INFLUENCE OF ANT (HYMENOPTERA-FORMICIDAE) ACTIVITY ON SOIL PROPERTIES

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Abstract:

Ecologists have considered anthills to have an effect on the surrounding soil and vegetation as ant mounds have longevity ranging from 30-60 years. Despite several attentions to ants' manipulation of soil properties in an ecosystem have been studied, however, the extent of many common ant species influence soil properties is still unknown. In this context, current investigation of ant activities in relation to soil properties were done by comparing soil moisture content, soil pH, soil organic matter, soil nitrogen content and available phosphorus between soil from ant nest and soil 1 meter away from ant nest as control. Finding observed that characteristics of soil showed that, concentrations of organic matter percentage and soil moisture content are more in the soil close to the ant hills than to the non-nest site. It was found that the organic matter between the soil close to ant mounds and the control site were statistically significant in both the seasonal cycle ($p < 0.05$, df =19).

Keywords: Ant activities, soil, nests, anthills

Introduction

Among social insects, ants are classified as eusocial due to their characteristic features consisting of cooperative brood care and overlapping of generation among workers within the colony. There are three distinct castes: male, female (queen), and the sterile workers, with the worker caste showing great diversity and polymorphism (Wilson, 1971). Ants are herbivores, carnivores or scavengers. Some use plants and their products (seeds, fruits, plant sap and nectar) as food (Beattie, 1985; Kaspari, 1993), while some preys on arthropods (Wilson, 1971).

Ant nests are found in the soil and in the trees (Holldobler, 1983; Kaspari, 1993). Nesting habits vary in accordance to physical characteristics, availability of food, prey, predation as well as micro-environmental factors. They always nest in a variety of soil types ranging from hard clay, loamy to pure sand, beneath stone surface and vegetation (Kaspari, 1996). Property of soil can also influence ant community (Boulton et al., 2005). Their diversity varies with change in soil properties (Catangui et al., 1996; Bandeira and Harada, 1998; Bestelmeyer and Wiens, 2001; Kaspari and Weiser, 2000) vegetative community (Majer et al., 1997), seasonal and climatic factors (Bestelmeyer and Wiens, 1996) and plant productivity (Kaspari et al., 2000).

Ants play an important role in enrichment of the soil next to earthworm (Gunadi and Verhoef, 1993). Their biology has been studied in respect of their role and function in the exchange of energy in an ecosystem (Holdobler and Wilson, 1990). They are indicators for ecological change (Nepstad et al., 1995) and have been used as bioindicators in land management of mining areas (Andersen, 1993) and other land uses for forestry and pastoralism (Schonberg et al., 2004; Andersen et al., 2002; Majer, 1992). Although arthropods are more sensitive to habitat change, certain assemblages of ants are sensitive to the change in habitat such as agro-ecosystem intensification (Watt et al., 2002; Bruhl et al., 2003). They constitute an important group that act as agent for seed dispersal and also as a biological control agent of pests, thus protecting agricultural and horticultural plants (Way and Khoo, 1992).

Ecologists have considered anthills to have an effect on the surrounding soil and vegetation as ant mounds have longevity ranging from 30-60 years (Wagner et al., 1997) Studies have shown that the soil and vegetation of ant mounds differ from those of their surroundings in terms of soil pH, organic matter content, soil moisture and also the composition of vegetation (Kelly et al., 1996, McGinley, 1994, Wagner et al., 1997, Whitford, 1988, Madison et., al. 2019). Soil from beneath plants with ant nests contained significantly higher concentrations of nitrate, ammonium, phosphorus, and water than soil from beneath plants without nests (Wagner, 1997). Nests of the harvester ant *Pogonomyrmex barbatus* typically contain higher concentrations of organic matter, nitrogen and phosphorus than surrounding soils (Wagner, 2004). The soils near ant nests often contain higher concentrations of organic matter and mineral in the form of nitrogen and phosphorus than soils collected off the nest (Petal, 1998; Beattie, 1985; Folgarait, 1998; MacMahon et al., 2000). Ant nests contribute to soil nutrient heterogeneity in many ecosystems by aerating soil and cycling nutrients (Risch and Carrol, 1982). Ants serve as herbivores, predators, scavengers and prey. Food items are collected throughout the foraging range of the colony, but debris and waste products are deposited near the nest entrance, thereby concentrating these materials or debris onto the surface of their nest mound, (Gordon, 1992) leading to cycling of nutrients. They also play an important role in aerating of soil due to their continuous digging out of the soil which loosen and allow soil moisture absorption (Holldobler and Wilson, 1990). Ant may be considered as soil engineers. Therefore, their biology has been studied in respect of their role and function in the exchange of energy in an ecosystem (Holdobler and Wilson, 1990) and their interactive behavior with others organism like aphid, scale insect etc. (Wagner, 1997; Rashbrook et al., 1992; Bluthgen et al., 2000; Bluthgen et al., 2004; Edward et al., 2006).

