INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE & TECHNOLOGY
© VISHWASHANTI MULTIPURPOSE SOCIETY (Global Peace Multipurpose Society) R. No. MH-659/13(N)
www.vmsindia.org

Bioturbation: Induced By the Ground Dwelling Ants Species.

Seema G. Kadu
Assi. Prof. Dept. of Zoology,
S.S.E.S. Shri Shivaji Science College, Congress Nagar Nagpur,
gssskadu@gmail.com/ seema.kadu@sscn.in

Abstract
An ant represents a unique focal group having the potential to be used as biological indicators. There are several ground dwelling ant species involved in mounding and indirectly influence below ground level soil quality with total root biomass. The bioturbation occurs during the dwelling and mounding of soil with lag in total root biomass under newly heaped soil. Bioturbation is one of the most important ant activity that modifies and homogenizes soil profile. Soil homogenization and mounding are mainly influence the vegetation with below ground plant parameters. In the present study higher number of species from subfamily Myrmicinae followed by the subfamilies Pseudomyrmecinae and Dolichoderinae are arboreal species, ground dwelling species helps to modify soil structure with increasing porosity, accumulation of food and detritus making nests as hotspots of nutrient exchange. Also, the dwelling activity of these ants induced bioturbation from lower horizons to the surface area by ants aids which affects the mixing of organic and mineral fractions of the soil to increase the fertility. The faeces of ants also the basis for the formation of soil aggregates and humus, which physically stabilize the soil and increase its porosity to store nutrients. Present study examined the effect of mound maker, ant species as prodigious and legendary soil bioturbator with decrease in pH, increase in concentration of soil nutrients N, P(PO4,), S, Mg2+, Ca2+, K+ and C (organic).
Key Words: Bioturbation, Mound, Myrmicinae, Pseudomyrmecinae, Dolichoderinae, nutrients

Introduction

Soil and its biota are fundamental components of the “Critical Zone”: Earth's living skin that most directly sustains life. Within that zone, geologically-rapid soil and saprolite displacement by biota, particularly invertebrate meso- and macrofauna, affects a large proportion of Earth's soils. This was first recognised by late-19th century observers, on both sides of the Atlantic Ocean, who regarded bioturbation as fundamental to soil formation. Throughout much of the 20th century, however, the agronomical focus of soil scientists and the dominant paradigm of landscape evolution relegated bioturbation. As a result, many aspects of bioturbation are still not widely appreciated. Only in the last few decades has a re-evaluation commenced, in a range of disciplines (Sherri *etal,* 2008). Primary effects of bioturbation, which we quantify herein, include soil production from saprolite, the formation of surface mounds, soil burial, and downslope transport. Rates of bioturbation can be as rapid as sustained maximum rates of tectonic uplift. As plants grow, they consume nutrients in the soil. As the mineral content depletes in the soil, they need to be replenished. This is where the organisms living in the soil play their part by helping in the decomposition and transportation of nutrients to be used by plants. Some ants like weaver ants, pharaoh ants, wood cutter ant and carpenter ant species construct their nest in the soil to deposit their food and egg laying playing an important role in the basic nutrient cycle of the soil. In concert with surface geomorphic processes, bioturbation alters fundamental properties of soil, including particle-size distribution, porosity, the content of carbon and other nutrients, and creep flux rate. The precise influence of biotic mixing is regulated by its depth function.

As some wood ants are keystone species in woodland ecosystems, with effects on the community structure of local invertebrates as well as providing a food source for predators (Hughes and Broome, 2007). Nest construction results in modification of soil structure, increasing porosity (Frouz and Jilková, 2008) and accumulation of food and detritus makes nests hotspots of nutrient exchange (Domisch et al., 2009). The nests constructed by these ants support high levels of biodiversity, including many species that are dependent on the nests as habitat (Parmentier et al., 2014). There are different ant species shows burrowing activity among these the is very important in soil tilting during nest building. The carpenter ants makes the soil more porous, provide better aeration, improves the moisture content and helps in the transfer of organic materials into the soil. These ants uses plant residues, animal manure or other organic materials decomposed by bacteria, fungi and converts the complex organic matter into simple components (Eldridge and Pickard,1994). These reduced simple organic components are carried by the ants in to soil where they are further being absorbed by the plants as growth nutrients (Underwood and Fisher, 2006). The population of ants effects on physical, chemical and biological properties of soil through the modification of soil profile, aeration, drainage and density and are therefore able to influence the energy and nutrient cycles and to act as ecological engineers (Folgarait, 1998; Frouz and Jilkova, 2008).

