Entomology, Ornithology & Herpetology
Jawaheer et al., Entomol Ornithol Herpetol 2013, 2:3
DOI: 10.4172/2161-0983.1000111
Research Article
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A Survey of Roadside Soil Arthropod Communities from Three Elevations in Mauritius

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Abstract

This study was carried out in Mauritius during summer from November 2012 to April 2013. The objectives of this study were to quantify the species richness and diversity, abundance and biomass of soil arthropod from roadside trees found at three different elevations in Mauritius. Soil arthropods were collected utilizing pitfall traps made of plastic cups at three different elevations (Flic en Flac, 5 m; Rose-Hill, 221 m; and Mare aux Vacoas, 569 m). Traps were placed among *Casuarina equisetifolia* (5 m), *Dictyosperma album* (221 m) and *Pinus sylvestris* (569 m) trees. A total of 18422 arthropods were sampled of which 10681 individuals were sampled at 5 m, 5216 individuals at 221 m and 2525 individuals at 569 m. The abundant soil arthropods were Hymenoptera (Formicidae) (54.0%) and Coleoptera (Nitidulidae) (32.7%). The alpha diversity of soil arthropods varied between elevations [(5 m, 0.907), (221 m, 0.727), (569 m, 1.54). Soil arthropod species evenness was highest at 221m (0.77) followed by 5 m (0.69) and lowest at 569 m (0.53). Formicidae was abundant at 221 m (91.4%) while Anisolabidae (38.6%) was abundant at 569 m. Significant difference in weight between elevation ($p<0.05$) and significant differences in weight and abundance with bait types ($p<0.05$) was observed. This study can be useful in determining soil arthropods and their plant host specificity as such data has implications for biological control as well as for collection of specific insects. Moreover, this study also has implications for town planners with respect to planting roadside trees and their ensuing edaphic communities for managing insect pests.

Keywords: Soil arthropods; Elevation; Bait traps; Mauritius

Introduction

Mauritius is located some 900 km east of Madagascar and is of volcanic origin covering an area approximately 1865 km² [1]. The island nation has lost most of its forest since being colonized by the French in the 17th century [2] and forest cover now stands at 2% of the island area [3]. Active conservation efforts including planting roadside trees in urban areas was undertaken to reverse the loss in tree cover [4]. Roadside trees are part of the urban landscape where they help reduce soil erosion, water runoff, flooding [5] and also offer aesthetic value. Roadside trees help stabilize leftover soils after road construction [6] and are important habitats of arthropods which are ecosystem-engineers influencing soil properties as well as redistributing resources used by other organisms [7].

Notwithstanding being a small and isolated island, Mauritius has a well-developed native insect fauna comprising endemic species but there is however, paucity of information on the soil arthropod community. Most studies on arthropods in Mauritius have mainly focused on sugarcane pests and endangered endemic taxa [8]. This study was thus designed to determine the soil arthropod species richness and community structure from roadside trees located at different elevations in Mauritius. The choice of roadside trees is obvious as they are easy to reach and sample, even at high elevations. The data generated would provide an account of soil arthropod species richness and community structure in Mauritius.

Materials and Methods

Soil arthropod sampling sites were Mare aux Vacoas (569 m, 20°22'31.46'S, 57°30'18.58'E), Rose-Hill (221 m, 20°13'60S, 57°28'0E) and Flic en Flac (5 m, 20°16'47.2074'S, 57°21'59.2302'E) (Figure 1). The primary species of roadside trees at Flic en Flac was *Casuarina equisetifolia*, at Rose-Hill was *Dictyosperma album* and at Mare aux Vacoas was *Pinus sylvestris*.

Bait traps made of plastic cups were utilized to sample the soil arthropods. Three bait traps each containing different baits (soapy water, beef extract, and beer and banana) were placed within 200 m intervals among the roadside trees along a 2 km transect line at each elevation (in total 30 bait traps per elevation: 10 containing soapy water; 10 containing beef extract; and 10 containing beer and banana). The beef bait trap consisted one cube of Knorrox Beef Flavour (in total 1080 cubes) in 15 ml of soapy water (prepared as 1ml of liquid soap in 1.5l of tap water); the beer and banana bait trap consisted of a 3 mm slice of banana with peel immersed in 15 ml of beer (Phoenix Beverage - malted spring barley, 5% alcohol) (total of 54 bottles each being 650 ml); while soapy water bait contained 15 ml of soapy water.

