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Density and diversity in relation to the distribution of earthworms in Madras

S A ISMAIL*, C RAMAKRISHNAN and M M ANZAR
Department of Zoology, The New College, Madras 600 014, India
*Present Address: Regional College of Education, Mysore 570 006, India

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Abstract. Earthworm density and diversity have been studied in a sandy loam site and a clay loam site, each comprising of 50 locations, at Madras. *Lampito mauritii* is the dominant species in the sandy loam while it is *Octochaetona serrata* in the clay loam. The indices of dominance, diversity and dissimilarity have been estimated and discussed in relation to the distribution of earthworms.

Keywords. *Lampito mauritii*; *Octochaetona serrata*; density; dominance; diversity; dissimilarity.

1. Introduction

Earthworms are among the most widely spread invertebrate animals in the tropical and temperate regions of the world and are found mainly in the soils of forests, woodlands and grasslands which together cover about 80 million square kilometres, or about 54% of land surface of the earth (Whittaker and Likens 1973). Various ecological as well as mechanical parameters influence the size of earthworm populations, their species diversity, dominance and vertical distribution (Edwards 1983; Krishnamoorthy and Ramachandra 1988). *Lampito mauritii* Kinberg, *Drawida modesta* Rao, *Octochaetona pattoni* (Michaelsen), *Octochaetona serrata* (Gates), *Octochaetona thurstoni* (Michaelsen) and *Ramiella pachpaharensis* (Stephenson) have been reported from the soils of Madras (Ismail and Murthy 1985).

The present investigation is a detailed study of the soil system applying principles of quantitative ecology in two sites of Madras each comprising of 50 locations. These sites signify as representations of sandy loam and clay loam soils. Atmospheric temperature, soil temperature, soil moisture, bulk density of soil, pore space, maximum water holding capacity of soil, pH, oxidizable organic matter and plant cover have been investigated; and the population density, dominance, diversity and dissimilarity that exist between the locations in each site with special reference to earthworms have been recorded.

2. Materials and methods

Ecological studies were conducted in two sites of Madras (13°5'N, 80°18'E), categorically being designated as sites A and B. Site A is situated in Ameer Mahal (a stretch of private land in Madras city) where the soil is light brown sandy loam. *Ricinus communis* Linn (Euphorbiaceae), *Acalypha indica* Linn (Euphorbiaceae), *Cleome viscosa* Linn. (Capparidaceae), *Rhynchosia heynei* W and A (Fabaceae), *Boerhaavia diffusa* Linn. (Nyctaginaceae), *Ageratum conyzoides* Linn. (Asteraceae),

Kyllinga sp. (Cyperaceae), *Cyperus* sp. (Cyperaceae) and *Cynodon* sp. (Poaceae) are the floral associates of the community. Of the 50 locations surveyed in site A, locations 44–50 are from a frequently trampled path.

Site B situated in the National Park, Guindy, on the outskirts of the city has brown clay loam. Totally protected and with natural surroundings, this reserve forest has a high density of trees, shrubs and herbs providing shade and litter. *Mullugo* sp. (Aizoaceae), *Oldenlandia* sp. (Cyperaceae) and *Cynodon* sp. (Poaceae) are the floral associates. Of the 50 locations surveyed here, locations 38–50 lie on the path.

Atmospheric temperature (30 cm above soil surface), soil temperature (10 cm below soil surface), soil moisture (Misra 1968), bulk density (dry weight of soil/volume of soil), porosity and water holding capacity (Keen and Raczkowski 1921), pH (Hanna 1968) and oxidizable organic matter (Walkley 1947) of the soil samples were estimated in all the 100 locations. In each location 30 cm depth of soil from an area of 0·1 m^2 was excavated, macrofauna was handsorted and preserved in 5% formaldehyde.

In order to study species composition, the methods used in the study of trophic structure of the ecosystem were adopted. The standing crop per unit area was measured and described. Each collection was individually sorted out, animals belonging to different species were grouped and counted. Using the data so obtained the following indices of species structure in community were assessed:

(i) Index of dominance (c) (Simpson 1949)

$$c = \Sigma\,(ni/N)^2,$$

where ni = number of individuals for each species and N = total number of individuals in that location.

(ii) Index of similarity (Sorenson 1948)

$$S = \frac{2C}{A+B},$$

where A, B = number of species in samples A and B and C = number of species common to both samples.
Index of dissimilarity = $(1 - S)$.

(iii) Index of general diversity ($\bar{H}$) (Shannon and Weaver 1949 cf Odum 1971)

$$\bar{H} = -\Sigma\, ni/N \log_e ni/N,$$

where ni = importance value for each species and n = total of importance value.