In this current finding, study on the effect of antnest site on the soil physical and chemical properties was carried out where ant mound of *Pheidole smythiesii* Forel, 1902 were examined. *Pheidole sp* is dimorphic, divided into the minor workers and the major workers, or soldiers which generally have enormous heads and mandibles. A colony contains one or several queens, and (in mature colonies) virgin, winged females and males. Their nests are mostly found in the soil and in beneath rocks and stones. Therefore, study of ant activity in relation to soil properties were done by comparing soil moisture content, soil pH, soil organic matter, soil nitrogen content and available phosphorus between soil from ant nest and soil 1 meter away from ant nest as control.

Material and methods

To study the effect of soil physical and chemical properties on ant activities, soil samples were taken from near ant nest and from 1 metre away from the ant nest (as control) to determined variation in soil pH, moisture content, organic content, nitrogen content and available phosphorus. Soil Sample were collected for a period of two years during warmer seasons. After measuring pH and moisture content, some soil samples were air dried for 48 hours, crushed with pestle and sieved through 2 mm mesh for the organic content analysis using standard volumetric method (Jackson, 1958), Semi-Kjeldahl distillation method was used to analyse nitrogen content and available phosphorous by means of molybdenum blue method (Allen et al., 1974).

One way-ANOVA was used to compare the variations in soil pH, moisture, organic content, nitrogen content and available phosphorus between ant nest and non-nest site.

Result and Discussion

Soil pH, soil moisture content, soil organic matter, nitrogen content and available phosphorus of nest sites were 11.75±0.93, 37.46±1.89, 08.57±0.58, 00.59 ±0.21, 06.04±0.33 in the first annual cycle and it was 06.04±0.33, 37.47±1.90, 08.58±0.59, 00.60±0.21, 10.11±0.69 in the second annual cycle respectively. Whereas, in non-nest site were 06.44±0.11, 27.61±2.48, 05.71±0.31, 00.52±0.07, 11.41±0.55 in the first annual cycle and 06.44±0.12, 27.61±2.48, 05.72±0.32, 00.49±0.07, 08.56±0.38 in the second annual cycle. Characteristics of soil from *Pheidoles smythiesii,* close to the ant hills and the control sites 1 meter away from ant hills showed that concentrations of organic matter percentage and soil moisture content are more in the soil close to the ant hills than to the non-nest site soil. It was found that the organic matter between the soil close to ant mounds and the control site were statistically significant in both the seasonal cycle ($p < 0.05$, df =19) (Fig. 1).

Table: 1. Soil properties within nest site of Pheidole smythiesii compared with control. (n=20).

Samples	Soil properties	First Year	Second year
		Mean ± SE	Mean ± SE
Nest	pH	06.04±0.33	06.04±0.33
	Soil moisture content (%)	37.46±1.89	37.47±1.90
	Soil organic matter % (SOM).	08.57±0.58	08.58±0.59
	Nitrogen content (%)	00.59 ±0.21	00.60±0.21
	Available phosphorus (µg /g)	11.75±0.93	10.11±0.69
Non-nest	pH	06.44±0.11	06.44±0.12
	Soil moisture content (%)	27.61±2.48	27.61±2.48
	Soil organic matter % (SOM).	05.71±0.31	05.72±0.32
	Nitrogen content (%)	00.52±0.07	00.49±0.07
	Available phosphorus (µg/g)	11.41±0.55	08.56±0.38

Soil organic matter concentration between the ant nests soil and the nonnest, (soil 1 meter away from the mound) showed to be less in the control point samples than the soil close to ant hills. A significant difference was also found in the soil moisture between the ant nest and the control sites, with more moisture in soil of ant nest site than non-nest soil in both the seasonal cycle ($p < 0.05$, df = 19). There was no statistically significant difference in pH, nitrogen, available phosphorus between the ant mounds soil and the soil 1 meter away from the ant nest ($p > 0.05$, df = 19).