The traps were lodged into the ground to a depth of 5 cm and were placed at their respective elevations among the roadside trees between 4 am to 10 am and arthropod samples were collected after 48 hours. Thirty-six sampling trips were conducted during the summer season from November 2012 to April 2013. Collected samples were separated into containers according to sites and pitfall trap types. In the laboratory the soil arthropods were washed with distilled water to remove debris and then preserved in 70% alcohol. The soil arthropods were enumerated; their biomass recorded and was identified at the Mauritius Sugarcane Research Institute (MSRI). The Shannon Wiener Diversity,

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Received August 22, 2013; **Accepted** October 22, 2013; **Published** October 29, 2013

Citation: Jawaheer Z, Singh HR, Ganeshan S (2013) A Survey of Roadside Soil Arthropod Communities from Three Elevations in Mauritius. Entomol Ornithol Herpetol 2: 111. doi:10.4172/2161-0983.1000111

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Figure 1: Location of study sites in Mauritius [12].

		Absolute abundance (%)			Mean abundance (%)		
Soil Arthropods (Order: Family)		569m	221m	5m	569m	221m	5m
1	Araneae: Agelenidae	1.52	0.47	0.26	2.71	1.64	0.30
2	Dermaptera: Anisolabididae	38.63	0	0	36.18	0	0
3	Blattodea: Blaberidae	0.04	1.49	1.12	0.2	3.82	1.17
4	Diptera: Drosophilidae	1.52	0.47	0.16	1.06	0.34	0.13
5	Coleoptera: Elateridae	0	0	0.04	0.1	0	0.063
6	Hymenoptera: Formicidae	7.08	91.42	50.17	5.66	71.87	63.85
7	Lithobiomorpha:Lithobiidae	0	0.02	0	0	3.75	0.03
8	Coleoptera: Nitidulidae	25.81	4.78	45.53	21.66	14.06	30.74
9	Isopoda: Porcellionidae	3.04	0.16	0.33	2.89	1.6	0.62
10	Amphipoda: Talitridae	20.12	0	0	28	0	0
11	Coleoptera: Tenebrionidae	2.24	1.19	2.41	1.52	2.92	3.13

Table 1: Absolute and mean abundance (%) of the soil arthropods sampled from three elevations.

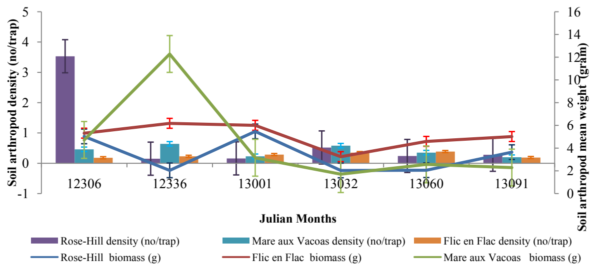

Figure 2: Soil arthropod mean abundance (no/trap) and mean weight (g) per trap during six months of sampling.

H [9], Shannon Evenness J [10], Similarity [11] and the Margalef, D [10] indices were utilized to determine the community structure of the soil arthropods. A One-way ANOVA was conducted for elevation and bait traps on soil arthropod abundance and biomass utilizing SPSS ver. 22 software.

Results

A total of 18,422 soil arthropods from 11 orders, 11 families comprising 16 species were collected in this study of which 10,681 individuals were sampled at Flic en Flac (9 families, 16 species), 5216 individuals at Rose-Hill (10 families, 13 species) and 2525 individuals at Mare aux Vacoas (10 families, 11 species). Anisolabididae, Nitidulidae and Talitridae were abundant at Mare aux Vacoas, Formicidae was abundant at Rose-Hill while Formicidae and Nitidulidae were abundant at Flic en Flac (Table 1).

