Original Article

# Free-living marine nematode communities in a *Rhizophora mucronata* Lam. (Rhizophoraceae) forest at Mida Creek, Kenya

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**Western Indian Ocean**
JOURNAL OF
**Marine Science**

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## Abstract

Nematodes are among the most abundant organisms in marine ecosystems where they play a critical role in nutrient cycling, provision of nourishment to the higher organisms in the food web, pest control, and act as disease-causing vectors. This study determined the abundance and community structure of nematodes in three plots of *Rhizophora mucronata* forest stand at Kirepwe Macho and Dabaso sites at Mida Creek, Kenya. Replicated sediment samples were randomly collected from one forest plot in Kirepwe Macho and two plots in Dabaso during the months of January and April 2011. Total organic matter, sand and silt proportions were not significantly different across the study sites and between January and April. A total of 90 and 81 nematode genera were encountered in the month of January and April, respectively. At both sampling times, the nematode community was dominated by *Terschellingia* (20.5 %-15.3 %) and *Paracomesoma* (10.6 %-6.6 %). The Shannon-Weiner diversity index was relatively high in the three forest plots both in January and April ranging from 2.76 to 3.40. There was no significant difference in nematode community assemblage within sites ($p>0.05$, 0.901) but there were differences between sampling time ($p>0.05$, 0.001). The results showed that the three sites had similar nematode community structure suggesting that the three *Rhizophora mucronata* mangrove forest plots did not differ in terms of nematode generic composition even though the plots were not all close to each other.

**Keywords:** mangroves, *Rhizophora mucronata*, free living nematodes, diversity, nematodes community structure, Mida Creek

## Introduction

Mangroves are woody halophytic plant communities which are found in tropical and sub-tropical regions worldwide (Giri *et al.*, 2011). They offer a wide variety of goods and services including food, timber, dyes, medicine, carbon sequestration, land accretion, pollution control, animal habitat and coastal protection from tsunamis, cyclones, floods and tidal inundations (Hogarth, 2015). Initially, three quarters of all tropical and sub-tropical coastal regions were occupied by mangroves, but currently more than half of the mangrove forests are degraded (Shapiro-ilan *et al.*, 2012). These forests are globally threatened, and it is estimated that 1-2 % of global cover is lost every year (Duke *et al.*, 2007; Giri *et al.*, 2011). This trend varies from region to region and differences might be caused by proximity to urban areas which leads to deforestation to create room for a growing population (Lee *et al.*, 2014). However, forest cover increase has recently also been documented in some areas across the globe

(Saintilan *et al.*, 2014; Giri *et al.*, 2015). Kenyan mangrove ecosystems have declined at a rate of 0.7% per year between 1985 and 2010 leaving the current acreage to be 45,590ha (Kirui *et al.*, 2013). The decline was accelerated by overharvesting of mangrove products, change of land use and weak policies (Kirui *et al.*, 2013; Ashton, 2022). However, recent efforts to rehabilitate mangroves has received attention and placed Kenya in the lime light as hosting the world's first conservation project to link mangrove forests to the global carbon market (Cameron *et al.*, 2019).

Muddy sediments associated with mangroves provide an important habitat for benthic communities, especially the meiofauna (< 1mm and > 38 µm) which is well represented by nematodes making up > 80% of the total meiofauna community (Portnova, *et al.*, 2017). Meiofauna, and especially nematodes, represent the most abundant benthic metazoan organisms (Venekey *et al.*, 2010) in organically enriched sediments with low oxygen levels such as mangrove sediments. Nematoda, usually referred to as roundworms, are a diverse animal phylum inhabiting a broad range of ecosystems from polar regions to the tropics, marine to fresh water, mountain tops to ocean trenches (Gaston *et al.*, 1997; Ramirez-Llodra *et al.*, 2010). They are ubiquitous in freshwater, marine, and terrestrial environments, where they often outnumber other animals in both numbers and species count (Abebe *et al.*, 2008). They represent 90 % of all animals on the ocean floor (Jairajpuri and Ahmad, 1992; Hourston *et al.*, 2009) and numerically often exceed a million individuals per square meter (Blome and Faubel, 1996; Bongers and Bongers, 1998). They play crucial ecological role as a food source for higher trophic levels (Alves *et al.*, 2013) while they are important in the decomposition of organic matter and soil bioturbation (Hourston *et al.*, 2009; Schratzberger and Ingels, 2018).

