Research Journal of

Soil Biology

ISSN 1819-3498

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Soil Biology 7 (1): 21-27, 2015
ISSN 1819-3498 / DOI: 10.3923/rjsb.2015.21.27

An Investigation into the Preferential Palatability of Earthworms (*Eisenia fetida*) on Leaves of *Terminalia catappa*, *Blighia sapida* and *Hibiscus rosasinensis*

Abdullah Adil Ansari and Leeanna Humphrey
Department of Biology, University of Guyana, Georgetown, Guyana, South America

Corresponding Author: Abdullah Adil Ansari, Department of Biology, University of Guyana, Georgetown, Guyana, South America

ABSTRACT

This research was carried out during the year 2006-07 to study the preferential palatability of earthworms on the leaves of three plant species. Most species of earthworms can distinguish between different kinds of litter. Present experiment involved the collection, drying and cutting into uniform disc of leaves of *Terminalia catappa*, *Blighia sapida* and *Hibiscus rosasinensis*. These leaf discs were placed in culture pots containing the specific number of earthworms for period of 60 days. Several replications were conducted. The results indicated that *Eisenia fetida* preferred leaf discs of *Hibiscus rosasinensis* compared to two other plant species. This was indicated by preferential palatability percentage 93.87% (*Hibiscus*) compared to 46.88% (*Terminalia*) and 30.73% (*Blighia*). Earthworm population was maximum in *Hibiscus* and *Blighia* which could have been influenced by chemical composition of leaves, organic matter content, nitrogen content and pH which was near neutral in *Hibiscus*.

Key words: Earthworm, ecology, epigeics, preferential palatability

INTRODUCTION

Earthworms are scientifically classified as animals belonging to the order Oligochaeta, class Chaetopoda, Phylum Annelida. In this phylum there are about 1800 species of earthworms grouped into 5 families and distributed all over the world (Hartenstein, 1986). Earthworm species can be classed into one of the three morpho-ecological groupings (Bouche, 1977). Epigeic species live in organic horizons and ingest large amounts of undecomposed litter. These species produce ephemeral burrows into the mineral soil for dispauses periods only. They are relatively exposed to the climate fluctuations and predator pressures and tend to be small with rapid generation times. A common example is *Eisenia fetida* (California red worm) which is used in vermicomposting. Endogeic species forage below the surface, ingest large quantities of soil with a preference towards organic rich soil and build continuously ramifying burrows that are mostly horizontal. These species are apparently not of their major importance in litter incorporation and decomposition since they feed on subsurface material. They are important in other soil formation processes including root decomposition, soil mixing and aeration.

Species which build permanent, vertical burrows that penetrate the soil deeply were termed anecics by Bouché. These species are detritivores and come to the surface to feed on partially decomposed litter, manure and other organic matter. The permanent burrows of anecics create a microclimate gradient and the earthworms can be found shallow or deep in their burrows depending on the prevailing conditions. Anecics have profound effects on organic matter decomposition, nutrient cycling and soil formation. The most common examples are the *Eisenia fetida*, *Lumbricus terrestris* and *Aporrectodea longa*.

Palatability of different types of litter to earthworms may depend on nitrogen and carbohydrate content and the presence of polyphenolics such as tannins (Satchell, 1967). Earthworms prefer materials with a low C/N ratio, such as clovers, to grasses which have a higher C/N ratio (Jerez *et al*., 1988). Colonization of litter residues by microorganisms also increases palatability (Cortez *et al*., 1989), as does leaching of feeding inhibitors. Darwin in 1881 showed that earthworms could distinguish readily between different food substances and it has been shown that *Eisenia fetida* can react to a diverse range of chemicals stimuli. Such reactions probably help in the selection of food, warning of adverse conditions such as soil acidity. Different earthworm species differ in their tolerance to soil acidity, but all have a threshold of a pH below which they cannot live for long, so the ability to detect pH is essential for survival. The interactions between environmental factors influence earthworms. Temperature and moisture are usually inversely correlated and it is often difficult to separate their effects. Similarly it is difficult to separate the effects of soil organic matter content from the availability of decaying plant material as food (Edwards and Bohlen, 1996). However, it could be separated by combined preferences for organic matter, soil texture and moisture content. Most of the sense organs that react to chemical stimuli are on the prostomium which comes into contact with substances when the buccal chamber is everted during feeding.