3. Results

Table 1 provides data for the parameters investigated in the two sites A and B.

Site A is inhabited by the earthworms *D. modesta*, *L. mauritii*, *O. pattoni*, *O. serrata*, *O. thurstoni* and *R. pachpaharensis* in association with insects (*Gryllotalpa* sp. and *Anthia* sp.), myriapods and molluscs (*Ariophanta* sp. and *Vaginulus* sp.). Earthworms constitute 80·18% of the faunal density corresponding to 77·37% of the faunal biomass from this site. Of the earthworm species *L. mauritii* is the most dominant in site A contributing 44% of the biomass followed by

Table 1. Results of the parameters investigated at sites A and B (mean ± SD).

	Site A	Site B
Atmospheric temperature (°C)	26·39 ± 3·63	28·41 ± 0·52
Soil temperature (°C)	25·20 ± 0·80	27·14 ± 0·72
Moisture (%)	15·96 ± 1·11	17·28 ± 1·26
Bulk density (g/cm^3)	1·18 ± 0·05	1·31 ± 0·07
Porosity of soil (%)	54·98 ± 6·98	53·23 ± 8·38
Maximum water holding capacity of soil (%)	47·61 ± 7·00	55·15 ± 5·92
pH	6·98 ± 0·46	7·18 ± 0·29
Oxidizable organic matter (%)	2·14 ± 0·47	2·12 ± 0·49
Plant cover (%)	30·10 ± 12·43	62·40 ± 12·00
(g dry wt/0·5 m^2)	5·00 ± 2·62	10·16 ± 3·91
Earthworms:		
(nos/m^2)	53·42 ± 39·22	72·64 ± 22·67
(g live wt/m^2)	7·32 ± 5·77	9·77 ± 4·69
Total macrofauna		
(nos/m^2)	66·67 ± 44·93	76·86 ± 22·58
(g live wt/m^2)	9·34 ± 7·32	10·07 ± 4·94
Index of dominance (c)	0·50 ± 0·22	0·64 ± 0·18
Index of general diversity ($\bar{H}$)	0·85 ± 0·42	0·58 ± 0·28

Each value is mean of 50 observations.

O. thurstoni (24·62% of the biomass). Arthropods and molluscs contribute to 5·23 and 17·47% of the macrofaunal soil biomass respectively. *O. serrata* which is a dominant form in site B constitutes only 8·2% of the biomass in site A.

Site B is inhabited by the earthworms *D. modesta*, *L. mauritii*, *O. serrata*, *O. thurstoni* and *R. pachpaharensis* in association with coleopteran caterpillars and a scanty representation by arachnids (soil spider) and molluscs. Earthworms constitute 93·2% of the faunal density corresponding to 97·33% of the total biomass at B. Of the earthworm species *O. serrata* is the most dominant organism in site B contributing 72·31% of the total biomass followed by *L. mauritii* (18·96% of the biomass).

Plant cover is extensive in site B (62·4%) than in site A (30·1%), dry weight of the floral community being 101·6 and 50 g/m^2 respectively.

The average index of dominance at site A is 0·50 indicating that dominance is shared while it is 0·64 at site B indicating dominance by one or two species. It is indeed evident that the dominant species at site B is *O. serrata* (72·31% of the soil biomass). Converse are the results obtained from the index of general diversity; a value of 0·85 for site A indicating greater diversity of faunal population than in site B which has a value of 0·58. This is in conformity with the greater number of species in site A (15) than in site B (9). The index of general diversity forms a mirror image of the index of dominance (figure 1).

4. Discussion

A number of ecological parameters play a vital role in the distribution and abundance of earthworms (Dash and Patra 1977; Lavelle 1984), which may be due

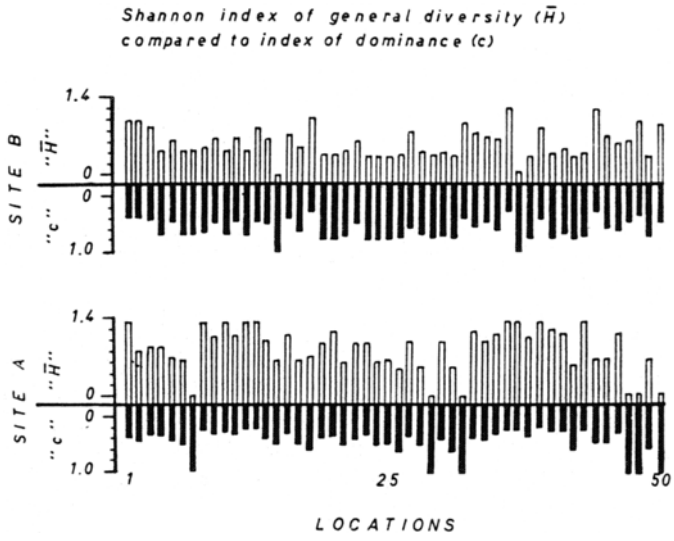

Figure 1. Indices of dominance (■) and general diversity (□) for sites A and B.

