International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133, Print ISSN: 2664-7125
Received: 28-07-2022, Accepted: 13-08-2022, Published: 30-08-2022
Volume 4, Issue 3, 2022, Page No. 119-124

Studies on the variability in earthworm's morphometric features in relation to soil factors in Joseph Sarwuan Tarka University, Makurdi, Nigeria

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Abstract
Earthworms constitute one of the largest biological components of the soil among all animal biomass and are commonly referred as ecosystem engineers due to their lifestyle. The study was carried out in the Joseph Sarwuan Tarka University, Makurdi between July through October, 2021 to determine the variability in morphometric of earthworms from four communities within the University. Four different sampling sites were chosen for the study with 20 sexually matured earthworm's samples handpicked from each of these locations and their morphometric determined. Soil samples collected were also analysed for pH and organic matter content. Data obtained were analysed using ANOVA and correlation. From the result, the highest recorded mean value for all parameters studied is in samples collected from Ujam community. Samples from Animal's Farm had the least mean values for both weight and length while samples from South Core had the least mean value for metamerism. The total weight of 20 earthworms sampled was 13002g, of all the locations sampled, Ujam community was more massive with 769.4g (mean weight 38.5 g) compared to the others. The least was from Animal's Farm with 16.6 g (mean weight 0.83 g). ANOVA shows a significant difference between Weight (g) and Local (F=138.3 P=0.000). The total length from the study population was 2687.8 m. Earthworm sampled from animal farm were shorter in length (209.3 m; mean 10.5) compared to those from the other locations. Samples from Ujam community recorded the longest lengths (1237m: mean 61.9). However, there was a significant difference between Weight (g) and Local (F=129.00, P=0.000). Locations and segments were significant (F=20.78, Df=79, P=0.000) as samples from Ujam community had the highest number of segments of 7030 with a mean of 351.5 followed by the samples collected from middle core 6328 segments with a mean of 316.4. However, earthworms with the least number of segments were those from South Core (3960 with a mean of 198.0). Correlation exists between weight and segments (P=0.022), while weight and length show a very weak correlation (P=0.006). Although the pH of all soil samples is slightly acidic, organic matter content was highest in soil samples from Ujam community which probably explains the wide variable in morphometric of samples from this community compared to the other locations studied.

Keywords: variability, communities, biological components, soil samples

Introduction
Earthworms constitute one of the largest biological components of the soil among all animal biomass in soil and are commonly referred as ecosystem engineers due to it lifestyle (Blouin *et al*., 2013; Alkesh *et al*., 2016) [4, 1]. Earthworms are considered to be the most important soil animals in Nigeria due to their enriching potentials. The reason for this consideration is based on high contribution to ecological and agronomical important aspects. Earthworms are one of the principal components of the invertebrate community in most soils. Earthworm has a high influence on microbial community as well as physical and chemical properties of soil (Iordache and Borza, 2010) [5].

The soil physico-chemical characteristics like pH, organic matter, nitrogen (N), phosphorus (P), soil structure, gas dynamics, water flow, and C turnover and stabilization may be altered by the presence and community structure of earthworms (Sankar and Patnaik, 2018) [14]. Earthworms can be divided into three basically ecological groups based on their physiology, feeding and burrowing behavior (Xiao, 2017) [17]: epigeic earthworm species inhabit and feed on the surface litter; anecic species produce deep vertical burrows in the mineral soil but browse on the soil surface and are important in the burial of surface litter; and endogeic species burrow horizontally and feed mainly in the rhizosphere and subsoil (Xiao, 2017) [17].