Nematodes are classified in three broad groups depending on their source of food. Plant parasitic nematodes feed on plants, entomopathogenic nematodes feed on insects' larvae and free-living nematodes feed on bacteria, fungi, and some are predators. The free living nematode community structure and composition varies depending on sediment composition, water depth, oxygen levels (direct or indirect), hydrodynamic disturbances (Ingels *et al.*, 2009) and food availability (Muthumbi *et al.*, 2004; Leduc *et al.*, 2014). Within marine environments, free-living nematodes are recognized as the most abundant

invertebrate group in sediments and the dominant taxon in heavily polluted habitats (Coull and Chandler, 1992). Despite their similar basic morphology, they perform different roles and occupy distinctive trophic levels in the sediments where many species feed on bacteria, algae, detritus and dissolved organic matter (Alongi *et al.*, 1993; Schmid-Araya and Schmid, 2000). Nematodes also are used for fishing bait, control of pests and can be disease-causing vectors, while a considerable number form prey for larger animals (Schmid-Araya *et al.*, 2002). Thus, the high functional and structural diversity of nematodes makes them very versatile and able to survive in diverse environments, including in polluted areas. They have thus been proposed within the Water Framework Directive (Lepper, 2005) as tools for evaluating the ecological quality status of vulnerable marine ecosystems (Baan, *et al.*, 2013).

Researchers have focused on topics relating to mainstream ecology such as latitudinal patterns of biodiversity (Mokievsky and Azovsky, 2002; Gobin and Warwick, 2006), links between taxonomic diversity, functional traits (Schratzberger *et al.*, 2006) and ecological factors driving the structure of assemblages of nematodes (Hua *et al.*, 2009). Changes in structure and composition of nematode communities are mainly correlated to sediment composition, but especially food, oxygen and salinity determine the species composition of these communities (Ingels *et al.*, 2009). According to Abebe *et al.*, (2008) and Pinto *et al.*, (2012), diversity of marine nematodes has been proven to be high in mangrove ecosystems compared to other benthic taxa. However, the patchy distribution patterns of nematodes in different microhabitats are yet to be explored. Knowledge on nematodes distribution in different microhabitats will provide a baseline for mangrove conservation measures using the meiofauna community as a proxy for the sediment conditions representing a major component of marine biodiversity. Little is known about free living nematode distribution in specific mangrove forest areas related to specific tree species.

This study focused on the spatial and seasonal variability in the nematode communities of the *Rhizophora mucronata* Lam. single species mangrove forest in Mida Creek on the north coast of Kenya.

## Materials and methods
### Description of the study area
The study was conducted in Mida Creek (3°23' S 39°56' E)

located east of Arabuko Sokoke forest, 20 km south-west of Malindi town and 15 km from Watamu town (Fig. 1). It is an extensive area of 31.6 km² consisting of a tidal inlet, sand and mud flats, located near Dabaso village (Kairo *et al.*, 2002). This is one of the most productive mangrove regions and has been recognized as an international bird area where waders, kingfishers, waterfowls, crab plovers and migrating birds from Europe and Eurasia overwinter (Frank *et al.*, 2017). Together with Arabuko Sokoke forest, Mida Creek forms a UNESCO Biosphere Reserve. Mida Creek is characterized by two rainy seasons; a short rainy

## Sampling

Sampling was conducted in the months of January and April 2011 during the spring low tide. Two study sites, Kirepwe Macho and Dabaso, were selected in Mida Creek since they had monospecific stands of *Rhizophora mucronata*. Dabaso forest was composed of mature *R. mucronata* trees with no undergrowth of young trees. Two adjacent stations (20 m apart) separated by a small channel were selected (Dabaso 1 and Dabaso 2). The third station was situated in Kirepwe Macho and had mature *R. mucronata* trees with an undergrowth of young trees. Three sediment cores were collected



**Figure 1.** Map of the Mida Creek study site, showing the location of the sampling stations (Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2).

season from October till December and a long rainy season from April to June with temperatures ranging from 22°C to 31°C (Kenya Meteorological Department). The mangrove area in the creek is estimated to cover 1757.8 ha (Cohen *et al.*, 2013) comprising seven species of mangroves with *Ceriops tagal*, *Rhizophora mucronata* and *Avicennia marina* as the dominant species (Gang and Agatsiva, 1992). Mida Creek forest mangrove coverage consists of mixed species zones. *Avicennia marina - Lumnitzera racemose - Xylocarpus granatum species tend to* occupy the landward side, *Rhizophora mucronata - Bruguiera gymnorhiza - Ceriops tagal species* occurs mainly in the middle zone, while *Sonneratia alba - Rhizophora mucronate - Avicennia marina* occurs on the seaward side (Ruwa, 1993).

randomly at each sampling station using transparent Perspex tubing of 3.6 cm diameter, pushed 10 cm deep in the sediment during low tide and preserved with 5 % buffered formaldehyde solution.