The soil arthropod biomass was generally higher at Flic en Flac except during December 2012 (Figure 2). Flic en Flac and Rose-Hill however, had somewhat similar mean biomass throughout the study. Highest soil arthropod abundance was recorded from Rose-Hill (mean=3.53 no/trap) in November 2012 whilst the highest biomass was recorded at Mare aux Vacoas (mean=4.72 g) in December 2012 (Figure 2).

No significant difference in abundance (no/trap) of soil arthropods was observed between elevations ($p>0.05$) but the biomass at Flic en Flac (mean=3.23 g) was higher than that at Mare aux Vacoas (mean=0.5 g) and Rose-Hill (mean=0.4 g) ($p<0.05$). Soil arthropod abundance in beef extract (mean=12.4 no/trap) and beer and banana (mean=13.4 no/trap) traps were significantly higher than that of soapy water (9.6 no/trap) traps ($p<0.05$). The biomass in the soapy water traps (mean=2.64 g) was significantly higher to that of the beef extract (mean=0.88 g) and the beer and banana (mean=0.62 g) traps.

Alpha diversity was highest at Mare aux Vacoas and lowest at Rose-Hill (Table 2). The Margalef Index (D=1.03) was highest at Mare aux Vacoas while the Evenness Index was highest at Rose-Hill (J=0.77) (Table 2). The Similarity Index was highest between Mare aux Vacoas and Rose-Hill (0.71), followed by between Rose-Hill and Flic en Flac (0.69) but lowest between Flic en Flac and Mare aux Vacoas (0.47) (Table 3).

Discussion

The Formicidae was most abundant at Rose-Hill and this was probably due to the higher species richness of roadside trees (11 species) as compared to Mare aux Vacoas (1 species) and Flic en Flac (1 species). According to Knops et al. [14], plant species richness may affect soil processes by influencing microclimate. An increase in plant diversity can lower the soil temperature by 3°C [15]. Biones et al. [16] and Carrera et al. [17] state that temperature reduction by vegetation has positive impact on soil fauna through stress reduction and higher feeding rates [18]. The high abundance of the Nitidulidae and Formicidae during the hotter months (January, February and March) at Flic en Flac (public beach) was probably a result of increased human activity such as camping and picnics which gave rise to more litter at the site. It is believed that introduced species (Nitidulidae) are more successful in colonizing disturbed areas than closed forest habitat [19,20]. Nitidulidae prefer warm and dry habitats [21,22] characterized by low relative humidity [23] as observed at Flic en Flac (relatively warm and dry). During December 2012, the large mean biomass recorded at Mare aux Vacoas was due to the greater presence of Anisolabididae (ear wigs). Earwigs are cosmopolitan and are generally moisture-loving [24] and are found under dead and decaying logs, beneath bricks and

	Diversity scores			Margalef	Evenness
	Alpha (H)	Beta	Gamma	D	J
5m	0.907	0.35	1.25	0.75	0.69
221m	0.727	0.53	1.25	0.82	0.77
569m	1.54	-0.29	1.25	1.03	0.53

Table 2: Diversity, Mangalef and Evenness values of the soil arthropods.

	569m	221m	5m
569m	-	0.71	0.47
221m	0.71	-	0.69
5m	0.47	0.69	-

Table 3: Similarity Index for the 3 study sites.

