International Scholars Journals

African Journal of Ecology and Ecosystems ISSN 2756-3367 Vol. 11 (5), pp. 001-004, May, 2024. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Assessing soil micro-arthropods as bioindicators of oil pollution in a secondary rainforest, Rivers State, Nigeria

Samuel Okiwelu [1]*, Gbarakoro Tambeke[1] and Badejo Adetola[2]

[1]Department of Animal and Environmental Biology, University of Port Harcourt, Port Harcourt, Nigeria.
[2]Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Accepted 25 October, 2023

Comparisons were made of the species richness and densities of soil micro-arthropods- (mites, collembolans) from a relatively undisturbed secondary forest and a nearby area, where there had been an oil spill, approximately 1 year before the commencement of the 2 yr study, May, 2007 to April, 2009. Soil samples were taken monthly with an 8.5 cm diameter bucket -type auger. Extraction was by the Berlese-Tullgren funnel. Identification was undertaken with the aid of standard keys and comparisons were made with type specimens. Mean Total Hydrocarbon (THC) values were 630 mg/kg (43.0 to 1000.0) and 10 mg/kg at the polluted and undisturbed habitats respectively. Among the mites, Cryptostigmata (Oribatids) were dominant in both undisturbed (69.85%) and polluted (74.25%) habitats; the least abundant were the prostigmates. Within the oribatids, *Scheloribates* spp., *Galumnidae spp.*, *Parallonothrus nigeriensis* and *Bichythermamia nigeriana* were collected from both habitat types. In contrast, *Mixacarus* sp., *Aunecticarus sp.*, *Atropacarus sp.*, *Bellidae sp.*, *Cephalidae sp.*, *Oppia sp.*, *Basilobellidae* sp., *Epilohmaunia sp.*, *Mesoplophora sp.*, *Aecheogozettes magnus* and *Northrus lasebikani* were restricted to the undisturbed habitat. In the Mesostigmata, only *Parasiticidae sp* . and *Rhodacaridae sp*. were found in both habitat types; *Polyaspidae sp.*, *Uropodidae sp. and Asca sp.* were restricted to the undisturbed habitat. The Prostigmata, *Bellidae* sp. were collected from undisturbed and polluted habitats. Among Collembolans, *Cryptophagous* and *Paranolla* were found in both habitat types while *Hypogastina*, was restricted to the undisturbed habitat. Abundance and densities of mites and collembolans were respectively significantly reduced in the polluted habitat ($p < 0.05$; df = 9; F = 20.5; $p < 0.05$; df = 9; F = 30.08). These findings are discussed within the context of the use of monitor (tolerant) and indicator (sensitive) species in bio-monitoring and assessment of oil pollution.

Key words: Soil mites, collembolans, oil pollution, densities, monitor/indicator species, rainforest, Nigeria.

INTRODUCTION

Simple physical or chemical determinations are limited in monitoring the effects of pollution because the total concentration measured in the individual can easily over-estimate its biological significance; high levels of surface contamination or the binding of the pollutant at inert sites may mean that the effective dose is much lower. Other limitations include restriction of data to the moment of sampling and the methods do not take cognizance of the patchy distribution of chemicals in the environment; chemical analyses are time consuming, expensive and often limited to suspect compounds.

Biological monitoring aims to assess the significance of a pollutant for an organism in its habitat and other members of its community. Two basic approaches are used to measure the impact: the use of monitor and indicator species (Martin and Coughtrey, 1982). Monitor species are organisms whose ability to accumulate

---

*Corresponding author. E-mail: okiwelu2003@yahoo.com. Tel: (+234) 8033382424.

pollutants is used to assess the scale and distribution of the pollution insult. They are generally insensitive or tolerant of the stress. In contrast, indicator species are sensitive to the pollutant and their presence or absence is taken to indicate a significant level of contamination (Beeby, 1993).

Among the acari, Cryptostigmata (Oribatids) are considered suitable indicators of soil systems; they have high diversity, densities and are sensitive to environmental changes (Behan-Pelletier, 1999; Paoletti et al., 2007). They are similar to K-selected organisms; they are long-lived, iteroparous, have low fecundity and slow development rates (Norton, 1985; 1994). They have little capacity for rapid population growth and few are adapted for dispersal; they are therefore unable to easily escape environmental stress (Behan-Pelletier, 1999).

