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Original Article

Agro-Related Anthropogenic Activities on Soil Nematodes in the Niger Delta, Nigeria

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ABSTRACT

A study to determine the influence of agro-related anthropogenic activities on soil nematode spatial distribution in the Niger Delta was carried out in three designated areas with different cropping practices. Soil samples were randomly collected from the Niger Delta Development Commission (NDDCF) farm: mixed-cropping (Site A); Rivers State Oil Palm (RISOPALM) plantation: mono-cropping (Site B); and the University of Port Harcourt Botanical Garden (UPHBG): an undisturbedsite(Site C). Soil samples were collected at 0-5cm, 5-10cm and 10-15cm depths per core using a modified 5cm diameter soil auger. The Baermann's extraction technique was used to recover nematodes from the samples. A total of 458 nematodes were recovered comprising 13 species out of which 249(54.3%) nematodes of 11species came from Site C; Site B yielded 168(36.6%) nematodes of 4 species while Site A yielded 41(8.9%) nematodes. There was variability in nematode assemblage in relation to specific core depths ($p>0.05$). The overall nematode abundance and diversity was highest at depth 0-5cm(52.6%) followed by depth 5-10(35.5%) and depth 10-15cm(11.7%). The depth related decline in nematode species diversity and abundance was associated with nutritional affiliations of the nematode species and the level of agro-related anthropogenic interference. However, specialist nematode species distribution was influenced by specific host factors while the distribution of the generalist nematode species were influenced by specific environmental factors. Mix-cropping and mono-cropping were major anthropogenic activities that influenced nematode distribution. The study also revealed that mono-cropping influenced the specialist nematodes while mix-cropping generally declined nematode species abundance and richness which could be exploited as a control measure against specific parasitism of crops especially in the Niger Delta where subsistent agriculture prevails.

INTRODUCTION

The emphases on conservation of environmental resources by Governments and Non-Governmental Organizations worldwide, confirm the heavy toll the environment bears as a result of the numerous anthropogenic interferences in the ecosystem. Top on the list of anthropogenic activities that impact the environment include; agriculture, waste disposal and industrialization[1]. Although, the actual impact of anthropogenic influences on the soil biodiversity is still in a flux, however, the realization of the impact on the environment prompted the idea of environmental evaluation through impact assessment studies[2]. Conventionally, the determination of the population dynamics of the biological components of an ecosystem in the presence of an identified environmental stressor gives the environmentalist an idea of the role of specific organisms in the ecosystem[3].

Microorganisms and arthropods have been invaluable in the determination of the health status of the environment due to their sensitivity to minute ambient physico-chemical alterations[4]. Considering the ubiquity and great diversity of nematodes in the environment it is ironical that soil and aquatic nematode community characteristics are not usually included in the majority of environmental impact assessment studies especially in Nigeria[5].However, numerous studies on this unique fauna have concentrated on the plant parasitic types, obviously due to their economic importance in food security worldwide[6-8].

Nematodes microscopic nature, their laborious extraction procedures, short life cycle and the inconsistency in their taxonomy compromise their inclusion in environmental impact assessment studies especially in Nigeria. Nevertheless, their unique characteristics such as large population, functional diversity with a wide range of trophic survival specialism, and their ready response to environmental changes can be exploited by environmentalist in assessing the environmental health status of an ecosystem[9]. Nematode diversity and abundance index analyses can also provide quantitative and qualitative information on the condition of the environment around it, which should rightly place them as good bio-indicators or biological monitors[9].According to Sims[10], the wealth of information in the taxonomy and feeding role of nematodes should place them at the top echelon of meiofauna most useful for community indicator analysis.

Although most of the free living soil nematodes do not parasitize plants nevertheless they are beneficial in the decomposition of organic matter and other essential ecosystem processes[11,9]. McSorley[12], stated that typical free living soil nematodes occupy the water-filled pore spaces between soil aggregates and are most abundant in soil layers rich in organic matter. This further accentuates their vital role in ecological processes that involve the breakdown of organic matter into forms available to plants[13,14].

It is envisaged that any disturbances in the soil ecosystem that may affect food resources would definitely modify the population structure of the nematode taxa. According Neher,[13] this unique role of detecting minute disturbances in the ecosystem by nematodes maybe associated with their functional diversity and ubiquity. Additionally, Ficus and Neher[15]opined that the tight relationship between soil characteristics and nematode abundance in various functional guilds could be exploited in developing a universal standard for evaluating the faunal integrity of an ecosystem. However, Bongers, *et al*.,[16] expressed some reservations about the adoption of nematode maturity index-values as environmental assessment tool as the parameter can only give a rough indication of disturbances, but would be unable to identify the dominant stress factors. Since the myriads of stress factors evident in the ecosystem are directly or indirectly associated with anthropogenic activities; this study aims at determining the influence of three different cropping practiceson the soil nematode spatial distribution in the Niger Delta of Nigeria.

