4 Newly Documented Species Of Earthworms In A Coastal Mangrove Ecosystem of Guyana, S.A.

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Abstract

Mangrove ecosystems are harsh environments due to their high levels of salinity and constant disturbance from the shifts in tides and actions of waves. An investigative study was conducted to establish the presence or absence of earthworms in this environment and if present, to determine the population dynamic exhibited. Sampling was done along a 120m horizontal transect which yielded 4 new species. Of the 4 species *Pontodrilus litoralis* showed a high affinity for this high salinity environment which allowed it to access resources unhindered, establishing dominance. *Drawida barwelli's* population, however, was suppressed by the presence of *Amynthas sp.* and *Eukerria saltensis*, the latter of which has a higher sensitivity to high salinity.

The presence of high levels of salinity and sulphur, along with the disturbance of waves, are responsible for the low ecological diversity in this ecosystem. However, the presence of these organisms is still astounding given the intensity of significant soil chemical parameters.

Introduction

Earthworms belong to the class Oligochaeta and are one of the most important macrofauna of soil due to their roles in shaping soil physical, chemical and biological properties. They can be found in a wide range of terrestrial ecosystems. Guyana has a recorded 12 species of earthworms, however, only a handful of the locations are known, Brown & Fragoso, 2007. Of the known locations, mangrove ecosystems, among a number of others, were not sampled. The coastal mangrove ecosystem covers about 290 km of Guyana's 430 km coast, and is declining due to increased rates of deforestation. This harsh ecosystem houses unique flora and fauna, however, nothing was known about its earthworm population, if they were at all present. There are a number of species of earthworms that are capable of surviving in extreme environments and as such this study aimed to investigate whether or not earthworms were indeed present in one such extreme environment, the mangroves.

Keywords: mangrove; salt-tolerance; diversity; population structure

Materials and Methods

2.1 Description of Study Area

The site sampled was a mangrove ecosystem situated along the coast of Region 5. The predominant vegetation was *Avicennia germinans*, known as the black mangrove. The soil type was classified as marine alluvium. The site suffered significant pollution, most of which were in the non-biodegradable form.

2.2 Experimental Design

20 sampling points of dimensions 0.5m³ were established along a horizontal linear transect at 6m intervals. The soil was removed from each sample point by digging, after which the removed soil was hand sorted for earthworms which were categorized and counted, Persaud, 2019. Ecotypes were denoted by their colouration, and adults were denoted by the presence of a clitellum. 2 adults from each morphospecies were collected and placed in separate labelled ziplock bags containing 95% ethanol. The circumference and length of each morphospecies was recorded along with the type and position of key external features which was followed by methodological dissections to allow for its identification.

2.3 Data Analysis

Earthworms were placed into families based on Blakemore's 2006 family key and Chang, *et al*., 2009.

The statistical data was analyzed using R version 3.4.4, 2018, where the ANOVA function was utilized.

Measurement of species richness

Margalef's index was used to determine the species richness (Margalef, 1958).

Margalef's index = $(S - 1) / \ln N$

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

Measurement of diversity

The diversity index was calculated using the Shannon-Wiener diversity index (1949).

Diversity index = $H = -\sum P_i \ln P_i$

where $P_i = S / N$

S = number of individuals of one species

N = total number of all individuals in the sample

In = logarithm to base e

Measurement of evenness

The evenness of species was calculated using the Pielou's Evenness Index (Pielou, 1966).

e = H / ln S

H = Shannon – Wiener diversity index

S = total number of species in the sample

Measurement of Dominance

The calculation of dominance was done using the Berger-Parker Dominance Index, (Caruso, et al., 2006).

d = N(max)/N

N(max)= number of individuals in the most abundant species

N= total number of individuals

RESULTS

4 taxonomically distinct species of earthworms belonging to 3 families were found, Table 1.0. Of the 4 species, *P. litoralis* was found to be the most abundant, accounting for 64.5% of the population, while *Drawida barwelli*. was found to be the least abundant, accounting for 2.2% of the population. The abundance of the 4 species were found to be of statistical significant difference with a p-value of 0.0001. Of the 3 families, Glossoscolecidae was found to be the most abundant containing 2 species which together accounted for almost 92% of the observed population. *P. litoralis* had a higher proportional abundance in comparison to the other 3 species. The distribution pattern of the species was exponential, Figure 1.0. Juveniles were found to be 3 times more abundant than adults, accounting for 71% of the population, Figure 2.0. The abundance of juveniles and adults were found to be of statistical significant difference with a p-value of 0.002. The geometric model series showed a rank abundance distribution that had an r-square value of 0.988.