## Nematode extraction

The meiofauna samples were rinsed and sieved through a 1 mm sieve and collected on a 38 μm mesh size sieve. The samples were then centrifuged twice at 6000 rpm using magnesium sulphate of 1.25 specific density and once using specific density of 1.28. The supernatant was rinsed and preserved with 5 % buffered formaldehyde solution and stained with three drops of Rose Bengal overnight. Using a dissecting microscope, a minimum of 200 nematodes were picked from each
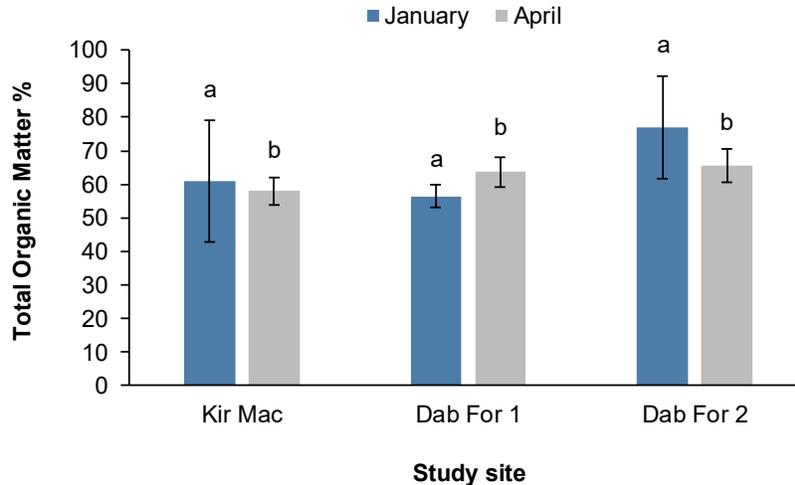
**Figure 2.** Total organic matter percentage from Mida Creek sampling stations (Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2) for the two sampling months (January and April). Values represent mean ± standard error for three replicates. For each sampling site, means with the same letter have no significant difference (P>0.05, Turkey test).

sample, processed and mounted onto permanent glass slides (Somerfield and Warwick, 1996).

### Nematode identification

Identification of nematodes to genera was carried out with a compound microscope equipped with a X 100 oil immersion lens, and identification keys of Platt and Warwick (1988).

### Statistical analysis

The Shannon-Wiener diversity index (H), Evenness_ e^H/S and species richness was calculated using PAST software (Hammer *et al.*, 2001). Two-way Analysis of Variance (ANOVA) was used to determine the difference in the total organic matter, grain size, nematodes diversity, evenness and sampling time differences among the three sites. Community assemblage was analyzed using Multidimensional scaling on Plymouth Routines in Multivariate Ecological Research (PRIMER) software (Clarke and Warwick, 2001).

## Results

### Abiotic parameters

*Total Organic Matter (TOM)*

In January, Dabaso 2 recorded the highest TOM (77 %) followed by Kirepwe Macho (61 %) and Dabaso 1 had the least organic matter (56 %). Similarly, in April, Dabaso 2 recorded the highest TOM (66 %), followed by Dabaso 1 (64 %) and Kirepwe Macho (58 %) (Fig. 2). The mean TOM content was not significantly different during the month of January (P value=0.242) and April (P value=0.194) in Kirepwe Macho, Dabaso 1 and Dabaso 2.

*Grain size*

January samples had the highest sand percentage recorded in Kirepwe Macho (74 %) followed by Dabaso 2 (66 %) and finally Dabaso 1 (65 %). Silt proportion was highest in Dabaso 1 (35 %) followed by Dabaso 2 (34 %) and Kirepwe Macho recorded the lowest silt proportion (26 %) (Fig. 3). There was no significant difference between sand and silt proportion in all study sites (P value=0.132).

April samples recorded the highest sand percentage in Kirepwe Macho (67 %), followed by Dabaso 1 (62 %) and Dabaso 2 (59 %). Silt proportion was highest in Dabaso 1 (41 %) followed by Dabaso 2 (38 %) and finally Kirepwe Macho (33%) (Fig. 3). There was no significant difference between sand and silt proportion in all study sites (P value=0.073).