The earthworm feeds on organic matter in the soil and plant matter which it drags down into its burrow. The worm's habitat is moist, humus rich soil. In dry weather it burrows deeper in the soil to avoid drying out. The worm's niche is an herbivore and macro-decomposer. It is important as a source of food for birds. It also helps aerate the soil and helps increase soil fertility by manuring it with leaf litter. The environment in which the earthworms are found is humid, moist and cool. Earthworms can use a wide variety of organic materials for food and even in adverse conditions can extract sufficient nourishment from organic matter and micro-organisms in soil to survive. The kind and amount of food available influences not only the size of the earthworms' populations but also the species present and their rate of growth and fecundity (Edwards and Bohlen, 1996).

Earthworms derive their nutrition from many forms of organic matter in the soil, things like decaying roots and leaves and living organisms such as nematodes, protozoan, rotifers, bacteria and fungi. They will also feed on the decomposing remains of other animals. They can consume in just 1 day, up to one third of their own body. Earthworms possess very strong mouth muscles-they do not have teeth. Earthworms often surface at night to pull fallen leaves down in their burrows. When the leaf decomposes or softens a little they pull small bits off at a time to munch on. They also 'swallow' soil as they burrow and extract nutrients from it. Earthworms from the beginning have been recognized for contributing to soil fertility. Although vitality for centuries; not much has been done so far to harness to maximize the benefits (Ismail, 1997; Kale, 1998). Organic mulches enhance earthworm habitat by moderating microclimate and supplying a food source (Werner and Dindal, 1989).

Most species of earthworms can distinguish between different kinds of litter. Darwin (1881) claimed that earthworms showed preference for leaves of particular shapes, but Satchell (1967) found that there was an order of preference for certain leaf species, if uniform discs of a range of species were offered. Several workers have demonstrated the selection of and preference for, particular forms of leaf litter of earthworms (Edwards and Bohlen, 1996). Satchell (1967) reported that the palatability of leaves to earthworms depended greatly on their polyphenols content and if water soluble phenols were washed out of oak leaves, they became much more palatable to *Eisenia fetida* (Edwards and Bohlen, 1996). The alkaloid substances above a certain concentration were not accepted by earthworms (Edwards and Bohlen, 1996). It seems from this and other evidence that most food preferences of earthworms depend on chemoreception. Earthworms can also detect acids. Acids such as phosphoric, tartaric, citric, oxalic and malic acids found in plant materials were accepted at low concentrations but not at high ones (Edwards and Bohlen, 1996).

Eisenia fetida is a large reddish worm that is widely distributed. It is an epigeic worm, that is, it is found on the surface and feed on litter matter. An unusual habit of this species is to pull leaves into the mouth of its burrow where they partially decay before being eaten. While they generally feed on plant material, they have been observed feeding on squashed insects and faces.

Earthworm populations and palatability depend on both physical and chemical properties of the soil, such as soil temperature, moisture, pH, salts, aeration and texture, as well as type of food and the ability of the species to reproduce and disperse. One of the most important environmental factors is pH, but earthworms vary in their preferences. Most earthworms favor neutral to slightly acid soil. The major benefits of earthworms' activities to soil fertility are decomposition of organic matter, enhanced soil porosity and nutrient enrichment. Various species of epigeic and anecic worms are used in vermiculture, the practice of feeding organic waste to earthworms to decompose (digest) it, a form of composting by the use of worms.