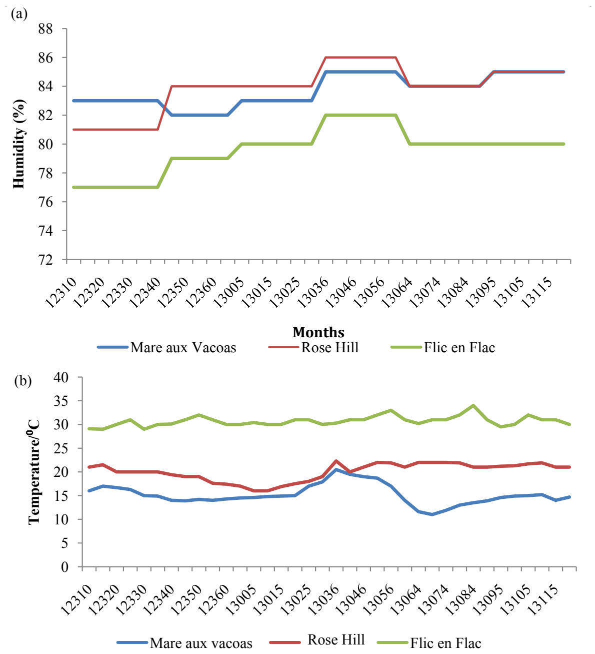

Figure 3: Humidity (a) and temperature (b) at the study sites shown for six months [13]. Mare aux Vacoas recorded the lowest temperature and highest humidity while Flic en Flac recorded the highest temperature and lowest humidity throughout the study (Figure 3).

stones, edges of streams, rivers and moist places [25]. Mare aux Vacoas consisted of tall grass, a considerable amount of decaying tree logs and it is a water catchment area and is an ideal habitat for the Anisolabididae.

The relatively higher diversity of soil arthropods at Mare aux Vacoas (D=1.03, H=1.54) was probably due to lack of anthropogenic disturbance as compared to the other two sampling sites but recorded low eveness (J=0.53) suggesting dominance by certain taxa (Anisolabididae). The higher Shannon Evenness at Rose-Hill (J=0.77) and at Flic en Flac (J=0.69) suggests lack of dominance by soil arthropod taxa. The low Margalef Index at Flic en Flac (D=0.75) is reflected by anthropogenic disturbances at the study site (picnic, camping and litter). The low Similarity Index between Flic en Flac and Mare aux Vacoas probably reflects differences in habitat structure, microclimate (Figure 3) and disturbance of the soil arthropods which is reflected by the beta diversity score.

Climatic variations such as temperature and moisture can influence variation in distribution, richness patterns and diversity inclinations of organisms [26-29]. Climatic changes do have direct impact on the composition of soil arthropods where temperature and moisture can modify soil arthropod function and behaviour [30,31]. This may be reflected in the community differences of the soil arthropods at the study sites where temperature and moisture varied between Mare aux Vacoas, Rose-Hill and Flic en Flac (Figure 3).

The trap preference by soil arthropods suggests their food preference and this in turn relates to the type of arthropods present at each elevation besides the effect of microclimate and tree types. The size of the plastic bait traps limited the abundance of the larger soil arthropods which were sampled at Mare aux Vacoas (Anisolabididae and Talitridae) and Rose-Hill (Blaberidae) and recommendation for future works would be to use larger plastic cups.

Acknowledgement

The authors would like to thank the Mauritius Sugarcane Industry Research Institute (MSIRI) for laboratory facilities and expertise and the Ministry of Agro-Industry and Food Security, Republic of Mauritius.

