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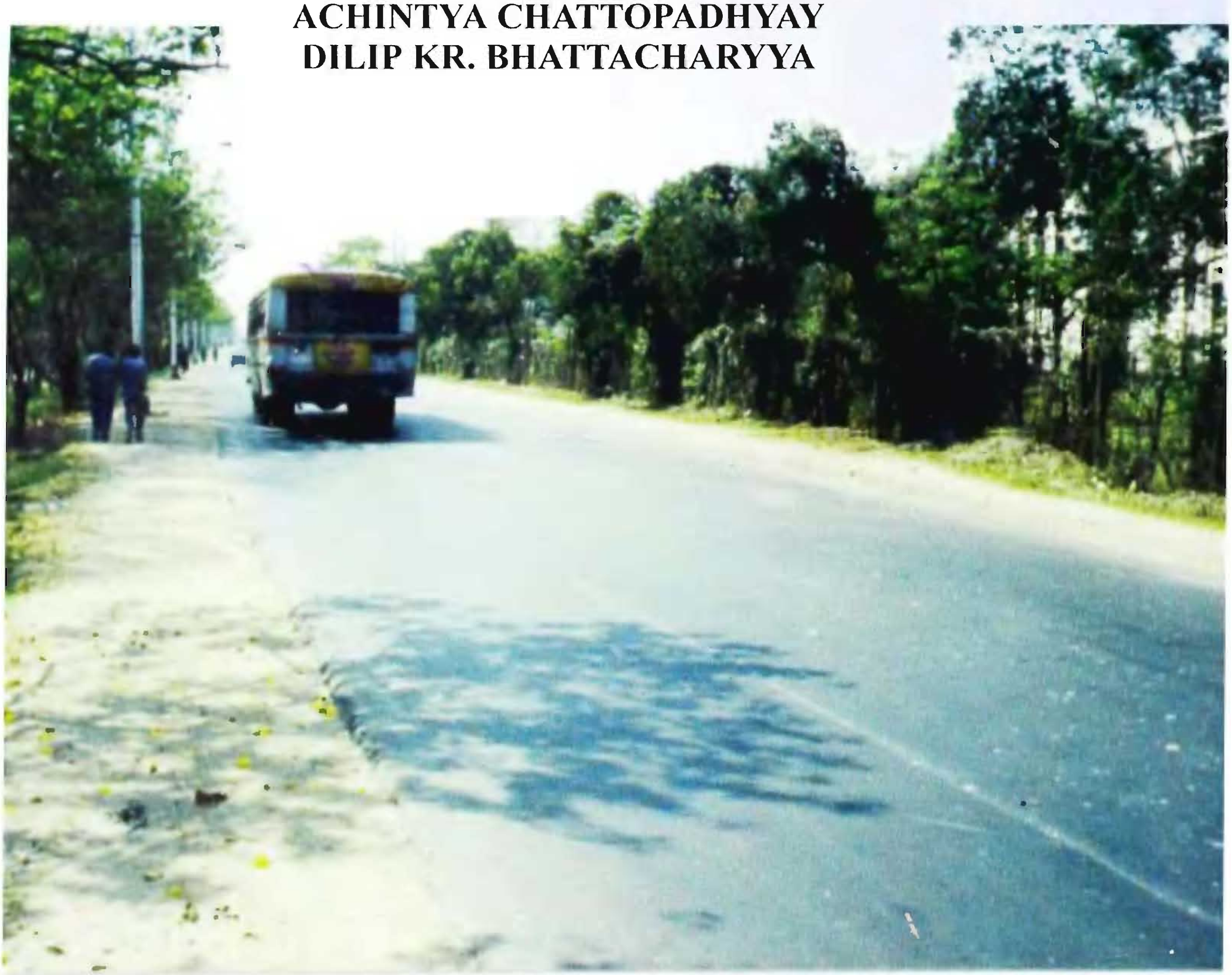

ZOOLOGICAL SURVEY OF INDIA

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RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA OCCASIONAL PAPER

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CONTENTS

INTRODUCTION

The latin word 'Solum', means floor, is the mother of the word soil. Natural activities like wind, water-flow etc., have been acting for hundreds and thousands of years upon the rocks resulting the process of disintegration of rocks into very small particles, gradually. These particles mixing with organic matters form the soil which supports life.

The process of formation of soil can be divided into two steps. The first one is the transformation of primary rock into unconsolidated mass of internally unaltered grains (Thompson and Troeh, 1979). This product is known as parent material. In the next step biochemical changes occur in the parent material by the influence of living organisms as well as by the nature. Thus it can be said that soil is a decomposition product with two main constituents, one is mineral material and other is organic material.

The vegetation growing on the soil and the soil animals sustaining on them provide the organic material of soil. The decomposition of organic matter starts with the infestation of micro-organisms, like bacteria, fungi, etc. Their activities induce changes in the texture and chemical composition of the organic matter, which then provides nutrients to the plants and ultimately to the soil animals like earthworms, insects, millipeds, collembolans, mites, etc. (Wallwork, 1970). Wastes and remains of plants and animals are decomposed by the micro-organisms and nutrients again return to the soil. Thus the cycle is being completed for the sustenance of a stable soil ecosystem. As the soil animals play a key role in this process of cycling, they are considered as the part and parcel of the dynamic soil system.

Ants, belonging to order Hymenoptera under family Formicidae of class Insecta, are one of the dominant organisms living in the soil. They live in society forming colonies and found in almost all suitable ecological habitats. They are polymorphic and the castes found in each colony are male, female (fertile) and worker (sterile female). Each caste has definite works to perform for its society. Workers are seen most commonly, which are apterous, and they are responsible for the maintenance of the colony. Males and females are winged and their only work is reproduction. Females, also called queen, usually shed their wings after nuptial flight. This caste differentiation is related to the food given to the larvae. Protein rich diet may lead to the development of queen, whereas protein deficient diet results into the development of larvae to worker.

Ants are polyphagous. Types of food of ants include plant leaves, seeds, nectar, aphid exudation, remains of dead animals, cooked or raw human foods, etc.

Ants make their nests in different habitats and the shape of which also varies widely. Some make a simple hole in soil, others make galleries with a number of compartments inside. Some make their nest in the cracks and crevices. Some modify the cavities inside the stem of tree as their nest. Some others build large nest in upper portion of trees using leaves and silken thread from their larval secretion.

By building up their nests in soil and for their regular activities to maintain the society, ants can modify the physical and chemical properties of soil. These modifications, in turn, exert effects on other living resources of soil also. Physical changes are concerned with the movement of smaller particles of soil and organic matters both in vertical and horizontal directions by the activities of ants (Petal, 1977), thereby bringing about changes in the porosity, temperature, aeration and waterholding capacity of the soil, which in turn influence the biotic activities in the soil itself. Chemical changes are somewhat related to the physical changes. These are due to the accumulation of organic matter in the nest and from decomposition processes. The potassium and phosphorus content of soil in ant nest is found higher than surrounding soils (Czerwinski *et al.*, 1971; Gaspar, 1972). Concentration of exchangable cations is also found slightly higher in the nest (Czerwinski *et al.*, 1969). The process of decomposition of organic matter is higher in ants' nests due to higher accumulation of bacteria and fungi in the nests (Petal, 1977).

Ants are related to organisms of different trophic levels of the ecosystem they live in. They constitute the largest group of animals consisting of polyphagous species with a predominance of either plant or animal materials in their food basket. Some ants are considered as herbivorous and represented by the genera *Atta, Acromyrmex*, etc. Some are granivorous *viz., Pogonomyrmex and Holcomyrmex.* Different species of *Atta* are dependent on fungus garden grown in their nests. Most of the ants, however, depend on other invertebrates for their food. Ants of the genera *Leptothorax, Dolichoderus, Lasius, Crematogaster* consume honey dew of aphids, nurured in their colony. The species of the genera *Dorylus, Formica, Pheidole, Tetramorium* etc. are considered as true predators. They reduce the number of Araneae, Auchenorrhyncha, Diptera and even some of the beetles. The number of ants also get restricted due to their intra- and interspecific competition leading to annihilation of some forms by the others. Thus ants are associated to the members of every trophic level of the ecosystem they live in. Even they help in decomposition of organic matters, plant and animal remains by propagating the production of decomposers in their nests and also by fragmentation of the organic matters thereby facilitating microbial activities. Soil dwelling ants therefore have a direct role to play in maintaining the soil texture and other healthy physical and chemical properties of soil and also help in enriching the soil with nutrients through direct and indirect effects. Different anthropogenic activities not only affect the soil dwelling ant community but also create a diversified effect on other soil organisms and the soil as a whole.

The exponential growth of human population, rapid urbanisation and industrialisation have resulted into production of numerous effluents in the form of solid wastes, liquid discharges, as well as obnoxious gases. Many of those are either dumped or get settled on the soil and interfere with the natural process, both physico-chemical and bio-geo-chemical, which in turn affect the biotic components of the soil ecosystem. Thus all the intrinsic activities in the soil system which are responsible for the sustenance of a healthy soil system, its fertility, biota holding capacity may get adversely altered and thereby affect the soil ecosystem as a whole by the presence of various pollutants in excessive amount.

The pollutants reach the soil through diffused sources. However, in the urban areas the vehicular emission contains heavy metal lead, that remains admixed in the motor fuel as tetraethyle lead, which acts as antiknock compound and gets deposited on the roadside soil. The lead particles, being heavy in nature, is expected not to drift much away alongwith the wind current for years together. That the lead pollution of the soil may cause enormous changes in the bionomics of the soil arthropod population has already been demonstrated by Krzysztofiak (1986) and Wuorenrinne (1989). It has also been observed earlier that in comparison to other soil arthropods, ants have unique characteristic feature by which they can survive and sustain well in polluted environments (Brower, 1966; Petal *et al.*, 1975; Petal, 1978).

The use of insects as biological indicator in monitoring the environmental quality is gaining ground. The possibility of utilising ants, soil forms in particular, as the index organisms are being explored in different parts of the world (Petal, 1978; Newman and Schreiber, 1984; Daniels, 1991).

In terms of the number of registered vehicles, Kolkata is one of the largest metropolitan cities in India. The vehicular exhausts contribute more than 60% of total air pollution in the city of Kolkata, of which 85% comes from petrol driven vehicles. A major cause of pollution is very limited road area, only 6%, in Kolkata against average 10-15% in other metropolitan cities in our country, whereas international norms demand it to be 30%. In addition, poor road conditions in Kolkata indirectly contribute to pollution (CPCB, 1998).

The study of ants started back from eighteenth century by Linnaeus. Studies on ants have become centred mainly around the fields of systematics, behaviour, socio-biology, etc. As such, comprehensive works on the ants of the world have been done by Hölldobler and Wilson (1990). Later Bolton (1995) published complete catalogue of the Formicidae of the world incorporating 16 subfamilies, 296 genera and 9536 species. In India and West Bengal in particular, studies on ants are mainly restricted to its systematics. Bingham (1903) published "The Fauna of British India, including Ceylon and Burma", which is worthy till date. Jerdon (1851), Forel (1900), Wheeler (1928), Mukherjee (1930), Donisthorpe (1942), Baroni Urbani (1977), Bolton (1977) have made valuable contributions on Indian Fauna of Formicidae.Tiwari (1999), Tiwari *et al.* (1998, 2003) published some State Fauna Series on Formicidae. Mathew (1980), Tiwari (1994) described few new species and Sheela and Narendran (1997, 1998) established one new genus and few new species also. Ghosh *et al.* (2005) described a new species from Kolkata while studying ants of Rabindra Sarovar, Kolkata.

From the above studies about 500 species distributed over 72 genera and 7 subfamilies have so far been reported from India. Tiwari *et al.* (1998) reported 128 species belonging to 47 genera from West Bengal of which only 28 species belonging to 18 genera of ants were from Kolkata. Ghosh *et al.* (2005) recorded 29 species under 20 genera from Rabindta Sarovar area, Kolkata. Altogether 48 species of ants belonging to 26 genera have already been reported from Kolkata.

Little attention has been given to ecological studies of this group, particularly on their seasonal occurrence, species diversity, population dynamics, community structure and effect of pollution on the population/community of ants, etc.

Considering the vehicular congestion in Kolkata it is expected that lead, emitted through vehicular exhausts and deposited on the roadside soil, has its effects on the community of the soil dwelling ants.

In this context the present study has been undertaken with the following objectives :

1. To make a comprehensive account of the fauna of Formicidae of roadside soil of Kolkata and its metropolis.
2. To study the seasonal occurrence, population dynamics and species diversity of this group of the said areas.
3. To study the effects of general abiotic parameters of soil on the population/community structure of the said areas.
4. To assess the effect of automobile exhausts, with reference to lead, on the ant community of the roadside soil of the study areas.
5. To assess the effect of lead on the population of ant species with reference to its bio-accumulation in the body tissues.
6. To identify the ant species, if any, which could serve as an indicator species.

LITERATURE REVIEW

A. On General Edaphic Factors

The history of works on soil fauna dates back from early years of twentieth century.

Edwards (1929) opined that the faunal composition of soil and its population build up depended upon the nature and type of soils and also on environmental factors.

