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Community Structure and Habitat Specific Variations of Soil-Inhabiting Nematodes in the Forests of Gangotri National Park, Uttarakhand, India

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ABSTRACT: Studies conducted on soil-inhabiting nematode community structure in the forests of Gangotri valley in Gangotri National Park (GNP), Uttarakhand, yielded 57 genera belonging to eight orders. In terms of abundance of nematodes, Dorylaimida (30%) represented the most abundant order followed by Araeolaimida (21%), Rhabditida (17%), Tylenchida (13%), Monhysterida (11%), Aphelenchida (5%), Enoplida (2%), and Mononchida(1%).The trophic diversity exhibited the relative abundance of bacterivores (43%), which was the highest, followed by predators (21%), plant parasites (16%), fungivores (11%), and omnivores (9%). *Aporcelaimus* and *Discolaimus* were the most dominant genera among predatory nematodes, followed by bacterivorous nematodes *Plectus* and *Wilsonema*. Bacteriovorus nematodes were significantly positively related to Nitrogen (P=0.017), whereas total nematode diversity positively correlated with soil organic carbon, nitrogen and soil moisture content ($p<0.5$). Multivariate analysis showed that the areas with higher nitrogen, organic carbon and soil moisture had higher faunal diversity of bacterial and fungal feeders. Low channel Index (0.52±0.08) showed the bacterial decomposition pathway in the region. High nematode diversity (2.80± 0.09), Structure Index (74.88±3.02), and Maturity Index (2.6±0.08) indicated that the soil of GNP was less disturbed, structured, and mature. The results provided preliminary data on the ecological aspects of soil-inhabiting nematodes which can be used to assess soil health status in the high-altitude forests of GNP. The baseline data on nematode community structure in the region can also be utilized as a tool to understand and compare the soil health status in long term biomonitoring studies in the Indian Himalayan Region.

Keywords: Nematode community structure, Soil health, Gangotri National Park, Uttarakhand, India

Soil nematode community and their structural changes have been considered as a potential tool for assessing soil conditions, above-ground vegetation and biomonitoring system (Bongers, 1999; Ritz & Trudgill, 1999), as they respond rapidly to disturbance and enrichment (Korthals *et al.*, 1996, Tenuta & Ferris, 2004). In soil, nematodes have direct contact with their microenvironment and occupy key positions in soil food webs (Neher, 2001). They feed on various soil organisms and are food for many others, influencing vegetation succession. Soil nematodes play important roles in crucial ecological processes in the soil such as maintenance of food web, maintenance of microbial biomass, and dispersal of both the organic matter and the decomposers. Bacterial and fungal-feeding nematode liberates nitrogen when it feeds on it's prey groups and is thus responsible for much of the Nitrogen available to plants (Ingham *et al.*, 1985). The abundance of various nematode species in the soil system transfigured into ecological indices and parameters can be used to assess soil health status, disturbance level, and decomposition pathway (Gomes *et al.*, 2003).

Characterization of soil nematode community of high-altitude wilderness area can provide a glimpse of current micro-environmental conditions. We need to have the baseline data and thorough knowledge of soil-inhabiting nematode community structure for their utilization in long-term monitoring and to understand the soil health of the region. The present study was undertaken to study community structure of soil-inhabiting nematodes, in context with soil physicochemical properties, in high altitude forest of Gangotri valley, in Gangotri National Park, within the elevational range of 3000m-4000m.

MATERIAL AND METHODS

Soil samples were collected from the elevational range of 3000-4000 m, in the high altitude region of Gangotri valley of GNP, following a stratified random sampling design. At each stratum, one to three sampling sites were selected randomly. A total of seventeen sites were sampled; at each site, four to five subsamples were collected and mixed into a composite sample. Samples were collected from 10-20 cm depth, using soil auger of diameter 3cm (Rizvi, 2008). Vegetation comprised Himalayan Birch (*Betula utilis*) and subalpine mixed conifer forests, with West Himalayan Fir (*Abies pindrow*), Deodar (*Cedrus deodara*) and Blue Pine (*Pinus wallichiana*) being the dominant species. Samples were tagged and brought to the laboratory for further processing. Nematodes were extracted by sieving and decantation (Cobb, 1918) method, were counted and identified up to generic level and were allotted to respective trophic groups (Yeates *et al.*, 1993) and colonizer-persister groups, based on Bongers (1990).