to the adaptability of that particular species to the soil sample studied (Lavelle 1983). Temperature, moisture, bulk density of the soil, pore space, water holding capacity and organic matter in soils function as important parameters in the distribution of the earthworms. Though the soil is sandy loam at site A and clay loam at site B, edaphic factors in these two sites are within the preferred range for the distribution of earthworms in Madras (Ismail and Murthy 1985).

Due to the differences observed in the distribution pattern of species in locations of both the sites, it was felt necessary to estimate the index of dissimilarity between locations in each site. The degree of dissimilarity in each site has been represented using a dissimilarity matrix (figure 2). The matrix clearly indicates that the similarity in faunal constitution is not the function of closeness of locations but probably is the result of various other factors as suggested by Dash and Patra (1977) and Lavelle (1983, 1984). There appears to be more similarity between locations of site B while the locations at site A show considerable dissimilarity among themselves. Of particular interest in site A are locations 44–50 which show maximum dissimilarity when compared with any other location of this site. Locations 44–50 in site A represent a path frequented by human and cattle. Earthworm abundance and biomass have been shown to decline as a result of trampling by humans (Chappell *et al* 1971; Aritajat *et al* 1977) and cattle (Briggs 1978). The density of earthworms in these locations due to trampling was just 17·1/m^2 (biomass 1·47 g/m^2) and the total number of macrobiota was 28·6/m^2 (biomass 1·63 g/m^2).

Observations reveal that the faunal associates are reduced to about 20 in the region of the path in site A but trampling does not seem to have such an effect in site B where locations 38–50 are also representations of path. At site B the floral associates are reduced by 20%, i.e. 80% of the plant cover of that present at the other locations exists. Results on the effect of trampling conform to the findings of Piearce (1984) and it could be added that the results of trampling have a more pronounced effect on sandy loams altering their faunal structure.

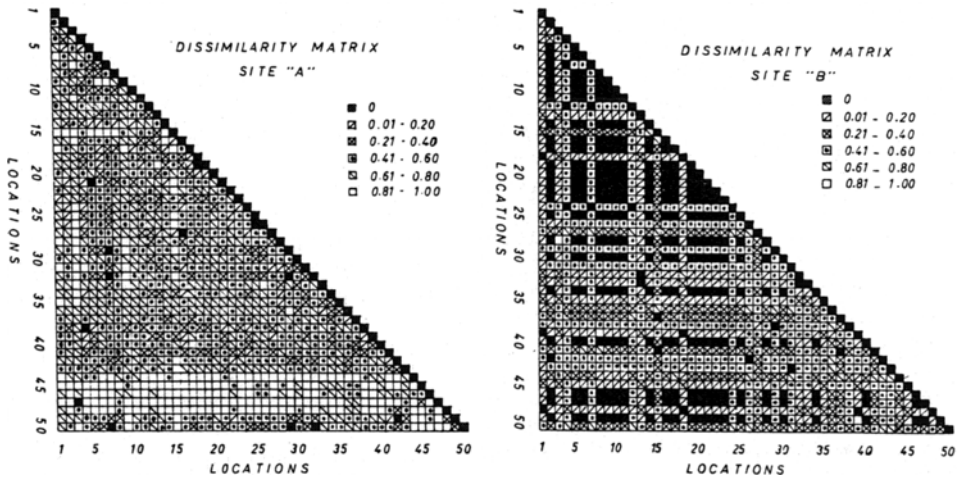

Figure 2. The dissimilarity matrix for sites A and B.

The macrobiota of site B is chiefly represented by the earthworms, the dominant species being *O. serrata*. Soil here being a clay loam, *O. serrata* successfully inhabits this site making use of its powerful buccopharyngeal musculature for eating through the soil. The dissimilarity matrix (figure 2) clearly indicates that the clay loam soil does not favour diversity of species and the degree of dominance is generally concentrated to one or two species. Such dissimilarity matrices (figure 2) would also be useful to the students of field biology in deferring from generalizing the distribution of organisms with a few samples investigated. Each site therefore possesses a region of different density, dominance, diversity and dissimilarity in its organisation.

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