Frenzell (1936) made a comparative study of soil fauna depending on the influence of edaphic factors and indicated that the population of soil organisms became maximum in early winter and early spring, while the minimum in mid-winter and mid-summer.

Macfadyen (1952) and Murphy (1953) had the observations that the population size of soil fauna was maximum during winter, and that also on upper layer.

Vegetation, temperature, pH and organic carbon content of soil were the influencing factors of soil microarthropods as observed by Sheals (1957) and Davrs and Murphy (1961).

Rapoport and Najt (1966) found two different population peaks in two different months investigating microarthropods of two places in Argentina.

The population density of Acari alone and that of microarthropods in total, declined significantly in a plot treated with manure first and then application of herbicide, which was in sharp contrast to untreated plot, observed by Bhattacharya and Joy (1977).

Study conducted by Roy and Ghatak (1977) revealed the irregular trend of population fluctuation, which was maximum in July-August and minimum in April-May.

Study of Mitchel (1979) revealed that temperature directly affected microbial and faunal metabolism, as well as the population growth and interspecific relationships between fauna and their microbial food resources.

Hazra and Choudhuri (1981) had the opinion that the microarthropods, like collembola and acarina, showed maximum population in July-August and minimum in April-May in uncultivated and unpolluted plots.

B. On Soil Pollution

Studies on effect of soil pollution on soil fauna started comparatively in recent years.

Intensive study on the effect of pollutants on soil fauna was first carried out by Edwards (1969) who recorded that species diversity and abundance of pollutants were inversely proportional.

Edwards and Lofty (1969) observed that application of organic manure could cause drastic population fluctuation of soil microarthropods.

Imhoff *et al.* (1971) put forward that the concentration of heavy metals interfered the decomposition and stabilisation of sewage sludge by causing adverse effect on the biota.

Jenkins (1972) stated that many of the soil microfauna bore the properties of good bio-indicators.

Viets (1971), Gambrell and Peele (1973), Hinriches *et al.* (1974), Larson *et al.* (1975), Harrington (1978) observed and discussed the problems of cattle and beef fed pollution in the soil, consequences of disposal of cannery and other wastes on land and also the role of plants on the retention of heavy metals in the soil.

The effect of heavy metals on productivity was studied by Tyler (1972) and he found that cadmium was strongly absorbed by humus.

Applehof (1974, 1980) pointed out that soil invertebrates played a considerable role in the processing of organic matter. Almost similar observation was made by Edwards and Jeff (1974), who noticed that earthworms could degrade within their tissues some pesticides, even the most stable one – D.D.T. to D.D.E.

According to Dindal *et al.* (1975) irrigation by waste water cause a drift of soil fauna towards earthworms as well as decrease in species diversity in general. He found a negative relationship between lead and calcium content in the body of oligochaets.

Findings of Petal *et al.* (1975) confirmed the adverse effects of high levels of heavy metals in soil on soil microflora and fauna.

Dindal *et al.* (1977) again showed that the structure and functioning of soil organisms might be hampered by the irrigation through municipal waste water.

Authors like Vanek (1967), Gorny (1975), Petal *et al.* (1975), Petal (1978) and Bhattacharya *et al.* (1980) reported that the population size of soil invertebrates was reduced by the air pollutants from industries while Gorny (1976) found that population of ants, like *Formica polyctena*, was increased.

Reports published by Council for Agricultural Sciences and Technology, Iowa, U.S.A. (1976) stated that heavy metals indirectly interfered the sewage sludge decomposition and stabilisation by affecting the biota adversely.

Getz *et al.* (1977) reported a very high level of lead in the kidney and liver of starlings (song birds) from urban environments, as these lived on earthworms contained high levels of lead contaminated from polluted soils.

Williams *et al.* (1978) and Prento (1979) found the accumulation and physiological significance of different heavy metals in meadow voles and earthworms.

Anderson (1979) stated that the activity of earthworms as well as accumulation of lead in their body were less in winter, while both were high in summer.

Several authors like Joose and Buker Topp (1979), Anderson (1980) observed adverse effect of heavy metals on soil ärthropod population.

Przybylski (1979, 1981) pointed out that the invertebrate fauna occurring in areas exposed to the action of pollutants suffered some quantitative and qualitative degradation.

Anderson (1980) also observed the concentration of heavy metals in earthworms on the roadside soils contaminated with sewage sludge and reported supression of reproduction in some species of earthworms. He also reported that in all the species, concentration of metals in individuals was directly proportional to the levels of contamination of the soil. Moreover, he also found that the metal content was highest in the individuals of certain species from soil, close to the street and directly polluted by automobile exhausts. The low pH value of soil nearest to the street, was resulted by the acid pollution from the motor traffic.

Edwards (1980) reported that utilisation of organic fertilisers like sewage sludge, animal slurries, etc. might increase the population of earthworms with possibility in accumulation of heavy metals like lead, cadmium, etc. into the tissues of earthworms.

Mitchel and Horner (1980) observed that presence of organic (phenols) and inorganic (heavy metals) pollutants in the sewage sludge might limit its utilisation as soil amender because of its toxic effects on soil biota.

Hartenstein *et al.* (1981), Jaggy and Streit (1982) showed that lead and copper present in the sewage sludge affected the growth of some annelids.

Chattopadhyay and Hazra (1983) studied the soil arthropod population from the bank of an open drain in Calcutta and revealed that Acarines were the most dominant group with the maximum concentration (64.96%) of arthropod population at the surface layer (0-5 cm) of soils. They (2000) also reported that the density of total arthropod population was found more in non-polluted areas than in polluted ones and observed significant negative relationship of heavy metals with total arthropod population in polluted areas.

Effects of pollutants on insects and particularly on ants have been studied by various workers from early sixties of this century. From these investigations it is established that ants can withstand the adverse environmental conditions successfully.

That the ants are greatly resistant to environmental pollution and can withstand adverse condition successfully was recognised by the observations of De Witt and George (1960), Brower (1966), Cadwell (1973) and Petal (1978, 1980).

De Witt and George (1960) also indicated that ants are much more resistant to the effect of insecticides than other insect group.

Golley and Gentry (1964) opined that the density of nests of ants were more susceptible to the rapid changes in the environment than the number of individuals in nests and this was due to the fact that majority of them always stayed inside the nest.

Torossian and Causse (1968) as well as Jakubczyk *et al.* (1973) observed high adaptive capability of ants in industrially polluted area.

Czerwinski *et al.* (1971) noted that in both rich and poor soil, ants could be seen in dense population groups. They also added that the changes produced by ants in the soil favoured the development of vegetation in sandy barren soil.

Accroding to Dethier (1971), insects including ants were able to detect changes in the external environment and make appropriate responses in order to operate efficiently.

Petal (1974, 1976) observed a decrease in the number of species and density indices of ants in habitats under augmenting effect of intensive organic and mineral fertilisation. He again remarked that ants tended to avoid habitats intensively managed by man.

Petal (1978) indicated that environmental pollution, specially of nitrogen and sulphur compounds, exerted negative effect on the size of ant communities. The decrease of number of species, density of nests, number of individuals in colonies, were seen with the increasing pollution, which increased the acidity of soil and caused depletion of total biological activity of soil. Petal (1981) also observed that food resources were one of the important factors influencing the population of ants and therefore low temperature and prolonged rain resulted in a decrease in the density of ants. However, ants could regulate the population size due to the complex competitive relationships among individuals, castes and colonies and these interactions helped to lower their susceptibility to environmental impacts.

Vespalainen and Wuorenrinne (1978) reported the ill-effects of urbanisation on ants.

Nuorteva *et al.* (1978) reported the transfer of heavy metals from contaminated fish into body tissue of a wood ant species *Formica aquilonia.*

Newman and Schreiber (1984) suggested that the use of various groups of insects as bioindicators of environmental pollution seemed to be of increasing interest both for theoretical and practical reasons.

Migula (1985) and Byczkowski and Sorenson (1985) pointed out that many insects were able to respond to toxic heavy metals by various physiological and behavioural mechanisms. They also added that excretion of accumulated metals, their deposition in the alimentary system, binding with metallothionines or other carriers was an energy demanding process, and thus might have effects on energy distribution with possible harmful consequences for growth and reproduction.

Migula (1985, 1989) observed that one of the crucial dysfunctions caused by heavy metals was to deplete ATP concentration which worked as an activator of various metabolic pathways. It was also found that heavy metal, like cadmium, might express its negative effects in the offsprings of ants, as found with other groups of insects.

Observations of Fangmeyer and Steubing (1986) and later Stary and Kubiznakova (1987) showed a very high burdens of metals in ants (genus *Formica),* which exceeded 100 μg/gm dry body weight with a tendency to increase during the summer season.

Stray and Kubiznakova (1987) studied the content and transfer of heavy metal air pollutants in population of wood ants (*Formica* spp.). Their observations revealed that the ants used to come in contact with those airborne pollutants during utilising the contaminated plant pieces for building their nests, making their roads in searching food in polluted environment. They pointed out that though the effects of increased heavy metal air pollutants on ant reproduction, mortality, population exchange, etc. had not been examined thoroughly, it was observed that the *Formica* spp. were able to survive for a long time in environments polluted with heavy metal air pollutants. It was suggested also that the ants could be utilised as bioindicators of heavy metal air pollutants in forest environment. They also observed a wide range of lead concentration ranging from 6.9-374.09 μg/gm of dry body weight of several species of *Formica.*

Hopkin (1989) remarked that among terrestrial arthropods majority of the pollutants enter the body cavity with food and therefore the physiological and biochemical conditions of digestive tract might play an important role in the normal functioning of these animals in heavy metal contaminated areas.

Hopkin (1989), Migula and Jethon (1990) observed that in insects most of the heavy metal ions were not taken up by intestine and were lost from the gut through excrement.

Studies of Nuorteva (1990) and Nuorteva *et al.* (1991) revealed that negative effects of pollutants on beneficial organisms like ants, which controlled the number of herbivores, was one of the causative factors of declination of forests.

Krzysztofiak (1991) observed that concentration of lead in the body of soil-dwelling *Lasius niger* (L.) in the range of 0.4-4.5 ppm only. He also observed that the level of soil pollution with heavy metals exerted an effect on ant bodies.There was a positive correlation between the degree of soil habitat pollution with lead and its content in the bodies of *L. niger.* A similar correlation was detected for zinc also.

Daniels (1991) observed that ants would turn out to be good indicators of ecosystem as these had become a most dominant and successful component of ecosystem.

Gadagkar *et al.* (1993) opined that ants have achieved tremendous ecological success and dominance in tropical ecosystem.

According to Migula *et al.* (1993) ants are able to survive in environments heavily polluted with metals.

Migula and Binkoswska (1993) observed the concentration of lead from 5-8 μg/gm dry body weight of grasshoppers fed with lead contaminated leaves. It was observed that there was no significant increase of lead and cadmium contents in insects and most of the metals were excreted through faeces. The excess of metals, consumed by adults exposed to contaminated leaves, was voided with faeces proportionally to their content of leaves. When insects were exposed to a diet with excess of metals, their body burdens of metal increased, but the loss of heavy metals with faeces diminished. The heavy metals were also lost by larvae during the last moult with the exuviae. Excretion of metals was noticed predominant in insects from unpolluted areas, while those from heavily polluted ones were able to tolerate higher concentration of metals in their tissues.

Petal (1994) reported that ants tried to withstand the habitat changes by mobilising different behavioural defensive mechanisms to modify the habitat and altering certain parameters of their societies and populations.

Ghosh *et al.* (2005) compared the diversity of ant species in polluted area (divider of a busy road) and that of nearby unpolluted area (inside a lake of national important) and observed the diversity of species was less in polluted area in comparison to the other.

MATERIALS AND METHODS

A. Sites of Sampling

Kolkata is located on the eastern bank of river Hooghly at 88°20′ East longitude and 22°82′ North latitude; height from sea level is 5.3 meters.

For comparative study Kolkata was subdivided into four geographical zones, *viz.*, East Kolkata, Central Kolkata, South Kolkata and North Kolkata; one busy road at each zone was selected for this study. The characteristic features of each site were as follows :

East Kolkata : The Eastern metropolitan Bypass, which has built recently, is the main arterial road in Eastern Kolkata. The collection site was chosen near Rubi General Hospital, from both east and western side of that road. The site was characterised by the presence of good vegetal growth which included herbs, shrubs and trees. The ground vegetation was however scanty.

Central Kolkata : At Central Kolkata the Red Road was selected for having high vehicular density. The sampling site was near the Fort William on either side of the road which was characterised by the presence of thick ground vegetation, mainly of grasses of different species, interspaced by various species of very old trees. And as the site-level being lower than the road surface, it experienced frequent inundation by monsoon water.

North Kolkata : Tala Park Avenue, situated at the northern fringe of the city, also carries a heavy traffic load. The divider on it was selected as the study site where vegetation was very poor and was planted with some shrubs and tree species. The ground vegetation was almost nil except the monsoon season when some greens were seen to appear on the surface of the soil.