Soil parameters such as soil pH, soil moisture, organic carbon, nitrogen, potassium, phosphorus and soil texture were analyzed in the laboratory by using standard protocols. The soil pH was determined in 1: 2.5, soil: water ratio, using the pH meter with glass electrodes; electrical conductivity (µSc m-1) was determined by the method of Jackson (1973). Organic carbon and total nitrogen in the soil was estimated by the methods suggested by Walkley and Black (1934) and Kjeldahl (1883). $NaHCO_3$ extractable P was analyzed by spectro-photometer (Olsen *et al.* 1954), and ammonium acetate extractable K was examined by a flame photometer (Hanway and Heidel, 1952).

Community analysis and Diversity Indices (Norton, 1978; Tomar *et al.* 2006):

Frequency N: Frequency of nematode genus, i.e. the number of samples in which the genus was present. Absolute frequency (AF): (Frequency of the genus) / total number of samples counted X 100. Mean density (D): Number of nematode specimens of the genus counted in Samples / total number of the samples collected. Relative density (RD) %: Mean density of the genus / Sum of the mean density of all nematode genera X 100.

Various indices were calculated: Shannon's diversity H'-Σ pi ln pi; Maturity indices were calculated based on c-p values assigned to different genera of soil nematodes (Bongers, 1990); PPI- Plant-parasitic nematodes ; Nematode Channel Ratio NCR - B/B+F; Enrichment index (EI) - (e/e+b) x100, Structure index (SI) - (s/s+b) x100 and Channel ratio (CI) to understand the dynamics of soil food web where Pi - proportion of individual of Taxon I in the total population; b, e & s represents sum products of assigned weights & number of individuals of all genera.

Spearman correlation coefficient and it's significance at $P<0.05$ level among various soil physicochemical parameters, trophic group and various nematode orders were calculated. Principal Component Analysis (PCA) was carried out to establish the relations between soil physicochemical properties, nematode genera distributions and the elevations of the sampling locations using the R statistical platform.

RESULTS

A total of 57 genera, belonging to eight orders were identified from the Gangotri valley of GNP (Table 1). Bacterivores (44%) represented the highest generic diversity, followed by predators (19%), plant parasites (18%), omnivores (12%), and fungivores (7%). Based on individual abundance, bacterivores represented the highest abundance (49%), followed by predators 15%, omnivores 14 %, plant parasite 13%, and fungivores 9%. In terms of abundance of nematodes, the order Dorylaimida (30%) represented the most abundant order followed by Araeolaimida (21%), Rhabditida (17%), Tylenchida (13%), Monhysterida (11%), Aphelenchida (5%), Enoplida (2%), and Mononchida (1%). While in terms of frequency, the order Dorylaimida was most

Table 1 Population structure of soil-inhabiting nematodes in Gangotri valley.