Collembolans are among the most abundant arthropods on earth with a long evolutionary history (Engel and Grimaldi, 2004). Most species consume fungi, in soil and leaf litter, they have radiated into many niches, from the littoral zone to mountain tops and are particularly abundant in epiphytes of tropical rainforests (Hopkin, 1997). Collembolans are an integral part of soil ecosystems and are vulnerable to the effects of soil contamination. The abundance and diversity of Collembola have been widely used to assess the environmental impact of a range of pollutants on soils (Van Straalen and Lokke, 1997; Van Straalen and Van Leeuwen, 2002; Van Straalen, 2003, 2004).

Comparisons were made of the species richness (with emphasis on monitor and indicator species) and densities of soil micro-arthropods (mites - Cryptostigmata, Mesostigmata, Prostigmata; Collembolans) from a relatively undisturbed secondary forest and a nearby forest, where there had been an oil spill, approximately 1 year before the commencement of the study.

MATERIALS AND METHODS

The study was conducted at Norkpo (04O 44.161N, 07O 12.317E) and Gio (04O41.927N, 07O14.836E), in the Tai Local Government Area (LGA), Rivers State, Niger Delta region, Southeast Nigeria. The relatively undisturbed secondary forest at Norkpo was approximately 3500 m^2 and the polluted habitat at Gio was about 200m, southeast of the fallow area, the vegetation of the area has been described (Gbarakoro et al., 2010). A 3500m^2 area was demarcated within the polluted habitat. The undisturbed and polluted habitats were each divided into twelve 24 x 12 m sub-plots, to ensure total coverage during sampling over a 2 yr period, May 2007 to April, 2009. Soil samples were taken monthly with an 8.5 cm diameter bucket-type auger at the southern section of each sub-plot during the first year, May, 2007 to April, 2008.

In the second year, May, 2008 to April, 2009, samples were taken from the northern section. Depths of soil samples were 0 to 5.0 cm, 5.1 to 7.5 cm, 7.6 to 10.0 cm, 10.1 to 12.5 and 12.6 to 15.0 cm. The auger was also used to collect 567.2 cm^3 soil samples from each habitat-type for Total Hydrocarbon Content (THC) analysis, by the modified ASTM D3921 method. To ensure that the soil in each range was collected, the auger was rotated clockwise and anticlockwise until all soil was taken. Each sample was placed in a plastic bag, labelled and taken to the laboratory for analyses in a 3-stage process (extraction, sorting and identification). The modified Bukard model of the Berlese-Tullgren funnel was used for extraction (Lasebikan, 1974). The extractor complex consists of two rows of 8 units each, enclosed in a wooden cabinet. Description of the extractor unit and extraction procedure has been documented (Badejo, 1996). The duration of extraction was 7 days. The extracts containing soil micro-arthropods were placed in Petri- dishes under a dissecting microscope; the mites and collembolans were carefully removed.

Temporary slides were prepared and identification undertaken under a WETZLAR compound microscope, at the Entomology Research Laboratory, University of Port Harcourt. Identification keys (Krantz, 1978; Norton, 1990; Woolley, 1990) were used. Unidentified specimens were taken to the Laboratory of Systematics and Ecology of Micro-arthropods, Obafemi Awolowo University and compared to type specimens. Identified mites and Collembolans were counted and abundance calculated as the mean from the 2 year study. Density was obtained by the division of abundance by soil volume. Data were subjected to statistical analyses.

RESULTS

Mean Total Hydrocarbon Content (THC) values were 630 mg/kg (430.0 to 1000.0) and 10.0 mg/kg at the polluted and the relatively undisturbed habitats respectively. The oribatids (Cryptostigmata) were dominant among mites in both undisturbed (69.85%) and polluted (74. 25%) habitats (Table 1). The least abundant were the prostigmates: 3.03 and 8.4% in undisturbed and polluted habitats, respectively. There were 27 mite species (Cryptostigmata-19, Mesostigmata-7, Prostigmata-1) and 3 Collembolan species in the undisturbed habitat; the number of species was reduced in the polluted habitat (Table 1). Among the oribatids, *Scheloribates spp.*, *Galumnidae* spp., *Parallonothrus nigeriensis* and *Bicrythermaimia nigeriana* were collected from both habitat types.

In contrast, *Mixacarus* sp., *Aunecticarus* sp., *Atropacarus* sp., *Belbidae* sp., *Cephalidae sp., Oppia* sp., *Basilobellidae* sp., *Epilohmaunia sp., Mesoplophora* sp., *Archegozettes magnus* and *Northrus lasebikani* were restricted to the undisturbed habitat. In the Mesostigmata, only *Parasiticidae sp*. and *Rhodacaridae sp*. were found in both habitats; the remaining five species: *Polyaspidae sp.*, *Trahyllropodidae* sp., *Prodinichidae* sp., *Uropodidae sp.* and *Asca* sp. were exclusive to the undisturbed habitat. In the Prostigmata, *Bdellidae* sp. was collected from undisturbed and polluted habitats. There was approximately a 90% reduction in total mite abundance and density in the polluted habitat; the difference in total mite densities in undisturbed and polluted habitats was significant ($p < 0.05$; df = 9; Fc = 20.5) (Table 1).