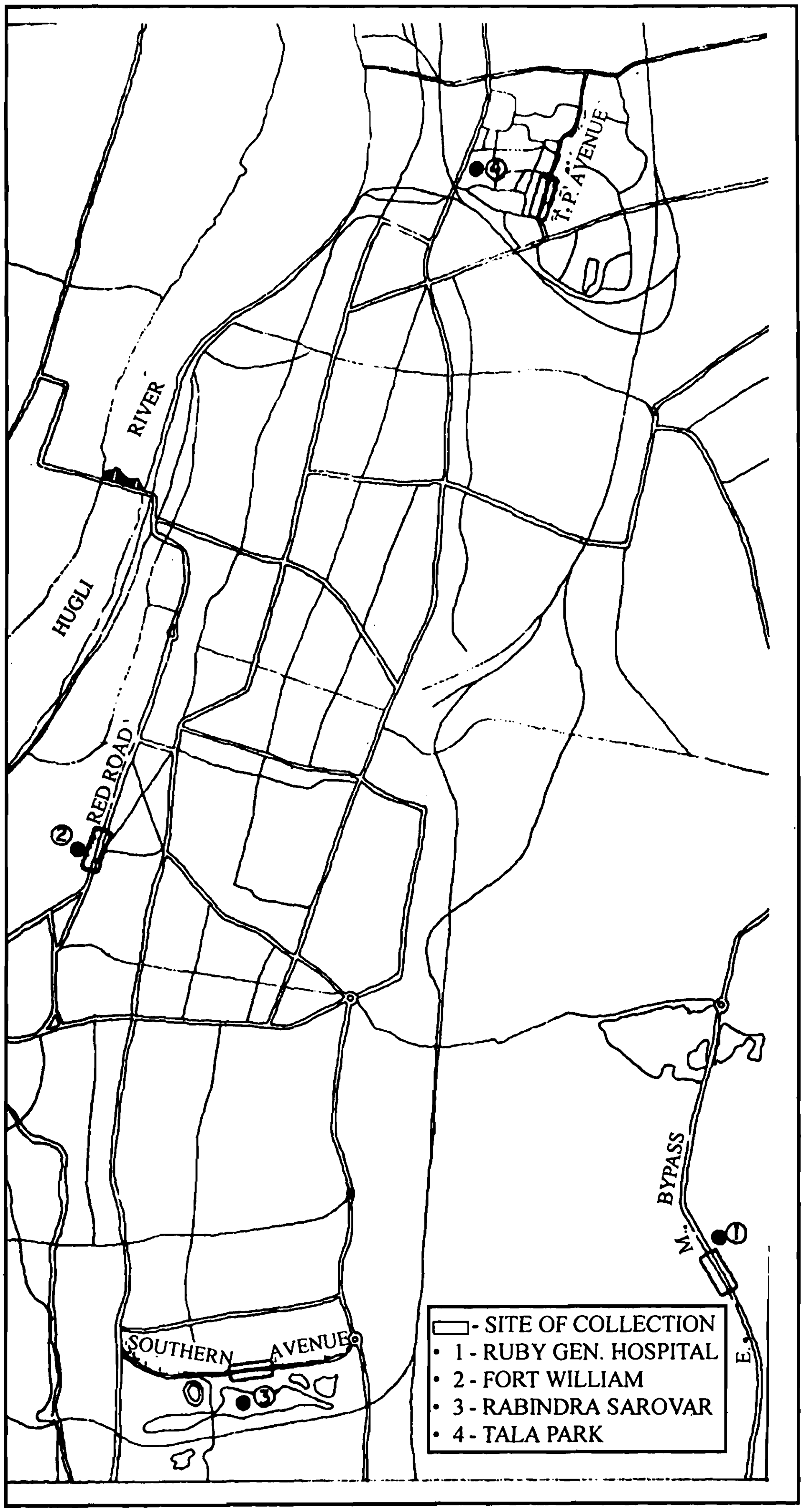
South Kolkata : Southern Avenue, another busy arterial road at South Kolkata, also experiences heavy to very heavy vehicular movements. The divider on the road, selected as collecting site, is comparatively wider to that of Tala Park Avenue. This site was characterised by a well maintained greenery by the Department of Forests, Government of West Bengal, which included different varieties of herbs, shrubs and trees. The ground vegetation was mainly composed of various species of grasses.

Henceforth the above sites are to be referred as EK (East Kolkata), CK (Central Kolkata), NK (North Kolkata) and SK (South Kolkata) respectively.

B. Method of Sampling

The designing of a suitable soil sampler has its long history. Different workers modified this according to their own requirements.

However, the ants being highly mobile in nature, for this study a digging-cum-scrapping apparatus was used which was a modified form of that one used by Chattopadhyay and



Map 1: Four experimental sites selected for the study

Hazra (2000). The apparatus was made up of steel plates having length of about 15 cm and breadth of about 10 cm. The three sides of the plate had foldings of about 5 cm with a handle (10 cm long) fitted on the 10 cm side. The side opposite to the handle, which did not have any folding, was used as digging edge. (Fig. 1).

At each site three plots, measuring about 2mt x 5mt and horizontal to the respective roads, were selected and denoted as plot A, B and C respectively from nearer the road and away. Ten random samples of soil, each measuring about 150 square cm. from 0-5 cm layer, were collected from each plot of each site at monthly intervals. The sampling was carried out from August 1995 to July 1997.

C. Extraction of Samples

In this study, to extract the soil fauna, the apparatus used was slightly modified as that of Macfadyen (1953) and as described by Chattopadhyay and Hazra (2000) (Fig 2).

The soil samples were exposed to constant light and temperature for 72 hours. Soil fauna were collected in 70% alcohol in the glass tubes. The collected fauna were then sorted out into different groups under stereoscopic binocular microscope, counted and preserved in glass vials containing 70% alcohol for further study.

Comparatively larger forms of ants present in the soil samples, which might come out from the samples during transit from collection site to laboratory, were collected by hand in the laboratory before placing the samples in the extractor.

D. Analysis of Abiotic Factors

Edaphic factors : For analysis of edaphic factors, soil was collected from each plot adjacent to the region from where soil samples were collected for population study throughout the period of sampling. Factors like temperature, pH and heavy metal like lead were analysed by means of following standard methods.

Temperature : Temperature of the soil was measured by a soil thermometer inserting directly into the soil at each sampling plot. The thermometer was calibrated from 0°C to 100°C having a minimum division of 0.1°C.

Hydrogen ion concentration (pH) : To determine the pH, 20 gm of soil from each soil sample was collected and was produced to fine powder through 100 mesh sieve. The soil was taken in a reagent bottle containing 100 ml distilled water. The mixture was then shaken for an hour by a mechanical shaker. The suspension was transferred to a beaker and its pH value was measured in room temperature by using a digital (Beckman) pH meter.

Quantitative estimation of heavy metal (Lead) of soil sample : Quantitative estimation of heavy metal (Lead) was done by following standard spectrographic method using Automatic Spectrograph E742 (Manual of Chemical Analysis, 1982, published by G.S.I., Calcutta).

Photo 1. Site of collection at East Kolkata

Photo 2. Site of collection at Central Kolkata

Photo 3. Site of collection at North Kolkata

Photo 4. Site of collection at South Kolkata

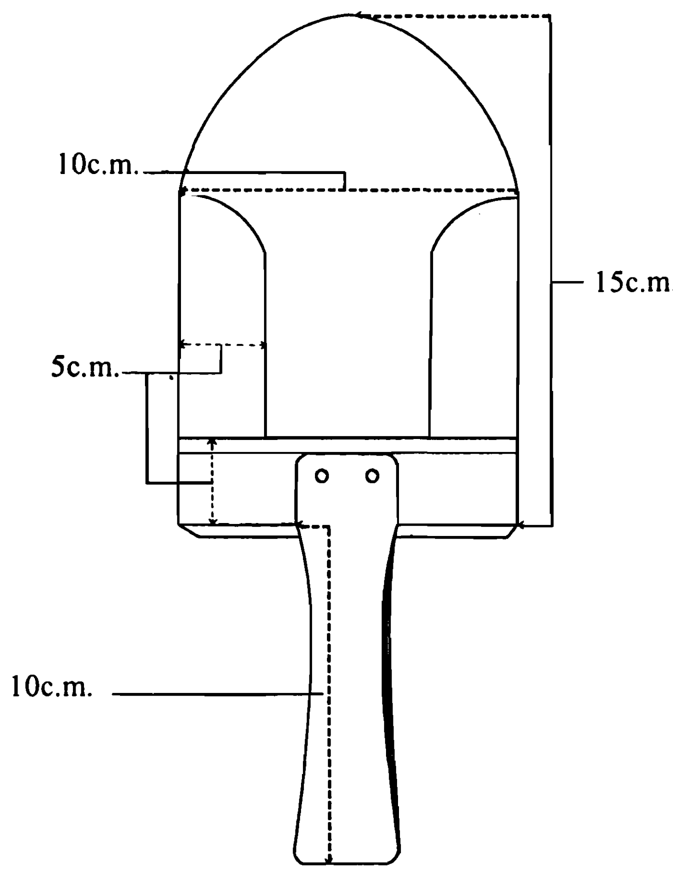


Fig. 1. Soil sampler used in this study

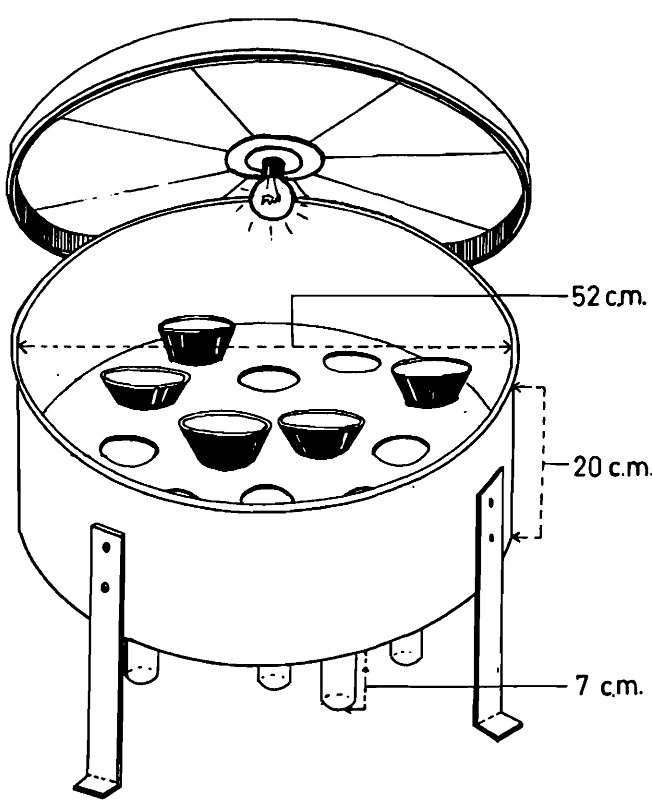
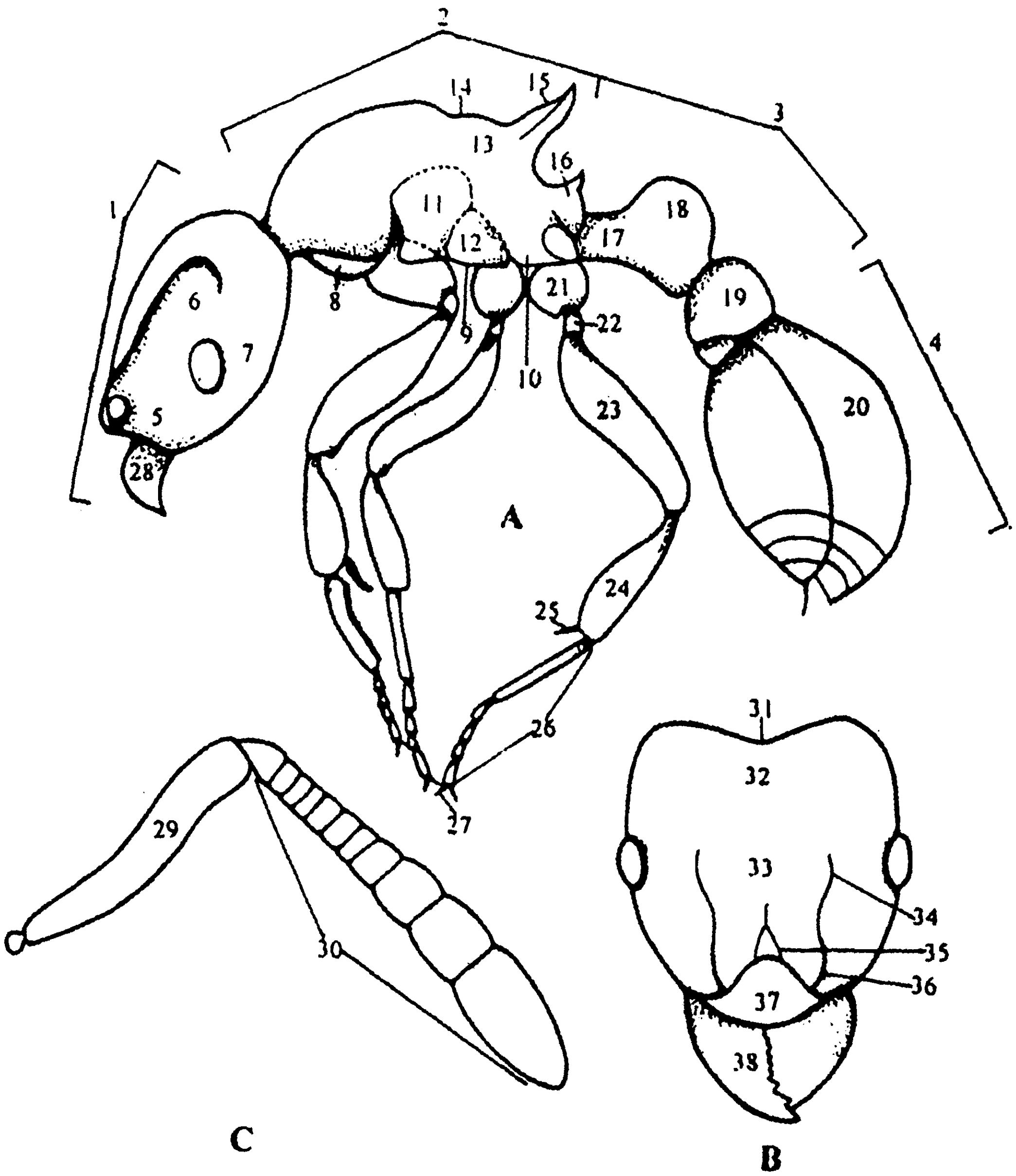


Fig. 2. Extraction apparatus used in this study

Quantitative estimation of heavy metal (Lead) in body tissue : 'Quantitative estimation of lead of ants' body was done by following standard method using Atomic Absorption Spectrophotometer [Perkin–Elmer S5100PC] (Greenberg *et al.* 1992).