References

1. Montaggioni L, Nativel P (1988) LA Reunion, Ile Maurice geologie et apercus biologiques, Masson, Paris, France.
2. Cheke AS (1987) An ecological history of the Mascarene Islands, with particular reference to extinctions and introductions of land vertebrates. In: Diamond AW (eds). Studies of Mascarene Island birds, Cambridge University Press UK 5-89.
3. Page W, D'Argent G (1997) A vegetation survey of Mauritius to identify priority areas for conservation management [draft report]. Mauritian Wildlife Foundation, Mauritius.
4. Griffiths OL, Florens VFB (2006) A field guide the non-marine molluscs of the Mascarene Island. (1stedn) 4-32.
5. Sjoman H, Ostberg J, Bufiler O (2012) Diversity and distribution of the urban tree population in ten major Nordic cities. Urban Forestry & Urban Greening 11: 31-39.
6. Knispel AL, McLachlan SM (2010) Landscape-scale distribution and persistence of genetically modified oilseed rape (Brassica napus) in Manitoba, Canada. Environ Sci Pollut Res Int 17: 13-25.
7. Reyes-López J, Ruiz N, Fernández-Haeger J (2003) Community structure of ground-ants: the role of single trees in a Mediterranean pastureland. Acta Oecologica 24: 195-202.
8. Motala SM, Krell FT, Mungroo Y, Donovan SE (2007) The terrestrial arthropods of Mauritius: a neglected conservation target. Biodivers Conserv 16: 2867-2881.
9. Weaver W, Shannon CE (1949) The mathematical theory of communication. The University of Illinois press, USA 119-131.
10. Magurran AE (1988) Ecological Diversity and its Measurement. Princeton University Press, USA 179.
11. Sørensen T (1957) A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Kongelige Danske Videnskabernes Selskab 5: 1-34.
12. Google Earth (2013) Mauritius Islands. Mauritius.
13. Mauritius Meteorological Services (2013) Mauritius.
14. Knops JMH, Wedin D, Tilman D (2001) Biodiversity and decomposition in experimental grassland ecosystems. Oecologia 126: 429-433.
15. Spehn EM, Joshi J, Schmid B, Alphei J, Korner C (2000) Plant diversity effects on soil heterotrophic activity in experimental grassland ecosystems. Plant Soil 224: 217-230.
16. Biones MJI, Ineson P, Piearce TG (1997) Effects of climate change on soil fauna; responses of enchytraeids, Diptera larvae and tardigrades in a transplant experiment. Appl Soil Ecol 6: 117-134.
17. Carrera N, Barred ME, Gallego PP, Briones MJI (2009) Soil invertebrates control peatland C fluxes in response to warming. Funct Ecol 23: 637-648.
18. Sturm M Jr, Sturm M, Eisenbeis G (2002) Recovery of the biological activity in a vineyard soil after landscape redesign: a three-year study using the bait-lamina method. Vitis 41: 43-45.
19. Elton CS (1958) The Ecology Of Invasions By Animals and Plants. Methuen, London, UK 181.
20. Spence JR, Spence DH (1998) Of the ground beetles and men: introduced species and the synanthropic fauna of Western Canada. Mem Ent Soc Can 144: 151-168.
21. Gould GE, Moses HE (1951) Lesser mealworm infestation in a brooder house. J Econ Entomol 44: 265.
22. Pfeiffer DG, Axtell RC (1980) Coleoptera of Poultry Manure in Caged-layer Houses in North Carolina. Environ Entomol 9: 21-28.
23. Salin C, Vermon P, Vannier G (1998) The supercooling and high temperature stupor points of the adult lesser mealworm *Alphitobius diaperinus* (Coleoptera: Tenebrionidae). J Stored Prod Res 34: 385-394.

24. Al-Dosry MM (2010) Distribution and ultrastructure of sensillae on legs and anal cerci in earwigs *Anisolabis maritima* (Dermaptera: Carcinophoridae). Journal of King Saud University - Science 22: 21-30.

25. Zoological Survey of India (2013) Contribution to the Faunal Diversity of India, Insecta: Dermaptera. Zoological Survey of India, India.

26. Hawkins B, Field R, Cornell H, Currie D, Guegan JF, et al. (2003) Energy, water, and broad-scale geographic patterns of species. Ecology 24: 3105-3117.

27. Whittaker RJ, Willis KJ, Field R (2003) Climatic-energetic explanations of diversity: macroscopic perspective. In: Blackburn TM, Gaston KJ (Eds.). MacroEcology: concepts and consequences. Blackwell Publishing, Oxford, UK 107-129.

28. Currie DJ, Mittelbach GC, Cornell HV, Field R, Guegan JF, et al. (2004) Predictions and tests of climate-based hypotheses of broad scale variation in taxonomic richness. Ecol Lett 7: 1121-1134.

29. Segev U (2010) Regional patterns of ant-species richness in an arid region: The importance of climate and biogeography. J Arid Environ 74: 646-652.

30. Schneider S, Mearns L, Gleick P (1992) Climate-change scenarios for impact assessment In: Peters RL, Lovejoy TE (Eds.), Global Warming and Biological Diversity, Yale University Press, New Haven, CT, USA 38-55.

31. Harte J, Torn M, Chang FR, Feifarek B, Kinzig A, et al. (1995) Global warming and soil microclimate: results form a meadow-warming experiment. Ecol Appl 5: 132-150.