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# Earthworm species as pointer for herbaceous flora distribution and health of soil in Onigambari Forest Reserve, Oyo state Nigeria

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**ABSTRACT**

Amongst various and diverse organisms, earthworms (*Annelida: Oligochaeta*) are the most important components of soil biota when it comes to soil formation and maintenance of soil structure and fertility. The presence of earthworms modifies the soil quality of the environment due to their burrowing and casting. This affects the activities of other organisms. Thus, they are also termed "ecosystem engineers". However, while we begin to understand the role of surface casts, it is still unclear to what extent plants utilize subsurface casts. This work is a study of the floral community structure as influenced by surface cast so as to determine the functional groups of earthworms in the natural forest zone of Onigambari Forest Reserve. This reserve is located at latitude 07°25'N and longitude 3°53'E within the low and semi-deciduous forest belt of Nigeria. It is divided into two: natural and plantation forests. Herein, the simple random sampling technique was used to select 10 geo-referenced plots (15 m × 15 m each). Three 1.0 m × 1.0 m square quadrats were randomly laid on each plot to give 30 sampling points surveyed for data collection. Data were collected on floral composition, relative importance values (RIV), earthworm composition and diversity, and physicochemical components of the soil. Twenty eight herbaceous plants were enumerated. *Andropogon gayanus* had the highest relative importance value (RIV) of (20.499), while *Acroceras zizanoides* and *Platostoma africanum* had the least RIV (1.1782) amongst other four. Seven earthworm species were enumerated, with *Eisenia fetida* having the highest RIV (28.571), while *Octoclasion cyaneam* and *Lumbricum rubellus* had the least. The species richness of earthworms was high (0.8061) and evenly distributed (0.8405), but with a low diversity (H' = 1.772). There are two functional groups of earthworm in the natural forest zone, seven were surface dwelling, while only *Lumbricus terrestris* was sub-surface dwelling. The health of flora and soil of the natural forest zone of Onigambari forest reserve is low. Prevention of outside influence on the forest zone, seeding and deposition of organic waste matter to the soil are strategies that would enhance abundance and diversity of earthworms in the natural forest zone.

***Keywords*:** Natural forest, Earthworms, Soil fertility, Relative importance value, Floristic composition

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## 1. INTRODUCTION

Among various and diverse organisms found in the soil, earthworms (*Annelida: Oligochaeta*) are the most important components of soil biota when it comes to soil formation and maintenance of soil structure and fertility (Curry, 2004). Earthworms (EWs) play a key role in soil nutrient dynamics by altering the soil physical, chemical and biological properties which are generally in synchrony with plant demand (Lavelle *et al*., 1989). Therefore, integrating earthworms into agricultural/forest management in order to increase yield has attracted more focus (Lavelle *et al*., 1989; Senapati *et al*., 2002).

The crop production is usually higher in the soil with high number of earthworms than no or less earthworms (Edwards and Bater, 1992; Elmer, 2012). From evolutionary point of view the earthworms (EWs) are very old species. They survived over million years due to their ability to adjust to different environmental conditions. They live mostly in damp soil enriched with organic substances. They take breaths through the skin, and they are very sensitive to changes in temperature, they are light on touch. During the winter they bury themselves in deeper layer to protect their body from low temperature, and during the summer and dryness to protect themselves from dehydration (Brusca and Brusca, 2003).

Their muscle system is built with circular (segments) and longitudinal muscles and with their shrinkage and spread the earthworms are able to move. The body of EWs is covered with small fluffs, which is important in environmental adjustment and for search of the food in the soil. The waste product of earthworm's diet enrich the soil with nutritive substances, which stimulate the growth of plants. However, the earthworms are very important source of diet for numerous animals in the soil. They are hermaphrodites, which means that each individual has both, female and male reproductive systems. This attribute also contributes well to their environmental adjustment, because it aides them to reproduce very easily. Their eggs are hutched in soil, protected with capsule, which arises from the secret *clitellum* (front part). The capsule protects the young worm until complete maturation (Pechenik, 2009).