Genera	c-p	Frequency N	AF%	MD	RD%
Bacteriovore					
Acrobeles	2	13	76.47	9.41	5.55
Acrobeloides	2	12	70.59	6.18	3.64
Alirhabditis	1	1	5.88	0.06	0.03
Cephalobus	1	6	35.29	1.41	0.83
Cervidellus	2	3	17.65	1.76	1.04
Chiloplacus	2	11	64.71	3.24	1.91
Cryptonchus	4	1	5.88	0.06	0.03
Eucephalobus	2	3	17.65	0.53	0.31
Pseudacrobeles	2	9	52.94	1.41	0.83
Stegelletina	2	7	41.18	1.82	1.08
Plectus	2	14	82.35	10.29	6.07
Anaplectus	2	5	29.41	0.76	0.45
Ceratoplectus	2	9	52.94	3.29	1.94
Cylindrolaimus	3	12	70.59	6.12	3.61
Prismatolaimus	3	11	64.71	18.41	10.86
Rhabdolaimus	2	6	35.29	1	0.59
Wilsonema	2	14	82.35	11.65	6.87
Teratocephalus	3	8	47.06	3	1.77
Mesorhabditis	1	5	29.41	0.76	0.45
Monhystera	1	5	29.41	0.65	0.38
Nothacrobeles	1	6	35.29	0.94	0.56
Panagrolaimus	1	3	17.65	0.35	0.21
Protorhabditis	1	1	5.88	0.06	0.03
Rogerus	2	4	23.53	0.82	0.49
Tylocephalus	2	1	5.88	0.06	0.03
Fungivore					
Aphelencus	2	9	52.94	2.82	1.67
Aphelencoides	2	12	70.59	5.59	3.3
Tylenchus	2	8	47.06	4.12	2.43
Tylencholaimus	4	11	64.71	1.06	0.62
Axonchium	5	9	52.94	1.12	0.66
Herbivore					
Basiria	2	6	35.29	1.65	0.97
Coslenchus	3	3	17.65	2.12	1.25
Helicotylenchus	3	9	52.94	2.35	1.39
Hemicycliophora	3	9	52.94	3	1.77
Hoplolaimus	3	10	58.82	3.06	1.8
Merlinius	3	3	17.65	1.24	0.73
Paratylenchus	3	4	23.53	1.71	1.01
Pratylenchus	2	3	17.65	1.18	0.69
Tylenchorynchus	3	10	58.82	2.82	1.67
Dorylaimellus	5	11	64.71	2.41	1.42
Omnivore					
Campydora	4	3	17.65	0.47	0.28
Eudorylaimus	4	13	76.47	9.59	5.66
Moshajia	4	14	82.35	4.59	2.71
Oriverutus	4	3	17.65	0.71	0.42
Thornenema	4	13	76.47	2.41	1.42
Dorylaimoides	4	10	58.82	3.88	2.29
Dorylaimus	4	9	52.94	2.59	1.53
Predator					
Actinolaimus	4	14	82.35	3.41	2.01
Aporcelaimellus	5	14	82.35	5.18	3.05
Aporcelaimus	5	15	88.24	4.71	2.78
Clarkus	4	4	23.53	0.65	0.38
Coomansus	4	3	17.65	0.47	0.28
Discolaimus	5	15	88.24	6.41	3.78
Discolaimoides	5	11	64.71	2.88	1.7
Mylonchulus	4	1	5.88	0.12	0.07
Prionchulus	4	4	23.53	0.35	0.21
Tripyla	3	6	35.29	0.82	0.49

frequent (26%) with 15 genera, followed by Rhabditida (23%) with 13 genera. The Tylenchida, though less abundant, showed greater diversity (18%) with ten genera, than Araeolaimida (12%) with seven genera; five genera represented Mononchida (9%), three genera represented Enoplida (5%), Monhysterida (4%), Aphelenchida (3%) with two genera.

Aporcelaimus and *Discolaimus* were the most dominant genera among the predators, with the highest frequency of occurrence, 88.24% and RD 4.71 and 6.41% respectively, followed by *Plectus* and *Wilsonema,* with the frequency of occurrence, 82.35% while *Cryptonchus, Tylocephalus*, and *Alirhabditis* were found to be rare, with a frequency of occurrence, 5.88% and RD 0.03%. Among the predators, *Mylonchulus* was recorded as a rare genus (N-1 and AF-5.88%).*Plectus* and *Wilsonema* were the most dominant genera among the bacterivorous with the highest frequency of occurrence, 82.35 % and RD 6.07and 6.87% respectively, while *Cryptonchus* was the rarest, with a frequency of occurrence, 5.88% and RD 0.03%. Among plant parasite, *Dorylaimellus* was the most dominant genus (N-11, AF- 64.7%), while *Pratylenchus, Merlinius,* and *Coslenchus* were the least common (N-3, AF-17%). The most frequent genus among fungivores was *Aphelencoides* (N-12, AF-70%) and least was *Tylenchus* (N-8). *Moshajia* was the most dominant genus in omnivores (N-14, AF- 82%) whereas *Campydora* was the least frequent (N-3) (Table 1).

The trophic relationships among soil-inhabiting nematodes (Table 2)

The trophic relationships among the nematodes were evaluated by the following parameters:

Frequency: Omnivores were found to be the most frequent trophic group in the community with N-9.3 (coefficient of variation CV-49.46% and AF-54 CV-50.59%). Fungivores were quite frequent trophic group in the community with N-9 (CV-20%), followed by predators with N-8.7 (CV-65.5%) and AF-51.2 (CV-65.7%); Bacterivorous with N-6.8 (CV-61.7%) and AF-40 (CV-62.7%) and plant parasites with N-6.6 (CV-48.48%) and AF-38.8 (CV-49.05%).