Earthworm casts are sources of nutrients for plants. Lumbricids in a pasture soil produced casts that contained 73% of the nitrogen found in the ingested litter; indicating both the importance of earthworms in incorporating litter nitrogen into the soil and the inefficiency of nitrogen digestion by earthworms (Syers *et al*., 1979). Earthworms increase the amount of nitrogen mineralized from organic matter in soil. Because nitrification is enhanced in earthworm casts, the ratio of nitrate-N to ammonium-N tends to increase when earthworms are present (Jerez *et al*., 1988). Nitrogen-fixing bacteria are found in the gut of earthworm casts and higher nitrogenase activity, meaning greater rates of N-fixation, are found in casts when compared with soil (Simek and Pizl, 1989). Earthworms prefer materials that contain a low C/N ration than those that contain a high C/N ratio. Colonization of litter residues by microorganisms also increases palatability as does leaching of feeding inhibitors.

Objectives of the study were to determine the leaf preference by earthworms, chemical composition of leaves and nutrient status of compost harvested. In Guyana there is no known research done, however other study was carried out by Edwards and Bohlen (1996) on earthworm's palatability. Such study would help in knowing what earthworms would prefer to consume in order to have a successful culture for other experiments and future use of the compost.

MATERIALS AND METHODS

Experimental set-up: The units were set up at the University of Guyana Biology Labs. Small buckets were used in triplicate for three treatments namely *Hibiscus* (*Hibiscus rosasinensis*)-T_H, Tropical almond (*Terminalia catappa*)-T_T and Ackee tree (*Blighia sapida*)-T_A. It was set up by using a layer of stones at the base. This was covered with a thin layer of fine sand. Over this was a layer of cattle manure. Water was sprinkled over a 4 days period to get rid of the acidity of the manure. The leaves species were collected and allowed to dry in the sun, however not in direct sunlight. The dried leaves were then cut in small discs of 3 cm in diameter before they were given to the worm to be consumed. The leaves discs (16) were placed between the manure and then the earthworms were introduced. These units were watered once in 7 days and covered so as to reduce the amount of light present. Once in every 14 days the earthworm's compost was collected to be analyzed.

Analysis: The observations were recorded pertaining to earthworm population (number of juveniles, non-clitellate and clitellate earthworms) at the end of the experiment (after 42 days). The compost samples that were collected were dried in the oven for 48 h at 50°C to be analyzed. Soil and vermicompost samples were analyzed for their physiochemical characteristics (pH, TKN, available phosphates, potassium and magnesium using standard guidelines (Homer, 2003). Chemical analysis of the above mentioned samples were done at the University of Guyana Chemistry and Biology laboratory.

Statistical analysis: The data recorded was subjected to statistical tool (ANOVA).

RESULTS AND DISCUSSION

The major component of the soil biota is earthworms whose principal source of food is the litter contributed by plants. Earthworms are saprophagous animals; the bulk of the food ingested is dead and decayed floral and faunal tissues. Along with the dead and decaying organic matter, earthworms also feed on living microorganism and fungi. The earthworms are classified as detritivores and geophages based on their feeding habits. While the detritivores feed at or near the surface of the soil and feed mainly on plant litter or other plant material and are called humus formers; the geophages ingest large quantities of organically rich soil and are thus called humus feeders. One of the primary functions of earthworms is in the removal of plant litter, dung and other organic material from the soil surface. Darwin (1881) observed that earthworms could readily distinguish between leaves of various plant species. He claimed that the earthworms have a well-developed "Sense of Taste".

The earthworm population was recorded at the completion of the experiment (42 days) are presented in Table 1. It was observed that the total earthworm population was greater in T_H followed by T_A and T_T. However the Juvenile population was greater in T_A followed by T_H and T_T. Non-clitellate population was greater in T_H followed by T_A and T_T. Clitellate population was greater in T_A followed by T_H and T_T.

Table 2 shows the number of leaves left after being consumed by the earthworms over the 42 days period. *Hibiscus* was the most preferred since it had the least number of leaves discs left while the tropical almond was the least preferred. The earthworms showed least preference for the Ackee tree. This can be seen by the high number of leaves remaining.