Investigating the potential of the earthworms to integrate into agricultural/forestry management, knowledge on different physical, chemical and management factors that affect the distribution and abundance of earthworm population is important as that will help to identify the ecological appropriateness of the earthworms in order to supplement their existing population and quantify the impact of earthworms on agricultural/forest lands (Mele and Carter, 1999). Not only from agricultural perspective, earthworms are equally important from ecological point of view because they contain highest soil macro-faunal biomass (Edwards and Bohlen, 1996) and are also increasingly regarded as bio-indicators of soil quality (Pérès *et al*., 2011).

Earthworms (EWs) are the major decomposers of dead and decomposing organic matter, and acquire their nutrition from the bacteria and fungi that grow upon these materials. They decompose the organic matter and make the major contributions to recycling the containing nutrients. Earthworms occur in the warmest soils and many tropical soils. They are divided into 23 families, more than 700 genera, and more than 7,000 species. Their size ranges from an inch to two yards, and are found seasonally at all depths of the soil (Pechenik, 2009). The presence of earthworms modifies the soil quality of the environment due to their various activities, like burrowing and casting which affect the activities of other organisms. So, they are also termed as "ecosystem engineers" (Kalu *et al*., 2015).

Earthworms (*Annelida: Oligochaeta*) deposit several tons per hectare of casts enriched in nutrients and/or arbuscular mycorrhizal fungi (AMF) and create a spatial and temporal soil heterogeneity that can play a role in structuring plant communities (Zaller *et al*., 2007).

Earthworms incorporate organic materials into the soil hence enhancing plant root penetration and can increase the water infiltration rates up to 10-folds. Research in the temperate regions show that casts are heterogeneously distributed showing associations with certain plant species and thereby specifically stimulating their growth (Zaller *et al*., 2007). Earthworms (EWs) impact plant communities both, through the modification of soil chemical, physical and microbiological properties and through seed ingestion (Bityutskii *et al*., 2002). Seed ingestion by earthworms might impact seed germination and seedling growth through two possible different mechanisms: the provision of a nutrient-rich cast substrate that benefits seed germination, i.e., the earthworm cast, and the alteration of the seed coat. The quality of this substrate is closely linked to the earthworm capacity to choose the soil and litter particles that they ingest, which tend to increase cast content in organic matter, and to its capacity to modify soil properties, mainly through an increase in mineralization. Cast properties depend on both, the ingested soil type and the earthworm species and seedlings that emerge from casts likely respond to these soil properties. The impact of earthworms on plant growth differs with plant species and with soil properties (Eisenhauer and Scheu, 2008; Laossi *et al*., 2009). However, while we have some understanding on interactions between earthworm surface casts and plant species (Decaens *et al*., 2004), we know virtually nothing regarding the functional significance of the casts on pasture flora distribution and carbon stocking potentials of tropical forest zones. Agricultural soils can significantly contribute to the global greenhouse gas (GHG) exchange, but the contribution varies among the gases. For nitrous oxide ($N_2O$), the emissions from agricultural soils account for 60% of the anthropogenic emissions (Smith and Read, 1997), whereas for methane ($CH_4$), mineral agricultural soils are usually sinks as the aerobic topsoil favours methanotrophic bacteria (Hütsch, 2001). For carbon-dioxide ($CO_2$, soils can be either sinks or sources, depending on the balance of carbon input and output. $N_2O$ emissions are mainly regulated by soil oxygen status, but also by the availability of nitrogen and organic carbon (Granli and Bøckman, 1994). The oxygen availability varies with soil structure and moisture and the potential for $N_2O$ emissions is the greatest when the water-filled pore space (WFPS) is 60–70% (Davidson, 1991) as this enables both nitrification and DE nitrification. When the WFPS is above 70%, only DE nitrification takes place due to the shortage of oxygen, and the dominating end product is the $N_2$ gas. Earthworm (EWs) casts and burrow linings have high microbial activity and more denitrifying bacteria than the bulk soil (Brown *et al*., 2000) and the moist anaerobic environment in the earthworm gut can stimulate microbial $N_2O$ production (Karsten and Drake, 1997). Earthworms can increase micro aggregate formation and the stability of soil carbon (Fonte *et al*., 2007; Six and Paustian, 2014).