OBSERVATION



Figs. A-C : General diagram of a typical ant
A : Body profile; B : Head; C : Antenna

1-head, 2-alitrunk, 3-waist, 4-gaster, 5-antennal socket, 6-scrobe, 7-eye, 8-propleuron, 9-mesopleuron, 10-metapleuron, 11-anepisternum, 12-katepisternum, 13-propodeum, 14-metanotal groove, 15-propodeal spine, 16-metapleural lobe, 17-peduncle, 18-petiole, 19-post petiole, 20-gastral tergite, 21-coxa, 22-trochanter, 23-femur, 24-tibia, 25-tibial spur, 26-tarsal segments, 27-claw, 28-mandible, 29-scape, 30-funicular segments, 31-occipital margin, 32-vertex, 33-frons 34-frontal carina, 35-frontal area, 36-frontal lobe, 37-clypeus, 38-mandible [after Ghosh *et al.* 2005]

A. SYSTEMATIC ACCOUNT

The classified list with diagnostic features of the ant species (Insecta : Hymenoptera : Formicidae) with their habit and habitat occurred during the study.

Subfamily DORYLINAE

Characters :

1. Body with a single segment (petiole) between alitrunk and gaster.
2. Eyes absent; frontal lobes do not conceal the antennal sockets.
3. First gastral segment entirely confluent with the second one, only an impression is there.
4. Pygidium impressed and armed with a short spine or tooth at each side posteriorly.

Genus *Dorylus* Fabricius

1. ***Dorylus orientalis*** Westwood, 1835

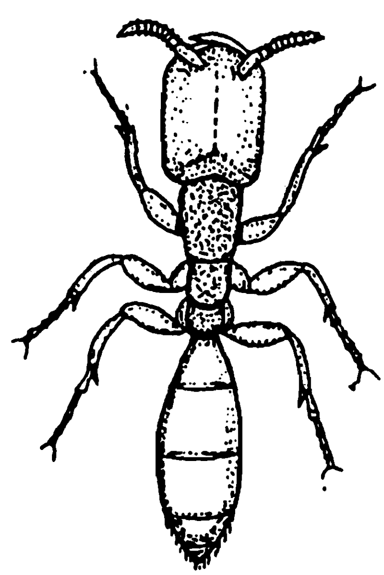


Fig. 3 : *Dorylus orientalis* Westwood

Characters :

1. Head broader anteriorly, occiput deeply emarginate.
2. Petiole convex.
3. Mandibles with two teeth on the masticatory margin, apex broader.
4. Antennae 9-segmented.
5. Brownish yellow in colour, gaster lighter; tength 5-6 mm (worker).

This species form its nest in the ground, sometimes at a considerable depth. The male, frequently comes into houses in the evening and resembles with a night flying wasp. Carnivorous in habit.

Subfamily PONERINAE

Characters

1. Body with a single segment (petiole) between alitrunk and gaster.
2. A marked constriction between basal two gastral segments.
3. Antennal carinae widened anteriorly.

Genus ***Amblyopone*** Erichson

2. ***Amblyopone rothneyi*** Forel, 1900

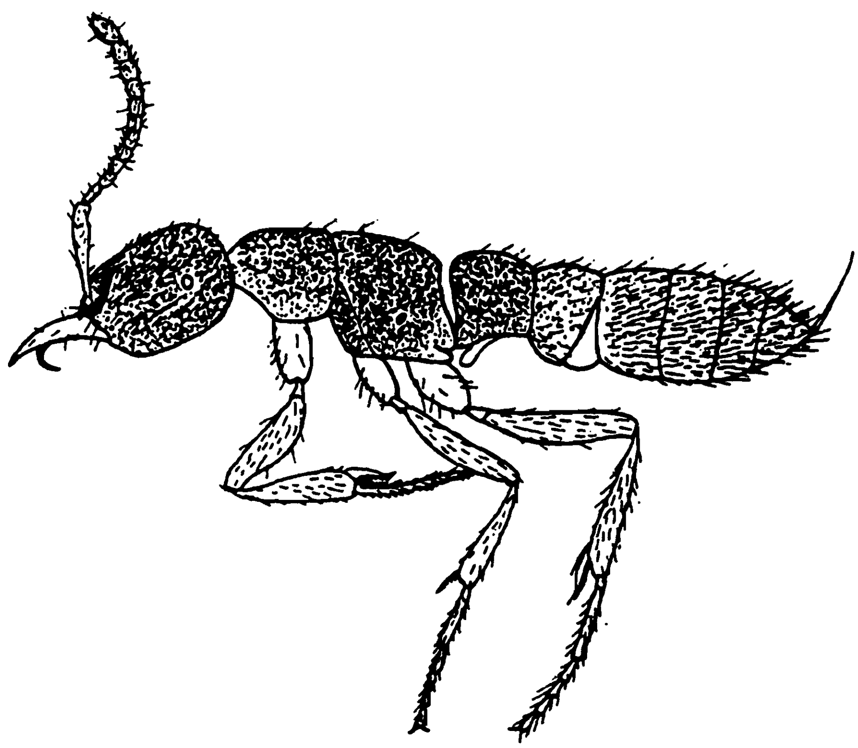


Fig. 4 : *Amblyopone rothneyi* Forel

Characters

1. Petiole without a free posterior face and broadly attached to first gastral segment.
2. Mandibles elongate, pointed at apex, multidentate and linear; articulated at corners of anterior margin of head.
3. Eyes large.
4. Flagellum of antennae nearly half as long again as mandibles.

5. Black in colour; length 8.5-9 mm.

The nest of this species is subterranean. Carnivorous, mainly entomophagous.

Genus ***Anochetus*** Mayr

3. ***Anochetus graeffei*** Mayr, 1870

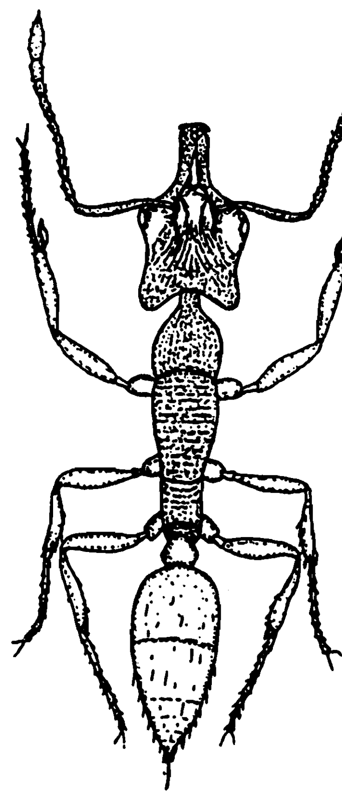


Fig. 5 : *Anochetus graeffei* Mayr

Characters :

1. Petiole with a free posterior face and narrowly attached to first gastral segment by a slender articulation.
2. Mandibles with 3 apical teeth long and linear, articulated close together in the middle of the anterior margin of head.
3. Antennal hollows not confluent posteriorly.
4. Basal segment of gaster closely punctured, opaque.
5. Punctures on head and thorax more distinct, not running into longitudinal striae.
6. Yellowish brown in colour; length 5-5.5 mm.

This species excavates soil for making small nest. Carnivorous, specially entomophagous.

Genus ***Diacamma*** Mayr

4. ***Diacamma rugosum*** (Le Guillou, 1842)

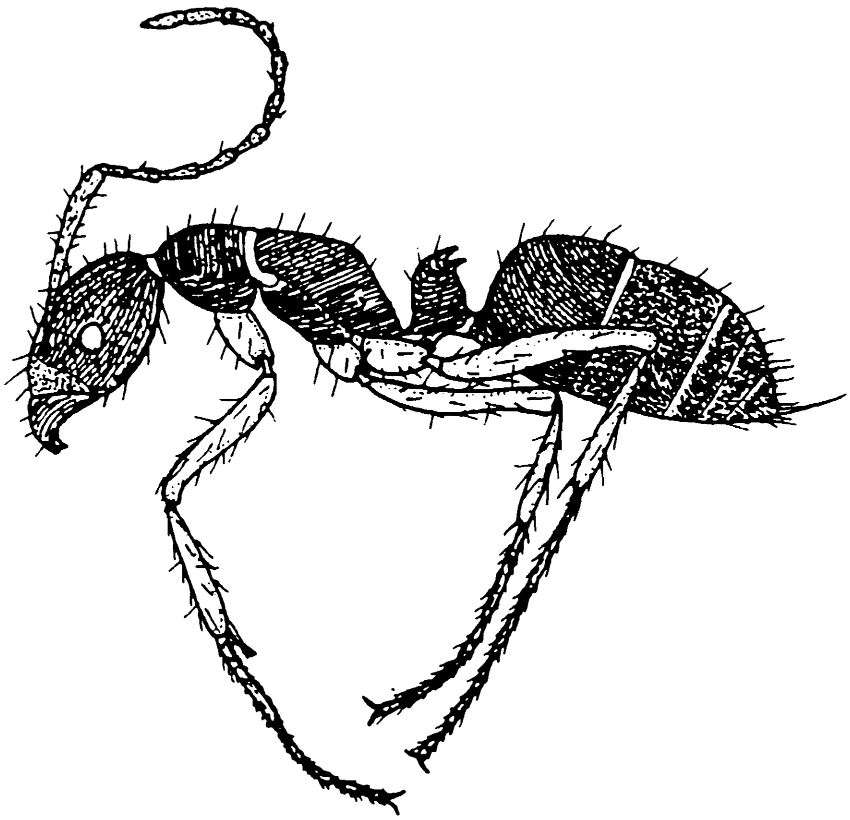


Fig. 6 : *Diacamma rugosum* (Guillou)

Characters

1. Petiole with a free posterior face and narrowly attached to first gastral segment by a slender articulation.
2. Pygidium transversely rounded.
3. Mandibles articulated to anterolateral corners of head.
4. Hind tibiae with a large pectinate spur and a much smaller simple lateral spur.
5. Pretarsal claws of hind legs neither pectinate nor armed with preapical tooth.
6. Petiole bispinous posteriorly, which are thick at base pointing backwards in continuation of the upper surface of petiole.
7. Pronotum with transversely arched striae.
8. All striae on first gastral segment are in concentric arches from back to front.
9. Black in colour; length 8-9 mm.

This species is considered to be one of the most intelligent of all Oriental ants. Carnivorous. Subterranean in habit, mostly live under stone.

