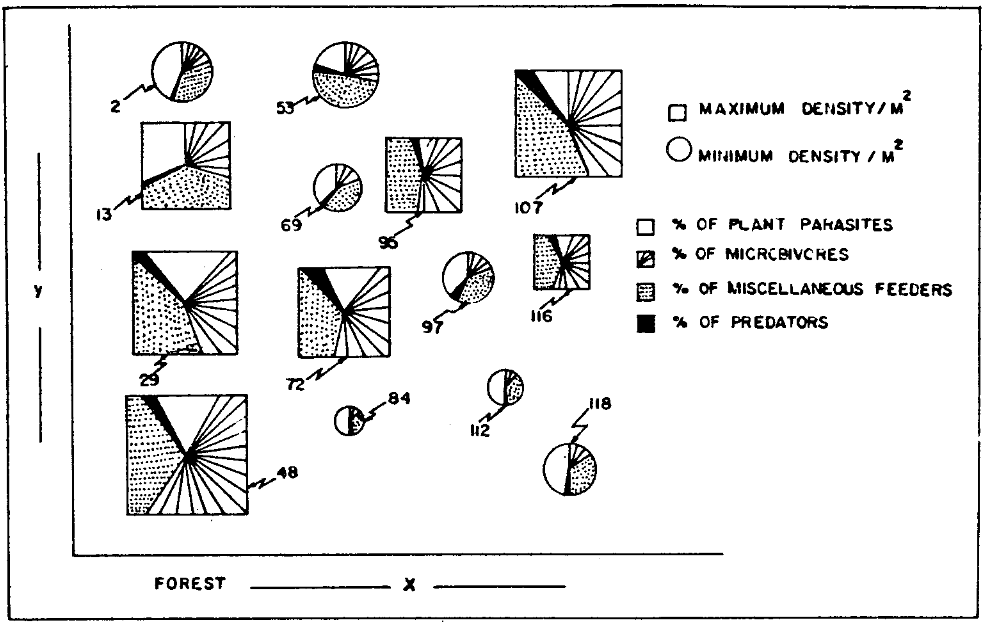

Figure 1. Ordination of 4 trophic groups of nematodes during maximum, and minimum population density. Squares and circle sizes depict abundance in study sites.

The total nematode density ranged from $15{\cdot}1 \times 10^4/m^2$ (May) to $66{\cdot}1 \times 10^4/m^2$ (November) during the study period. The population density increased gradually during rainy season reaching the peak density in winter and then declined gradually reaching minimum density in summer.

4.3 *Biomass*

For the determination of biomass, measurement of greatest body length and body width of 15 numbers of nematodes of each trophic group from different soil layers and different seasons were done. The average dry weights (μg) for plant parasite, microbivore, miscellaneous feeder and predator were 0·05, 0·02, 0·06 and 0·12 respectively. The average individual dry weight was 0·07 μg. The nematode dry weight biomass ranged from $9{\cdot}6$ mg/m^2 (May) to $37{\cdot}0$ mg/m^2 (November) with a monthly mean of $18{\cdot}86 \pm 8{\cdot}36$ mg/m^2. The maximum to minimum biomass ratio and maximum to average biomass ratio comes to about 4 and 2.

4.4 *Soil nutrients*

The organic carbon (4·2%) and total nitrogen (0·26%) increased after the commencement of rain in November and then gradually declined and reached minimum in May (3·3% and 0·1%). The nematode biomass showed a positive correlation with soil organic carbon ($r = +0{\cdot}53$) and soil total nitrogen ($r = +0{\cdot}64$) during sampling months (figure 3).

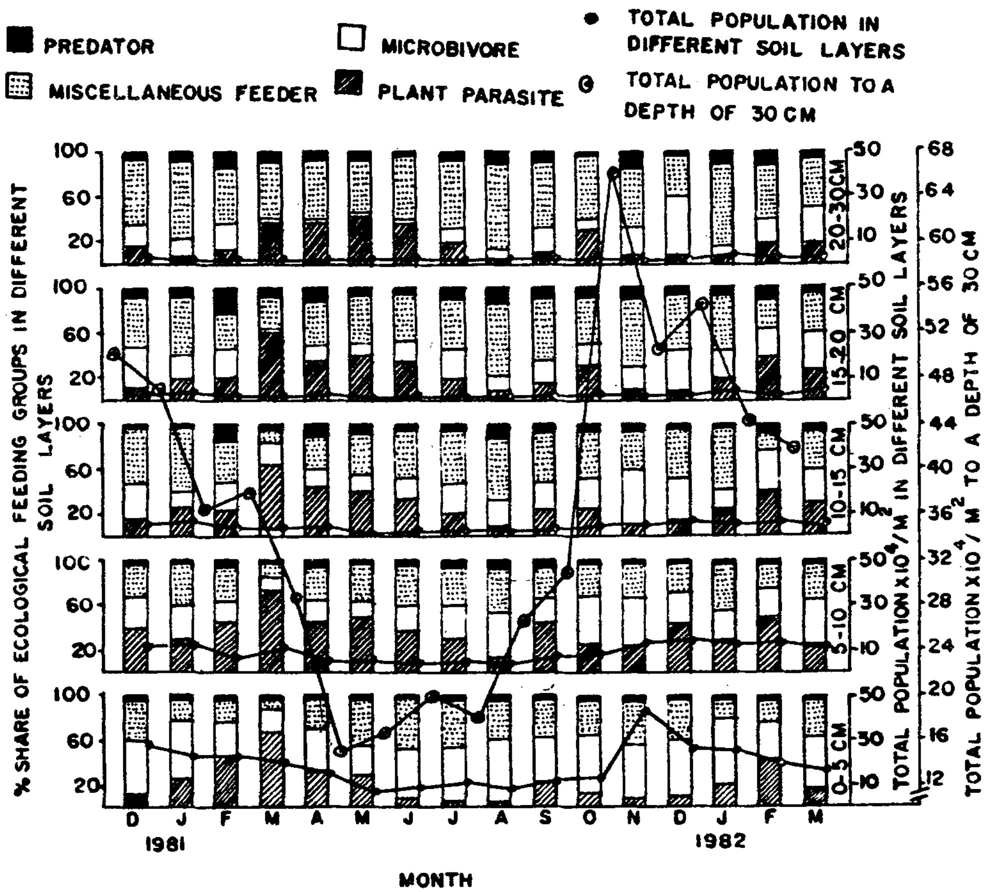

Figure 2. Population dynamics, biomass and per cent share of ecological feeding groups of nematodes in different soil layers of the study site.