In the majority of terrestrial ecosystems, earthworms are the most abundant animal biomass (Lavelle and Spain, 2001). Earthworms are typical ecosystem engineers as they have a large impact on soil structure, which is not necessarily associated with trophic relationships. For example, the tropical earthworm *Reginaldia omodeoi*, Sims, formerly known as *Millsonia anomala*, can ingest up to 30 times its own biomass of soil per day, but very little of the ingested organic matter is then assimilated (8%). Furthermore, little of the assimilated carbon is used in biomass production (6%); the remainder is respired (94%) during activity and physical modifications of the soil (Lamotte and Bourli`ere, 1978; Lavelle, 1978). In temperate ecosystems, earthworms also ingest large amounts of material (2–15% of organic matter inputs)

(Whalen and Parmelee, 2000) and expend much energy in their modification of the soil (74–91% of assimilated carbon is respired) (Petersen and Luxton, 1982). Reduced tillage and no-till increase the densities of anecic, deep-burrowing earthworms in arable fields (Whalen and Parmelee, 2000). In the temperate and boreal fields, this group is mainly represented by the dew-worm, *Lumbricus terrestris* L. (Chen, 2001). In Finland, *L. terrestris* is the second most common earthworm species in arable fields, lagging only behind *Aporrectodea caliginosa*. (Nieminen *et al*., 2008), and has the typical positive association with non-inversion cultivation (Nuutinen *et al*., 2011). It is a large earthworm, which efficiently forages on crop residues (Shuster *et al*., 2002) and builds middens (i.e. small mounds of collected litter and surface castings) at the openings of its permanent burrows, often penetrating deeper than 1 m (Nuutinen and Butt, 2003). Trees, herbs, floral, hedges diversities, and land use have an influence on the spatial distribution of earthworm species. However, this aspect is little accounted for in literatures due to the scarcity of studies on it.

### 1. 1. Objectives of the study

The geographical distribution of earthworms in Onigambari forest reserve is still very poorly known and much valuable information can be obtained by sampling the various earthworm species that can be found there. The broad goal of this study is to investigate the effect of earthworm cast on herbaceous flora distribution and Carbon Sequestration potential of top soil in the natural forest zone of Onigambari forest reserve.

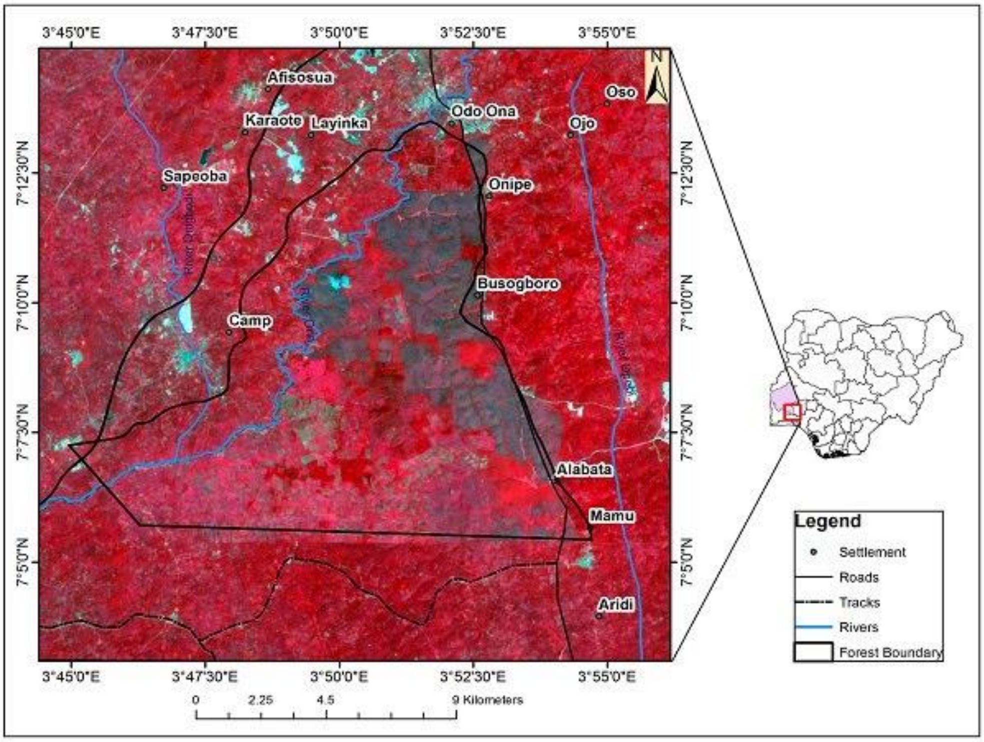
The specific objectives of the study were:

1) To determine floral community structure of the natural forest zone of Onigambari forest reserve as influenced by surface casts
2) To determine the functional group(s) of earthworms (EWs) at the natural forest zone of Onigambari forest reserve
3) To determine the carbon stocking potential of the natural forest zone of Onigambari forest reserve under the influence of earthworm casts.

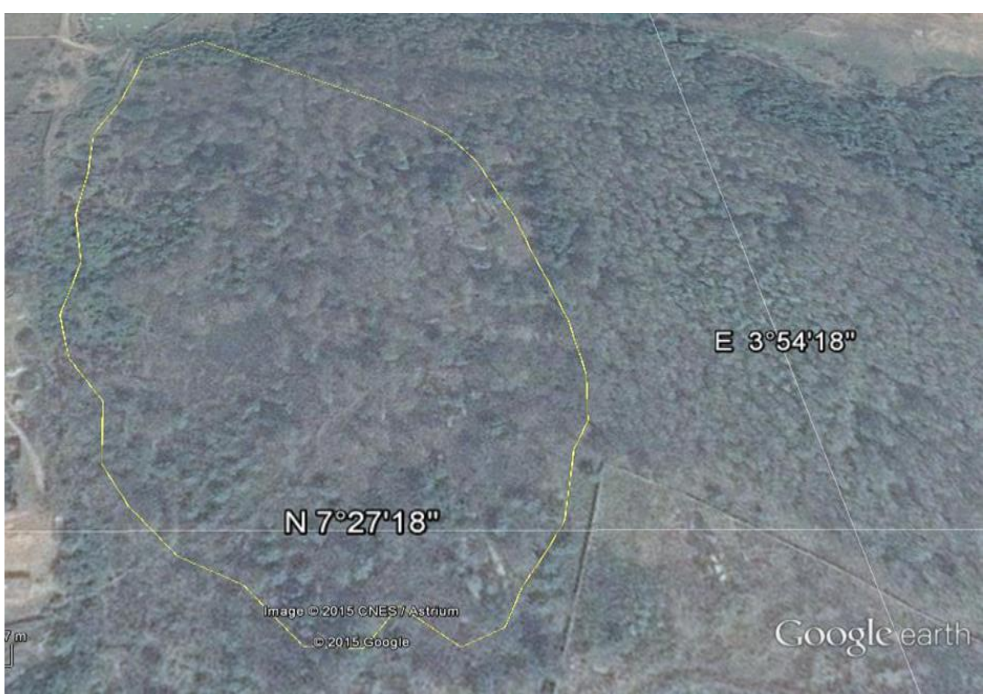
## 2. METHOD AND INSTRUMENTS /EQUIPMENT USED

### 2. 1. Study area

Onigambari forest reserve is located on latitude 07°25'N and longitude 3°53'E within the low and semi-deciduous forest belt of Nigeria (**Picture 1**). The forest reserve stands on an elevation range of 185 m – 205 m above sea level (ASL). The reserve is divided into two: natural and plantation forests. The natural forest zone of the forest reserve (which will be used for this study) consists of indigenous species, such as *Terminalia sp, Tripochiton scleroxylon, Irvingia garbonensis, Treculia africana, Chrysophylum albidum, Artocarpus atilus, Xylopia aethiopica* and *Terapleyra tetraptera* among other tree species. It is also composed of species physiognomy replica of a tropical vegetation pattern that is peculiar to a lowland rainforest consisting of trees, shrubs and herbaceous flora, while the plantation forest is made up of exotic species such as *Gmelina arborea* and *Tectona grandis*. Indigenous or settler farmers from different parts of the country live in several communities located around the forest reserve. The natural forest zone of the reserve has a perimeter of 2.55 km and an area of 14.476 hectares (Earth Point, 2019).