Genus ***Hypoponera*** Santschi

5. ***Hypoponera truncata*** (Smith, 1860)

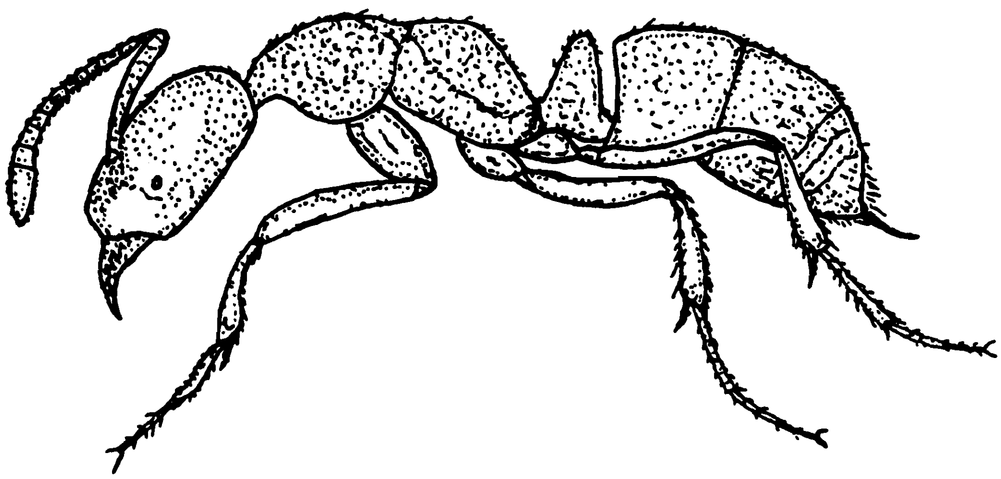


Fig. 7 : *Hypoponera truncata* (Smith)

Characters

1. Petiole with a free posterior face and narrowly attached to first gastral segment by a slender articulation.
2. Pygidium transversely rounded.
3. Mandibles articulated to anterolateral corners of head.
4. No projection overhanging the mandibles.
5. Hind tibiae with only one pectinate spur.
6. Frontal lobes closely approximated.
7. Mandibles triangular.
8. Subpetiolar process in profile with a simple lobe, without an acute posteroventral angle.
9. Clypeus with anteriorly bifurcate carina.
10. Thorax above distinctly rounded and convex.
11. Castaneous brown in colour; length 3-3.5 mm.

This carnivorous species makes small nest in soil or in old logs lying on the soil.

Genus ***Pachycondyla*** Smith

6. ***Pachycondyla rufipes*** (Jerdon, 1851)

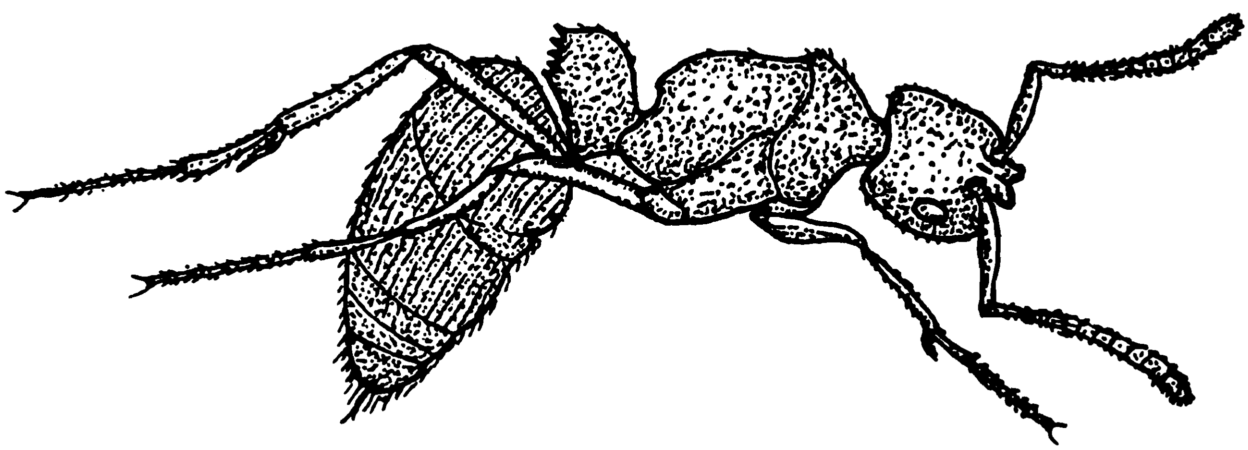


Fig. 8 : *Pachycondyla rufipes* (Jerdon)

Characters :

1 Petiole with a free posterior face narrowly attached to first gastral segment by a slender articulation.

2. Pygidium transversely rounded.

3. Mandibles articulated to anterolateral corners of head.

4. Hind tibiae with a large pectinate spur and a much smaller simple lateral spur.

5. Pretarsal claws of hind legs neither pectinate nor armed with preapical tooth.

6. Petiole armed with a number of blunt processes or teeth.

7. Pro- and metanotum unarmed.

8. Black in colour; length 13-15 mm.

This robustly built species also makes small nest in soil. It also bears carnivorous habit, mainly entomophagous.

Subfamily CERAPACHYINAE

Characters :

1. Body with a single segment (petiole) between alitrunk and gaster.

2. Pygidium margined laterally and posteriorly with a row of large or small spines.

3. Antennal fossa more or less encircled by a lateral carina of the cheek.

Genus ***Cerapachys*** Smith

7. ***Cerapachys typhlus*** (Roger, 1861)

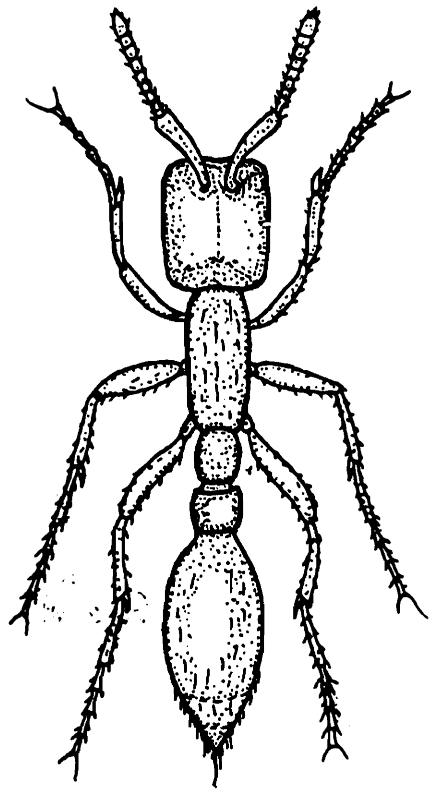


Fig. 9 : *Cerapachys typhlus* (Roger)

Characters :

1. Head rectangular, transverse posteriorly.
2. Eyes absent.
3. Narrow mandibles with long, acute, curved apical teeth.
4. 9-segmented antennae short and stout with massive apical joint.
5. Petiole nearly as broad as thorax.
6. First gastral segment separated by a well-marked constriction from second.
7. Brownish red in colour; length 2.75-3 mm.

This species makes nest excavating the soil. Carnivorous.

Subfamily DOLICHODERINAE

Characters

1. Body with a single segment (petiole) between alitrunk and gaster.
2. First gastral segment entirely confluent with the second one.
3. Anal aperture in the form of transverse slit, no acidopore.

4. Pygidium and hypopygium both unarmed.
5. Eyes present.
6. Sting vestigial or absent.

Genus ***Tapinoma*** Foerster

8. ***Tapinoma melanocephalum*** (Fabricius, 1793)

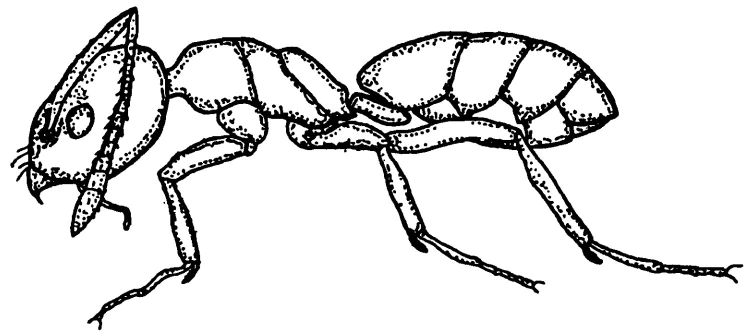


Fig. 10 : *Tapinoma melanocephalum* (Fabricius)

Characters

1 Base of gaster gibbous, overhanging the petiole which usually not visible in dorsal view when alitrunk and gaster are in same plane.
2. In dorsal view only 4 gastral targites visible.
3. Fifth one bent forward over the fourth one; anal orifice thus situated ventrally.
4. Maximum diameter of eye usually distinctly greater than maximum width of antennal scape.
5. Antennae long, scape extending beyond the top of the head.
6. Head and thorax black, abdomen yellowish white; length 2 mm.

This tiny species is seen more or less everywhere. It makes nest in dead plant stems lying on soil, abandoned plumbing and even soils under solid clothing. It emits a very pungent smell.

Genus ***Technomyrmex*** Mayr

9. ***Technomyrmex albipes*** (Smith, 1861)

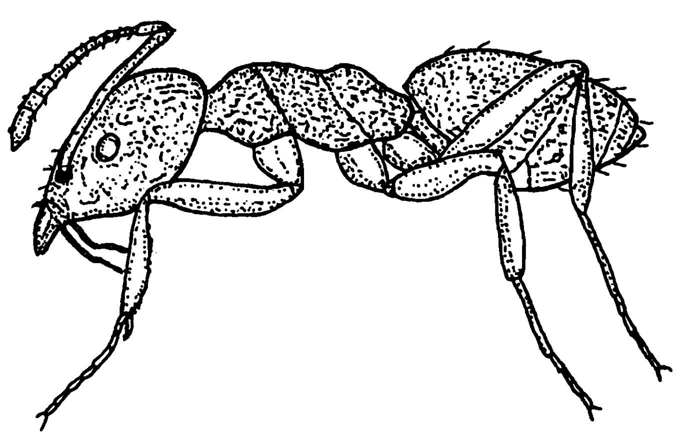


Fig. 11 : *Technomyrmex albipes* (Smith)

Characters :

1. Base of gaster gibbous, overhanging petiole which usually not visible in dorsal view when alitrunk and gaster are in same plane.
2. Five gastral targites visible dorsally.
3. Fifth one small but continuing the line of gaster; and orifice thus situated apically.
4. Anterior margin of clypeus with a deep crescentic emargination.
5. Scape of antennae scarcely extending beyond top of head.
6. Body colour black, but tarsi whitish in marked contrast.
7. Black in colour; length 2.5-3 mm.

It also makes nest in dead plant stems and rotten leaves lying on soil.

Subfamily FORMICINAE

Characters :

1. Body with a single segment (petiole) between alitrunk and gaster.
2. No constriction between basal two gastral segments.
3. Apex of gaster with semicircular to circular acidopore formed from hypopygium.
4. Acidopore ciliated round the margin.
5. Sting absent.

Genus ***Camponotus*** Mayr

10. ***Componotus compressus*** (Fabricius, 1787)

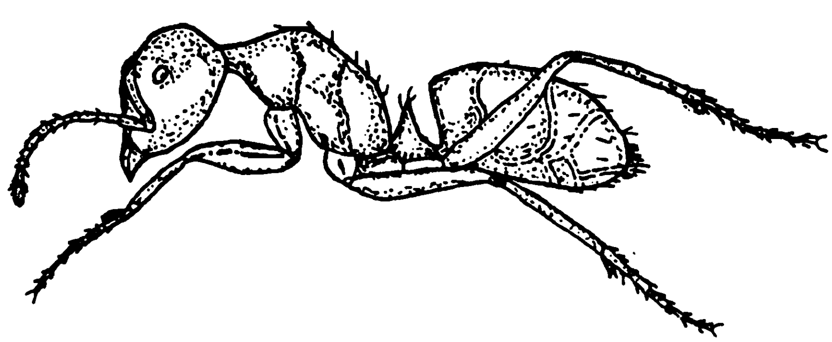


Fig. 12 : *Camponotus compressus* (Fabricius)

Characters :

1. Antennae with 12 segments.
2. Mandibles subtriangular.
3. Antennal sockets situated far behind the posterior clypeal margin.

4. Mandibles with 5-7 teeth.
5. Maxillary palpi 6-segmented.
6. Thorax and petiole neither dentate nor spinous.
7. Thorax viewed from side forming a regular arch.
8. Head, thorax and abdomen black.
9. Tibiae of legs prismatic.
10. Head posteriorly narrow but not constricted to form a collar.
11. Black in colour; length 12-18 mm.

This species is known as 'farmer ants', keeping and tending aphids and other ant-cattle. It makes nest in the soil surrounding tree-trunk, or crevices in the tree-trunk near soil surface.

