

Observation on the Trophic Groups of Soil Nematoda (Dorylaimida) and their occurrence in Four Wildlife Sanctuaries of West Bengal, India

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ABSTRACT

An attempt has been made to investigate the occurrence of soil-inhabiting Nematoda in respect to their feeding habits of the order Dorylaimida in four small wildlife sanctuaries (WLS), situated in four districts of southern part of West Bengal, India. 19 species of Dorylaimida have been reported from the forest ecosystem of Ballavpur WLS, Birbhum district, 13 species from Ramnabagan Wildlife Sanctuary (commonly known as Bardhaman Zoo Garden), Bardhaman district, 17 species from Bethuadhari Wildlife Sanctuary, Nadia district and 20 species from Bibhutibhusan Wildlife Sanctuary, North-24-parganas district of West Bengal. Soil nematodes play a crucial ecological role in providing ecosystem services like decomposition of soil organic matter, nutrients cycling, and mineralization of soil substances to sustain a healthy soil ecosystem. This process supports growth of plant by ensuring an available food supply. To understand this better, feeding habits and trophic groups with a comparative study of the feeding guilds up to species level have been done in four different forest ecosystem. The feeding guild abundance with the inter-sanctuary hierarchy in 52 species from nine different feeding groups have concluded on a diversified feeding practice rather than depending on a specific diet. The Principal component analysis of the nematode species in lieu of similarity in their trophic groups distributed in each WLS explores the nature of the trophic pattern.

Key words: Dorylaimida, Feeding habit, Nematoda, West Bengal, Wildlife sanctuaries.

JEL classification number: Q00

Mathematics Subject Classification: 6202, 6502

1. Introduction

Nematoda is a primitive group of invertebrate metazoans and ranks among the most abundant and diverse animals on Earth. They occupy a wide range of habitats, may be terrestrial, aquatic or marine. Nematodes of the order Dorylaimida are terrestrial soil inhabitants, although some species can also be found in aquatic habitat. They can be categorized into different feeding groups like free-living, omnivore, plant feeder, bacterivore, hyphal feeder, predatory etc.¹. They have since been classified into microbial feeders, predators, and parasites based on their various feeding apparatus and methods, including piercing, sucking, crushing, scraping, processing and ingesting². Soil nematodes play important role in soil microhabitat. They contribute to the decomposition of soil organic matters,

promoting plant growth by facilitating nutrient cycling, which can be viewed as an ecosystem service offered by these microorganisms. They are also significant soil indicator for maintaining the soil health³. These important ecosystem services have established them as one of the key indicators for sustaining a healthy soil ecosystem⁴. The present study was conducted in four small wildlife Sanctuaries located in different districts of southern West Bengal. Those are Ballavpur wildlife Sanctuary, Birbhum district having an area of 200 hectares (2sq. km.) with the geographical location 23.6850°N & 87.6530 °E, Ramnabagan wildlife Sanctuary commonly known as Bardhaman Zoo Garden, Bardhaman district has an area of 14.31 hectares (0.1432sq. km.) located at 23.2529°N & 87.8509°E, Bethuadhari wildlife Sanctuary, Nadia district is with an area of 67 hectares (0.67sq. km.), located at 23.5816°N & 88.4031°E and the area of Bibhutibhusan wildlife Sanctuary, North-24-parganas district is 86 hectares (0.86 sq. km.) with geographical coordinates 23.1861°N & 88.7620°E. The locations of these wildlife sanctuaries have been shown in figure 1. In the present study 19 species of Dorylaimida have been documented in the forest ecosystem of Ballavpur WLS, as well as in the agro-ecosystem nearby or within this protected area, 13 species from Ramnabagan WLS, 17 species from Bethuadhari WLS, Nadia district and 20 species from Bibhutibhusan WLS, West Bengal, India.