Among the Collembolans, there was no dominant species: *Cryptophagus* sp. (43.91%), *Paronella* sp. (31.73%) and *Hypogastina* sp. (24.36%). *Cryptophagus* and *Paronella* spp. were recorded at the undisturbed and polluted habitats, although numbers were lower at the polluted site; *Hypogastina* sp. was restricted to the

Table 1. Species richness and densities of mites at undisturbed and polluted habitats.

Species	**Habitat types**	
Cryptostigmata (Oribatida)	**Undisturbed**	**Polluted 1year pre-study**
Scheloribatids spp (3)*	1857	232
Galumnidae spp. (3)*	1467	254
P. nigeriensis	338	58
B. nigeriana	302	30
Mixacarus sp.	324	-
Aunecticarus sp.	298	-
Atropacarus sp.	312	-
Belbidae sp.	380	-
Cephalidae sp.	272	-
Oppia sp.	229	-
Basilobelbidae sp.	213	-
Epilohmaunia sp.	169	-
Mesoplophora sp.	109	-
A. magnus	150	-
N. lasebikani	81	-
Sub- total	6501	574
Densities **	7.64	0.67
Mesostigmata		
Polyaspidae sp.	558	-
Trachyllropodidae sp.	352	-
Prodinichidae sp.	252	-
Uropodidae sp.	490	-
Parasitidae sp.	381	53
Rhodacaridae sp.	417	81
Asca sp.	74	-
Sub-total	2524	134
Densities	2.97/cm^3	0.16/cm^3
Prostigmata		
Bdellidae sp.	282	65
Densities	0.33/cm^3	0.08/cm^3
Total	9307	773
Cumulative density	10.94/cm^3	0.91/cm^3

* Number of species in family/genus. ** Densities are number of mites per unit volume. The soil volume was 850.14 cm^3.

undisturbed habitat (Table 2). There was a significant difference in total Collembolan densities between undisturbed and polluted habitats ($p < 0.05$; df = 9; Fc = 30.08).

DISCUSSION

It is apparent that the oribatids: *Scheloribatids* spp., *Galumnidae spp*, *P. nigeriensis, B. nigeriana* and the Collembolans: *Cryptophagus* sp. and *Paronella* sp. had the ability to withstand the stress caused by the oil pollution, either by tolerating high levels or accumulating the pollutants. They have some preferred characteristics (abundance, widely distributed and long-lived species) used in biological monitoring but their small size, difficulty in collecting and identifying them at all ages throughout the year, problems with aging, limit their possibilities as monitor species (Beeby, 1993).

Since the final field collections were undertaken about 3 years after the initial pollution insult (oil spill), it was apparent that the absent oribatid species (*Mixacarus* sp.,

Table 2. Species richness and densities of collembolans at undisturbed and polluted habitats.

Species	Habitat types	
	Pristine	**Polluted 1year pre-study**
Cryptophagus sp.	465	110
Paronella sp.	336	81
Hypogastina sp.	258	-
Total	1059	191
Densities	1.25/cm3	0.23/cm3

Aunecticarus sp., *Atropacarus* sp., *Belbidae* sp., *Cephalidae* sp., *Oppia* sp., *Basilobelbidae* sp., *Epilohmaunia* sp., *Mesoplophora sp., A. magnus* and *N. lasebikani*), Mesostigmata (*Polyaspidae* sp., *Trachyllropodidae* sp., *Prodinichidae* sp., *Uropodidae sp*., *Asca* sp.) and the Collembolan *Hypogastina* sp. were sensitive to the pollutant. They are indicator species because their absence indicated a significant level of contamination.

The significantly lower densities of mites and collembolans at the polluted habitats were probably caused by direct lethal effects on micro-arthropods, negative impact on their reproductive rates or indirectly on their food sources. The soil pollution might have posed a risk to soil processes and soil-based trophic networks (Arroyo et al., 2006). According to Seniczak et al. (1995), pollution primarily caused decrease in density; however, Siepel (1995), Skubala and Kafel (2004) stated that species richness and density were also affected, while Migliorini et al. (2005) observed qualitative changes. Qualitative (species richness) and quantitative (density) indices were adversely affected by the oil pollution.