### Biotic parameters

*Nematode composition and abundance*

A total of 121 nematode genera from 31 families were encountered in the *R. mucronata* forest in the two study sites during the sampling period in Mida Creek. For the month of January, 90 nematode genera belonging to 25 families were encountered (Fig. 4 and Table 1). The family Linhomoidea recorded the highest relative abundance ranging between 27.1-31.5 % in the three stations followed by Desmodoridae (10.4-18.4 %) and Comesomatidae (10.3-17.1%). The three families cumulatively accounted for 56.1 % while the other 22 families accounted for 43.9 % (Table 1). The 14 most abundant genera accounted for 80 % of the nematode community in
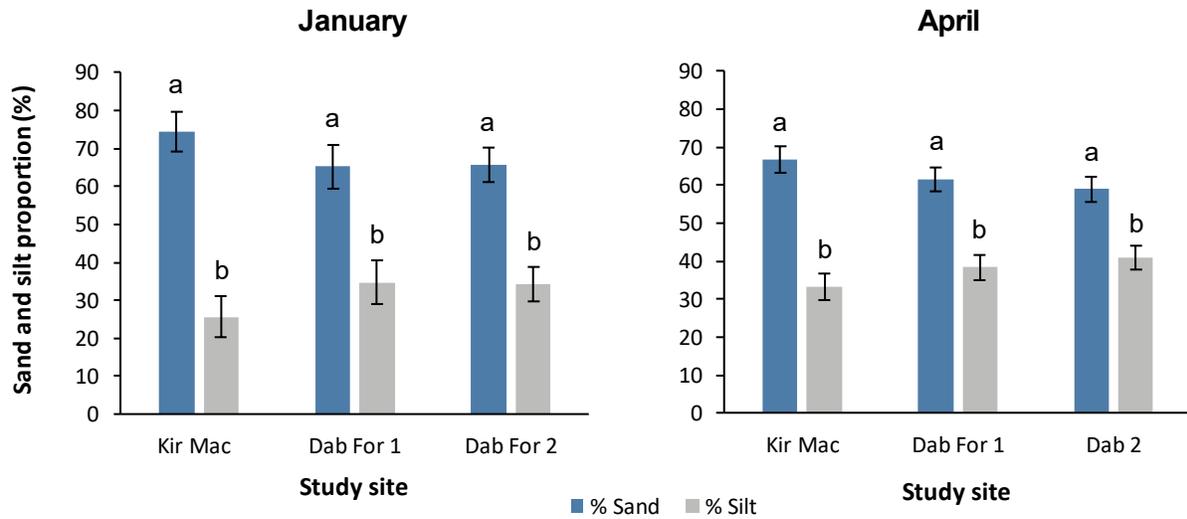
**Figure 3.** Sand and silt percentage proportion from Mida Creek sampling stations (Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2) for the two sampling months (January and April). Values represent mean ± standard error for three replicates. For each sampling site, means with the same letter have no significance different (P>0.05, Turkey test).

Kirepwe Macho, 70 % in Dabaso 1 and 60 % in Dabaso 2 (Fig. 4). The most abundant genera were *Terschellingia* with the highest relative abundance of all genera (between 18 % to 25 %) in the three forest plots (Fig. 4) followed by *Paracomesoma* (5%-8%) and *Spirinia* (1 %-5 %).

The rest of the genera had less than 3 % abundance in each station.