MATERIALS AND METHODS

Study Areas

The study areas include three designated Sites A, B and C in Rivers State (Fig. 1), of Nigeria with different agronomical practices. Generally, the study areas share similar climatic conditions with an annual average rainfall range of 2000-2500cm[3] and temperature range of between 28˚C- 30˚C which supports the rainforest vegetation type. The three study areas are sub-urban in structure with about 30-40% rural presence.

Designation of Sampling Sites

Site A: Rivers State oil palm plantation (RISOPALM) practicing monoculture. Located at N 05° 11' 626, E 006˚ 5' 791in Emohua Local Government Area (L.G.A);

Site B: Niger Delta Development Commission Area farm (NDDCAF) practicing mixed cropping. Located at N30° 04' 391, E07° 066' 162; in Eleme L.G.A, and;

Site C: University of Port Harcourt, Botanical Garden (UPHBG); undisturbed vegetation. Located at N 04° 54' 295, E 06° 55' 373 in ObioAkpor L.G.A.

Samples Collections

Soil samples were collected randomly with the aid of a modified 5cm diameter soil auger from the three designated study locations as stated above. A total of 50 soil samples were collected from each study area. Samples were collected from each core at different depths; 0-5cm, 5-10cm and 10-15cm. The samples were placed into properly designated polyethene bags to prevent evaporation and taken to the laboratory for extraction of nematodes.

Nematodes' Extraction and Identification

Nematodes were extracted using the Baermann extraction technique[17,18]. Hydrogen peroxide was added into the extraction medium at four hour intervals while identification of nematodes was according to Goodey[19].

Data was analysed using Analysis of Variance (ANOVA) while the Shannon Wiernner's Diversity Index was used to analyse nematodes population dynamics.

RESULTS AND DISCUSSION

The three study areas yielded a total of four hundred and fifty eight (458) nematodes belonging to twelve families and thirteen species (Table 1.).Out of these, one hundred and sixty eight (36.6%) nematodes extracted from study area A had five (5) species of nematodes belonging to five (5) families; study area Bhad 41(8.9%) nematodes. The nematode population from this study area comprised of four families and four species while study area C yielded 249(54.3%) nematodes belonging to 12species in11families.In the same vein depth related occurrence showed a total of 241(52.6%) nematodes from the 0-5cm core depth; 163(35.5%) nematodes from the 5-10cm core depth and 54(11.7%) nematodes from the 10-15cm core depth (Fig 2 and 3.). There was a progressive decline in core specific abundance and diversity of nematodes as depth increased in all the study sites; a pattern which was not statistically significant ($p>0.05$). However, the vertical distribution pattern of soil nematodes in all the study areas was attributed to nematode trophic affiliations. Plant parasitic nematodes genera and species were the most dominant in terms of diversity and abundance in all the habitats and at different trophic levels as represented by the varied core depths. In this study soil nematode abundance and species diversity seemed to be influenced by anthropogenic interference such as repeated tillage as observed in (Table 1). However, the spatial distribution in terms of vertical distribution was associated with soil organic constitution at specific study sites. This observed distribution in the study supports Bongers *et al*.,[16] who stated that soil organic composition influences soil nematode assemblage.

There was variability in the densities of the specialist species; the plant parasitic nematodes genera and species, for instance, *Ditylenchus* spp., *Hemicychliophora* spp.; *Meloidogyne* spp.; *Pratylenchus* spp. and *Trichodorus* spp. are indicative of nematodes responses to specific hosts and environmental factors but may not influence specific soil ecosystem processes such as mineralization, that may significantly modify the soil biota. On the other hand, the free-living generalist colonizers such as *Longidorus* spp. *Paratylenchus* spp. *and Strongyliodes* spp. (obligate parasite of vertebrates with alternation of generations which could be omnivorous) exhibited top soil dominance suggesting a preference for heavy litter. The generalist nematodes being grazers, depend strictly on micro-organisms hence their presence indicate rapid decomposition and mineralization. This knowledge could be incorporated in environmental evaluation studies in Nigeria where this soil meiofuana is ostracized and unappreciated.