Density: Omnivores were the most dominant feeders in the entire community of GNP forest, D-3.5; CV-88.57% and D-2.0; CV-90%, followed by bacterivores D-3.36; CV-133%, whereas the least dominant group was plant parasites with D-2.1; CV-33% and relative density RD-1.2; CV-33%.

Table 2. Community relationship between different trophic groups

Value	Predators	CV%	Bacteriovors	CV%	Plant Parasites	CV%	Omnivores	CV%	Fungivores	CV%
N	8.7± 1.77	65.5	6.8± 0.85	61.76	6.6± 1.05	48.48	9.3± 1.75	49.46	9± 0.84	20
AF%	51.2±10.45	65.7	40± 5.03	62.75	38.8± 5.89	49.05	54± 10.33	50.59	52.9± 4.92	20.79
MD	2.5± 0.74	84	3.36± 0.90	133.93	2.1± 0.22	33.33	3.5± 1.17	88.57	2.9± 0.87	67.24
RD%	1.5± 0.44	80	1.98± 0.53	131.31	1.2± 0.13	33.33	2.0± 0.69	90	1.7± 0.51	67.64

Table 3. Correlation coefficients and their significance p< 0.05 level between trophic groups with various soil physicochemical parameters

	pH	EC	N	P	K	SM	OC	B	F	PP	O	PR	Nem
pH		0.282	0.468	0.918	0.674	0.333	0.926	0.626	0.771	0.359	0.078	0.461	0.112
EC	0.28		0.498	0.436	0.305	0.633	0.328	0.009**	0.017*	0.081	0.014*	0.089	0.400
N	0.19	-0.18	1	0.381	0.580	0.009	0.000	0.015*	0.981	0.989	0.557	0.344	0.010*
P	-0.03	-0.2	-0.23		0.046	0.355	0.376	0.580	0.679	0.929	0.447	0.404	0.863
K	-0.11	-0.26	0.14	0.49		0.715	0.451	0.808	0.509	0.951	0.471	0.061*	0.198
SM	0.25	0.12	0.61	-0.24	-0.1		0.009	0.236	0.186	0.300	0.121	0.211	0.020*
OC	0.02	-0.25	0.92	-0.23	0.2	0.61		0.014*	0.669	0.506	0.593	0.377	0.012*
B	0.13	-0.61	0.58	-0.14	-0.06	0.3	0.58		0.944	0.344	0.583	0.209	0.141
F	0.08	0.57	0.01	-0.11	-0.17	0.34	0.11	-0.02		0.021	0.040	0.201	0.046
PP	0.24	0.44	0	0.02	-0.02	0.27	0.17	-0.24	0.55		0.004	0.323	0.137
O	0.44	0.58	0.15	0.2	0.19	0.39	0.14	-0.14	0.5	0.66		0.021	0.001
PR	0.19	0.43	0.24	0.22	0.46	0.32	0.23	-0.32	0.33	0.26	0.55		0.013
Nem	0.4	0.22	0.6	0.05	0.33	0.56	0.59	0.37	0.49	0.38	0.73	0.59	

SM-Soil moisture; OC-Organic carbon; B-Bacterial feeders; F-Fungal feeders; PP-Plant parasitic; O-Omnivorous; PR-Predators

Table 4. Relationships between nematode trophic group and indices in high altitude forest of Gangotri valley (significance p<0.5 level)

	MI	H.	EI	SI	B	F	PP	O	PR
MI		0.020	0.178	0.010	0.073	0.444	0.211	0.459	0.028*
H'	-0.56		0.127	0.926	0.765	0.110	0.0004***	0.027*	0.807
EI	-0.34	0.38		0.941	0.434	0.001**	0.071	0.445	0.881
SI	0.6	0.02	-0.02		0.0003***	0.669	0.145	0.094	0.0012**
B	-0.45	0.08	-0.2	-0.76		0.944	0.344	0.583	0.209
F	-0.2	0.4	0.73	0.11	-0.02		0.022	0.040	0.201
PP	-0.32	0.76	0.45	0.37	-0.24	0.55		0.004	0.323
O	0.19	0.53	0.2	0.42	-0.14	0.5	0.66		0.021
PR	0.53	-0.06	-0.04	0.72	-0.32	0.33	0.26	0.55	