**Picture 1.** Picture showing the map of Onigambari forest reserve




**Picture 2.** Google earth showing the map of Onigamabri forest reserve (within the yellow line is the natural forest zone)

The study area is characterized by climatic conditions peculiar of the tropical rainforest, with a mean annual rainfall of 1,200 mm, and monthly mean temperature of 26 $^{O}$C, relative humidity of 75% and sunshine of 3.77 hours (**Table 1**). The vegetation of the area is determined by a combination of maritime air mass blowing in from the Blight of Benin in the Atlantic Ocean to the south region of the country, and Continental air mass that blows in from the Sahara desert in the north. The general region of the study area experiences a bimodal rainfall type with its peaks in June and September.

**Table 1.** Agro-meteorological parameters for Onigambari forest reserve and environs in 2017

| **Parameter (n = 50)** | **Value** |
|---|---|
| Mean monthly temperature | 27 ºC |
| Mean annual rainfall | 1,200 mm |
| Mean monthly relative humidity | 75% |
| Mean monthly wind run | 7.81 km/day |
| Mean daily sunshine hours | 3.77 hours |

SOURCE: NIMET, 2017

## 2. 2. Floral sampling procedures

### Layout of sampling Area and Plots for Floristic sampling

Simple random sampling technique was used to select the plots used for the assessment of the herbaceous flora. Statistical sampling function of MS Excel 2013 was used for the random selection of 10 plots for the floristic assessment. Herbaceous flora was sampled using three 1.0 m × 1.0 m square quadrats randomly laid on each of 15 m × 15 m randomly using GPS- located grids. A total of 10 grids were selected for the survey to give 30 sampling points surveyed for data collection.

Google earth (2015) was used to complement the layout with an aerial view of the Onigambari forest reserve in conjunction with Garmin$^{TM}$ 12 *etrex* Vista H model Global positioning system was used to locate and mark the different points of the coverage area, while the compass was used to ensure accuracy in the direction of the points in the location.

## 2. 3. Species identification and enumeration

### Herbaceous species

The herbaceous flora occurring in each quadrat was identified following published herbaceous handbooks of (Akobundu and Agyakwa, 1998) and (Johnson, 1997). Where on-field identification was not possible, the specimens were collected and preserved for later identification.

### 2. 4. Data collection

Data on floristic composition and land use types were collected as follows:

#### Herbaceous flora

1. Species types by visual and use of standard flora
2. Count of individuals in the quadrats and plots for abundance, frequency, density and diversity indices calculations
3. Fresh litter biomass per plot.

#### Collection of earthworm data

Earthworms were extracted from the soil using 60 g of mustard seed powder mixed with 350 mL of water, and the following data were collected:

1. Species composition per plot
2. Density of earth worm per plot
3. Dry weight of cast per plot
4. Nutrient composition of cast.

#### Collection of Soil data

1. Top soil sample was collected From (0 – 25) cm depth using a pre-calibrated hand trowel
2. Nutrient composition, including soil Carbon
3. Soil organic matter per plot.

### 2. 5. Data analysis

Raw data collected were arranged and analyzed for species abundance, diversity (Dominance, Species richness/Simpson index, Evenness index and Equitability index), Relative Importance Values (RIV), carbon sequestration, such as the health of the natural forest zone of Onigambari forest reserve was determined by assessment of species diversity.

Species diversity indices were computed using Paleontological statistics Software (PAST 2.14) (Hammer *et al.*, 2001). The following was taken into account from the diversity index analysis following (Hammer *et al.*, 2001).

#### Abundance

Abundance measures the quantity or number of each species and families in an ecological system.