While significant research has been conducted on the dorylaimid fauna of West Bengal, no studies have been carried out in the protected areas examined in this study. Various nematologists conducted comprehensive studies on Dorylaimida to describe and report nematode species from the districts included in the present study⁵⁻¹⁶. Chaturvedi & Khara reported some nematode species associated with jute crop in West Bengal including Bardhaman and Nadia districts¹⁷. 119 species of Dorylaimida in different districts of West Bengal was compiled and recorded¹⁸. Nematode pests of crops across various districts of West Bengal, including those involved in the current study, identifying *Xiphinema index*, *X. insigne*, *X. americanum*, *Longidorus* spp. and *Paralongidorus citri* as the plant-feeding pest organisms was investigated¹⁹.

2. Material and Methods

For the present study, soil samples were collected from forest ecosystem of Ballavpur, Ramnabagan, Bethuadhari and Bibhutibhusan Wildlife Sanctuaries. Soil samples of about 500gm were taken from the rhizospheric zone of various plants from forest ecosystem with the help of a scooping hand-shovel. Geographical co-ordinates of each of the sampling sites were recorded by a GPS (Garmin GPS72H). At the time of collection, the collection data were kept. The collected soil samples were processed by 'Cobb's sieving and decantation technique'²⁰ followed by 'modified Bearmann's funnel technique'²¹ for extraction of nematodes. The extracted nematodes were killed and fixed instantly in their characteristic body posture by Seinhorst's method in hot Formaldehyde-acetic acid (f. a. 4:1) solution²². These were kept in glycerine-alcohol solution inside a desiccator for dehydration of the nematode specimens. After complete dehydration, permanent slides were prepared to examine and identify the nematodes using a Nikon Eclipse Ni microscope. Whittaker plot and Heatmap dendrogram cluster analysis were done using R 4.4.1. The Principal Component Analysis and the plot for the same has been done in PAST4.06b. The locality plot of the four wildlife sanctuaries was

created using QGIS software, utilizing a land use and land cover (LULC) map from the Bhuvan geo platform (an Indian geo-portal) with a resolution of 10 meters (Fig. 1).

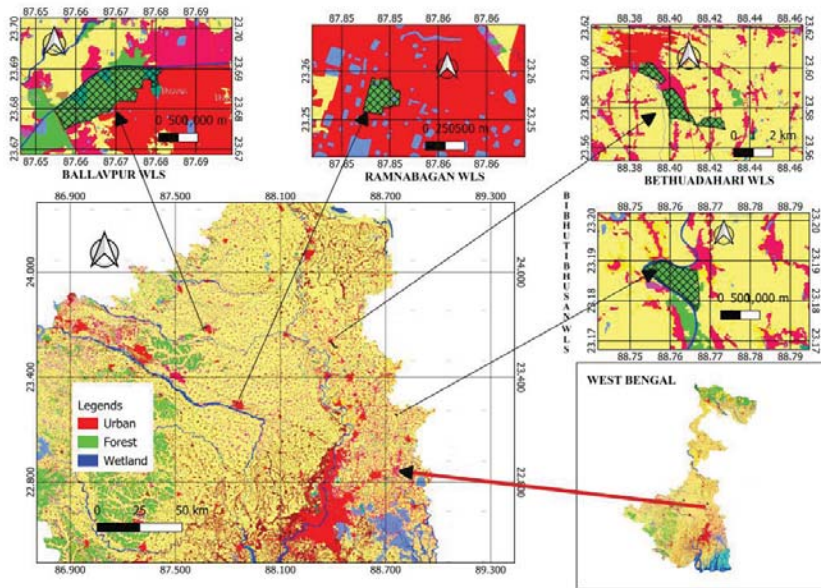


Figure 1. Locality Map of the Four Wildlife Sanctuaries (Land Use Land Cover) showing the locations of Ballavpur, Bibhutibhusan, Bethuadahari and Ramnabagan Wildlife Sanctuaries.

3. Results

The taxonomic investigation indicated the presence of the nematode species under the order Dorylaimida and their feeding habits or trophic groups were recorded in the four wildlife sanctuaries, on the basis of previous studies¹⁻² as shown in table 1.