Material and Method

The aim of this study was to compile the occurrences of species sampled a well as analysis of soil sample collected from different vegetative areas having ant mounds. We organized the information available from a previous inventory undertaken in such mound areas to analyse bioturbadation of soil. This experiment was conducted to find out whether the fauna inhabiting the soil will only help with soil fertility and plant growth or indirectly help in bio mantling of the compact soil. The ten (n=10) different plots of gardens and vegetative areas chosen as the experimental areas and studied where the maximum population of different ant species in well-developed ant-mounds had been found. The ant species and soil samples collected from roof of the mound and tested in the research laboratory using Soil Testing Kit. The concentration of N, P(PO4,), S, Mg2+, Ca2+, K+ and C (organic) and pH of the soil tests measure in ppm. The undisturbed areas without mounds and ants population were also studied as check or control.

Observation and results -

In the present study the subfamily Myrmicinae showed a higher number of species followed by the subfamilies that harbor strictly or partially arboreal species, such as, Pseudomyrmecinae (Ward 1999) and Dolichoderinae (Shattuck 1992). In soil and leaf litter ants inventories, this subfamily is normally the most frequent and diverse, probably because it comprises generalist species, specialists predators and fungus growing ants which have different nesting habitats, such as rotting wood, soil, leaf litter and on the vegetation (Fowler et al. 1991). It is observed that the soil collected from different sustainable ant-mounds regions shows variable concentration of than the control soil sample. The hypothesis that the presence of ants in the soil help in bioturbation of soil as well as better plant growth. Standard soil analyses included: N, P(PO4,), S, Mg2+, Ca2+, K+ and C (organic) and pH of the soil tests. All the given soil nutrients in the respective soil sample collected from different sustainable areas shows increasing concentration as compared to control area (Table-1)

Table-1 : Concentration of Soil Nutrients (in ppm) ten (N=10) experimental ant mound areas.

S. No.	Soil-Nutrients (Concentration in ppm)	N-1	N--2	N--3	N--4	N- 5	N--6	N--7	N - 8	N--9	N-10	Control A-C
1.	**pH**	7.0 >	6.8 >	6.7 >	6.9 >	7.1 >	6.5 >	7.2>	6.5 >	6.1>	7.5>	5.5 <
2.	**N**	55>	65>	70>	42>	58>	68>	40>	54>	75>	72>	40 <
3.	**$P(PO^4)$***	54>	68>	72>	62>	55>	66>	55>	62>	65>	56>	25<
4.	**$S(SO4^2)$***	20.5 >	25>	20>	22>	25>	35>	28>	21>	22>	16>	10.5<
5.	**Mg^{2+}***	188 >	155 >	167 >	175 >	180 >	192 >	166 >	185 >	190 >	200 >	80 <
6.	**Ca^{2+}**	2300 >	2200 >	1800 >	2100 >	2300 >	2150 >	2650 >	2880 >	1990 >	2250 >	1500<
7.	**K^{+}***	140 >	165 >	186 >	195 >	202 >	155 >	165 >	142 >	182 >	198 >	110<
8.	**C (organic)**	3% >	4% >	3% >	2% >	4% >	5% >	3% >	2% >	4% >	4% >	0.5% <

*** $P<0.001$

Discussion and conclusion:-

The present study work carried out in District Nagpur which is the metropolitan city in the state of Maharashtra, India located at 21°56'N 76°45'E. In Maharashtra state ant fauna, represent the diverse group of species, including ten known subfamilies like; Aenictinae, Amblyoponinae,Cerapachyinae, Dolichoderinae, Dorylinae, Ectatomminae, Formicinae, Leptanillinae, Myrmicinae, Ponerinae, Proceratiinae and Pseudomyrmecina (Nagaria and Pawar, 2014; Kadu, 2015; 2016).