5. Discussion

5.1 *Diversity*

The greater the fluctuations in species diversity of a community, the less is its stability (Mac Arthur 1955). The diversity index ranging from 1·41–1·73 does not show heavy fluctuations and indicates a stable community. In the forest, nematodes are mostly abundant in the decomposition zone, where there is greater microbial activity (Twinn 1974). The present finding is in agreement with Twinn's observation as the nematodes were comparatively more in the upper 0–10 cm layer containing high organic matter. This has also resulted in higher number of microbivores and miscellaneous feeders in the upper layer. *Shorea robusta* was the dominant tree of the study site. The less diversified understorey vegetation and accumulation of organic matter might have resulted in the occurrence of fewer plant parasitic species.

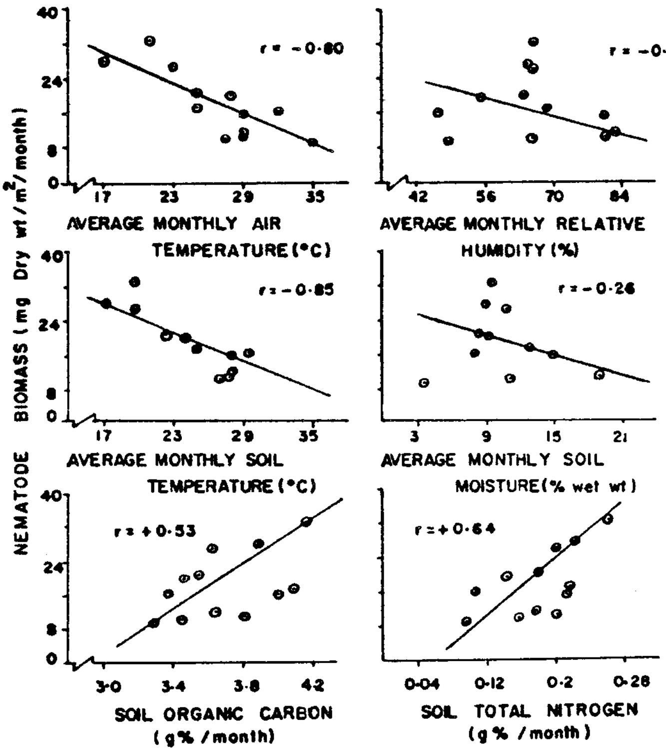

Figure 3. Correlation between environmental factors, soil nutrients and total nematode biomass of the study site.

5.2 *Density*

Nematode population densities varied from site to site. Based on the data of Petorson, Yeates (1979) had tabulated the average nematode population which was $3,900,000/m^2$ for tundra ecosystem, $1,919,000/m^2$ for 6 temperate grasslands, $423,000/m^2$ for a desert, $2,811,000/m^2$ for 9 deciduous forests and $56,000/m^2$ for a tropical forest. Population estimates ranged from 50,300 to $312,800/m^2$ and 40,000 to $215,900/m^2$ in the tropical rice field and pasture soil of India (Mishra and Dash 1981). In this investigation the population density ranged from 150,600 to $661,100/m^2$ which was more than other above reported tropical soils but very less when compared with other temperate soils. The ratio between maximum and minimum nematode density was around 4 and it was within the range reported in previous findings (Yeates 1979).

Previous studies indicate that changes in soil moisture and temperature are related with population changes. The decline in nematode abundance from November to May followed the increase in temperature and was correlated with a very dry period. During rainy season with increased soil moisture and moderate temperature recruitment to the fauna continued and the nematode population density reached peak in November when the temperature was low and soil moisture was moderate. Nematode biomass showed a significant negative correlation with soil temperature ($r = -0{\cdot}85$,

$n=12$, $P<0.01$) and air temperature ($r=-0.80$, $n=12$, $P<0.01$). This was in conformity with the findings of Mishra and Dash (1981). The nematode biomass was negatively correlated with relative humidity (%) and soil moisture (figure 3).

5.3 *Biomass*

The mean individual nematode dry weight of this study site was comparable with other temperate forest ecosystems (Yeates 1979) but very less than the tropical rice field and pasture of India (Mishra and Dash 1981). The proportionately higher number of microbivores with lower individual dry weight might have resulted in relatively lower biomass value in relation to population size for tropical soils.

5.4 *Nutrients*

Stockli (1952) suggested that nematode abundance is linked with readily decomposing organic substrate. The nematode abundance was dependent on the litter biomass (Dash and Pradhan 1984) due to greater variety of food source available, high organic matter, higher fungal biomass (Behera and Dash 1980) and bacterial biomass. The organic matter is important in nematode ecology (Norton 1978) and significant positive correlation exists between soil nematodes and soil organic carbon (%) (Yeates 1979). In the forest site the decomposing litter layer has resulted in altering the soil characteristic features like organic carbon and nitrogen, both of which are related to plant growth and essential for the growth of soil organisms.

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