The earthworm density per cubic meter within the mangrove forest was 59.4. The Shannon H of the site was 0.89, Pielou's E was 64.1%, Margalef R was 0.47 and Berger-Parker D was 64.5%, Table 2.0.

The soil displayed extremely high levels of sodium, sulfur, salinity, along with a low pH, Table 3.0.

DISCUSSION

This research provides the first documentation of 4 new earthworm species and the family Moniligastridae in Guyana. Of the 3 recorded families, Glossoscolecidae and Ocnerodrilidae have been previously recorded in Guyana, while Moniligastridae has not, Brown and Fragoso, 2007. Moniligastridae has however been recorded in a number of Caribbean islands, Gonzalez, *et al.*, 2006. Prior to this study, mangrove ecosystems were never assessed for its earthworm population in Guyana, and as such these 4 species were never recorded as it is possible their distribution is limited to the coastal mangrove ecosystems. The potential relationship between these species and mangroves is further supported in literature with *Pontodrilus litoralis* being found in the mangrove forests of Asia, Sateeshkumar, *et al.*, 1985; Chang, *et al.* 2009, while 2 species of Amynthas have been found in mangrove ecosystems of Singapore, Shen & Yeo, 2005.

Pontodrilus litoralis was found to be the most abundant of the 4 species, accounting for 64.5% of the population. Despite being absent from Guyana's record, this species has been recorded in bordering countries Venezuela and Brazil, Brown and Fragoso, 2007. High salinity levels create a harsh environment where most species of earthworms would perish, however, *P. litoralis* is capable of surviving in this environment as noted by Easton, 1984. The 64.5% Berger-Parker dominance is a direct result of *P. litoralis*' ability to adapt to changes in salinity which allows them to successfully exploit their ecosystem in ways other species cannot and assume dominance. *Amynthas sp.* was the 2nd most abundant species, accounting for 27.4% of the population. As noted above, some species of Amynthas can be found associated with mangrove ecosystems.

Eukerria saltensis accounted for almost 6% of the population and have also been recorded in a number of South American countries, Christoffersen, 2008. This species, however, is usually found in freshwater environments, and as such its population growth is impeded in this high salinity environment explaining its low abundance. *Drawida barwelli* is likewise found in South American and some Caribbean countries, Fragoso, *et al.*, 1999. This species was the least abundant of the 4 species, occurring when either *Eukerria saltensis* or *Amynthas sp.* was absent. These species are likely to outcompete *D. barwelli* based on their distribution pattern, and when factoring in the stresses of a high salinity environment, the extremely low abundance of *D. barwelli* is expected.

The low Shannon diversity of this ecosystem is as a result of the high salinity, sodium, sulphur and low pH present. High salinity has significant negative effects on most species of earthworms, causing increased rates of mortality

and decreased rates of cocoon production as seen in an experiment done on *Lumbricus terrestris* by Guzyte, *et al.* in 2011; while high levels of sulphur decreases the pH, and is toxic to earthworm populations, which was observed in the experiment carried out by Carcamo, 1998. The periodic disturbance from the sea is likely to drown most species, particularly burrowing species, while the movement of waves will carry off some individuals from the population. This coupled with the above extreme parameters explain the low abundance and diversity in this environment, as only a select few species can tolerate this extreme environment.

As expected, *P. litoralis* had the highest average distribution, with *Drawida barwelli* having the least, for the same reasons discussed above. The distribution pattern exhibited by the 4 species was an exponential one; *P. litoralis* was the dominant species as it could fully exploit the resources in its ecosystem, despite the high salinity, which ensures its succession. The remaining resources are competed for by the remaining 3 species, 2 of which are seen to outcompete and suppress *Drawida barwelli*. The *Amynthas sp.* Was not as sensitive as *Eukerria saltensis* to the high salinity and as such its rate of succession was higher.

