DISTRIBUTION OF ECOSYSTEM HEALTH INDICATORS FOR BIOMONITORING OF OIL POLLUTION IN THE WESTERN NIGER DELTA, NIGERIA

ABSTRACT

As a result of the limitations of physical and chemical methods for monitoring pollution, interest on the more reliable biological monitoring intensified over the past four decades. Soil microarthropods, specifically the free-living mites (Cryptostigmata, Mesostigmata, Prostigmata) and Collembolans were used as monitor (ability to withstand pollutants) and indicator (sensitive to pollutants) species in the Eastern Niger Delta. Study was undertaken in the Western Niger Delta (Delta State) across three eco-vegetational zone (freshwater swamp forest, Mangrove swamp forest, Lowland rainforest) in the area to determine if these ecosystem health indicators were widely distributed in these zones. Collections were made during the rainy season over a 4-month period. A modified Berlese-Tullgren funnel was used for extraction of microarthropds. Free-living mites: Cryptostigmata (Oribatida) – *Archogozettes magnus, Opiida sp., Annecticarus sp., Bicyrthermania negeriana, Cephalida sp., Scheloribates sp., Galumnida sp.,* Mesostigmata (Gamasida) - *Asca sp., Trichuropodida* and Collembolan – *Paronella sp.,* were widely distributed across the eco-vegetational zones. Oribatids were dominant across eco-vegetational zones. These mesofauna contained the full complement of monitor and indicator species. It is therefore possible to use these mesofauna for biomonitoring of oil pollution across the Niger Delta (eastern and western sectors), Nigeria.

Key Words: Pollutants, Ecosystem Health Indicators, Mites, Collembolans, Biomonitoring, Niger Delta, Nigeria.

INTRODUCTION

The effective dose of a pollutant in an individual, determined by physical or chemical methods may be much lower than the result obtained. The total concentration may be raised by high levels of surface contamination or the binding of pollutant to inert sites. Thus the biological significance of the concentration in the individual may be overestimated. In contrast, biological monitoring assesses the significance of a pollutant for an organism in its habitat and other individuals in the community. Monitor and indicator species are used to measure pollutant impact (Martin and Coughtrey, 1982). Monitor species have the ability to withstand pollutants and they are used to assess the scale and distribution of the pollutant. In contrast, indicator species are sensitive to the pollutant and their presence or absence indicates a significant level of contamination.

Mites of the suborder Oribatida, also called “beetle” or “moss”mites are the world’s most numerous arthropods living in the soil (Seastedt, 1984). There are several thousand species, yet the fauna of much of the tropics is still unknown. They are the most abundant group of microarthropods in most forested, grassland and desert ecosystem (Seastedt, 1984). Mites and other microartthropods (Including Collembolans), part of the mesofauna play a crucial role in the context of soil biodiversity, decomposition and mineralization processes (Seastedt, 1984; Tiann *et al.*, 1998). Among the microarthropods, the feeders (mycophages) are dominant Collembolans free-living astigmatid mites and most oribatids (Cryptostigmites) have well-developed mouthparts, capable of fragmenting organic matter, while feeding on the microflora adhering to detritus. Fragmentation and communition are important to the decomposition and mineralization processes by creating new surface area for microbial colonization (Fountain and Hopkin, 2005). The decomposer community received greater interest within soil ecology in the past six decades (Bardgett, 2002). The free-living mites (Cryptostigmata, Mesostigmata, Prostigmata) and Collembolans have been used as monitor and indicator species to determine ecosystem health in Rivers State, Eastern Niger-Delta (Gbarakoro *et al.*, 2010; Okiwelu *et al.*, 2011a &b; Gbarakoro *et al.*, 2011).

This study was undertaken to produce baseline data on the species composition of mites and Collembolans in relatively undisturbed habitats in mangrove swamp forest, freshwater swamp forest, lowland rainforest in Delta State, Western Niger Delta, Nigeria. If they are distributed across these zones, they can be used for biomonitoring of oil pollution across the Niger Delta.

MATERIALS AND METHODS

The mangrove swamp forest is located on the bank of the Isaba River, Warri North Local Government Area (LGA) and the freshwater swamp forest, at Merogun, Warri South LGA, Delta State. Collections were made from two sites in each of in each of the LGAs. At Isaba in Warri North LGA, collections were made from the mangrove forest and in lowland rainforest approximately 200m away. In Warri South LGA, at Merogun, collections were from the freshwater swamp forest and approximately 200km away, in farm bush located in lowland rainforest.

Studies were conducted over a 4-month period, June-September, during the rainy season. At each location, an area 30.00cmx30.00cm was delineated. Each delineated area was divided into 4 sub-plots and collections made monthly in rotation from each sub-plot. Collections were made at 08.00-09.00hrs from litter and depths of 0.50cm, 5.0-10.0cm, 10.0-15.0cm; 15.0-20.0 cm, 20-25cm and 25-30cm. Samples were placed in labeled transparent bags. A modified Berlese-Tullgren funnel was used to extract the microarthropod species were identified to family levels by keys and illustrations provided by Badejo (1994) and type specimens in the Entomology and Pest Management Laboratory, University of Port Harcourt.

RESULTS

In the mangrove swamp forest, six species of Cryptostigmata (Oribatida) were collected: *Archogozettes magnus*, *Annecticarus sp.*, *Bicyrthermania negeriana*, *Cephalida sp.*, *Scheloribates sp.*, *Galumnida sp.*; a species of Mesostigmata (*Gamasida*) *Asca sp.* and a species of Collembola, *Paronella* sp. (Table 1). In the freshwater swamp forest, 4 Cryptostigmata (*Oribatida*) species - *Opiida* sp., *Galumnida sp.*, *Cephalid sp.*, *Scheloribates*, 1 Mesostigmata (*Gamasida sp*.) were collected (Table 2).