Feeding Rank Abundance: A total of 330 specimens of order Dorylaimida have been identified up to species level from the area of study. 134 specimens under 19 species from Ballavpur WLS, 57 specimens under 13 species from Ramnabagan WLS, 77 specimens under 17 species from Bethuadahari WLS and 62 specimens under 20 species from Bibhutibhusan WLS have been identified and the feeding habits were recorded. The abundance of omnivorous feeding group from Ballavpur Wildlife sanctuary (0.42) is the highest followed by the omnivorous group of Bethuadahari Wildlife sanctuary (0.35) as the occurrence of the species with omnivorous feeding habit is recorded highest from all the WLS. The third highest record of the feeding group is the Predatory omnivorous from Bethuadahari WLS (0.29). The relative abundance of different feeding guilds in these four WLS under study have been plotted in Whittaker plot (Fig. 2).

Table 1: Occurrence of dorylaimid nematodes and their feeding habit in the four wildlife sanctuaries under study ('+' Denotes the presence of nematode species and '-' denotes the absence of the species).

Name of the species	Trophic group	Ballavpur WLS	Ramnabagan WLS	Bethuadhari WLS	Bibhutibh ushan WLS
Family DORYLAIMIDAE De Man, 1976					
1. <i>Laimydorus baldus</i> Baqri & Jana, 1982	Omnivorous	+	-	-	-
2. <i>Laimydorus multialaeus</i> (Khera, 1970) Baqri, 1985	Omnivorous	+	-	-	-
3. <i>Laimydorus siddiqii</i> Baqri & Jana, 1983	Omnivorous	+	+	+	-
4. <i>Mesodorylaimus brassicus</i> Soni and Nama, 1981	Omnivorous	-	+	-	+
5. <i>Sicaguttur coomansi</i> (Baqri & Jana, 1980) Carbonell & Coomans, 1986	Microbial feeder	-	-	+	-
6. <i>Indodorylaimus saccatus</i> Ahmad & Jairajpuri, 1984	Not properly known	+	-	-	+
7. <i>Coomansinema dimorphicauda</i> Ahmad & Jairajpuri, 1989	Predatory	-	-	+	-
Family APORCELAIMIDAE Heyns, 1965					
8. <i>Aporcelaimellus amylovorus</i> (Thorne & Swanger, 1936) Heyns, 1965	Predatory omnivorous	-	+	-	-
9. <i>Aporcelaimellus baqrii</i> Ahmad & Jairajpuri, 1982	Predatory omnivorous	-	+	+	-
10. <i>Aporcelaimellus chauhani</i> Baqri & Khera, 1975	Predatory omnivorous	+	+	+	+
11. <i>Aporcelaimellus coomansi</i> Baqri & Khera, 1975	Predatory omnivorous	-	+	-	-
12. <i>Aporcelaimellus obtusicaudatus</i> (Bustian, 1865) Altherr, 1968	Predatory omnivorous	-	-	+	-
13. <i>Aporcelaimellus paraconicaudatus</i> (Meyl, 1956) Heyns, 1965	Predatory omnivorous	-	-	-	+
Family QUDSIANEMATIDAE Jairajpuri, 1965					
14. <i>Labronema</i>	Predatory	+	-	-	-