Genus ***Paratrechina*** Motschoulsky

11. ***Paratrechina longicornis*** (Latreille, 1802)

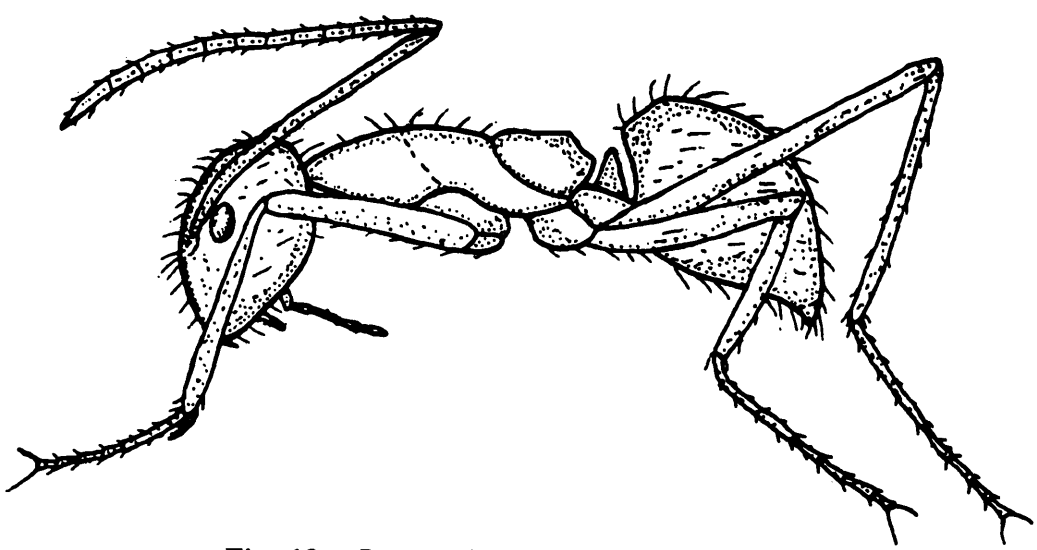


Fig. 13 : *Paratrechina longicornis* (Latreille)

Characters :

1. Antennae with 12 segments.
2. Mandibles subtriangular.
3. Antennal sockets situated close to the posterior clypeal margin.
4. Maxillari palpi 6-segmented.
5. With the head in full-face view, eyes at the mid-length of the sides.
6. Head and alitrunk with stout bristles.
7. Scape of antennae remarkably long.
8. Thorax not constricted at the meso-metanotal suture.

9. Dull brown in colour, abdomen lighter; length 2.5-3 mm.

This species is widely distributed and not uncommon in hot-houses and large conservatories. Commonly known as 'crazy-ants' and swarm under every type of debris in and outside the houses.

Genus ***Plagiolepis*** Mayr

12. ***Plagiolepis jerdonii*** Forel, 1894

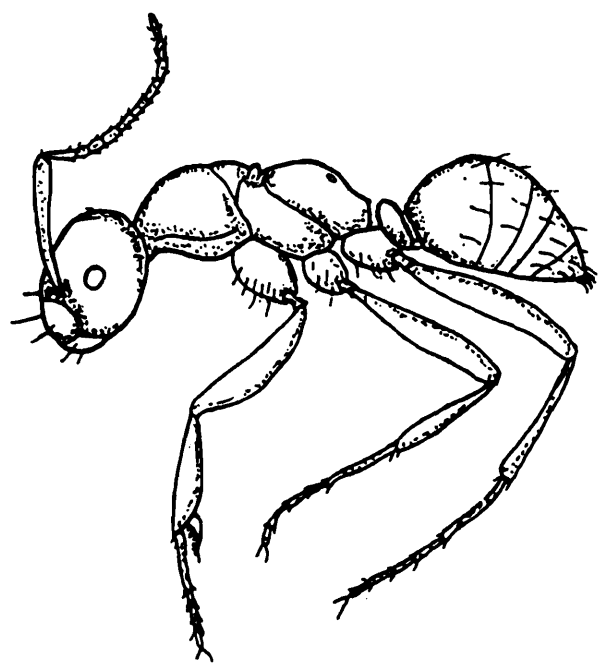


Fig. 14 : *Plagiolepis jerdonii* Forel

Characters :

1. Antennae with 11 segments.
2. Propodeum and petiole without any spine, tooth or tubercle.
3. Palpi 6-segmented.
4. In dorsal view, the mesonotum seen to be separated from the metanotum by a conspicuous transverse groove or impression.
5. Body colour black or dark chestnut-brown.
6. Head smooth, polished and shining.
7. Frontal area distinct, well-defined.
8. Pitch black in colour; length 1.5 mm.

This species makes nest in and outside the houses near soil surface. It also keeps aphids in its nest for getting secretion of aphids as 'honey-dew'

Genus ***Polyrhachis*** Smith

13. ***Polyrhachis tubericeps*** Forel, 1893

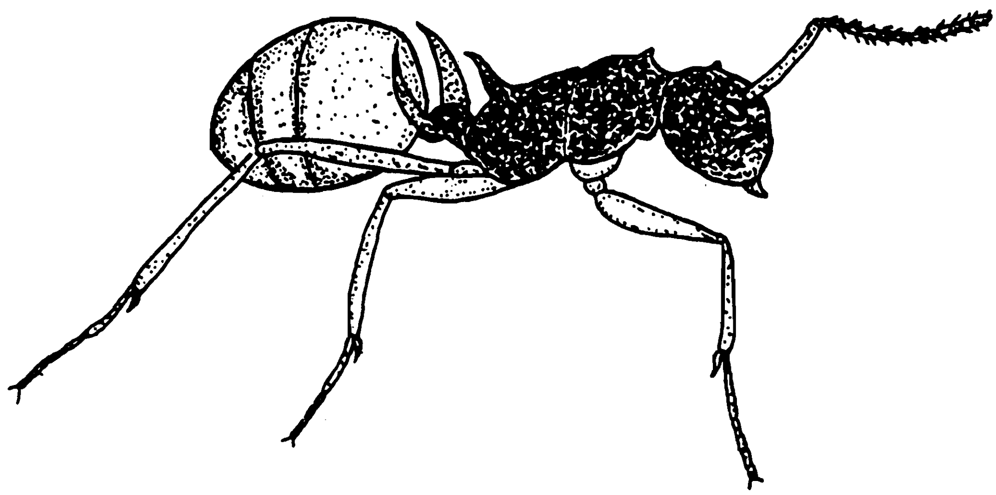


Fig. 15 : *Polyrhachis tubericeps* Forel

Characters

1. Antennae with 12 segments.
2. Mandibles subtriangular.
3. Antennal sockets situated far behind the posterior clypeal margin.
4. Mandibles with 5 teeth.
5. Maxillary palpi 6-segmented.
6. Basal segment of gaster much longer than second one.
7. Thorax rounded above, sides not margined.
8. Pro- and metanotum with a spine on each side, mesonotum unarmed.
9. Pubescence sparse.
10. Metanotal spines not forming hooks.
11. Spines on petiole long and wide-spreading, shaped so as to encircle front of abdomen and with two vertical short acute teeth between those.
12. Head with a tubercle on each side behind the eyes.
13. Dull black in colour; length 7-8 mm.

This species makes nest in the ground surrounding trunk of trees. A silky cobweb like secretion is used to line the galleries.

Subfamily PSEUDOMYRMECINAE

Characters :

1. Body with reduced petiole and postpetiole between alitrunk and gaster.

2. Pygidium transversely rounded.
3. Pro-mesonotal suture present.
4. Hind tibiae with conspicuous pectinate spur.
5. Posterior margin of median portion of clypeus not projecting back between antennal sockets.

Genus ***Tetraponera*** Smith

14. ***Tetraponera allaborans*** (Walker, 1859)

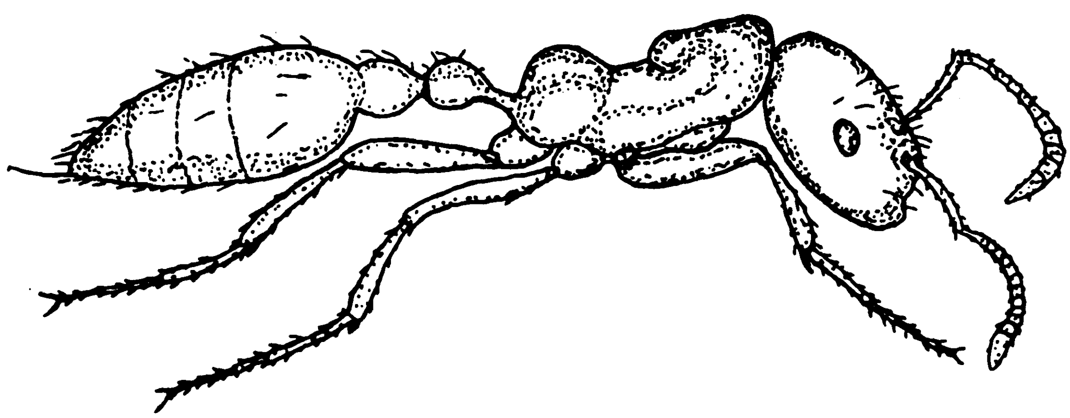


Fig. 16 : *Tetraponera allaborans* (Walker)

Characters :

1. Antennae with 12 segments.
2. Ocelli absent.
3. Head posteriorly as broad as in front, rectangular.
4. Petiole unarmed.
5. The anterior elongation of petiole shorter than the petiole itself.
6. In profile, metanotum not higher than pro-mesonotum.
7. Shining black in colour; length 5-6 mm.

This species makes nest in dead wood or hollows of tree. The hollows are laid down the tree upto the ground and it makes the entrance of the nest there.

Subfamily MYRMICINAE

Characters

1. Body with reduced petiole and postpetiole between alitrunk and gaster.
2. Pygidium transversely rounded.

3. Pro-mesonotal suture indistinct or absent.
4. Hind tibiae with or without spur; if present, simple.
5. Posterior margin of median portion of clypeus projecting back between antennal sockets.

Genus ***Cardiocondyla*** Emery

15. ***Cardiocondyla nuda*** (Mayr, 1866)

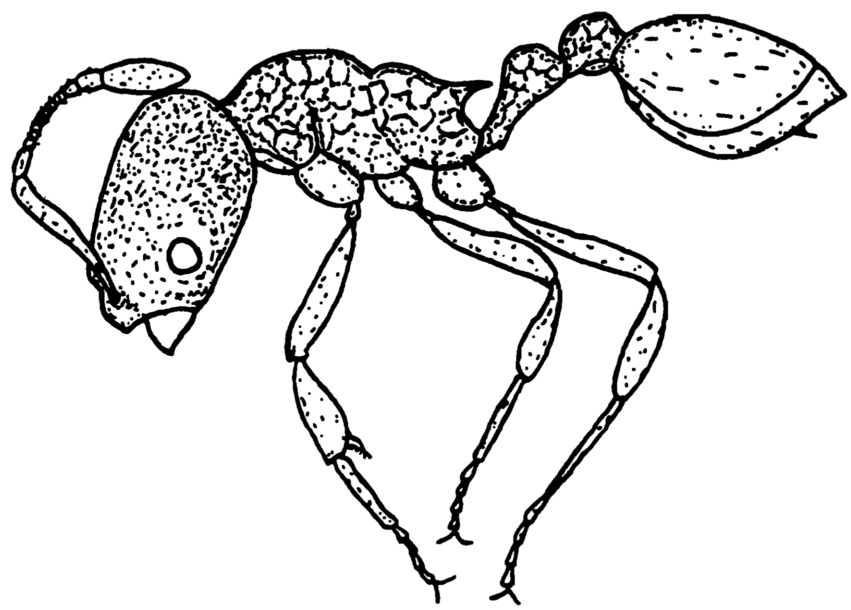


Fig. 17 : *Cardiocondyla nuda* (Mayr)

Characters :

1. No antennal scrobe.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 12-segmented antennae with distinct 3-segmented club.
4. Eyes present.
5. Median portion of clypeus not vertical, not bicarinate, lateral portion dorsoventrally flattened and prominent over mandibles.
6. Mandibles broad with 5 teeth, without any basal lobe.
7. Spurs on posterior tibiae absent.
8. Ventrolateral margin of head with no carina.
9. Pronotum unarmed.
10. Petiole pedunculate.
11. Occipital corners of head narrowly rounded, no distinct posterior margin.
12. Propodium with paired spines.

13. Orange red in colour, gaster black; length 2.5-3 mm.

This species makes nest in the trees and comes down to the ground for food.

Genus ***Carebara*** Westwood
16. ***Carebara lignata*** Westwood, 1840

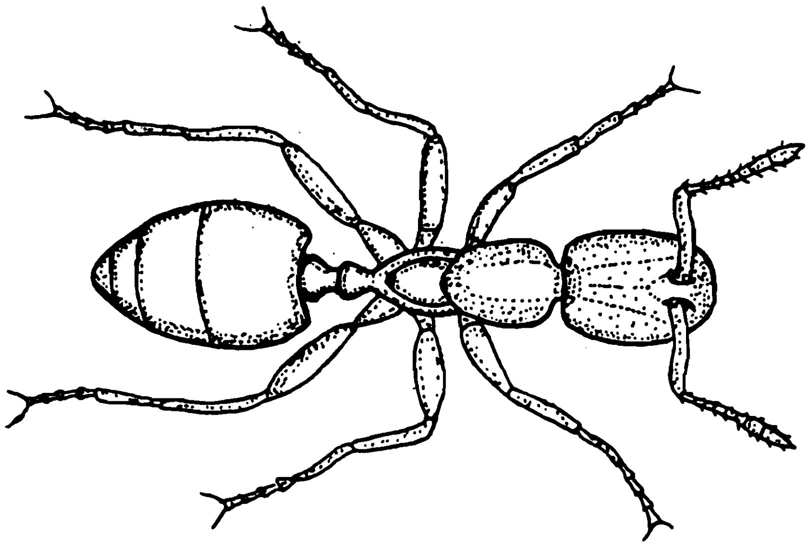


Fig. 18 : *Carebara lignata* Westwood

Characters :

1. No antennal scrobe.
2. Postpetiole articulated on anterior surface of gastral segment.
3. 9-segmented antennae with 2-segmented distinct club.
4. Anterior clypeal margin with a pair of setae; median portion of clypeus bicarinate longitudinally.
5. Eyes absent.
6. Propodium unarmed.
7. Pro-mesonotum not marginate laterally.
8. Abdomen broadly oval.
9. Pale yellow in colour; length 2.5 mm.