The distribution of earthworms is usually diverse and their density fluctuates in connection with the abiotic factors and land use patterns of the soil as well. Their distribution is also usually heterogeneous and their numbers fluctuate in change in the abiotic factors and environmental factors like temperature, pH, soil texture, and water content of soil also affect the distribution of earthworms (Singh *et al*., 2016) [15]. The association among biotic and abiotic factors, earthworm activities, climate change, agriculture and land use management practices are diverse and interrelated (Singh *et al*., 2016) [15]. The population and diversity of earthworm species vary across land habitats due to variation in soil moisture, soil temperature, soil properties, the abundance of surface litter, vegetation types, land use management, and human interventions (Ponge, 2015). Earthworms are thus sensitive to change in land use. In general, earthworm diversity is reduced in habitats with more intensive anthropogenic interventions.

Several research works have been carried out around the which investigate the relationship between the activity of earthworms, the soil properties and the relationship between them. Various ecological studies have reported the close relationship between the availability of different earthworm species and various land use patterns (Tao *et al*., 2013) [16]. Although some literature has been documented on earthworm and soil relationship, there is still the need to monitor their abundance and diversity based on soil profiling.

The diversity and activities of earthworms as one of the most important soil biotas influence the physical, chemical, and biological properties of soils (Mulia *et al*., 2021) [9]. Their physical movement creates soil pores which ease nutrient and water dynamic in the soils. As recyclers of organic materials, earthworms facilitate microorganisms such as fungi and bacteria to undertake further decomposing process (Bamidele *et al*., 2014) [2]. Through these activities, earthworms influence soil health and the provision of ecosystem services (Ponge, 2015). This study therefore aims at evaluating the diversity, abundance of indigenous earthworm species in relation to soil profiling in Makurdi Metropolis.

Materials and methods

Study area

The study was carried out in Makurdi, in the Joseph Sarwuan University, Makurdi. Makurdi town serves as a dual role of the headquarters of Makurdi Local Government Area as well as the Benue State capital. About 90% of the populations speak Tiv language. The town is located on latitude 07º41N and longitude 08º37E in the political and geographical middle belt of Nigeria. The vegetation type is savannah with scattered trees. The mean monthly temperature of the town ranges from 27.38^{0}C to 28.00^{0}C. Annual rainfall is over 100mm with rainy season between the months of April and October (Benue State house of Assembly Executive Diary 2011).

Experimental design and earthworm sample collection

Sexually mature earthworms as determined by the presence of the clitellum (Oboh *et al*., 2007) [10] were collected according to the method described by Owa *et al*. (2013) [11]. The soil was carefully turned using a spade while the earthworms were handpicked into containers and transported to Joseph Sarwuan University, Makurdi Biological Sciences laboratory where they were washed with distilled water and vital parameters taken for analysis.

Sampling: four different sampling sites (Middle Core, South Core, Animal's farm and Ujam community) were chosen for the survey of earthworms. A total of 80 earthworms, 20 each per site were handpicked from this location. The earthworm survey was carried out during July through October, 2021.

Soil sampling

Soil samples (0–15 cm) were removed from the side of each earthworm pit after gently scraping away vertical sections of soil that may have been compacted by digging. Bulk density and soil moisture were determined using cylindrical cores inserted horizontally into a wall of each pit. All soil samples were placed in cold storage immediately following collection and returned to the Joseph Sarwuan University, Makurdi Agronomy laboratory for subsequent analyses.

Statistical analysis

Data collected were subjected to statistical analyses which included descriptive statistics and Analysis of Variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 16.0. Post Hoc test was done using S-N-K. P-value was set at 0.05.

Results

A total of 80 earthworms were collected for this study, 20 each from each site respectively. The weights of the earthworms vary from one another within different locations (Table 1) (Fig 1). The total weight of 20 earthworms sampled was 13002 g, of all the locations sampled, Ujam community were more massive with 769.4 g (mean weight 38.5 g) compared to the others. The least was samples collected from Animal's Farm with 16.6 g (mean weight 0.83 g). ANOVA shows a significant difference between Weight (g) and Local (you mean location) (F=138.3 P=0.000).