<i>enigmatum</i> Baniyamuiddin & Ahmad, 2007	omnivorous				
15. <i>Labronema nepalense</i> Ahmad and Jairajpuri, 1982	Predatory omnivorous	-	-	+	-
16. <i>Eudorylaimus carteri</i> (Bastian, 1965) Andrassy, 1959	Predatory omnivorous	+	-	-	-
17. <i>Eudorylaimus meridionalis</i> Tjepkema, Ferris & Ferris, 1971	Predatory omnivorous	-	-	-	+
18. <i>Eudorylaimus subdigitalis</i> Tjepkema, Ferris & Ferris, 1971	Predatory omnivorous	-	-	+	-
19. <i>Ecumenicus monohystera</i> (De man, 1880) Thorne, 1974	Omnivorous Predatory omnivorous	-	+	-	+
20. <i>Discolaimus rotundicaudatus</i> Khan & Laha, 1982	Predatory	-	-	-	+
21. <i>Discolaimus tenax</i> Siddiqi, 1965	Predatory	-	-	-	+
22. <i>Discolaimus texanus</i> Cobb, 1913	Predatory	+	+	-	-
23. <i>Discolaimoides bulbiferus</i> (Cobb, 1906) Heyns, 1963	Predatory and microbial feeder				+
24. <i>Discolaimium paraconura</i> Siddiqi, 1965	Omnivorous	+	-	-	-
25. <i>Discolaimium simplex</i> Siddiqi, 1965	Predatory	-	-	-	+
26. <i>Mylodiscus nanus</i> Thorne, 1939	Omnivorous and microbial feeder	-	-	-	+
27. <i>Lordellonema macrodorum</i> Ahmad, Baniyamuiddin & Mushtaq, 2009	Microbial feeder and predator	-	+	-	-
Family NORDIIDAE Jairajpuri and A. H. Siddiqi, 1964					
28. <i>Kochinema farodai</i> Baqri & Bohra, 2001	Omnivorous	+	-	-	-
29. <i>Enchodelus (Paraenchodelus) satendri</i> Baqri & Jairajpuri, 1968	Omnivorous	-	-	+	-
30. <i>Lenonchium oryzae</i> Siddiqi, 1965	Microbial feeder	-	-	+	-
31. <i>Oriverutus anisi</i> Ahmad &Jairajpuri,	Omnivorous	-	-	+	-

1987					
32. <i>Oriverutus labiatus</i> Ahmad & Jairajpuri, 1987	Omnivorous	+	-	+	-
33. <i>Oriverutus sundarus</i> (Williams, 1964) Siddiqi, 1971	Omnivorous and microbial feeder	-	-	-	+
Family ACTINOLAIMIDAE Thorne, 1939					
34. <i>Paractinolaimus macrodentatus</i> Sukul, 1967	Predatory	+	-	-	-
Family LONGIDORIDAE Thorne, 1935					
35. <i>Paralongidorus sali</i> Siddiqi, Hooper & Khan, 1963	Phytophago-us (Plant feeder)	+	-	-	-
36. <i>Longidorus saginus</i> Khan, Seshadri, Weischer & Mathen, 1971	Phytophago-us (Plant feeder)	-	-	-	+
Family XIPHINEMATIDAE Dalmasso, 1969					
37. <i>Xiphinema basiri</i> Siddiqi, 1959	Plant and hyphal feeder	-	-	-	+
38. <i>Xiphinema insigne</i> Loos, 1949	Plant and hyphal feeder	+	+	+	-
Family BELONDIRIDAE Thorne, 1939					
39. <i>Axonchium</i> (<i>Axonchium</i>) <i>amplicolle</i> Cobb, 1920	Omnivorous and plant feeder	+	-	+	-
40. <i>Axonchium</i> (<i>Axonchium</i>) <i>elegans</i> Jairajpuri, 1964	Omnivorous and plant feeder	-	-	+	-
41. <i>Lindseyus indicus</i> Dhanachand & Jairajpuri, 1980	Not properly known	+	+	-	-
42. <i>Dorylaimellus</i> (<i>Axodorylaimellus</i>) <i>deviatus</i> Baqri & Jairajpuri, 1969	Plant and hyphal feeder	-	-	-	+
Family TYLENCHOLAIMIDAE Filipjev, 1934					
43. <i>Promuntazium pyxidorum</i> Siddiqi, 1982	Plant and microbial feeder	-	+	-	-
Family LEPTONCHIDAE Thorne, 1935					
44. <i>Basiotyleptus</i> (<i>Trichonchium</i>) <i>eximius</i> (Siddiqi & Khan, S. H., 1964) Siddiqi & Khan, E., 1965	Plant and microbial feeder	-	-	-	+