Table 1: Mean earthworm population feeding on the three leaves species

Treatments	Juvenile	Non-clitellate	Clitellate	Total
	(Mean±SD)			
Hibiscus (T_H)	4.00±5.10	4.00±3.83	3.33±2.56	22.67±1.89
Tropical almond (T_T)	1.67±2.62	0.17±0.37	2.67±3.54	9.00±6.16
Ackee tree (T_A)	6.50±4.977	0.33±0.82	4.33±2.58	22.33±15.33

Table 2: Preferential palatability of the earthworm on the three leaves species

Treatments	No. of leaves introduced	No. of leaves left after 42 days	Preferential palatability (%)
	(Mean±SD)		
Hibiscus (T_H)	16±0	0.17±0.450	93.75
Tropical almond (T_T)	16±0	11.08±19.75	30.73
Ackee tree (T_A)	16±0	8.50±15.39	46.88

Table 3: Single factor ANOVA Analysis was done on the preferential palatability of leaves

Parameter	Values
F_{cal}	24.06
F_{crit}	3.68

Table 4: Three leaves species and their mean percentage composition of the elements

Treatments	pH	Organic matter (%)	Organic carbon (%)	Total kjeldahl nitrogen (%)
	(Mean±SD)			
Hibiscus (T_H)	7.20±0.06	3.07±0.73	1.78±0.42	0.18±0.04
Tropical almond (T_T)	5.46±0.16	2.50±0.53	1.45±0.31	0.14±0.03
Ackee tree (T_A)	5.50±0.10	3.33±2.01	1.93±1.16	0.19±0.12

Statistical analysis (ANOVA) applied on preferential palatability of leaves by earthworms indicated highly significant difference between the three treatments (Table 3).

The pH range for the 3 leaves treatment. The tropical almond was the most acidic, similarly the ackee tree was also acidic. The *Hibiscus*, however, was neutral with pH ranges at about 7. This could also explain why it was the most preferred leaf species (Table 4). Table 4 shows the amount of organic matter present in the three leaves treatment. Ackee tree had the most organic matter present. It was followed by *Hibiscus* while tropical almond had the least amount of organic matter present. Variable quantity of nitrogen is recorded in the compost of the three treatments.

The distribution of organic matter in soil did not influence the distribution of the earthworms greatly nevertheless the high composition of organic matter present in the ackee tree population as seen in Table 4 could of accounted for their high population of earthworms (Curry and Bolger, 1984). Since the distribution of the organic matter is supposed to influence the distribution of the organic matter, it probably meant that the decaying organic matter led as a thick mat on the soil surface (Edwards and Bohlen, 1996). The kind and amount of food available influenced not only the size of the earthworm populations but also their rate of growth and fecundity. Since the earthworms prefer food with high organic matter component, it can also be the reason for the high population of juvenile in ackee tree population. The experiment also showed that more juveniles and non-clitellate worms were produced by the *Hibiscus* leaves because of their dark color, softer texture and faster rate of decomposition.

It was observed that earthworms consume different types of plant materials. When they were given a choice between Tropical almond (*Terminalia catappa*), Ackee tree (*Blighia sapida*) and Hibiscus (*Hibiscus rosasinensis*) they preferred the hibiscus leaves. The experiment showed that the *Eisenia fetida* preferred the softened hibiscus leaves to the hardened Ackee tree leaves and aromatic tropical almond leaves. From the experiments carried out it was seen that earthworms are much more attracted to moist litter than to the dry litter and to weathered litter as opposed to unweathered. Analysis of the compost and the leaves also revealed that certain chemicals such as tannins and flavonoids and physical factors such as pH, moisture content and nutrient composition of the leaves influenced the feeding preferences in the earthworms. It has been reported that the content of nitrogen, soluble carbohydrates and polyphenols in the leaves can be broadly correlated with leaf palatability.

The tropical almond leaves were not preferred and unattractive to the earthworm because of its bitter alkaloid while the Ackee tree had a noxious aromatic content. The worms showed a preference to leaves that were rich in nitrogen and soluble carbohydrate and lacking tannins to those that had low nitrogen and soluble carbohydrate content and high tannin content. The litter became more palatable with weathering, which leached the water soluble polyphenols and other unpalatable substances from the leaves. It was also found that the *Eisenia* sp. did not prefer leaves with high tannin content as was seen in the case of the tropical almond leaves and the Ackee tree leaves that was not highly palatable. Other factors influenced the palatability of leaves to the earthworms. 'Starved' earthworms consumed the leaves that had high tannin content and other unfavorable components and compositions which they would have normally rejected.