Ants are increasingly being recognized as useful tools for land managers to monitor ecosystem conditions. However, despite an abundance of studies on ant responses to both environmental disturbance and land management techniques, an analysis of the practice and value of including ants in monitoring is lacking. Consequently, conservation managers are left with little guidance as to if, when, and how ants can be used to assess conservation activities (Johnson etaal, 2005).

According to ant survey carried out in different vegetative areas was published until now (Kadu, 2015, 2016), although these insects are frequently mentioned as key-organisms to the functioning of tropical regions by changing the physical and chemical soil structure (Folgarait 1998; Sousa-Souto et al. 2007; Kadu, 2016, 2017), seed dispersion (Handel and Beattie, 1990, Levey and Byrne, 1993) and control of herbivorous insect population (Dyer and Letourneau 1999).

In general, ants shift nest pH toward a neutral value (Fig. 1), i.e., ants increase pH in acidic soils and decrease it in basic soils (Dlusskij 1967, Frouz etal, 2003). Increases in total C and organic C (BRIAN, 1978) as well as humus in the nest (Dmitrienko and Petrenko, 1976) have often been reported. A shift in the content of basic cations (Ca^{2+}, K^+, and Mg^{2+}) has often been noted in ant nests,

The soil dwelling ant species help to fertilize the soil in many ways. They help in the recycling of decomposed materials which increase soil porosity and may cause separation of soil particles according to their size. Some of the ants eat other insects and caterpillars that are harmful to the plants and will help nourish the soil with their processed food (Sherri *etal*, 2008). The burrowing activity of carpenter ants helps to penetrates water upto the plants roots. The ants also help in spreading the plants' seeds. Ant-mediated chemical changes of soil are represented mainly by a shift of pH towards neutral and an increase in nutrient content (mostly Potassium and phosphorus)(Kadu, 2015) in ant nest-affected soil (Frouz and Jilkova, 2008). These effects correspond with accumulation of food in the nests and the effect on biological processes, such as hastening of decomposition rate. Effects on biological soil properties may be connected with increased or decreased microbial activity, which is affected by accumulation of organic matter and internal nest temperature and especially moisture (Eldridge and Myers1998). Effects on the soil vary between ant species; substantial variation can be found in the same species living in different conditions. The increase in concentration of Potassium and phosphorus and neutral pH represent an ideal indicator for experiments targeting soil ecosystems (Alonso and Agosti, 2000; Underwood and Fisher, 2006; Bolton et al., 2007). In this study, we compared nutrient exploitation by spruce seedlings growing in substrates and ant mounds from abandoned ant nests from the control soil area (Ohashi et al., 2007). At field moisture, microbial biomass C and N were significantly more concentrated in ant nests at one of two study sites (Frouz et al., 2008). When moistened, ant nest soils had a higher capacity for microbial growth than soils from other microhabitats (Diane Wagner and Jeremy B. Jones, 2005). The soil sample collected from ant mounds perimeters was also substantially higher in total N than undisturbed (control) soil, undoubtedly in response to the available surplus due to ant-derived nitrogenous recovered excreta, uric acid, urea, and amino acids from artificial nest particles (i.e., silica gel) stained yellow or brown with S. invicta excretions and hypothesized that N-containing excretory compounds and phosphoric acid may contribute to the abundant vegetation commonly found around fire ant mounds (Sherri *etal*, 2008).

However, this study is the first to document the direct linkage of select nutrient availability in ant mound soils as well as soil bioturbation with enhanced nutrient levels expressed in perimeter vegetation. This is conclude that ants nest mound highly impact on the soil bioturbation by creating concentrated patches tilting of soil with increase in nutrients concentration could affect biogeochemical cycling rates and plant community dynamics.

Reference:-

Aravind Chavhan and S.S. Pawar (2011). Distribution and Diversity of Ant Species (Hymenoptera: Formicidae) in and Around Amravati City of Maharashtra, India. *World Journal of Zoology* 6 (4): 395-400.

Avinoam Danin and Yom Tov. 1990. Ant nests as primary habitats of *Silybum marianum* (*Compositae*). Pl. Sys. And Evo., Vol. 169, Issue-3, pp 209-217.