Table 2 focused on the length of earthworm across the four locations. The total length from the study population was 2687.8 m. Earthworm samples from animal farm were shorter in length (209.3 m; mean 10.5) compared to those from the other locations. Samples from Ujam community recorded the longest lengths (1237 m: mean 61.9). ANOVA Shows a significant difference between Weight (g) and Local (F=129.00, P=0.000). Also, ANOVA shows a significance difference between locations and segments (F=20.78, Df =79, P=0.000). Samples from Ujam community had the highest number of segments of 7030 with a mean 351.5 followed by the samples collected from middle core 6328 segments with a mean of 316.4. However, earthworms with the least number of segments were those from South Core (3960 with a mean of 198.0) (Table 3).

The mean of the three parameters (i.e. Weight, Length and segments/ metamerism of earthworm) in the study is given in Table 4; Fig. 2. Highest recorded mean values for all parameters studied is in samples collected from Ujam community. Samples from Animal's Farm had the least mean value for both weight and length while samples from South Core had the least mean value for metamerism. Although the pH of all soil samples is slightly acidic, organic matter content was highest in soil samples from Ujam community (Table 4).

Table 1: Weight of earthworms in the four locations studied

Samples	Middle Core	South Core	Animal's farm	Ujam community	Total
1	31.8	3.2	0.5	41.9	77.4
2	37.1	1.4	0.8	27.3	66.6
3	27.3	1.3	1.3	37	66.9
4	41.1	1.1	0.6	46	88.8
5	29.7	2.4	0.5	46.8	79.4
6	17	4.3	1.5	23.7	46.5
7	46.8	3.4	0.8	33.8	84.8
8	33.9	1.6	0.9	38.5	74.9
9	29.9	2	0.6	50	82.5
10	20.9	1.2	0.5	28.9	51.5
11	24.4	1.1	0.4	47.8	73.7
12	29.2	1.5	0.8	40.5	72
13	10.1	0.9	1.1	29.9	42
14	28.3	2.8	1.8	37.8	70.7
15	22.3	1.3	0.9	45.8	70.3
16	9.4	0.8	0.6	33.9	44.7
17	10	1	0.6	37.8	49.4
18	3.4	1.6	0.7	41.3	47
19	7	1.1	0.8	40.2	49.1
20	21	1.6	0.9	38.5	62
Total	480.6	35.6	16.6	767.4	1300.2