#### Dominance

This is a measure of the prevalence of a particular species in relation to other species in an ecosystem. Dominance shows the species with superior competitive ability to others regarded as inferior based on competition. It is the most of population in a community and the effect on any population is mainly influenced by the species of high dominance (Bernstein, 1981; Drews, 1998). It usually ranges from zero to one in value where one signifies high dominance.

**Simpson index**

It measures the number of individual species and their abundance in an ecosystem. It shows the richness of a species in a habitat in relation to total number of species present. Its value ranges from zero to one, where zero means low and one means completely rich in species.

**Evenness**

It is a spread rate of occurrence of a species in an ecosystem. It usually ranges from zero to one, with one signifying complete evenness of occurrence of species in an ecosystem.

**Equitability index**

This is a measure of occurrence of a species or otherwise of species in an ecosystem. It ranges from zero to one.

**Shannon Weiner**

This is a measure proposed by Claude Shannon and accounts for both abundance and evenness of species present in an ecosystem (Kent and Coker, 1992 and Olubode *et al*., 2011). It measures overall community characteristics. It usually ranges from one to infinity, where two and above signifies high random of species occurrence in an ecosystem.

**Relative Importance Values (RIV)**

The Relative Importance Value (RIV) of all species were determined following reference (Olubode *et al*., 2011). It was computed as:

$$\text{RIV} = \text{Relative frequency/Relative Density} \times 100$$

where:

**Frequency**

The number of occurrence of a specie in a set of quadrats or area.

**Relative Frequency**

It is a relative value of occurrence of a specie in a set of quadrat to total species in the quadrats:

$$\text{Relative frequency} = \frac{\text{Frequency of a specie}}{\text{frequency of other species}} \times 100$$

**Density**

It is the quantity of individual specie to abundance of species per unit area

$$\text{Density} = \frac{\text{Quantitative Values of a specie}}{\text{Quadrat size} \times \text{Number of quadrats laid}}$$

**Relative Density**

This is the relative number of individual of specie. Relative density was obtained using the formula:

$$\text{Relative Density} = \frac{ni}{N} \times 100$$

where:

ni is the total number of individual specie
N is the total number of different species in the entire population.

## 3. RESULTS

**Floristic compositions, herbaceous diversities and relative importance value of herbaceous flora in the study area**

A total of twenty eight (28) species of herbaceous flora belonging to eleven (11) families were enumerated in the assessment of (30) quadrats laid in ten (10) plots. *Andropon gayanus* (family: Asteraceae) had the highest relative importance value (20.499) in the study area. This was followed by *Desmodium scorpiurus* (family: Fabaceae) (15.783). Among species with the intermediate relative importance values are *Iisca rygo*e, *Shrankia leptocarpa*, *Ipomoaea triloba* and their RIVs, respectively, were 2.741, 2.33, and 2.33 (**Table 2**).

**Table 2.** Composition and relative importance values of flora in the study area

| S/N | Species | Relative Importance value |
|---|---|---|
| 1 | *Andropogon gayanus* | 20.49939 |
| 2 | *Desmmodium scorpiurus* | 15.78266 |
| 3 | *Tithonia diversifolia* | 6.07326 |
| 4 | *Oplismenus burmannii* | 4.713065 |
| 5 | *Synedrella nodiflora* | 4.688645 |
| 6 | *Sclerocarpus africanus* | 4.304029 |
| 7 | *Mitracarpus villosus* | 4.304029 |
| 8 | *Cleome rutidosperma* | 3.510379 |
| 9 | *Chromolaena odorata* | 3.125763 |
| 10 | *Iisca rygo* | 2.741148 |
| 11 | *Commelina erecta* | 2.741148 |
| 12 | *Shrankia leptocarpa* | 2.332112 |

| | | |
|---|---|---|
| 13 | *Ipomoaea triloba* | 2.332112 |
| 14 | *Bidens pilosa* | 2.332112 |
| 15 | *Tridax procumbens* | 1.971917 |
| 16 | *Senna occidentalis* | 1.947497 |
| 17 | *Mellanthera scandens* | 1.947497 |
| 18 | *Croton lobata* | 1.947497 |
| 19 | *Centrosema pubesens* | 1.947497 |
| 20 | *Sphenoclea zeylanica* | 1.562882 |
| 21 | *Poulzozia guineensis* | 1.562882 |
| 22 | *Platstomao africanum* | 1.562882 |
| 23 | *Schwenckia Americana* | 1.178266 |
| 24 | *Solanum nigrum* | 1.178266 |
| 25 | *Sida acuta* | 1.178266 |
| 26 | *Sagitaria latifolia* | 1.178266 |
| 27 | *Calopogonum mucunioides* | 1.178266 |
| 28 | *Acrocera zizanoides* | 1.178266 |