MI-Moisture index; H'-Shannon's Index; EI-Enrichment index; SI-Structure index; B-Bacterial feeders; F-Fungal feeders; PP-Plant parasitic; O-Omnivorous; PR-Predators

The soil in the park was sandy loam and acidic (5.57±0.08). The mean soil Nitrogen, Phosphorus, and Potassium contents were calculated as 0.311±0.01%, 0.697±0.1%, and 0.142±0.09 % respectively. The population of Dorylaimida showed a positive significant correlation (P =0.04) with MI and a high degree of correlation with the Structural index (P<0.01), while Rhabditida showed a significant negative correlation with Structural index. Araeolaimida also showed a significant positive correlation with the structural index (P < 0.05) (Fig. 1), and no correlation with other indices. In terms of the trophic group, bacterial feeders showed a negative correlation with EI and SI, while predators showed a positive correlation with MI (P<0.05). The predator showed a positive correlation with MI, but it was not significant (Table 4). Bacterial feeders showed a significant negative correlation with electric conductivity, while a positive correlation with Nitrogen and soil organic carbon; whereas fungal feeders and omnivores showed a significant positive correlation with electric conductivity. The population of all the feeders showed a significant correlation with total nitrogen, soil organic carbon, and soil moisture (Table 3).Various indices were calculated to understand the nematode community dynamics; the maturity index (MI) ranged from 2.60±0.08 (2.25-3.46), Plant parasitic index varied from 3.09 ± 1.02(1.90 – 4.86) and Shannon Diversity Index (H') varied from 2.80± 0.09 (2.18-3.64). The enrichment index (EI) and

Table 5. Summary of nematode diversity indices of Gangotri Valley

Indices	Values
MI-Maturity index	2.60±0.08 (2.25-3.46)
H'-Shannon's index	2.80± 0.09 (2.18-3.64)
NCR-Nematode control ratio	0.86±0.03 (0.42-0.98)
PPI-Plant parasitic nematodes	3.09 ± 1.02(1.90 – 4.86)
EI-Enrichment index	28.71±3.36 (3.50-49.36)
SI-Structure index	74.88±3.02 (54.99-94.40)
CI-Channel ratio	0.52±0.08 (0.02-1)
Simpson Index	0.9±0.011 (0.81-0.97)
Inverse Simpson	13.5±1.61 (5.27-31.88)
Dorylaimida%	28.95±3.73 (8.74-61.78)
Rhabditida%	17.56±2.50 (1.96-36.17)
Tylenchida%	12.16±2.59 (0-35.73)
Araeolaimida%	22.71±4.05 (0.81-56.31)
Aphelenchida%	5.3±1.87 (0.69-30.10)
Monohysterida%	10.59±2.88 (0.68-33.98)
Others%	2.6±0.70 (0.50-8.33)