In the month of April, a total of 81 genera belonging to 28 families were encountered. Desmodoridae was
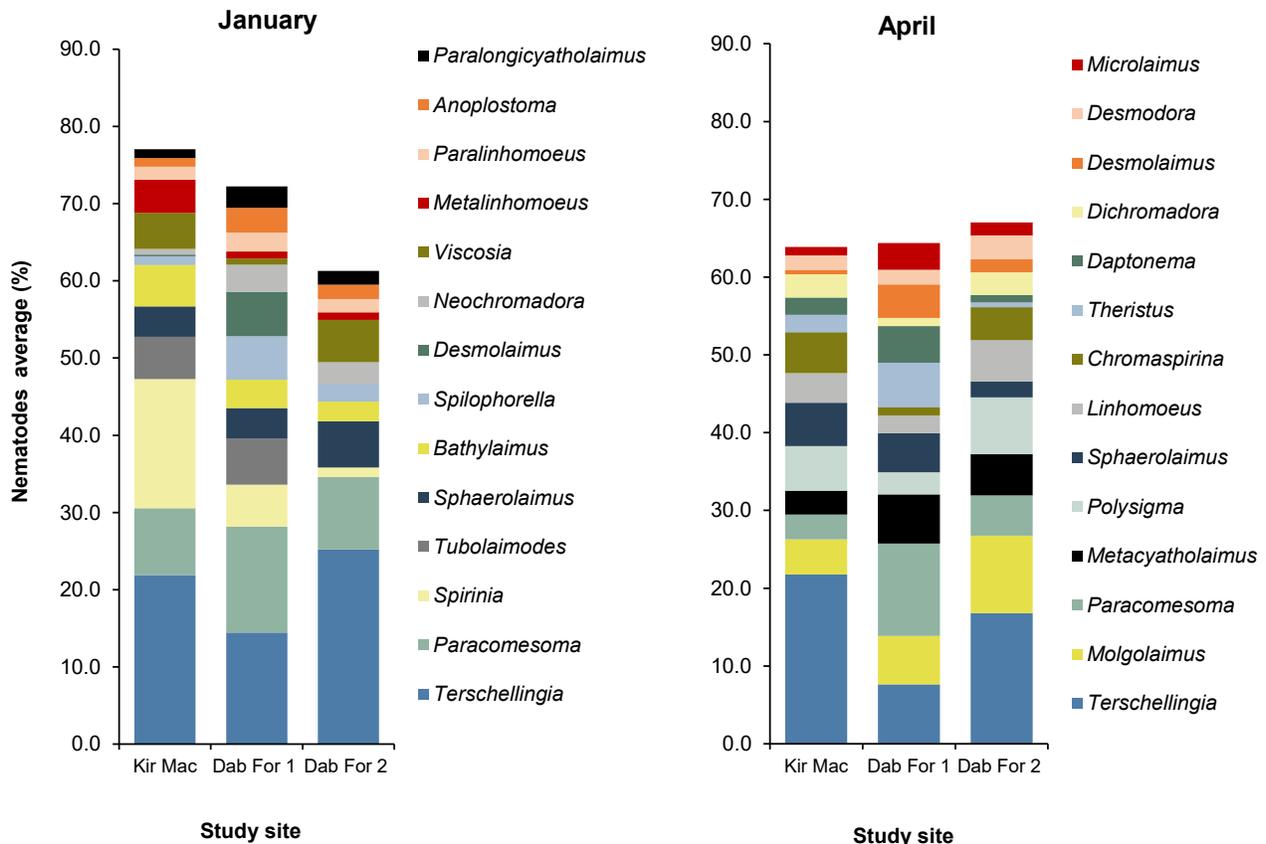


**Figure 4.** Percentage average of nematode genera from Mida Creek sampling stations (Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2) for the two sampling months (January and April).

**Table 1.** Percentage averages of nematode families in three sampling stations in the month of January and April. Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2.

| Nematode Families | Sampling stations | | | | | |
|---|---|---|---|---|---|---|
| | January | | | April | | |
| | Kir Mac | Dabaso For 1 | Dabaso For 2 | Kir Mac | Dabaso For 1 | Dabaso For 2 |
| Linhomoeidae | 31.5 | 27.1 | 30.0 | 30.0 | 16.1 | 25.8 |
| Desmodoridae | 18.4 | 12.0 | 10.4 | 18.7 | 14.8 | 30.9 |
| Comesomatidae | 10.3 | 17.1 | 11.6 | 4.3 | 16.3 | 10.8 |
| Chromadoridae | 10.8 | 8.0 | 9.6 | 4.6 | 6.0 | 6.5 |
| Spaerolaimidae | 3.9 | 4.0 | 6.0 | 5.6 | 5.0 | 2.0 |
| Oncholaimidae | 4.9 | 1.0 | 6.5 | 0.3 | 0.8 | 0.4 |
| Tripuloididae | 5.4 | 3.7 | 2.6 | 1.3 | 1.3 | 1.4 |
| Tubolaimoididae | 5.5 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| Xyalidae | 2.2 | 3.6 | 5.3 | 5.2 | 12.6 | 2.6 |
| Hypodontolaiminae | 1.1 | 5.6 | 2.3 | 1.2 | 3.0 | 1.0 |
| Cyatholaimidae | 2.0 | 3.6 | 2.9 | 10.5 | 8.6 | 10.4 |
| Anoplostomatidae | 1.1 | 3.2 | 1.9 | 2.8 | 1.3 | 0.9 |
| Selachinematidae | 0.4 | 0.6 | 3.4 | 3.1 | 1.3 | 1.4 |
| Oxystominidae | 0.4 | 0.4 | 1.8 | 0.7 | 0.2 | 0.7 |
| Anticomidae | 0.0 | 0.0 | 1.7 | 0.6 | 0.0 | 0.0 |
| Axonolaimidae | 1.5 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 |
| Microlaimidae | 0.0 | 0.4 | 1.4 | 1.3 | 3.4 | 1.7 |
| Ironidae | 0.2 | 0.2 | 1.1 | 2.0 | 0.5 | 0.6 |
| Leptolaimidae | 0.0 | 1.5 | 0.0 | 0.0 | 3.6 | 0.0 |
| Enchelidiidae | 0.0 | 0.6 | 0.6 | 1.1 | 0.0 | 0.5 |
| Monhysteridae | 0.0 | 0.2 | 0.5 | 0.3 | 0.5 | 0.0 |
| Neotonchidae | 0.2 | 0.0 | 0.2 | 0.8 | 2.6 | 0.2 |
| Paramicrolaimidae | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rhadinematidae | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Camacolaimidae | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.7 |
| Haliplectidae | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 |
| Trefusiidae | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 |
| Aponchiidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.9 |
| Monoposthiidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 |
| Phanodermatidae | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.0 |
| Desmoscolecidae | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |

the most abundant family ranging between 14.8-30.9 % in the three forest plots followed by Linhomoidae (16.1-30 %) and Comesomatidae (4.3-16.3%). The three families accounted for 54.9 % cumulatively while the other 25 families accounted for a total of 45.1 % (Table 1). *Terschellingia* was the most abundant genus with relative abundance between 5 % and 15.3 % in the three forest plots (Fig. 4) followed by *Molgolaimus* at 4 % to 10 % and *Paracomesoma* at 2 % -12 %. Other genera had less than 4 % of the total relative abundance each.

Nematode community assemblages (based on Multi-dimensional scaling-MDS plots) from the three forest plots did not show differences between sampling sites (R = 0.5; P = 0.901), however, there was a significant difference (R = 1; P =0.001) between the nematode community encountered in January and in April (Fig. 5). Analysis of Similarities (ANOSIM) results

illustrated no statistical differences among sites (R = -0.5; P value=1) while there were statistical differences between sampling times (R = 1; P value=0.001).

### Nematode diversity and evenness

The Shannon-Wiener diversity index (Fig. 6) showed that both Dabaso plots had a similar diversity index of between 3.3 and 3.4 in both sampling times (January and April). Kirepwe Macho Forest recorded a diversity of 2.8 in January and 3.3 in April. Analysis of variance showed no significant difference between forest stands in terms of diversity indices indicating that the three study sites and sampling times had very similar diversities (P value = 1.00, 0.99) respectively. The nematode community was relatively even with the January evenness ranging from 0.38 to 0.50 while that in April ranged from 0.48 to 0.56 (Fig. 6).
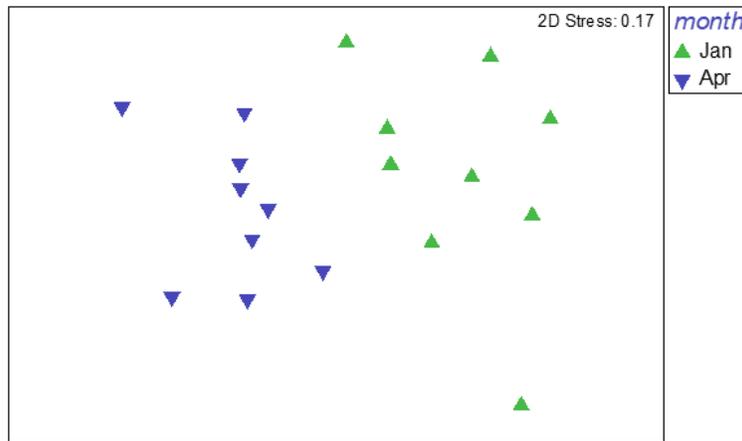
**Figure 5.** Non-Metric Multidimensional scaling plot of nematode community assemblage in January and April based on square root transformed data.