$F=138.3$, $P=0.000$

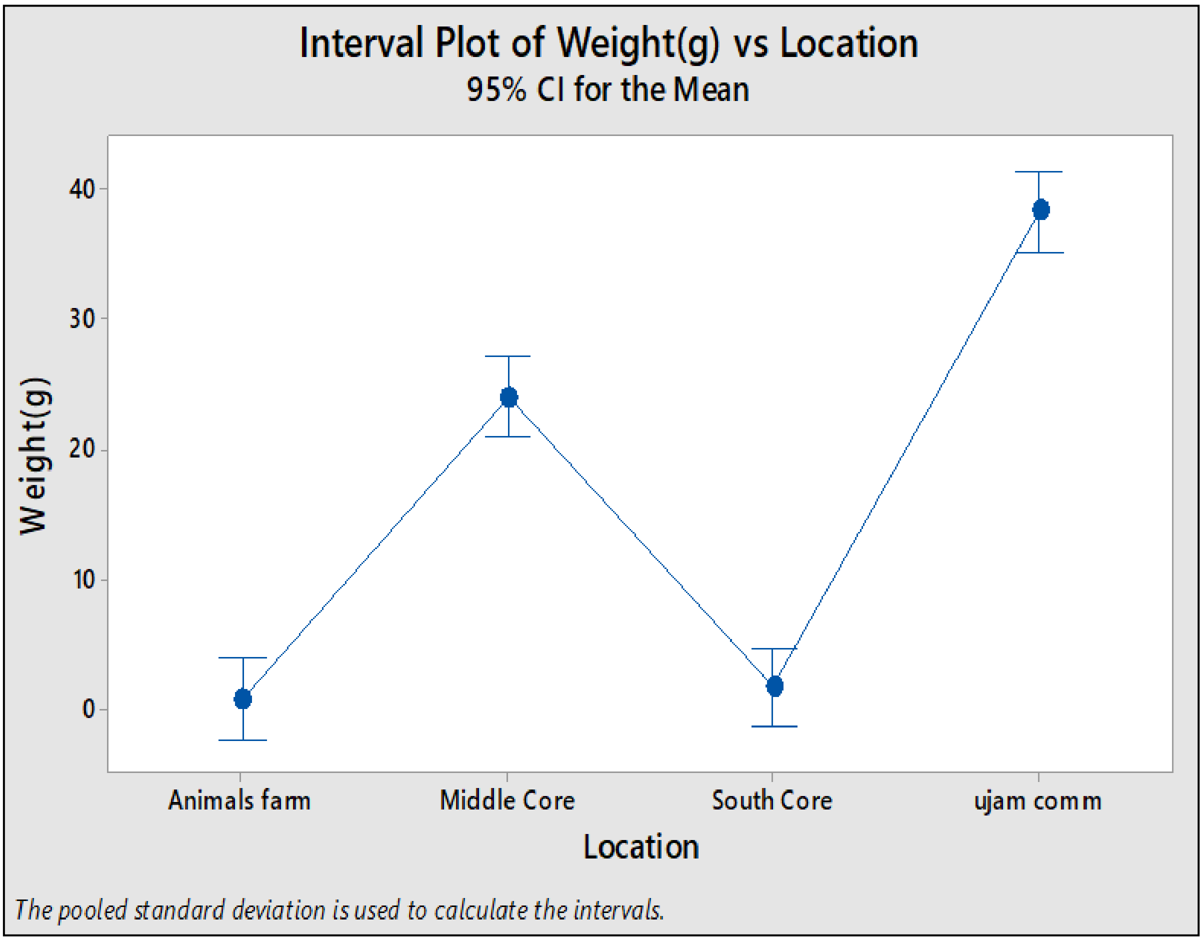

Fig 1: Interval Plot of Weight (g) vs Location

Table 2: Length of earthworm the four locations studied

Sample	Ujam community	Middle Core	South Core	Animals farm	Total
1	48	38	24	4	114
2	47	68	12	8	135
3	68	35	14	13	130
4	52	51	13	5.5	121.5
5	57	67	21	5	150
6	62	50	32	19	163
7	70	69	26	7.8	172.8
8	71	66	13	9.5	159.5
9	74	50	19	12	155
10	62	52	13	12	139
11	50	51	12	4	117
12	68	53	17	15	153
13	48	22	11.5	12	93.5
14	59	42	27	18.5	146.5
15	69	32	9.3	12	122.3
16	65	33	10.5	9	117.5
17	68	28	11.4	10.5	117.9
18	70	22	15	10	117
19	68	29	15.8	9.5	122.3
20	61	48	19	13	141
Total	1237	906	335.5	209.3	2687.8

F=129.00, P=0.000

Table 3: Metamerism/Segments of earthworms in the four different Locations

Samples	Ujam community	Middle Core	South Core	Animals farm	total
1	290	262	215	57	824
2	287	303	174	199	963
3	305	227	196	298	1026
4	447	436	182	87	1152
5	482	346	203	82	1113
6	300	272	237	396	1205
7	310	343	222	197	1072
8	418	346	196	225	1185
9	405	322	200	248	1175
10	388	307	192	257	1144
11	346	262	180	62	850
12	389	303	207	353	1252
13	302	227	178	251	958
14	370	436	230	513	1549
15	399	346	184	254	1183
16	358	272	167	210	1007
17	322	343	179	281	1125
18	307	346	202	263	1118
19	280	322	198	229	1029
20	325	307	218	291	1141
	7030	6328	3960	4753	22071