The manifestation of *Panagrolaimus* spp.; a generalist nematode that alternates between free-living habit by feeding on rhizosphere bacteria and sometimes accidentally parasitic[22-25] in study area A; the oil palm plantation; could be attributed to high litter content of the soil. It also indicates specific nematode adaptability to multiple functional guilds[15]. However, the absence of *Longidorus* spp.; a dominant free living species and *Aphelenchulus* spp. (poorly plant parasitic species) in study area B indicated the sensitivity of soil nematode species to specific ecological stressors. This observation support submissions by Neher[13], Fiscusand Neher[15] and Nzeako *et al*.,[9] that disturbances that affect the food chain in the soil ecosystem will surely influence the nematode community integrity and other meiofuana.

The study revealed that the variability in nematode community composition observed in the various study sites were intrinsically connected with the land use practices peculiar to the sites. In this context, Site C had relatively the highest nematode biodiversity not specifically due to the high organic composition of the soil but due to the diversity in composition of the vegetation. However the disparity in the overall nematode species diversity and abundance in relation to specific study areas underscored the impact of anthropogenic disturbances such as repeated tillage on soil nematode community status.

The Shannon Wiernner's Diversity index revealed that site C had the highest species richness (11), followed by Site A (5) and Site B (4). Data also showed that the undisturbed vegetation – site C, harboured more nematodes in terms of abundance and diversity at the 5-10cm depth. This observed distribution pattern indicates functional specialization of some species and the overwhelming influence of organic materials on nematodes assemblage[16]. Species Evenness (E) was similar to what was observed in the species diversity where the undisturbed site had a value of (0.88); site A had (0.55) and Site B(0.47). Site C also had the highest equivalent diversity of 8 equally-common species while Site A and B both had 2 equally-common species.

In this study, nematode assemblage was greatly influenced by two major factors; presence of organic compounds and frequent disturbances to the soil structure. The disparity observed in the nematode density and community structure could be attributed to human interferences such as tillage and cropping patterns[18]. The high nematode species diversity and abundance observed in the fallowed site indicated the association of specific parasitism to nematode assemblage and the negative impact of continuous cultivation on the biological properties of the soil[8,14,18,25,26]. This observation is also in line with the postulations by Nakamato *et al.*,[26], who stated that systems that turn the soil continuously without adequate replacement of soil organic matter, reduce the densities of soil animals especially nematodes.

CONCLUSION

The depth related decline in nematode species diversity and abundance observed in the study was associated with nutritional affiliations of the nematode species and the degree of anthropogenic interference. Nematode species richness was greatly impacted by mix-cropping and mono-cropping. In the study, it was also obvious that mono-cropping influenced the build-up of specialist nematode population while mix-cropping had the opposite effect on nematode species abundance and richness which could be exploited as a control measure against specific parasitism of crops especially in the Niger Delta where subsistent agriculture prevails.

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Competing Interest

Authors declare that there is no competing interest.

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Table 1. Nematodes species recovered from different core depths in the study Sites

NEMATODE SPECIES	Site A				Site B				Site C				Over all Total (%)*
	CORE DEPTH				CORE DEPTH				CORE DEPTH				
	5cm (%)	10cm (%)	15cm (%)	Total (%)	5cm (%)	10cm (%)	15cm (%)	Total	5cm (%)	10cm (%)	15cm (%)	Total (%)	
Aphelenchusspp	20 (16.1)	0	0	20 (16.1)	8 (38.0)	0	0	8 (19.5)	0	0	0	0	28 (6.11)
Aphlenchoidess pp	0	0	0	0	1 (4.7)	0	0	1 (4.7)	6 (7.0)	2 (1.5)	5 (15.1)	13 (5.2)	14 (3.1)
Ditylenchusspp	2 (1.6)	0	1 (7.6)	3 (9.2)	0	0	0	0	12 (14.1)	22 (17.3)	6 (18.1)	40 (16.0)	43 (9.3)
Hemicycliophor aspp	0	0	0	0	0	0	0	0	6 (7.0)	6 (4.7)	0	12 (4.8)	12 (2.6)
Longidorusspp	0	0	0	0	0	0	0	0	4 (4.7)	11 (8.6)	2 (6.0)	17 (6.8)	17 (3.7)
Meliodogynesp p	96 (77.4)	26 (83.8)	10 (76.9	132 (78.1)	10 (47.6)	13 (100)	7 (100)	30 (73.1)	17 (20)	36 (28.3)	4 (12.1)	57 (22.8)	219 (47.8)
Panagralamuss pp	4 (3.2)	3 (9.6)	2 (15.3)	9 (9.3)	0	0	0	0	0	0	0	0	9 (1.9)
Pratylenchussp p	2(1.6)	2 (6.4)	0	4(8)	0	0	0	0	2 (2.3)	10 (7.8)	4 (12.1)	16 (6.4)	20 (4.3)
Paratylenchuss pp	0	0	0	0	0	0	0	0	12 (14.2 1)	12 (9.4)	2 (6.0)	26 (10.4)	26 (5.6)
Trichodorusspp	0	0	0	0	2 (9.5)	0	0	2 (9.5)	2 (2.3)	0	0	2 (0.8)	4(6.8)
Tylenchulusspp	0	0	0	0	0	0	0	0	2 (2.3)	12 (9.4)	2 (6.0)	16 (6.4)	16 (3.4)
Rotylenchulussp p	0	0	0	0	0	0	0	0	20 (23.5)	10 (7.8)	8 (24.2)	38 (15.2)	38 (8.2)
Strongyloidspp	0	0	0	0	0	0	0	0	2 (2.3)	6 (4.7)	0	8 (3.2)	8 (1.7)
Total (%)*	124 (73.8)	31 (18.5)	13 (7.7)	168 (36.6)	21 (51.1)	13 (31.7)	7 (17.0)	41 (8.9)	85 (35.3)	127 (50.0)	33 (13.2)	249 (54.3)	458