The variation in their food preferences was attributed to the chemical substances that were present in the leaves which attract and extract feeding responses. The sites for sense organs capable of perceiving the stimuli of chemicals, taste and smell are on the buccal epithelium which comes in contact with the various substances during feeding by the movement of the buccal cavity. When new fresh leaves were added it was observed that they did not prefer that, the earthworms preferred the more decayed and decomposed leaves that were initially present in the units. It was also observed that the leaves with the high nitrogen content, that is the hibiscus and Ackee tree, produced more juveniles and the non-clitellate earthworms.

CONCLUSION

It can be concluded that the California red earthworm (*Eisenia fetida*) is more preferential to the leaves from the hibiscus tree (*Hibiscus rosasinensis*) than the other two plant species; the Tropical Almond tree (*Terminalia catappa*) and the Ackee tree (*Blighia sapida*). The number of earthworms present does not necessarily mean that the earthworms prefer that particular species of leaf, it could also be because of the organic matter present in the leaf as well as movement of earthworms from one unit to the next. The organic matter, components present in the soil and soil pH and can also affect the palatability of the earthworms.

REFERENCES

Bouche, M.B., 1977. Strategies Lombriciennes. In: Soil Organisms as Components of Ecosystems, Lohm, U. and T. Persson (Eds.). Vol. 25, Natural Science Research Council, Stockholm, Sweden, pp: 122-132.

Cortez, J., R. Hameed and M.B. Bouche, 1989. C and N transfer in soil with or without earthworms fed with ^{14}C-and ^{15}N-labelled wheat straw. Soil Biol. Biochem., 21: 491-497.

Curry, J.P. and T. Bolger, 1984. Growth, reproduction and litter and soil consumption by *Lumbricus terrestris* L. in reclaimed peat. Soil Biol. Biochem., 16: 253-257.

Darwin, C., 1881. The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habitats. John Murray Publisher, London, UK., Pages: 326.

Edwards, C.A. and P.J. Bohlen, 1996. Biology and Ecology of Earthworms. 3rd Edn., Chapman and Hall, London, UK., ISBN-13: 9780412561603, pp: 426.

Hartenstein, R., 1986. Earthworm biotechnology and global biogeochemistry. Adv. Ecol. Res., 15: 379-410.

Homer, F., 2003. Soil analysis manual. Central Analytical and Environmental Monitoring Services, Agriculture Research Department, LBI, Guyana.

Ismail, S.A., 1997. Vermicology: The Biology of Earthworms. Orient Longman, New Delhi, ISBN: 9788125010104, Pages: 92.

Jerez, E.R., P.R. Alll and R.W. Tillman, 1988. The Role of Earthworms in Nitrogen Release from Herbage Residues. In: Nitrogen Efficiency in Agricultural Soils, Jenkinson, D.S. and K.A. Smith (Eds.). Elsevier Applied Science, USA., ISBN: 9781851662401, pp: 355-357.

Kale, R.D., 1998. Earthworm: Cinderella of Organic Farming. Prism, Bangalore, ISBN: 9788172861001, Pages: 88.

Satchell, J.E., 1967. Lumbricidae. In: Soil Biology, Burges, A. and F. Raw (Eds.). Academic Press, New York, pp: 259-322.

Simek, M. and V. Pizl, 1989. The effect of earthworms (Lumbricidae) on nitrogenase activity in soil. Biol. Fertility Soils, 7: 370-373.

Syers, J.K., A.N. Sharpley and D.R. Keeney, 1979. Cycling of nitrogen by surface-casting earthworms in a pasture ecosystem. Soil Biol. Biochem., 11: 181-185.

Werner, M.R. and D.L. Dindal, 1989. Earthworm community dynamics in conventional and low-input agroecosystems. Rev. Ecol. Biol. Sol., 26: 427-437.