F=20.78, Df =79, P=0.000

Table 4: Morphometric of earthworm in relations to soil parameters

Location	Mean weight	Mean Length	Mean Segment /Metamerism	Mean Soil pH	Mean Organic Matter Content (%)
Ujam Community	38.37	61.85	351.5	6.22	3.21
Middle Core	24.03	45.3	316.4	6.29	1.13
South Core	1.78	16.775	198	6.31	0.84
Animals Farm	0.83	10.465	237.65	6.35	0.89

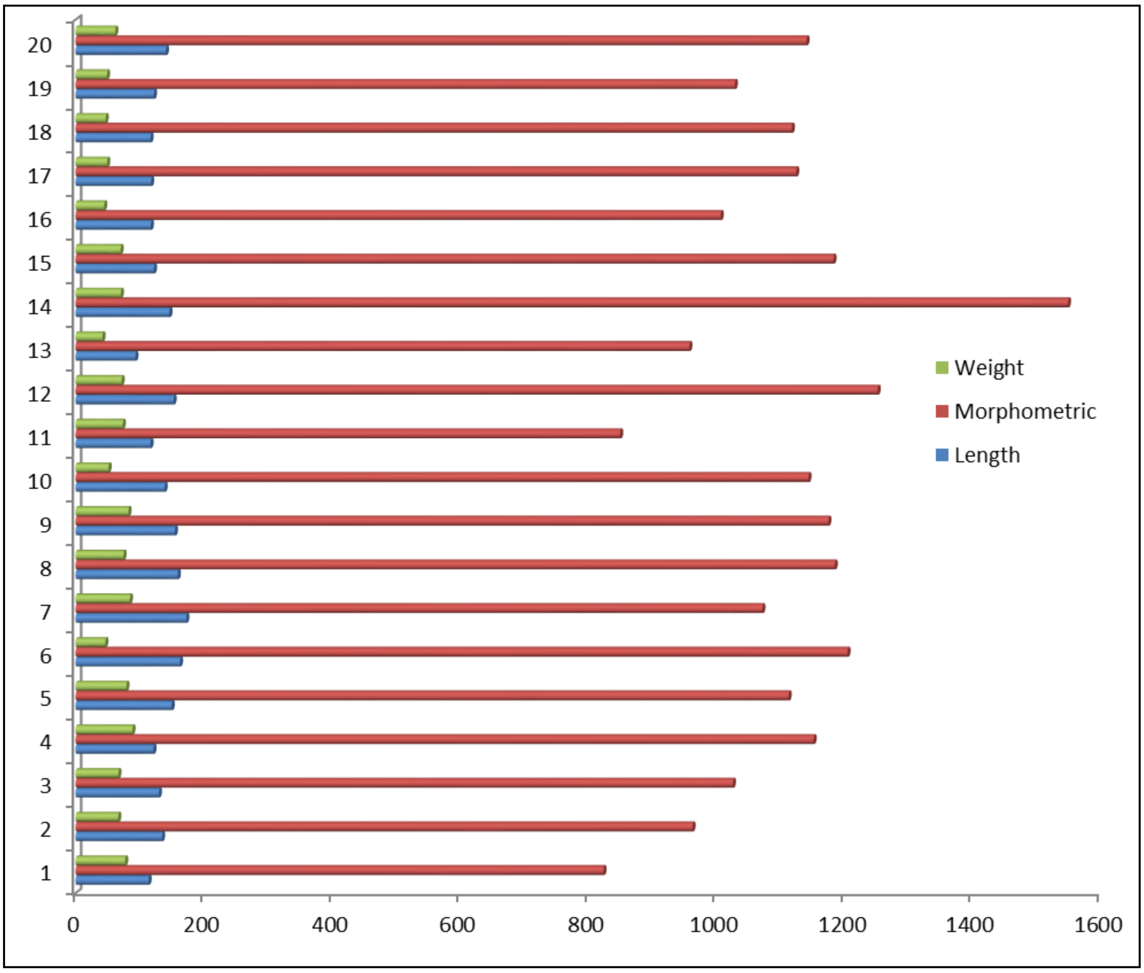

Fig 2: Weight, Morphometric and Length of earthworm in JOSTUM

Discussion

Vegetation type in many regions is the major biotic factor that directly influences the distribution and diversity of earthworms in the soil (Blouin *et al*., 2013) [4]. Earthworm's population vary in size ranging from only few individuals (sometimes totally absent) to more than 1000/m^2, depending on the physico-chemical characteristic of the soil and the climatic factors (Kale and Karmegam, 2011) all of which could also have an effect on the morphology of the worms.

The current study has revealed a great level of variability in the morphometric of earthworms in the different locations under study. The weight and length of earthworms from Ujam community was found to greatly differ from those of the other locations. On the contrast, samples from Animal's farm had the least value for both parameters. These differences observed may be due to type of soil and agricultural practices followed at different regions. This is consistent with the observation in Ujam community relative to Animals Farm since changes in soil texture and characteristic due to agricultural practices can have an impact on the earthworm population. This imply that management of soil conditions can thus influence soil properties by affecting aggregation directly or indirectly to earthworm abundance and their subsequent contribution to change in soil structure (Iordache and Borza, 2010) [5]. Similarly, the observations on the segments of the earthworms as well as the mean values for all the parameters studied portends to the fact that earthworm's species and relative significance of different ecological categories are affected by the type of vegetation, abiotic factors, and the soil characteristics (Lavelle and Spain, 2010) [8] and as well, anthropogenic activities in the area.

Although pH level is similar (slightly acid) across all soils sampled, organic matter content was highest in soils sampled from Ujam community. This observation tends to explain the relative variability in all the morphometric of earthworms from that community compared to the other locations. This further adds to the fact that earthworms do well in soils with high organic matter contents.