45. <i>Tyleptus projectus</i> Thorne, 1939	Plant and microbial feeder	-	-	-	+
Family MYDONOMIDAE Thorne, 1964					
46. <i>Dorylaimoides</i> (<i>Dorylaimoides</i>) <i>parateres</i> Siddiqi, 1964	Omnivorous and microbial feeder	+	-	-	-
47. <i>Dorylaimoides</i> (<i>Longidorylaimoides</i>) <i>elaboratus</i> Siddiqi, 1965	Omnivorous and microbial feeder	+	+	-	+
48. <i>Dorylaimoides</i> (<i>Longidorylaimoides</i>) <i>parvus</i> Thorne & Swanger, 1936	Omnivorous and microbial feeder	-	-	-	+
49. <i>Morasia</i> <i>dimorphicauda</i> Baqri & Jairajpuri, 1969	Omnivorous	+	-	-	
Family NYGOLAIMIDAE Thorne, 1935					
50. <i>Nygolaimus tenuis</i> Thorne, 1930	Predatory	-	-	+	
51. <i>Aquatides aquaticus</i> (1930) Thorne, 1974	Predatory	-	-	+	
52. <i>Laevides laevis</i> (Thorne, 1939) Thorne, 1974	Predatory	-	-	-	+

Whittaker Plot of Nematodes feeding guilds in WLS

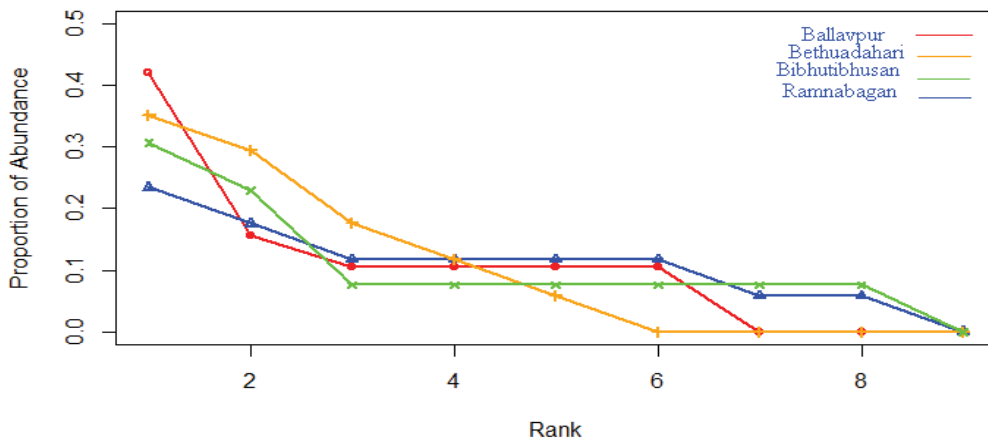


Figure 2. Whittaker plot of feeding guild rank abundance of nematodes in Ballavpur, Bibhutibhusan, Bethuadahari and Ramnabagan Wildlife Sanctuaries showing the highest rank abundance in Ballavpur by the trophic group of Omnivorous feeding habits.

4. Discussion

The literature review indicated that there is no significant study on the occurrence of soil nematodes from these wildlife sanctuaries of West Bengal, including observations on their feeding rank abundance and distribution pattern and correlation component analysis of various trophic groups. The role of soil nematodes in ecological webs was investigated, showing they can inhabit all types of ecosystems²³. The literature review indicated that there were no previous significant studies that aligned with the present investigation. In that context, the study on comparative feeding guilds and trophic groups of nematodes in forest ecosystem may be considered as first of its kind. The biodiversity of soil nematodes along with their feeding habits related with different elevation, ecological and edaphic factors in different landscapes patches in Kashmir valley, India was observed²⁴. This observation partially is similar with the present study, although it contradicts the finding that bacterivorous nematodes dominate, comprising nearly 33% of the nematode population. From table 1, it is evident that only *Aporcelaimellus chauhani* was found common in all the four wildlife sanctuaries; *Laimydorus siddiqii*, *Xiphinema insigne* and *Dorylaimoides (Longidorylaimoides) elaboratus* in three WLS; *Mesodorylaimus brassicus*, *Indodorylaimus saccatus*, *Aporcelaimellus baqrii*, *Ecumenicus*, *monohystera*, *Discolaimus texanus*, *Oriverutus labiatus*, *Axonchium (Axonchium) amplicolle*, *Lindseyus indicus* in two WLS. The remaining species were found to inhabit only one of the four protected areas. Among these, most of the species are omnivorous or predatory omnivorous except *Xiphinema insigne* having plant and hyphal feeding habit while the feeding habits of *Indodorylaimus saccatus* and *Lindseyus indicus* are not known. This indicates that omnivorous and predatory omnivorous feeding habit may enhance the chances of survival and occurrence. Conversely, seven species of omnivores and nine species of predatory omnivores were found to exist exclusively in one wildlife sanctuary.