*Eisenia fetida, Lumbricus terrestris, Eisenia hortensis, Allogophora chlorotica, Apporectodea longa, Lumbricum rubellus, Octoclasion cyaneam* were enumerated at the study area. *Eisenia fetida* had the highest relative density (28.57) at the study area, closely followed by *Lumbricus terrestris* and *Apporectodea longa* with relative densities of 21.43. *Eisenia hortensis, Allogophora chlorotica, Octoclasion cyaneam, Lumbricum rubellus* had relative densities of 7.14 (**Table 3**). Diversity indices (**Table 4**) of the earthworm indicated 7 species with a low dominance value (0.1939) across the study area, but with a high species richness (Simpson = 0.8061).

The species were highly evenly distributed in the ecosystem (0.8405), but on the overall, the diversity of the earthworms was quite low (H`= 1.772). The pH of topsoil was higher 7.2, while the worm cast pH was relatively low, 7.1. The values of nutrients in the worm cast were such that Nitrogen (N) = 2.15 – 0.67; Available Phosphorus (Avail P) = 8.14 – 7.29; Organic Carbon (Org C) = 22.39 – 3.66; and Potassium (K) = 0.24 – 0.60. However, the following were found to record increase after soil casting: Calcium (Ca) = 2.82 – 6.96; Magnesium (Mg) = 1.77 – 4.45; Sodium (Na) = 0.56 – 1.12; Manganese (Mn) = 108.6 – 301; Iron (Fe) = 52.3 – 145.0; Copper (Cu) = 3.10 – 24.90; and Zinc (Zn) = 2.44 – 6.0 (**Table 5**).

It is observed that worm cast had higher clay content (126 mg/kg) than top soil (86 mg/kg) as well as in sand (840 mg/kg) compared to 770 mg/kg in top soil. The textural class of the worm cast was loamy sand, while it was sandy loam for the topsoil of the study area (**Table 6**).

**Table 3.** Species composition of earthworms in the study area

| SN | Scientific name | Common name | Relative Density |
|---|---|---|---|
| 1 | *Eisenia fetida* | Common red worm | 28.57143 |
| 2 | *Lumbricus terrestris* | Dew worm | 21.42857 |
| 3 | *Eisenia hortensis* | night crawler | 7.142857 |
| 4 | *Allogophora chlorotica* | Green worm | 7.142857 |
| 5 | *Apporectodea longa* | Blackhead worm | 21.42857 |
| 6 | *Octoclasion cyaneam* | Blue-grey worm | 7.142857 |
| 7 | *Lumbricum rubellus* | Red earthworm | 7.142857 |

**Table 4.** Diversity of earthworms in the study area

| Indices | Value |
|---|---|
| Taxa_S | 7 |
| Dominance_D | 0.1939 |
| Simpson_1-D | 0.8061 |
| Shannon_H | 1.772 |
| Evenness_e^H/S | 0.8405 |

**Table 5.** Chemical properties of the Soil

| SN | Soil Organic matter | Top soil | Cast |
|---|---|---|---|
| **1** | pH ($H_2O$) | 7.2 | 7.1 |
| **2** | Org C (g/kg) | 22.39 | 3.66 |
| **3** | N (g/kg) | 2.15 | 0.67 |
| **4** | Avail P (mg/kg) | 8.14 | 7.29 |
| **5** | Ca | 2.82 | 6.96 |
| **6** | Mg (Cawl/kg) | 1.77 | 4.45 |
| **7** | K | 0.24 | 0.60 |
| **8** | Na | 0.56 | 1.12 |

| | | | |
|---|---|---|---|
| **9** | Mn | 108.6 | 301.0 |
| **10** | Fe | 52.3 | 145.0 |
| **11** | Cu | 3.10 | 24.90 |
| **12** | Zn | 2.44 | 6.0 |