Benoit Lafleur, Linda M. Hooper Bu, Paul Mumma, James P. Geaghan. 2005. Soil fertility and plant growth in soils from pine forests and plantations: Effect of invasive red imported fire ants *Solenopsis invicta* (Buren), Pedobiologia Volume 49, Issue 5, 3 October Pg.415–423.

Bolton B. (2003). Synopsis and classification of Zoological Survey of India Fauna of Meghalaya, Formicidae. Memoirs of the *American,Entomological* 7: 251-409. Institute, 71: 1-370.

Bolton, B., (1994). Identification Guide to the Ant Genera of World. Cambridge: Harvard University "Newly discovered sister lineage sheds light on Press.

Bharti, H. and G.D. Alpert, (2007). Ants of India. Downloaded from ww.antdiversity.com/ 26 December 2007.

Cammeraat L H, Willott S J, Compton S G, Geoderma L D, 2002. The effects of **ants**' nests on the physical, chemical and hydrological properties of a rangeland **soil** in semi-arid Spain,Geoderma, Vol. 105, Issues 1–2, January 2002, Pages 1–20.

Diane Wagner, Mark J. F. Brown and Deborah M. Gordon, 1997. Harvester ant nests, soil biota and soil chemistry, Oecologia, Vol. 112, Issue 2, pp 232-236.

Diane Wagner and Jeremy B. Jones (2005). The Contribution of Harvester Ant Nests, *Pogonomyrmex rugosus* (Hymenoptera, Formicidae), to Soil Nutrient Stocks and Microbial Biomass in the Mojave Desert.

Dlusskij, G.M. 1967: Muravji roda Formica. – Nauka, Moskva, 236 pp.

Dmitrienko, V.K. and Petrenko, E.S. 1976: Muravji tazenych biocenos sibiry. – Nauka, Novosibirsk, 220 pp.

Domisch J. Finer L. Ohashi M. Risch A.C. Sundstrom L.,Niermela P. and Jurgenser M. F., 2006. Contribution of Red wood ant mounds to forst floor CO2 in boreal Coniferous soil-Biology and Biochemitry, 38: Pg. 2425-2433.

Eldridge, D.J. and Pickard, J. (1994). The effect of ants on sandy soils in semi-arid eastern Australia. II. Nest turnover and consequences for bioturbation. *Australian Journal of Soil Research*32, 323-333.

Eldridge, D.J. and Myers, C.A. (1998). Some evidence that the ants *Aphaenogaster* *barbigula* (Myrmicinae) enhance soil nutrients around their nest entrances in semi-arid eastern Australia. *Australian Journal of Soil Research* 36, 1009-1017.

Folgarait P.J., 1998. Ant biodiversity and its relationship to ecosystem functioning a review. Biodiv. and Conserv., 7: Pg. 1221-1224.

Frouz J. and Kalick J. 1996. The role of ants for availability of phosphorous in spruce plantation proceedings of the national conf. about study of phosphorous and other elements. Pedobiologia, 75-80.

Frouz J., Holec M. and Kalick J. 2003. The effect of Lasius niger (Hymenoptera: Formicidae) ant nest on related soil chemical properties. Pedobiologia 47: 205-212.

Johnson DL, Domier JEJ, Johnson DN (2005) Animating the biodynamics of soil thickness using process vector analysis: a dynamic denudation approach to soil formation. Geomorphology 67, 23-46.

Ohashhi M, Kilpelainen, J., Finer L., Risch A.C., Domisch T. Neuvonen, S. and Niemela P. 2007a. The effect of red wood ant (Formica rufa group mounds on roof biomass, density and nutrient concentration in boreal managed forests, Jour. , Forest research, 12: Pg.113-119.)

Sousa-Souto, L., J.H. Schoereder and C.E.G.R. Schaefer. 2007. Leafcutting ants, seasonal burning and nutrient distribution in Cerrado vegetation. Austral Ecology 32(7): 758-765.

Sherri L. De Fauw, James T. Vogt and Debbie L. Boykin, 2008. Imported Fire Ant (Hymenoptera: Formicidae) Bioturbation and Its Influences on Soils and Turfgrass in a Sod Production Agroecosystem. J. Entomol. Sd. 43(1): 121-127.

❖❖❖❖❖