4.1. Nematode Feeding Habits and Functional diversity

All the nematodes under the order Dorylaimida observed from these four Wildlife Sanctuaries practice nine different feeding habits (feeding habit of two species being not properly known). Out of these nine types the nematode species belonging to Omnivorous habit is abundant (13 species) followed by Predatory Omnivores (11 species). The recorded richness of each feeding guilds shows as Omnivores (13 species, 25%) are dominant followed by Predatory Omnivores (11 species, 21%), Predatory (9 species, 17%), Phytophagous (5 species, 10%), Plant and Microbial feeder (3 species, 7%), Microbial feeder (2 species, 4%), Predatory microbial feeder (2 species, 4%), Omnivorous Microbial feeder (5 species, 10%), and lastly Some nematodes with the feeding habit not properly known (2 species, 4%) (Fig. 3). This observation also concurs with the individual feeding guild of the study areas. The clustered dendrogram depicts the relations among the feeding habits and distribution pattern of various trophic groups relative to each wildlife sanctuary under study (Fig. 4).

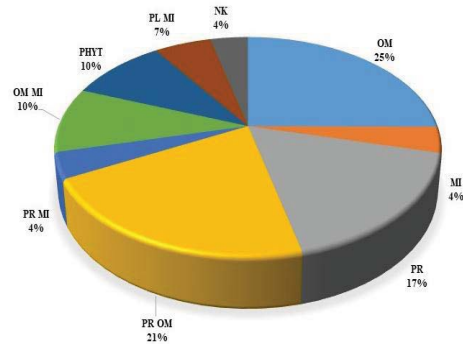


Figure 3. Pie chart showing the percentage of the feeding habits in four Wildlife sanctuaries (MI: Microbial feeder, PR MI: Predatory Microbial feeder, PL MI: Plant and Microbial feeder, NK: Not Properly Known, OM MI: Omnivorous Microbial feeder, PHYT: Phytophagous, OM: Omnivorous, PR: Predator, PR OM: Predatory Omnivore).

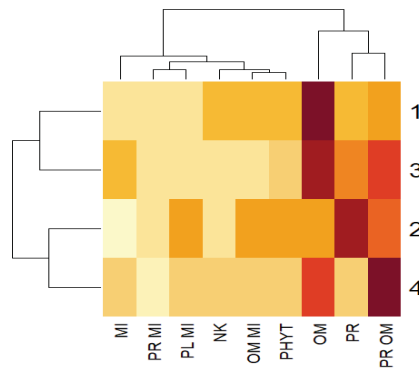


Figure 4. Heatmap showing the distribution cluster of various trophic groups in the four WLS forming the hierarchical relations. Yellow indicates the lower value and red indicates the higher value. The hierarchical cluster in dendrograms forms two groups in the distribution pattern of the four WLS; 1: Ballavpur WLS, 2: Ramnabagan WLS, 3: Bethuadahari WLS, 4: Bibhutibhusan WLS (MI: Microbial feeder, PR MI: Predatory Microbial feeder, PL MI: Plant and Microbial feeder, NK: Not Properly Known, OM MI: Omnivorous Microbial feeder, PHYT: Phytophagous, OM: Omnivorous, PR: Predator, PR OM: Predatory Omnivore).

4.2. Principal Component Analysis

The multivariate Principal Component Analysis of the trophic groups in these four Wildlife Sanctuaries have been correlated and the component variance have been calculated in 31.72%, 24.94% respectively in PC1 and PC2 for the different trophic groups discussed earlier. The PCA plot (Fig. 5) showing the relative correlated variance and distribution in each coordinate with the clustered overlapping of similar distribution of species component having similar trophic group. The omnivorous, predatory-omnivorous and phytophagous trophic groups are abundant in most cases. Total of 52 species have been observed with multiple or single occurrence with respect to their trophic group or feeding habits which constitutes individual feeding guilds for each WLS.