**Table 6.** Distribution of Soil particles

| SN | Soil particles | Top soil | Cast |
|---|---|---|---|
| **1** | Exch (Acid) | 0.6 | 0.4 |
| **2** | Exch ($H^+$) | 0.6 | 0.4 |
| **3** | Exch ($H^{++}$) | 0.0 | 0.0 |
| **4** | Clay | 86.0 | 126.0 |
| **5** | Silt | 144.0 | 34.0 |
| **6** | Sand | 770.0 | 840.0 |
| **7** | Textural Class | Sandy loam | Loamy Sand |

## 4. DISCUSSION AND CONCLUSION

This study investigated the effect of earthworm cast on herbaceous flora distribution and carbon sequestration potential of top soil in the natural forest zone of Onigambari forest reserve. The study indicated that the abundance and diversity of Earthworms was not high. It was further observed that the fertility of the topsoil is related to some grazing activities. Contrary to what was expected, the topsoil was not very rich in fertility. This may be due to inadequate return of organic matter to the soil by the grazing animals. Moderate grazing and trampling usually increase the diversity of plants by decreasing the ability of any one plant species to become dominant and exclude other species (Rikhari *et al*., 1993; Singh *et al*., 2003). Thus, the natural forest zone of the study area was not properly monitored as it is observed that grazing animals, such as cattle visit the forest reserve to browse through for pastures but sparsely find the right one to satisfy them in adequate quantity or some certain flora species have been overgrazed by this animals, thereby reducing the organic waste matter that could be deposited back to the soil for earthworm activities. This in return affects the fertility of the soil negatively. More so, the wandering of the animals on the land affects the activities of earthworm on the soil as they are inhibited from efficient burrowing and surface casting. This was further supported by the many different plant species in various families with low similar relative importance values, as indicated by findings of the study. *Andropogon gayanus* was the dominant species in the study area. This study shed more light on the importance of earthworms as indicators of health of the forest zone. Earthworm communities nearly always include species that pursue different ecological strategies and a familiarity with these strategies is essential to an understanding of the structure of earthworm's communities. Earthworm casting activity has been reported to cause spatially and temporally heterogeneous soil resources which can be specifically utilized by various plant species (Jackson, 1992), eventually affecting the structure of plant communities (Zallar *et al*., 2007).The earthworm enumerated were mainly surface functional groups, implicated in the soil mineralization and litter processing. (Tomati *et al*., 1990) have reported positive correlation between top soil dwelling earthworms with surface casts and grasses. Only *Lumbricus tenerstris* is known to be subsurface dwelling (Zaller *et al*., 2007) of all earthworms encountered. The natural forest zone of Onigambari forest was reserved with the aim of encouraging and protecting nature's biodiversity ranging from various tree species, various floristic composition in terms of various families and species of herbs and shrubs. However, the study has shown that the aim of reserving the natural forest is not fully achieved as it is indicated to have *Andropogon gayanus* and *Desmmodium scorpiurus* as the dominant specie with a very wide margin in their relative importance value from other floristic composition of the forest zone. Any management practice that would improve the abundance and diversity of the surface-dwelling functional groups of earthworms would help in recovery of the soil fertility in the natural forest zone of Onigambari forest reserve.

## 5. RECOMMENDATION

This study has helped to identify a problem that probably may have not been taken into awareness by the natural forest conservationist of the study area which includes poor soil health and fertility, low earthworm abundance/diversity and poor flora distribution in terms of their relative importance value. Hence this has led this study to propose the following recommendations:

1. Proper monitoring of the forest by the forest guards to prevent outside influence on the natural forest zone of Onigambari forest reserve
2. Strategies that will enhance abundance and diversity of earthworms in the forest zone, e.g. seeding and deposition of organic waste matter to the soil.

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