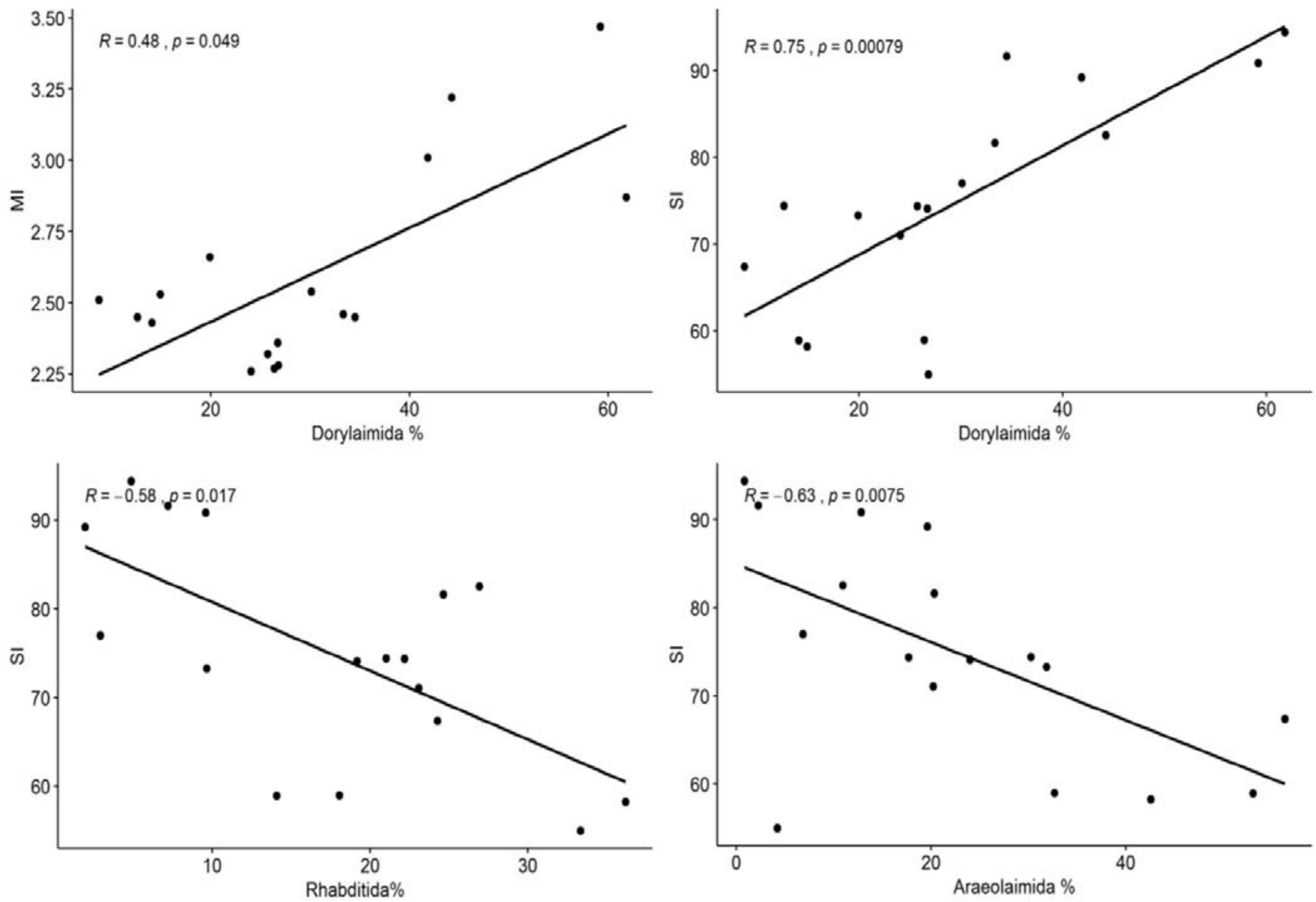

Fig. 1. Relationships between different nematode groups and indices in high altitude forest of Gangotri valley of GNP, Uttarakhand

the structure index (SI) ranged from 28.71±3.36 (3.50-49.36; 74.88±3.02 (54.99-94.40) respectively (Table 5).

The principal component analysis (Fig. 2) explains 43.8% of the variation. The first axis explains 27.8 % and 16% is defined by the second axis. The study showed that the plots with higher nitrogen, organic carbon, and soil moisture are associated with higher faunal diversity of bacterial and fungal feeders and also with the occurrence of genera, *Nothacrobeles, Axonchium, Dorylaimus*, and *Pseudacrobeles*. Omnivores and predators were highly contributing feeders. The analysis also highlighted that the majority of genera showed a negative relation with elevation.

DISCUSSION

Bacterial feeders dominate in the study area, followed by predators and plant-parasites. Dorylaimida was found to be the most abundant group, indicating fewer disturbances in the region. These results are in agreement with the findings of other studies on soil nematode community structure in forest areas (Johnson *et al.*, 1972; Thomas, 1978; Sohlenius and Wesilewska, 1984; Neher *et al.*, 2005). Dorylaimida, in any nematode community of an area, is sensitive to disturbance, whether it is agricultural practices such as ploughing, fertilizers, and pesticides, or other natural or anthropogenic disturbance; it therefore acts as an indicator of