CONCLUSION

4 new species of earthworms have been documented in Guyana as a result of the exploration of a harsh environment. *Pontodrilus litoralis* showed a high affinity for this high salinity environment which allowed it to access resources unhindered, establishing dominance. Drawida barwelli's population was suppressed by the presence of *Amynthas sp.* and *Eukerria saltensis*, the latter of which has a higher sensitivity to high salinity.

The presence of high levels of salinity and sulphur, along with the disturbance of waves, are responsible for the low ecological diversity in this ecosystem. However, the presence of these organisms is still astounding given the intensity of significant soil chemical parameters.

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Table 1.0- Earthworm species density, Mangrove Forest

Family	Species	Density	% Abundance
	Pontodrilus litoralis	38.3	64.5%
Megascolecidae	*Amynthas sp.*	16.3	27.4%
Ocnerodrilidae	*Eukerria saltensis*	3.5	5.9%
Moniligastridae	*Drawida barwelli*	1.3	2.2%

Table 2.0- Biodiversity indices

Index	Value
Density	59.4
Shannon H	0.8883

Pielou's E	64.10%
Margalef Richness Index	0.467
Berger-Parker Dominance Index	64.50%

Table 3.0- soil data, Mangrove Forest

N (mg/kg)	9600	Mg (meq/100g)	0.11
P (mg/kg)	10.2	Ca (meq/100g)	0.84
Cu (mg/kg)	0.2	Na (meq/100g)	54.8
Fe (mg/kg)	5.9	CEC (meq/100g)	56
Zn (mg/kg)	6.13	pH	5.8
Sulphur (mg/kg)	4373	EC	1559
O.C (%)	46.6	TDS	740
K (meq/100g)	0.2	Salinity	2.15

LIST OF FIGURES

Figure 1.0 - The average proportional distribution of earthworms in Mangrove forest
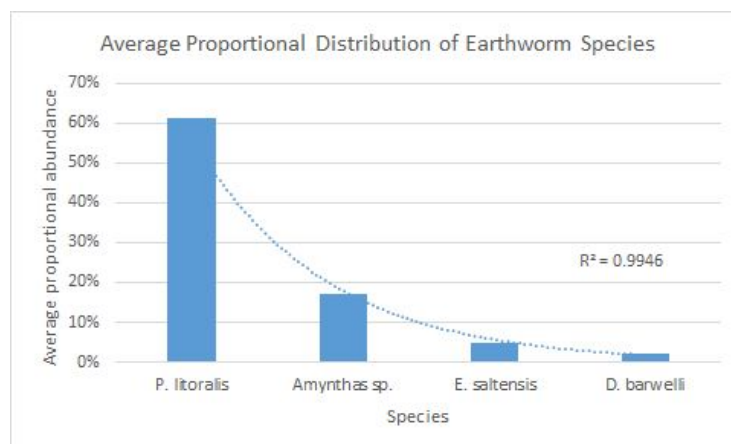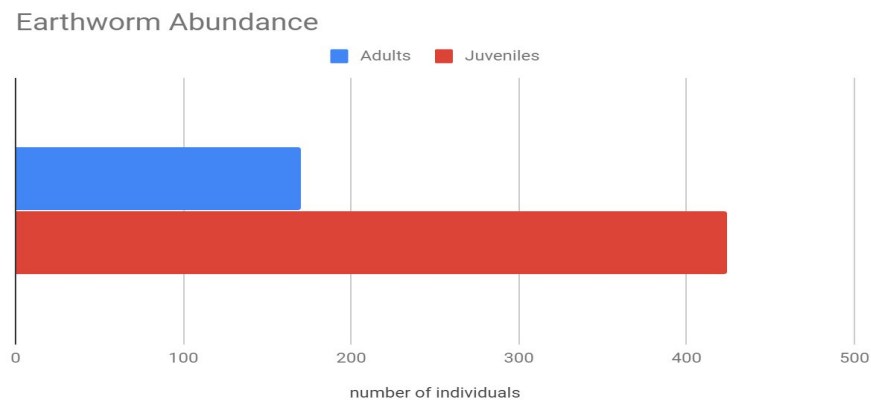
Figure 2.0- Earthworm abundance, adults & juveniles

Earthworm Abundance

Figure 3.0- Geometric Model of population