This is subterranean in habit. The workers feed on larval and adult termites. On account of their diminutive size and neutral odour, can move unnoticed among their soft-bodied hosts.

Genus ***Crematogaster*** Lund

17. ***Crematogaster rothneyi*** Mayr, 1879

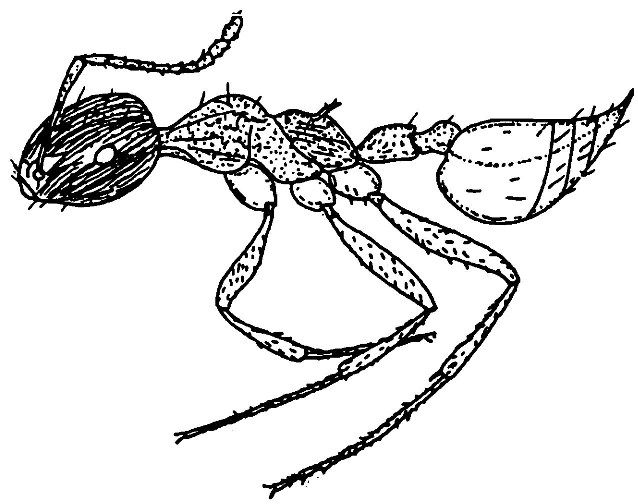


Fig. 19 : *Crematogaster rothneyi* Mayr

Characters :

1. No antennal scrobe.
2. Postpetiole articulated on dorsal surface of first gastral segment.
3. Petiole dorsoventrally flattened, broader in front without node.
4. Gaster, in dorsal view, roughly heart shaped.
5. Head entirely sculptured, little broader than long.
6. Pronotum reticulate.
7. Metanotal spines distinctly longer than metanotum.
8. Head, thorax and pedicel reddish brown in colour, gaster black; length 3-3.5 mm.

This species makes nest on the tree and comes down on the ground for food. Like some other species, it also keeps and tends 'ant-cattle' When excited or moving quickly it turns its gaster over its back.

Genus ***Lophomyrmex*** Emery

18. ***Lophomyrmex quadrispinosus*** (Jerdon, 1851)

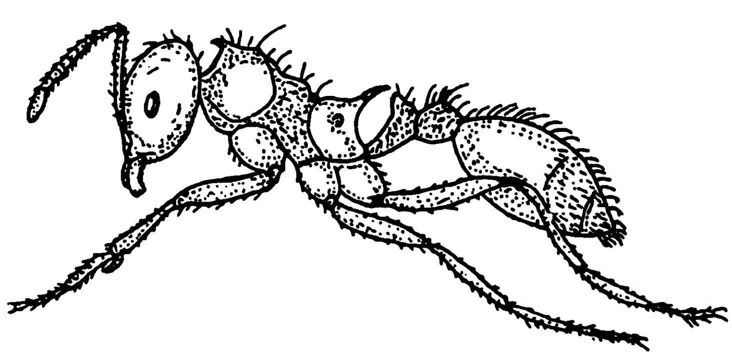


Fig. 20 : *Lophomyrmex quadrispinosus* (Jerdon)

Characters

1. Antennal scrobe short but prominent.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 11-segmented antennae with 3-segmented distinct club.
4. Eyes small.
5. Median portion of clypeus not vertical, convex and unarmed; lateral portion not raised in front of antennal insertions.
6. Mandible with less than 8 denticles.
7. Petiole sculptured, with short peduncle.
8. Thorax raised anteriorly, viewed from front with a sharp truncate transverse margin above.
9. Pronotal dorsum flat, lateral marginations terminating anteriorly in projecting flat acute spines.
10. Reddish brown in colour; length 3-3.5 mm.

Subterranean in habit. Carnivorous.

Genus ***Meranoplus*** Smith

19. ***Meranoplus bicolor*** (Guer., 1844)

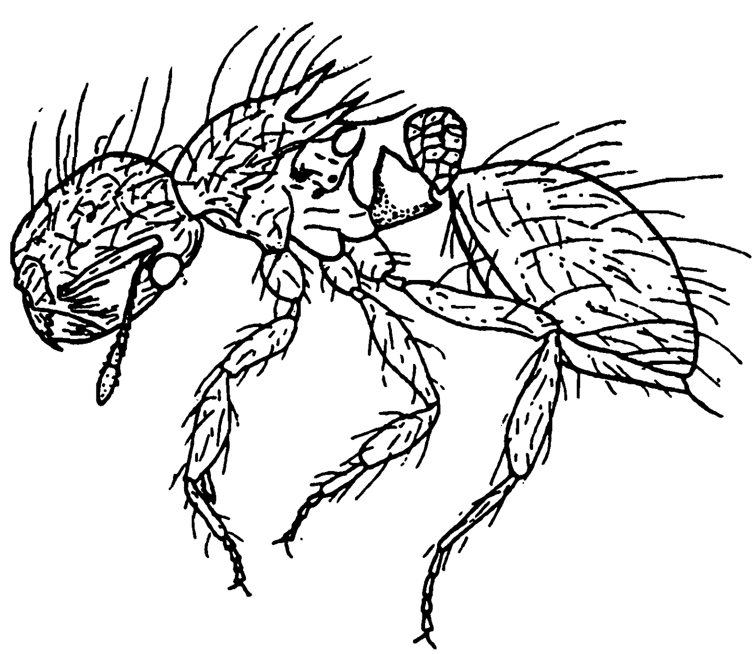


Fig. 21 : *Meranoplus bicolor* (Guer.)

Characters

1. Antennal scrobes present and running above the eyes.
2. Postpetiole articulated on anterior surface of first gastral segment.

3. 9-segmented antennae with 3-segmented club.
4. Mandible with 4 teeth.
5. Median portion of clypeus broad, not vertical.
6. Head trapezoidal, broader posteriorly than in front.
7. Pro-mesonotal shield undivided; pronotum dentate, mesonotum armed posteriorly with two long acute spines.
8. Pilosity very long, soft, abundant and of grey colour giving an wooly apperance all over.
9. Gaster black, rest other portion ferruginous red in colour, length 4-5 mm.

This species is widely distributed, makes subterranean nest leaving only few holes on the surface for the outlets of nest. Very sluggish in nature.

Genus ***Messor*** Forel

20. ***Messor barbarus*** (Linnaeus, 1767)

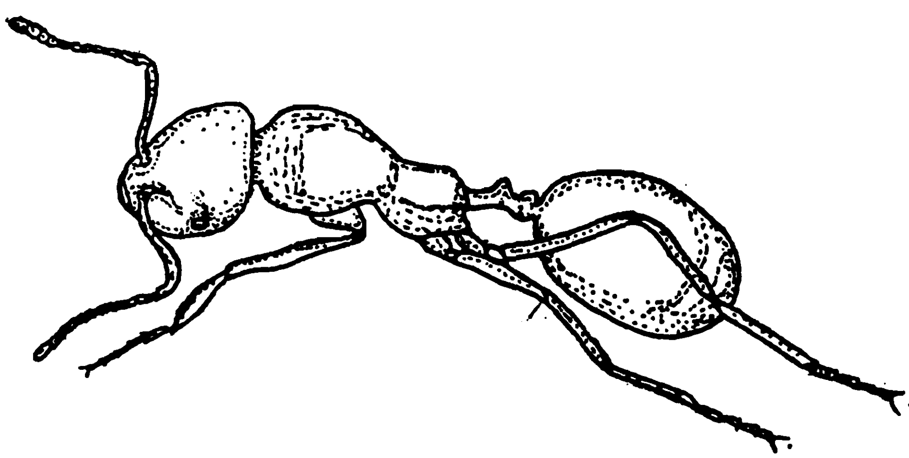


Fig. 22 : ***Messor barbarus*** **(Linnaeus)**

Characters :

1. Antennal scrobes short, wide apart.
2. Postpetiole articulated in the middle of anteior surface of first gastral segment.
3. Flagellum of antennae filiform without distinct club.
4. Antennae 12-segmented.
5. Mandibles massive, outer margin strognly curved, not hook-shaped, masticatory margin obsoletely dentate.
6. Small eyes placed about the midlength or somewhat behind the sides of head.
7. Clypeus medially little convex, not raised laterally.
8. Maxillary palpi 4-segmented.
9. Spurs on posterior tibiae simple.

10. Head transversely rectangular, ventrolateral margin without carina.
11. Alitrunk wholly unarmed, coarsely transversely striate.
12. Mesonotum raised anteriorly above the level of pronotum, posteriorly steeply sloped.
13. Dark red in colour, gaster black; length 4-9 mm.

This species is known as one of the harvester ants and makes its nest in the soil and maintains granaries in the nest.

Genus ***Monomorium*** Mayr

21. ***Monomorium floricola*** (Jerdon, 1851)

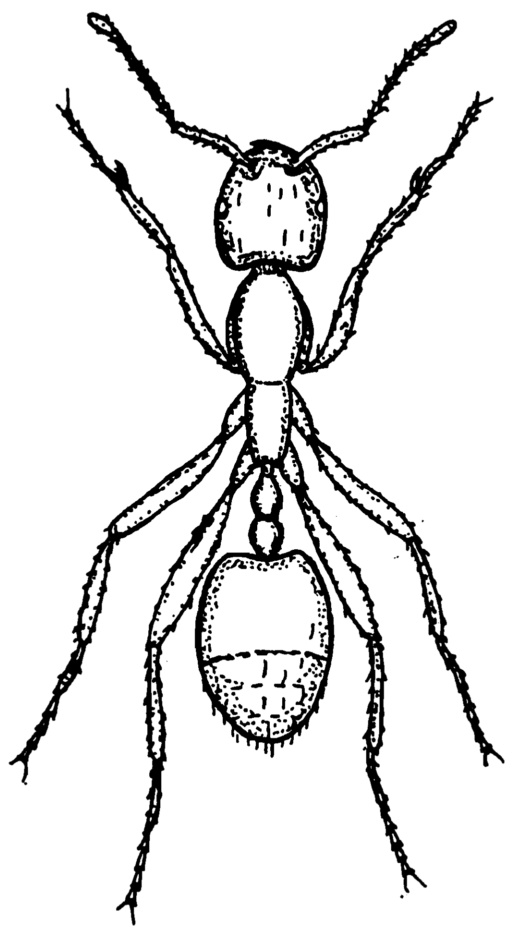


Fig. 23 : *Monomorium floricola* (Jerdon)

Characters

1. Short antennal scrobes, parallel.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 12- segmented antennae, rather long, with 3-segmented massive club.
4. Narrow mandibles with 4 teeth, but without posterior lobe.
5. Eyes placed below the middle.

6. Clypeus convex, mid point of anterior margin with a long unpaired seta.
7. Maxillary palpi 2-segmented.
8. Head more or less smooth and shining , rectangular, ventrolateral margin without carina, posteriorly rounded.
9. Dorsal alitrunk wholly unarmed.
10. Petiole pedunculate anteriorly.
11. Postpetiole little broader than petiole.
12. Basal portion of metanotum rectangular, posteriorly truncate.
13. Head, thorax and legs yellowish brown in colour, abdomen dark brown; length 1.5-2 mm.

This is a widely distributed species. It is considered as household nuisance for contaminating foods.

Genus ***Oligomyrmex*** Mayr

22. ***Oligomyrmex asinus*** Forel, 1902

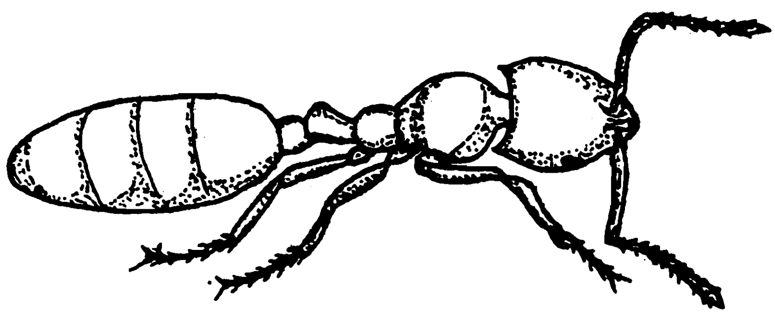


Fig. 24 : *Oligomyrmex asinus* Forel

Characters :

1. No antennal scrobe.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 9-segmented antennae short, with 2-segmented distinct club.
4. Clypeus bicarinate, with a pair of antero-median setae.
5. Postpetiole transverse, much broader than long, narrowly attached to gaster.
6. Yellowish in colour.
7. Head long, about twice as long as broad, very convex in front, posterior lateral angles prominent and each furnished with tooth on the apex.
8. Eyes comparatively large.
9. Propodeum submargined and subdentiform.

10. Reddish yellow in colour; length varies from 1 mm. to 4 mm.

This subterranean species also feeds on termites.