## Discussion

In general, the factors that play a significant role in nematode community distribution include organic litter (Rahman *et al*., 2014), sediment depth, oxygen levels (Muthumbi *et al*., 2011), sediment composition (Adão *et al*., 2009), macro- and meiobenthos interactions (Schrijvers *et al*., 1995; Carlén and Ólafsson, 2002) and mangrove species (Torres-Pratts and Schizas, 2007). This study recorded similar TOM, sand and silt proportions in all sites, and this could be attributed to sites having the same species and being in the same general location with minimum interference by human activities. Kyalo (2016) recorded higher TOM in Mida sediments compared to Gazi Bay in Kenya, and a higher productivity in Mida Creek leading to a high diversity of nematodes. Additionally, Mida Creek sediments were mainly sandy, and these results aligned with *R. mucronata* sediments studied by Kyalo (2016).

The sediments of *R. mucronata* mangrove plots in Mida Creek were characterized by taxonomically rich nematode communities similar to other mangrove areas worldwide (Table 2). Vietnam, Brazil and some parts of India recorded slightly lower numbers of nematode families and genera compared to Mida Creek (Mokievsky *et al*., 2011; Pinto *et al*., 2012).

The most abundant families in Mida Creek were Linhomoidea, Desmodoridae and Comesomatidae, in that order in all study sites and during the two sampling times (January and April). These results differed from those by Mokievsky *et al*. (2011) who encountered more Chromadoridae, Oncholaimidae and Zylidae families in Vietnam. India recorded Comesomatidae and Xyalidae as the most abundant families (Chinnadurai and Fernando, 2007). Itamara Island in Brazil recorded some similarities where Chromadoridae,
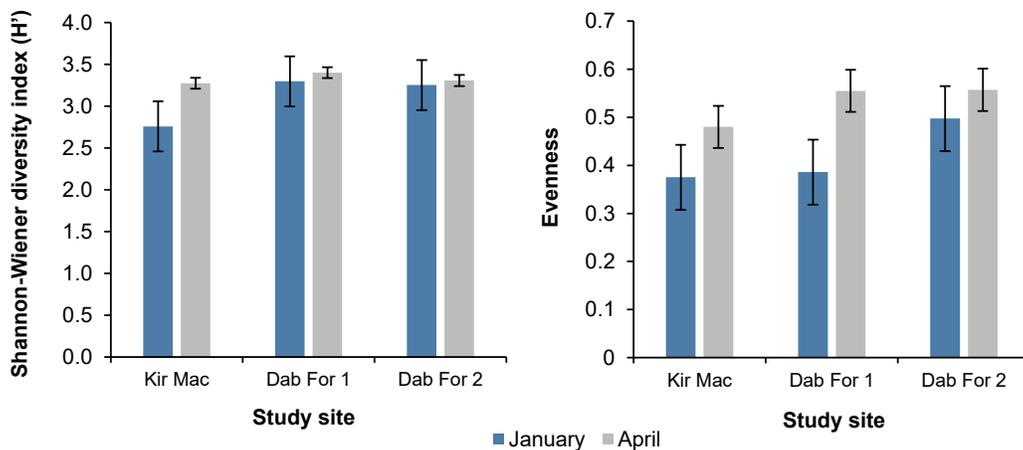


**Figure 6.** Nematode genus Shannon-Wiener diversity index (H') (on the left) and Evenness (on the right) in January and April sampling months at Mida Creek sampling stations (Kir Mac-Kirepwe Macho, Dab For 1-Dabaso 1 and Dab For 2-Dabaso 2). Values represent mean ± standard error for three replicates. For each sampling site, means with the same letter have no significance different (P>0.05, Turkey test).

**Table 2.** Nematodes distribution in mangrove forest sediments (Rhizophora spp.) from different locations in the world.

| Mangrove species (ecosystem) | Country | Families | Genera | Author | GPS Co-ordinates |
|---|---|---|---|---|---|
| *Aegiceras corniculatum, Avicennia marina, Bruguiera gymnorrhiza, Kandelia obovata, Rhizophora stylosa,* and *Sterculia apetala.* | South China | - | 67 | | Lat. 20°15´-21°55´N; Long. 109°40´-110°55´E |
| *Sterculia apetala* and *Kandelia obovata* | South China | - | 50 | | Lat. 24°38´-24°39´N; Long. 118°11´-118°12´E |
| Sediments dominated by *Avicennia marina* and *Rhizophora apiculate* | India | 28 | 36 | (Chinnadurai *et al.*, 2007) | Lat. 11°27´N; Long. 79°47´E |
| *Avicennia aff. alba* and *Rhizophora mucronata* | Vietnam | 24 | 48 | (Mokievsky *et al.*, 2011) | Lat. 12°12´N; Long. 109°11´E |
| *Rhizophora mangle* | Brazil | 25 | 73 | (Pinto *et al.*, 2012) | Lat. 7°46´S; Long. 34°52´W |
| *Avicennia marina* | India | 18 | 27 | (Ansari *et al.*, 2014) | Lat. 11°29´N; Long. 79°46´E |
| *Rhizophora mucronata* | India | 18 | 25 | (Ansari *et al.*, 2014) | Lat. 11°29´N; Long. 79°46´E |
| *Rhizophora mucronata* | Kenya | 25 | 90 | Present study | Lat. 3°23´ S; Long. 39°56´ E |