REFERENCES

Arroyo J, Iturrondobeitia JC (2006). Differences in the diversity of oribatid mite communities in forests and agrosystems lands. Eur. J. Soil Biol., 42: 259-269.

Badejo MA (1996). Measuring the diversity of soil microflora and microfauna in an area of conservation of biodiversity. In Biosphere resources for diversity conservation and sustainable development in Anglophone Africa (BRAAF), assessment and monitoring techniques in Nigeria, Abeokuta, Nigeria.

Beeby A (1993). Applying Ecology. Chapman & Hall, London, p. 441.

Behan-Pelletier VM (1999). Oibatid mite biodiversity in agro-ecosystems: Role for bioindicators. Agric. Ecosyst. Environ., 74: 411-423.

Engel MS, Grimaldi D (2004). New light shed on the oldest insect. Nature, 427: 627- 630.

Gbarakoro TN, Okiwelu SN, Badejo MA, Umeozor OC (2010). Soil Microarthropods in a Secondary Rainforest in Rivers State, Nigeria: -I- Seasonal Variations in Species Richness, Vertical Distribution and Density in an Undisturbed Habitat. Sci. Afr., 9(1): 48-56.

Hopkin SP (1997). Biology of the springtails (Insecta: Collembola). Oxford University Press, Oxford.

Krantz GW (1978). A Manual of Acarology. Oregon State University Book Stores Inc. Corvallis, p.509

Lasebikan BA (1974). Preliminary communication on microarthropods from a tropical rainforest in Nigeria. Pedobiologia, 14: 402 - 411.

Martin MH, Coughtrey PJ (1982). Biological monitoring of heavy metal pollution. Pollution Monitoring Series Ad. (Mellanby K. ed.). Applied Science Publishers Ltd. London and New York, p. 475.

Migliorini M, Pigino G, Caruso T, Fanciulli PP, Leonzio C, Bernini F (2005). Soil communities (Acari Oribatida, Hexapoda Collembola) in a clay pigeon- shooting range. Pedobiologia, 49(1): 1-13.

Norton RA (1985). Aspects of the biology and systematics of soil arachnids, particularly saprophygous and mycophagous mites. Quaestiones Entomologicae, 21: 523 - 541.

Norton RA (1990). Acarina: Oribatida. In:Dindal, D.L.(Ed.), Soil Biology Guide. John Wiley, New York, pp. 779-803.

Norton RA (1994). Evolutionary aspects of oribatid mites life histories and consequences for the origin of the Astigmata. In: M.A. Houck (Ed.), Mites: Ecological and Evolutionary Analyses of Life-History Patterns, Chapman & Hall, New York, pp. 99 -135.

Paoletti MG, Osler GHR, Kinnear A, Black DG, Thomson LJ, Tsitsilas A, Sharley D, Judd S, Neville P, D'Inca A (2007). Detritivores as indicators of landscape and soil degradation. Australian J. Exper. Agric., 47: 412 - 423.

Seniczak S, Dabrowski J, Dlugosz J (1995). Effect Of Copper Smelting Air Pollution On The Mites (Acari) Associated With Young Scots Pine Forests Polluted By A CopperSmelting Works At Giogow, Poland. I. Arboreal Mites. – Water, Air, and Soil Pollution, 94(3-4): 71-84.

Skubala P, Kafel A (2004). Oribatid mite communities and metal bioaccumulation in oribatid species (Acari, Oribatida) along the heavy metal gradient in forest ecosystems. Environ. Poll., 132(1): 51-60.

Siepel H (1995). Are some mites more ecologically exposed to pollution with lead than others? – Experi. Appl. Acarol., 19(7): 391-398.

VanStraalen NM (2003). Ecotoxicology becomes stress ecology. Environ. Sci. Technol., 37(17): 324A - 330A.

VanStraalen NM (2004). The use of soil invertebrates in ecological surveys of contaminated soils. In: Vital Soil, Function, Value and Properties (eds. P. Doelman and H.J.P. Eijsackers). Elsevier, Amsterdam, pp. 159-195.

VanStraalen NM, Lokke H (1997). Ecological approaches in soil ecotoxicology. In: Ecological Risk Assessment of Contaminants in Soil (eds NM Van Straalen and H Lokke). Chapman and Hall, London, pp. 3 - 21.

VanStraalen NM, VanLeeuwen CJ (2002). European history of species sensitivity distributions. In: Species Sensitivity Distributions in Ecotoxicology (eds. L. Posthuma, G. W. Suter II & T. P. Traas). Lewis Publishers, Boca Raton, pp. 19-34.

Woolley TA (1990). Acarology: mites and human welfare. New York. John Willey, p. 463.