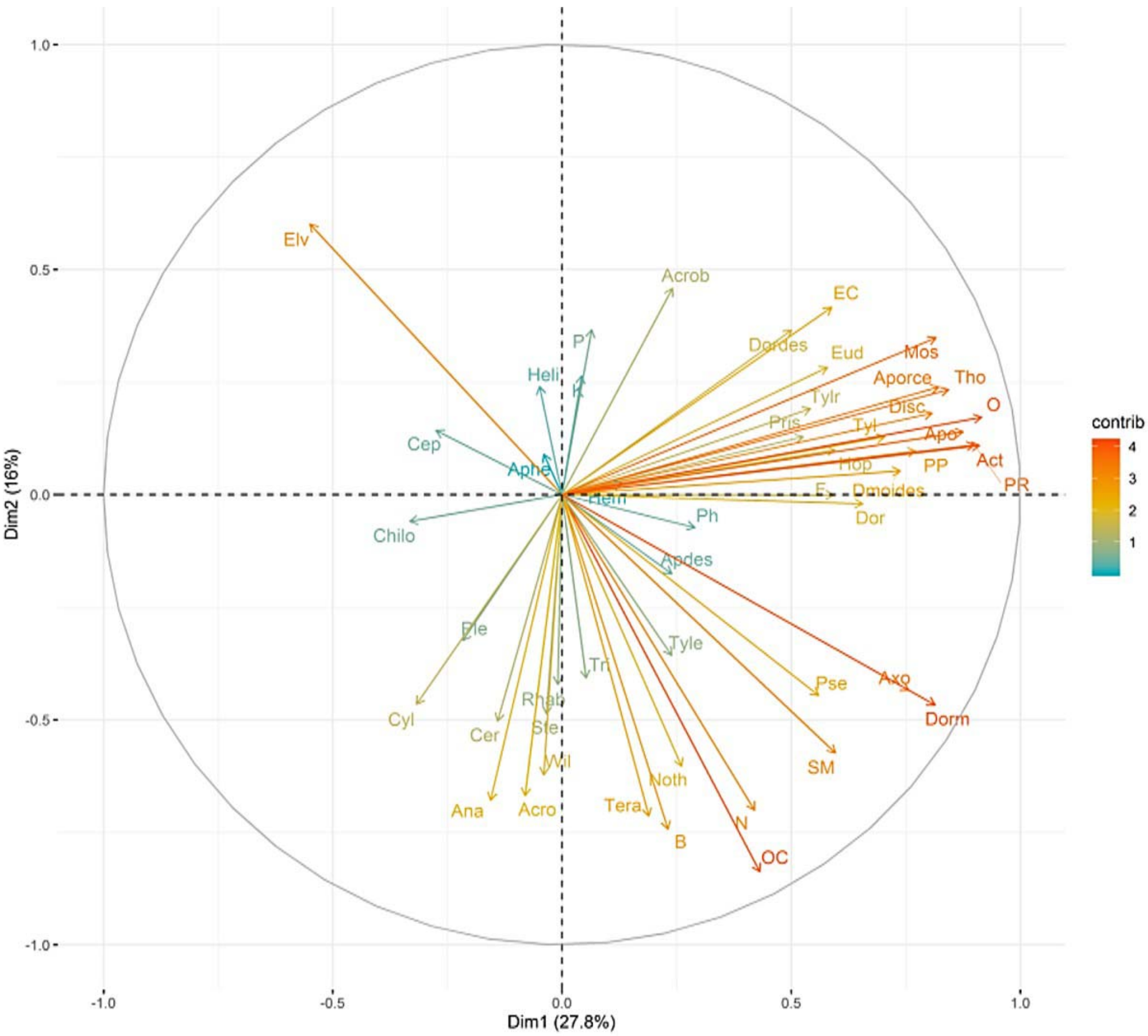

Fig. 2. Principal Component Analysis (PCA) on soil parameters and nematode data. Environmental variables and nematode genera's are marked by arrows. Percentage of variance explained was 27.8% & 16% for Dim 1 and Dim 2 respectively

environmental disturbances. Bacterial decomposition pathway recorded in the study area attributes to less acidic to slightly neutral pH ranges, from 5.22 to 6.02, indicating good soil fertility which might relate to soil organic matter turnover in the area (Porazinska *et al.*, 1999; Popovinci and Ciobanu, 2000). Though no particular pattern of acidity was established with elevation, it was found that higher elevation areas contain more acidic soil, which conforms to the findings of Kumar *et al.* (2019).