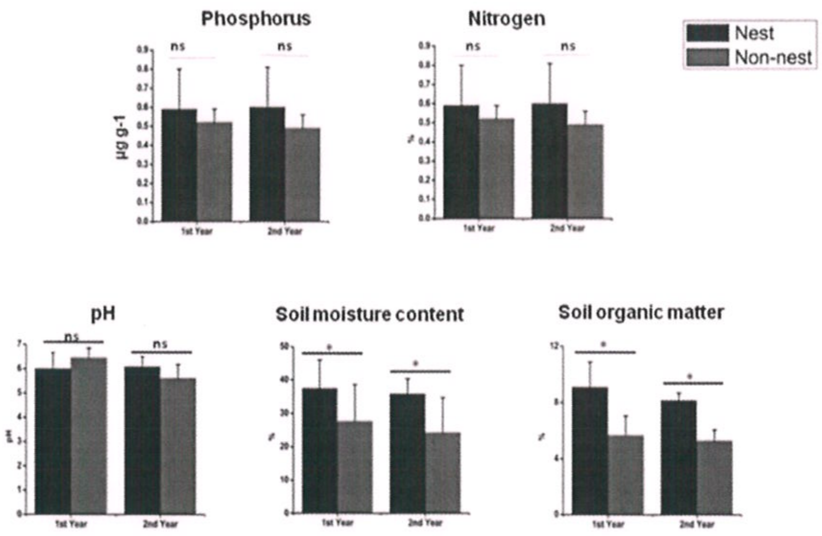

Fig 1. Influence of nest site of *Pheidole smythiesii* on soil properties

Characteristics of soil from *Pheidoles smythiesii* mounds close to the ant hill and control sites 1 meter away from ant hill showed that soil moisture content is more in the soil close to the ant hills than to the offset soil. Soil moisture content was comparable with the investigation found by Whitford (1988) and McGinley (1994). Ant mounds play a very important role on the surrounding soil and vegetation as ant mounds have longevity ranging from 30-60 years (Wagner et al., 1997). This difference in soil moisture could be due to the elevation of the ant mounds, which facilitates water penetration. Also, the tunnels within the ant mounds provide channels through which the water can flow into the mound and also provide an opportunity for air circulation, aerating of soil due to their continuous digging out of the soil which losses and allow soil moisture absorption (Holldobler and Wilson, 1990; Wagner, 1997). A significant difference was found in the concentrations of organic matter percentage between the ant nest and the control sites. This finding agrees with the studies of Petal (1998); Beattie (1985); Folgarait (1998); and MacMahon et al. (2000) who found that the soils near ant nests often contained higher concentrations of organic matter and mineral in the form of nitrogen and phosphorus than soils collected off the nest mound. Nests of the harvester ant *Pogonomyrmex barbatus* typically contain higher concentrations of organic matter, nitrogen and phosphorus than surrounding soils (Wagner et al., 2004). Although others investigation has reported significance difference between soil pH, nitrogen content and phosphorus in ant mound soil and the surrounding soil (Frouz et al., 2005; Wagner and Jones, 2006), the present finding showed no statistical significance in soil pH, nitrogen, available phosphorus between the ant mounds" soil and the soil 1 meter away from the ant nest. There was a slight increase of nitrogen content and available phosphorus in the soil near ant nest. This can be explained by the increase in nutrient accumulation by material used for building the nest in the particular species which brings about a change in the surrounding soil properties (Frouz et al., 2003; Alejandro, GFB and Victoria W, 2017,). Ant mound have been shown to affect the soil pH, ant nest shift pH toward neutral value, ants increase pH in acidic soil and decrease in basic soil (Frouz et al., 2003). Ant community plays a functional role in soil nutrient heterogeneity in many ecosystems by aerating soil and cycling nutrients (Risch and Carrol, 1982; Kadu, 2016). They have increased available nutrients in their nest; they serve as herbivores, predators, scavengers and prey. Food items are collected throughout the foraging range of the colony, with debris and waste products deposited near the nest entrance, thereby concentrating these materials or debris onto the surface of their nest mound, (Gordon, 1992) leading to cycling of nutrients. Ants may be considered as soil engineers, and their biology has been studied in respect of their role and function in the exchange of energy in an ecosystem (Holdobler and Wilson, 1990) and their behavioral interactions with others organism like aphid, scale insect and other microbial communities (Wagner, 1997; Rashbrook et al., 1992; Bluthgen et al., 2000; Bluthgen et al., 2004; Edward et al., 2006, Changting, et., al. 2017). Ants thus play a functional role in their ecosystems by continuously mineralizing of the soil (Beattie, 1985; Davidson, 1997, Qianqian, et., al. 2021).

Conclusion

From the findings it can be summarised that characteristics of soil showed that, concentrations of organic matter percentage and soil moisture content are more in the soil close to the ant hills than to the non-nest site soil. It was also found that the organic matter between the soil close to ant mounds and the control site were statistically significant in both the seasonal cycle. This investigation provides evidences confirming that ants are key role soil modifier and play as ecological engineer.

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