Cyatholaimidae, Desmodoridae, Xyalidae, and Linhomoeidae were the dominant families (Pinto *et al.*, 2012). Other parts of Brazil recorded Chromadoridae and Linhomoeidae as the most dominant families. This results from this study showed some similarities with South Asia data where Linhomoidea, Comesomatidae and Desmodoridae were the most abundant families (Fu *et al.*, 2021).

Nematode diversity as indicated by the Shannon-Wiener diversity index were in a similar range as observed by Mokievsky *et al.* (2011) who found a value of 2.99 in *Rhizophora stylosa* sediments in Be River, central Vietnam. Forest stands of similar mangrove species had high benthic diversity dominated by nematodes which were the most abundant infauna organisms. Pinto *et al.* (2012) found a significant difference in nematode assemblage structure in different microhabitats (sandy mud, mud flat, cyanobacteria mat, *Rhizophora* mangle and pneumatophores). Nematodes are adapted to a vast range of ecosystems, but specific genera colonize suitable habitats with adequate resources. Regional variations of nematode distribution in mixed species mangrove forests were also noted in Zanzibar (Ndaro and Olafsson, 1999), India (Ansari *et al.*, 2014) and southern Vietnam (Xuan *et al.*, 2007). However, according to

Ansari *et al.* (2014), there was no significant difference in nematode diversity between *Avicennia marina* and *R. mucronata* mangrove stands/forests.

In addition to only small taxonomical differences observed in terms of dominant nematode families and genera composition, the high abundance of Terschellingia is a common observation in many areas. Terschellingia was the most abundant genus in the three sampling stations and in both the month of January and April, while previous research has also shown that Terschellingia species survive well in hypoxic environments (Soetaert and Heip, 1995; Kotwicki et al., 2016), such as the organically enriched soft sediments in mangrove biotopes. The dominance of Terschellingia suggested that all stations sampled in this study had limited oxygen and that the present nematode communities had the ability to adapt and colonize hypoxic environments (Armenteros et al., 2009). The results from this study were only partly in accordance with observations in Rhizophora mangle sediments in Brazil (Pinto et al., 2012) and a R. stylosa habitat in Vietnam (Mokievsky et al., 2011) which recorded Terschellingia as the second most abundant genus after the genus Haliplectus, despite having the same mangrove genus of Rhizophora.

Seasonal changes in the ecosystem resulted in differences in recorded taxa which could be explained by abiotic and biotic variability (Venekey *et al.*, 2019; Ólafsson and Elmgren, 1997). The differences in nematode composition between the month of January and April as encountered in Mida Creek could be attributed to different factors such as temperature, food availability and salinity differences. The dry season recorded different nematode communities compared to the wet season which was contrary to the findings by Kyalo (2016) who found no seasonal differences, while Beier and Traunspurger (2003) did observe seasonal differences such as higher nematode densities in summer and low density during autumn and winter. Additionally, favorable hydrological conditions in the dry season like low water depth, slow water discharge to the ocean, sediment stability, high salinity and favorable temperatures for nematode metabolism are likely vital factors for nematode community stability in marine sediments compared to storm water disturbances, lower temperatures, reduced salinity and reduced water evaporation due to cloud cover during the wet season.

This study confirmed that similar mangrove habitats are likely to have similar nematode communities and diversity when the habitats are within the same location. Hence, it is possible to extrapolate the diversity and composition of nematodes, which are proxy for other ecosystem components, to larger forest areas in Mida Creek, particularly for *R. mucronata*, without the need for intensive sampling. However, it remains to be established how far apart similar habitats can be and still harbour similar nematode communities (genera distribution and diversity).

Most of the previous studies focused on mixed forest stands. There is a need to accumulate more data with pure forest stands in different mangrove regions to certify whether results vary with region. Similar experiments should be conducted in the remaining pure stands of mangrove species worldwide to determine whether the nematode community structure is affected by the mangrove tree species. This information will assist in conservation practices and governance of mangrove ecosystems in tropical and sub-tropical regions.

## Acknowledgements

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