Soil nutrient dynamics negatively correlated with elevation in Gangotri. Soil organic carbon, nitrogen, and soil moisture positively correlated with soil nematode diversity; organic carbon and soil moisture were also closely related to microfauna, as well as with Nitrogen (Table 3). Bacterivorous nematodes are known to be more active than fungivorous nematodes (Ferris *et al.*, 2004; Ingham *et al.*, 1985) and they provide an important ecosystem service by playing a crucial role in Nitrogen mineralization processes in soil. Further, bacterivorous nematodes were found to be positively related to Nitrogen, which conforms to the findings of Ou *et al.* (2005); Moreno *et al.* (2006) and Devetter *et al.* (2017).

The stability of the environment can be assessed by evaluating different indices like Maturity Index and Shannon diversity index. The maturity index (2.60±0.08) was calculated to assess the disturbance in the forest ecosystems (Table 5), based on c-p values assigned to various feeders. MI values depict the levels of a disturbance where value ranges from >2.0 in nutrient-rich disturbed systems to ±4.0 in a pristine undisturbed environment (Bongers and Ferris, 1999). Shannon diversity index varies with different habitats (crops, pasture, forests, etc); in the present study, the diversity index ranged between 2.18-3.64 (2.80± 0.09). The high MI and Shannon diversity index indicate a stable soil habitat. The results are in agreement with similar studies in the Beskydy Mountains spruce forests and Mountains of Vihorlat (Hánìl, 1996; Hánìl and Èerevková, 2010) and other studies on nematode (Odum, 1969; Hánil, 1995; Bongers and Ferris, 1999).

Further, the dynamics of soil food web and stability of ecosystem can be studied through various food web indices like Channel Index, Enrichment index, and Structural Index (Ferris *et al.*, 2001). In the present study, the value of SI (74.88±3.02) was high and conforms to similar studies by Ferris *et al.*, (2001) and Berkelmans *et al.*, (2003). The higher value of SI shows more trophic linkages due to the high abundance of predators and omnivores compared to other feeders in the soil system (Ferris &Matute, 2003). Enrichment Index showed that the region was moderately enriched (EI- 28.71±3.36), while Channel index (0.52±0.08) was low, which depicts that bacteriovores dominated decomposition of organic matter in the soil.

Plant parasite index (PPI) indicates the plant feeder nematodes resources, whether the soil community is undisturbed (High PPI) or disturbed (low PPI) (Bongers, 1999). In the present study, the value of PPI (3.09) depicted fewer disturbances in the study area which agrees with the previous study (Bongers *et al.*, 1995). All these indices suggest that different soil-inhabiting nematodes species composition can be used for maintaining structured and stable soil food web.

Diversity and abundance of Dorylaimida, Rhabditida, and Araeolaimida play crucial role in assessing the major nematode specific indices as they are present in various trophic groups in the soil ecosystem. Trophic group correlation with soil physicochemical properties provided the insight in nematode functional guild to understand the soil food web dynamics. Total nitrogen, soil organic carbon, and soil moisture were found to be important soil parameters related to various nematode trophic groups. The high affinity between soil physicochemical characteristics and abundance of nematodes in a different ecosystem, has been used as criteria to assess soil health and to understand the dynamics of food webs. It is a powerful tool to understand the soil status and its complexity in any ecosystem. As can be seen from the above results, the naturally forested region of the high altitude of the Gangotri valley of GNP has less disturbed, structured food web and mature ecosystem.

Nematodes are considered the most promising faunal group among soil organisms, as bioindicators of soil health status. As discussed above, it can be concluded that the natural forest of the Gangotri valley of GNP has mature, less disturbed, and structured soil ecosystems which are supported by various indices of soil-inhabiting nematode community structure. The results also highlight the importance of soil as habitat of nematodes and their significance as indicators of climate change. The less disturbed forest is favoring the bacterial decomposition pathway and harboring high soil-inhabiting nematode diversity. The baseline data generated in the present study on nematode community structure can be used for future studies in the assessment of soil health status by the application of various indices. The results can also be utilized to understand and compare the soil health status in long term monitoring studies, in the high altitude forest of Indian Himalayan Region.

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