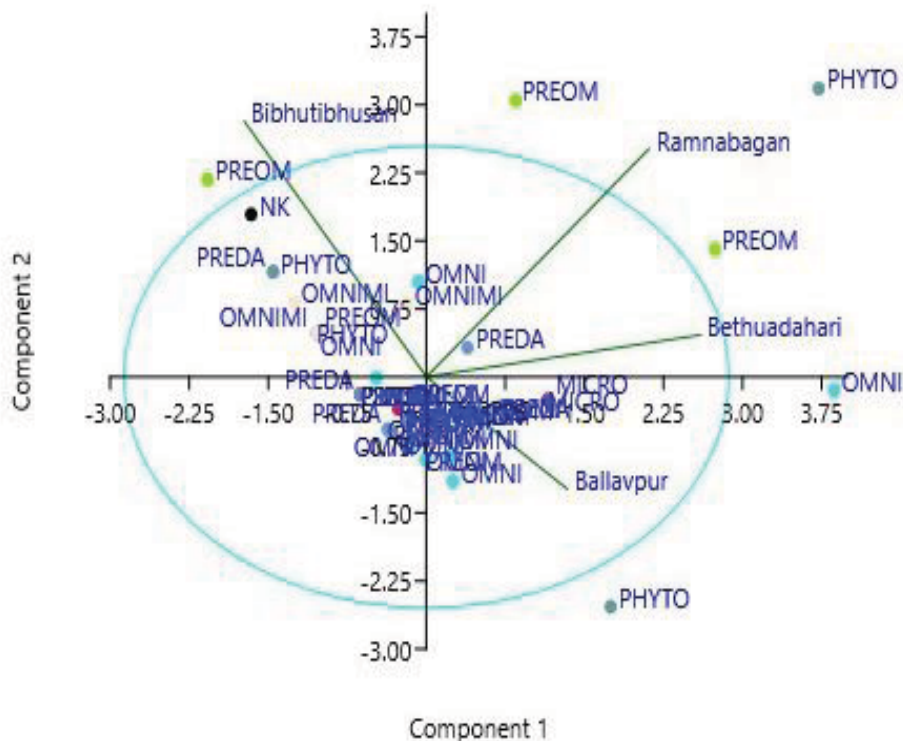


Figure 5. Principal Component Analysis of the Four Wildlife Sanctuaries Showing the Correlation in respect of Variance in Different Trophic Groups. OMNI: Omnivorous, MICRO: Microbial, PREDA: Predatory, PREOM: Predatory Omnivore, PREMI: Predatory Microbial, OMNIMI: Omnivorous Microbial, PHYTO: Phytophagous, PLNTMI: Plant Microbial, NK: Not Known.

5. Conclusion

It was observed that omnivorous and predatory omnivorous species are the most numerous across various wildlife sanctuaries. Although nine different trophic groups (one of which is not well-defined) have been observed and compared in four wildlife sanctuaries, the abundance of nematode examples seems to align more with diverse feeding habits rather than dependence on a specific diet. Dependence on a specific diet, such as being a hyphal feeder, bacterial feeder, or host-specific plant feeder, reduces the survival chances of free-living soil nematodes. The feeding apparatus of most recorded species of Dorylaimida in these wildlife sanctuaries are either piercers or ingesters, indicating that predation or omnivorous is the dominant feeding habit. With predatory feeding habit, the nematodes can feed on animals nearly its body size while microbial feeding depends on the smaller microbes like fungi, bacteria which expands the limits of the nematodes to adapt the feeding style depending on the microhabitat structure. The distribution and variation of trophic group abundance across these four wildlife sanctuaries are ecologically significant for establishing stable soil health in relation to their associated micro-organisms. Further studies are required to determine the primary roles of nematodes in relation to their distribution and specific feeding habits, as well as how these

factors interact with soil physio-chemical parameters. These parameters, which vary across different soil types, can significantly influence the structural dynamics of a soil ecosystem

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