In lowland rain forest - Warri North LGA (1), 4 species of Cryptostigmata (*Oribatida*) - *Archegozettes magnus*, *Galumnida sp.*, *Cephalid sp.*, *Scheloribates sp.*; 2 species of Mesostigmata (Gamasida), *Asca sp.* and *Uropodida sp.* and 1 species of Collembola - *Paronella sp.* were collected (Table 3). In lowland rainforest of Warri South LGA, 4 Cryptostigmata (*Oribatida*) - 4 species *Scheloribates sp.*, *Galumnida sp.*, *Cephalida sp.*, *Opiida sp.*; 2 Mesostigmata (*Gamasida*) - *Asca sp.*, *Uropopida sp.*, and 1 Collembola *sp.*- *Paronella sp.* were collected (Table 3). Oribatids were dominant across eco-vegetational zones. Lowland rainforest yielded the highest number of soil microarthropods (Table 4).

DISCUSSION

In the lowland rainforest, the species composition of mites and Collembolans was more limited than that of Okiwelu *et al.* (2011) from undisturbed habitat in lowland rainforest of eastern Niger Delta. This was probably due to the significantly reduced period for collection. The absence of any Prostigmata sp. was also probably due to the limited collection period. However, both monitor species of Cryptostigmata (*Galumnida sp.*; *Scheloribates sp.*) and indicator species of Cryptostigmata (*Cephalides sp.*, *Archeogozettes magnus*, *Oppia sp.*) and Mesostigmata (*Asca sp.*, *Trachyllropodida sp.*, *Uropodida sp.*) were encountered. The Collembolan monitor sp. (*Paronella sp.*) was encountered.

In the mangrove swamp forest, there were six spp. that consisted of both monitor spp. (*Bichrthermannia nigeriana*, *Scheloribates sp.*, *Galumnida sp.*) and indicator spp. Cryptostimata - (*Archegozettes magnus.*, *Cephalida sp.*) and Mesostigmata - (*Asca sp.*). The Collembolan monitor species - *Paronella sp.* was also identified. In the freshwater swamp forest, there were 2 monitor spp. - Mesostigmata (*Galumnida sp.*, *Scheloribates sp.*) and 3 indicator species – (*Oppia sp.*, *Cephalida sp.*) and Mesostigmata (*Asca sp.*). In lowland rainforest, 2 monitor species- Mesostigmata (*Galumnida* sp., *Scheloribates* sp.) and 1 indicator species - Mesostigmata (*Asca* sp.) were identified. The Collembolan monitor species - *Paronella* was also identified.

In a series of studies in lowland rainforest, Rivers State, eastern Niger Delta (Gbarakoro *et al.*, 2010, 2011; Okiwelu *et al.*, 2011 a & b), it was established that a full complement of soil microarthropods of monitor and indicator species was adequate for bio-monitoring to assess ecosystem health. Monitor species are used to assess the scale and distribution of the pollutants while indicator species are sensitive to the pollutant and their presence or absence indicates a significant level of contamination. The mangrove, freshwater swamp forests and lowland rainforests of the western Niger Delta also have these complements of soil microarthropods. Oil pollution biomonitoring with soil microarthropods is therefore feasible across all eco-vegetational zones in the Niger Delta and it is thus recommended.

CONCLUSION

The full complement of soil micro-arthropod ecosystem health indicators (monitor and indicator species) were widely distributed across the major eco-vegetational zones (Lowland rainforest, Mangrove swamp forest, Freshwater Swamp forest) of the western Niger Delta. They had been found extensively distributed in the eastern Niger Delta. Consequently, their use for biomonitoring of oil pollution in the Niger Delta is feasible and advisable.

Table 1. Species of microarthropods from Mangrove Swamp Forest

Vegetation type	Mites		Collembola
	Oribatida	Gamasida	
Mangrove Swamp Forest	*Archegozettes magnus*	*Asca sp.*	*Paronella sp.*
	Annecticarus sp.		
	Bicyrthermannia nigeriana		
	Cephalida sp.		
	Galumnida sp.		
	Scheloribates sp.		

Table 2. Species of microarthropods from Freshwater Swamp Forest

Habitat type	Mites		Collembola
	Oribatida	Gamasida	
	Cephalida sp.	*Ascidae sp.*	
Freshwater Swamp Forest	*Galumnida sp.*		
	Oppia sp.		
	Scheloribates sp.		

Table 3. Species of microarthropods from Lowland Rainforest

Vegetation type	Mites		Collembola
	Oribatida	Gamasida	
Lowland Rainforest - Warri North LGA	*Archegozettes magnus*	*Asca sp.*	*Paronella sp.*
	Cephalida sp.		
	Galumnida sp.		
	Scheloribates sp.		
Lowland Rainforest (Farm bush) - Warri South LGA	*Cephalida sp.*	*Asca sp.*	*Paronella sp.*
	Galumnida sp.	*Uropodidae sp.*	
	Oppia sp.		
	Scheloribates sp.		

Table 4. Mite and Collembolan abundance across eco-vegetational zones

Order	Sub-Order	Mangrove forest	Freshwater swamp forest	Lowland rainforest
Acarina	Oribatida	42	11	77
	Gamasida	6	3	15
Collembolan		2	0	9

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