Soil aggregate stability has been found to be primarily specific in relation to different land use patterns and subsequently affected by earthworm's activity within their ecosystem. However, many studies have examined both anthropogenic and environmental controls on earthworm populations in agricultural systems, forest land, and grass land. It reported that, soil degradation is associated directly with the decreases in abundances and diversity of earthworm population and other invertebrate communities (Lavelle and Spain, 2010) [8] which is a direct bearing to these activities as they relate to the wellbeing of the earthworms in the soil.

The observation from this study could also be as a result of the abiotic factors of the soil (Kale and Karmegam, 2011) in the locations sampled. Bhadauria and Ramakrishnan (1989) [3] reported different biotic and abiotic forces such as soil properties, surface litter inputs, local or regional climate, dynamic land management history, surface vegetation type, and human pressure at an extent are some of the major causes which effects the regional earthworm biodiversity and species dispersal pattern and all these could have a direct bearing the earthworm's physical structure.

According to Rajkhowa *et al*. (2014), diverse soil habitats are the most direct influencing factors that are affecting the overall earthworm distribution in a particular ecological zone. Changes in different land use patterns have also directly affected the composition and population structure of earthworm communities in different agro-climatic regions (Lalthanzara *et al*., 2011) [7]. This might explain the results gotten in the current study since the agricultural practices and chemicals used could have affected the earthworm's populations drastically compared to their counterparts elsewhere which are less disturbed.

Conclusion

Earthworms are one of the important components of soil ecosystem and have a key role in the development and maintenance of Physico-chemical properties of soil by converting biodegradable materials and organic wastes into nutrient rich components. Earthworms may be used as bio-indicators to evaluate soil fertility status. However, several factors such as anthropogenic activities, soil physiochemical factors as well as other abiotic factors could have a huge impact on their well-being and roles in the soil.

Recommendations

1. Further research regarding the relationship between the effect of anthropogenic activities, abiotic and soil physiochemical factors should be conducted to evaluate the interplay of these factors on the wellbeing of earthworms.
2. Also, it will be important to explore the potential role of earthworms in soil fertility and agricultural sustainability

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