*Population of nematodes in 1ml of aliquot

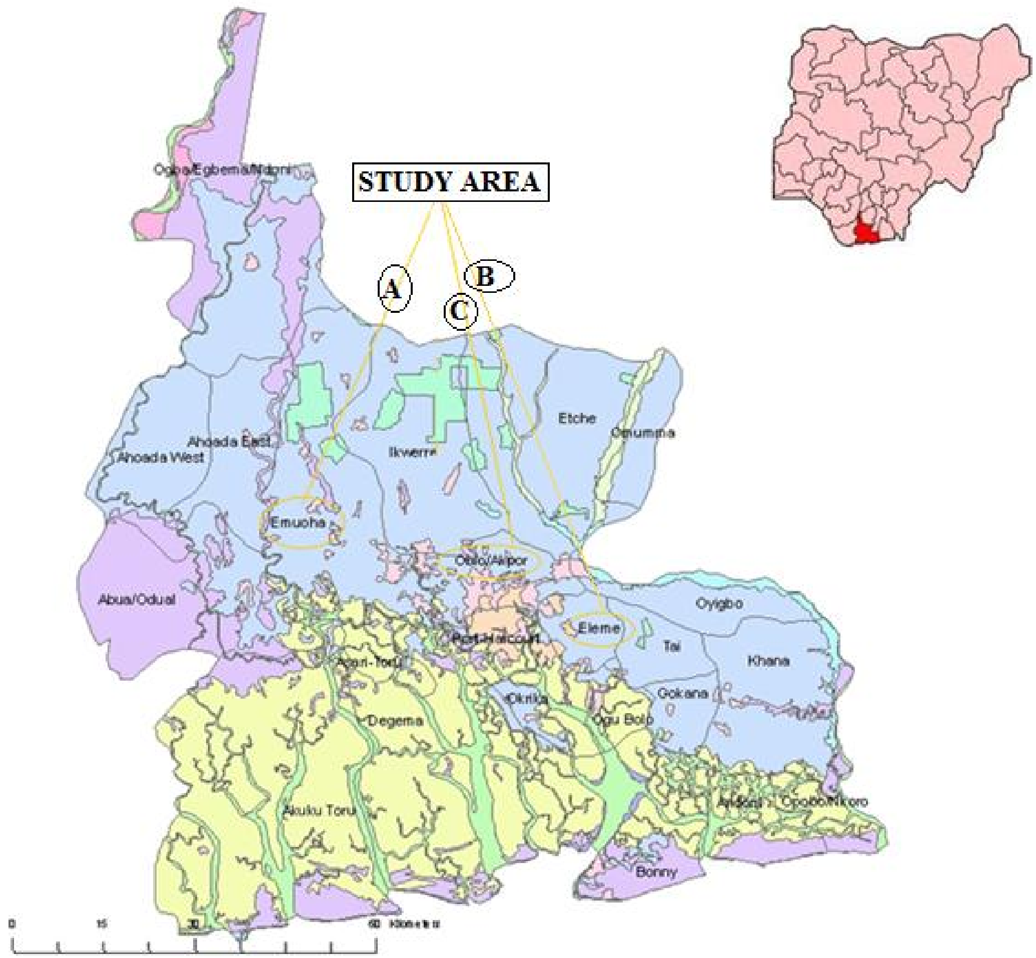

Figure 1: Maps of Nigeria and Rivers State showing the Study Areasin three different Local Government Authorities

Source: Map data Google[20,21]

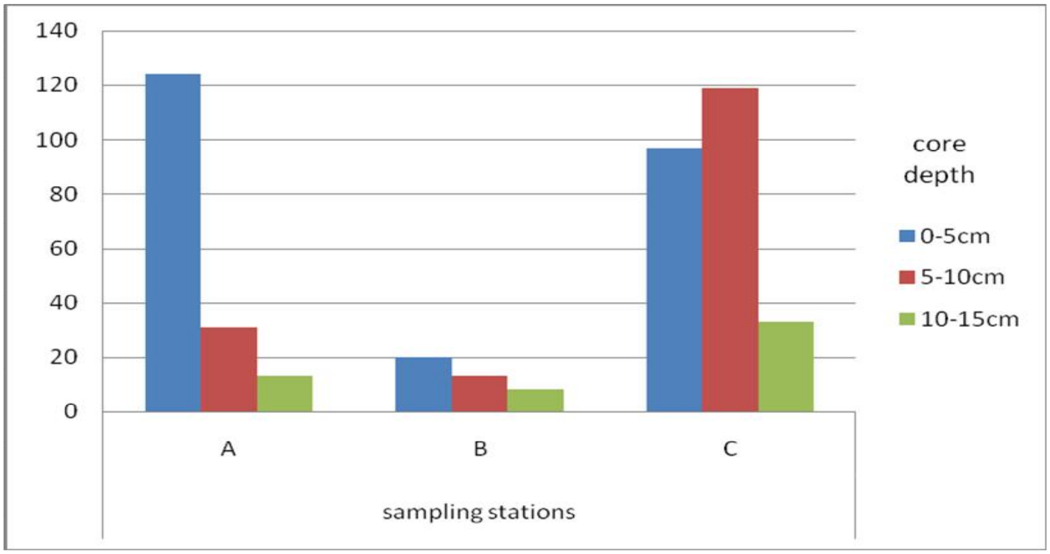

Figure 2: Overall population of nematode at various depths

Y axis; population of nematodes from 1ml of aliquot, x axis; different core depths

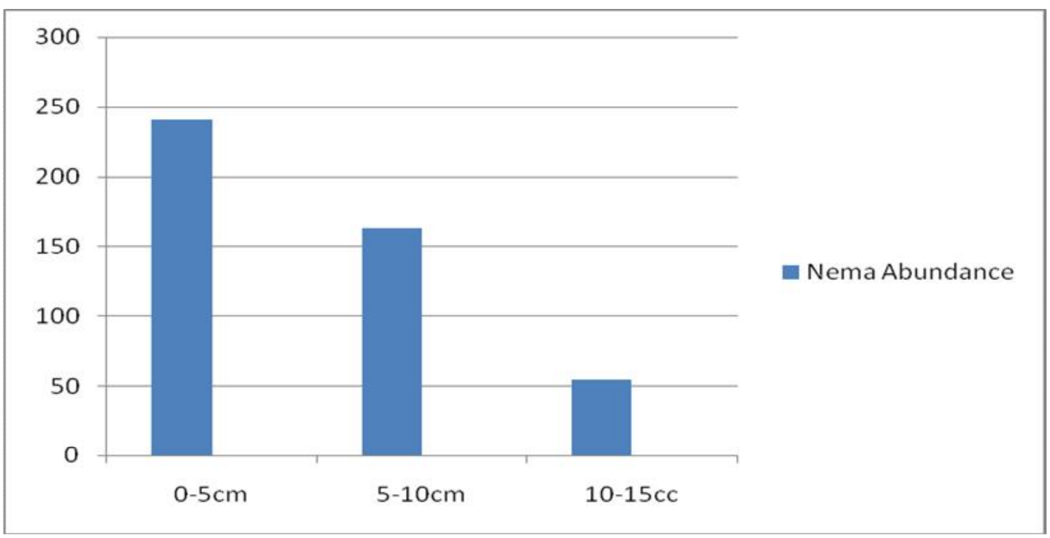

Figure 3: Overall core specific nematode abundance in the study

Y axis; nematode abundance, X axis; core depths

nd CV: Coefficient of variation