Genus ***Pheidole*** Westwood

23. ***Pheidole roberti*** Forel, 1902

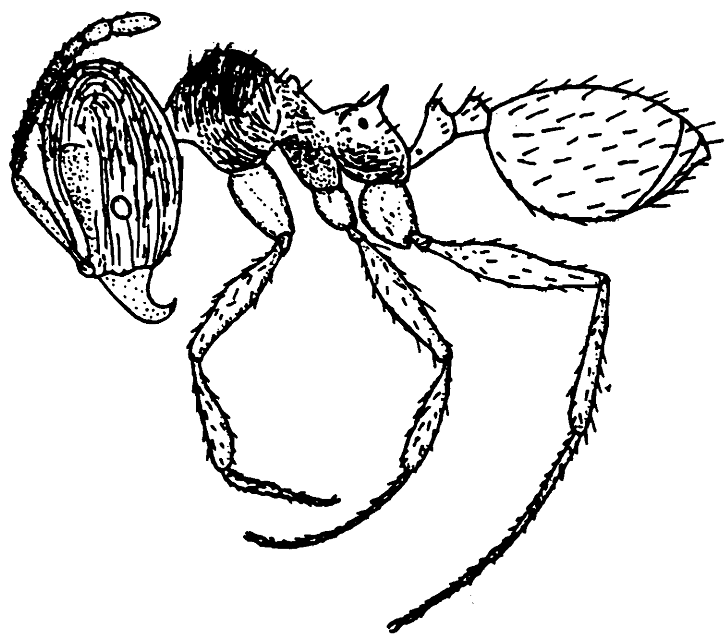


Fig. 25 : *Pheidole roberti* Forel

Characters :

1. Antennal scrobes running above the eyes, finely sculptured within.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 12-segmented antennae very long with 3-segmented club.
4. Clypeus not carinate, medially smooth and slightly advance; neither bilobed appendage over mandibles nor laterally raised portion.
5. Spurs on posterior tibiae simple.
6. Head rectangular, wholly sculptured, without carina on ventrolateral margin.
7. Spines on propodeum long and acute.
8. Postpetiole slightly oval and attached on the antero-medial surface of gaster.
9. Petiole with small anterior peduncle.
10. Mandibles strong, triangular, smooth, very shining, no lobe on basal boarder.
11. Occipital corners of head rounded, medially with deep emargination.
12. Alitrunk anteriorly gibbous.
13. Pro- and mesonotum not forming a single convexity.

14. Presence of transverse mesonotal ridge.
15. Red in colour; length of worker 2.5 mm. and soldier 4.5-5 mm.

This species is considered as one of the intelligent species of ants. It makes nest in soil and practises harvesting. Polymorphism seen prominently. Carnivorous as well as granivorous.

Genus ***Pheidologeton*** Mayr

24. ***Pheidologeton diversus*** (Jerdon, 1851)

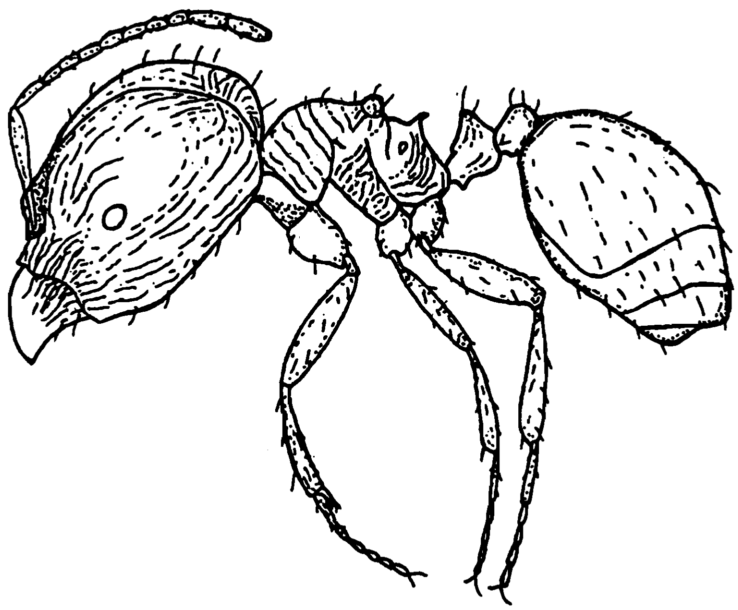


Fig. 26 : *Pheidologeton diversus* (Jerdon)

Characters :

1. Antennal scrobes short, divergent and running above the small eyes.
2. Postpetiole articulated on anterior surface of first gastral segment, twice as broad as petiole.
3. 11-segmented, pubescent antennae with 2-segmented club.
4. Clypeus slightly convex, not carinate.
5. Head rectangular, enormous; a deep impression from postero-median surface down to the front.
6. Mandibles large with two strong teeth at apex.
7. Pronotum unarmed.
8. Propodeal spine long and stout.
9. Presence of a single ocellus.
10. Dark brown in colour; length of worker 2.5-3 mm and soldier 6-12 mm.

This species forms its nests under bricks, stones, fallen logs. These omnivorous ants practises harvesting also.

Genus ***Recurvidris*** Bolton

25. ***Recurvidris recurvispinosa*** (Forel, 1890)

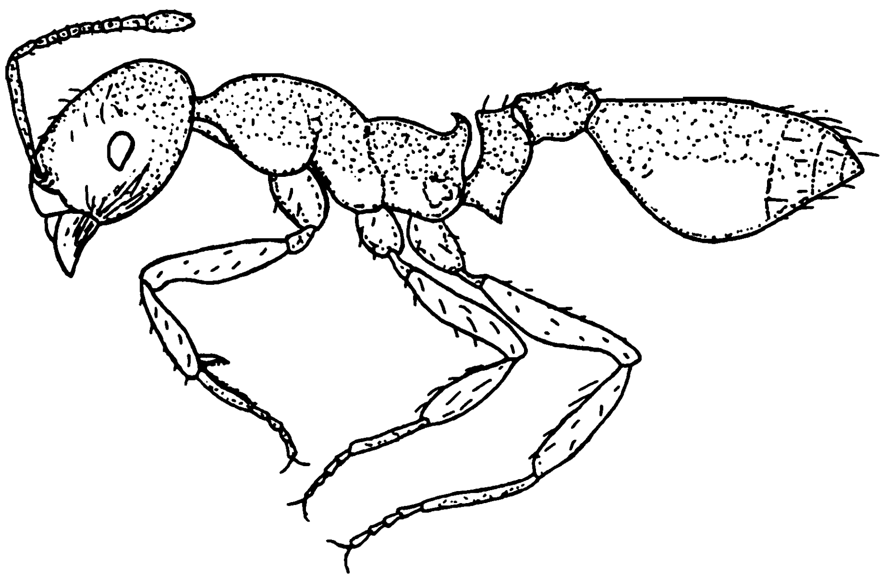


Fig. 27 : *Recurvidris recurvispinosa* (Forel)

Characters :

1. Antennal scrobes short, above the level of eyes placed a little front of the middle of the sides of head.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 11-segmented antennae with 3-segmented club.
4. Narrow mandibles with 4 teeth.
5. Clypeus convex, forming an angle with the portion of front above it, with two longitudinal carinae.
6. Maxillary palpi 4-segmented.
7. Petiole with a long thick peduncle anteriorly.
8. Postpetiole broader than petiole, rounded in front, transverse posteriorly; attachment with gaster narrow and dorsoventrally flattened.
9. Propodeum armed with a pair of spines which curved upward and forward.
10. Head viewed from side truncate anteriorly.
11. Gaster viewed from side triangular, flat above, the apex of triangle below.
12. Light yellow in colour; length 2 mm.

Subterranean in nature. Polyphagous.

Genus ***Solenopsis*** Westwood

26. ***Solenopsis geminata*** (Fabricius, 1804)

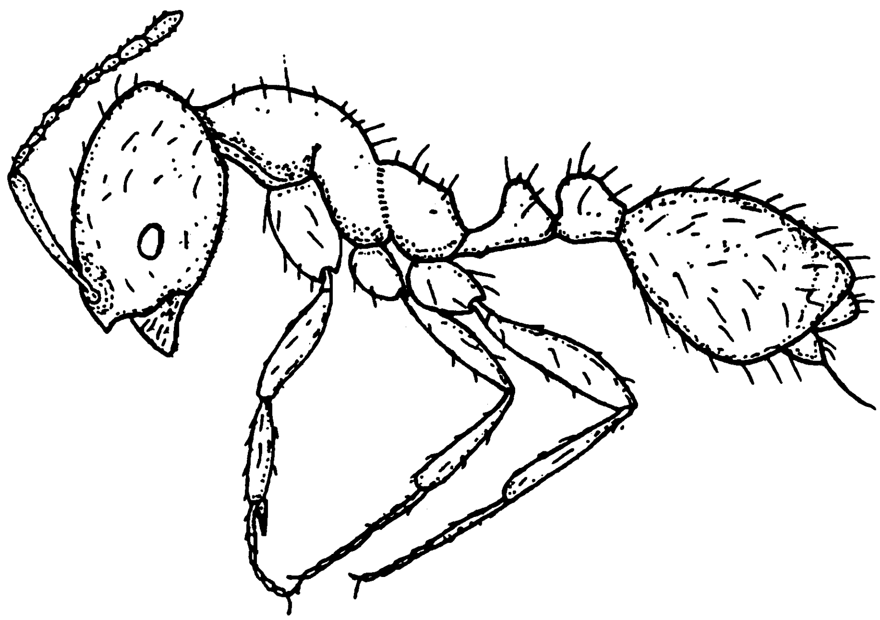


Fig. 28 : *Solenopsis geminata* (Fabricius)

Characters :

1. No antennal scrobe.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 10-segmented antennae with 2-segmented distinct club.
4. Clypeus narrow at the sides, bicarinate, sub-bidentate, with a single long, anteriorly projecting, unpaired median seta at the midpoint of anterior margin.
5. Pale yellow to reddish yellow in colour.
6. Entirely smooth and shining.
7. Mandible with 4 teeth, apical one long and acute.
8. Reddish yellow in colour; length of worker 3-4 mm. and soldier 7-8 mm.

This species is very widely distributed. It forms large nest in soil making the soil loose and porous, with number of outlets. It likes nesting along paths and roads and door-yards. It attacks and eats almost everything that comes on its way. Commonly known as 'fire-ant' for having a formidable sting which it uses on slightest provocation.

Genus ***Tetramorium*** Mayr

27. ***Tetramorium walshi*** (Forel, 1890)

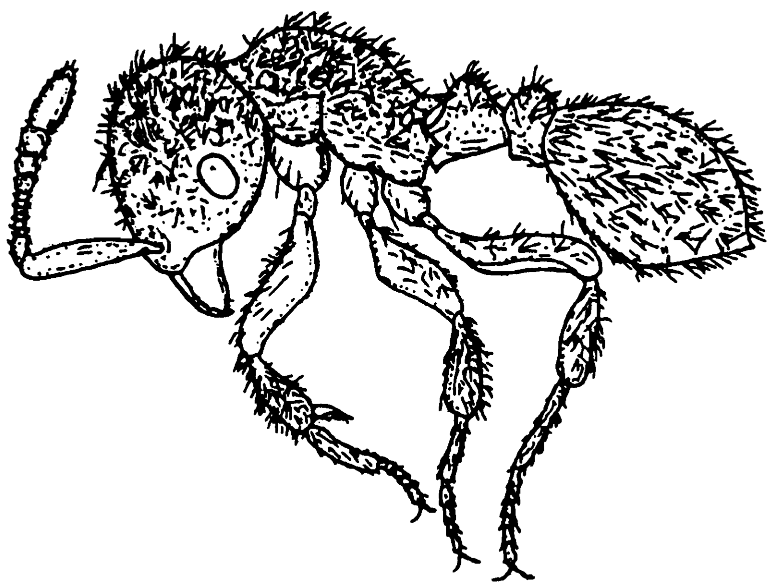


Fig. 29 : *Tetramorium walshi* (Forel)

Characters

1. Antennal scrobes present and running above the eyes placed at the middle of the sides of head.
2. Postpetiole articulated on anterior surface of first gastral segment.
3. 12-segmented short antennae with 3-segmented club.
4. Triangular mandibles broad and punctured with 4-5 teeth.
5. Clypeus triangular, anterior margin more or less transverse.
6. Maxillary palpi 4-segmented
7. Sting with an apicodorsal triangular lamellate appendage projecting from the shaft at an angle to its lower axis.
8. Head trapeziform, broader posteriorly than in front.
9. Petiole transverse, wider than long, anteriorly with peduncle which is nearly as long as the petiole itself.
10. Trifid hairs very dense all over the body, whitish in colour making woolly appearance.
11. Reddish brown in colour, gaster black; length 2-2.5 mm.

This species is subterranean, making holes on the surface. Very sluggish in nature.

B. FAUNAL COMPOSITION

A total 74,260 ants distributed over 27 genera and 27 species were collected throughout the study period from all the selected sites. Out of these, 22,710 ants were collected from East Kolkata site comprising of 20 genera and 20 species. From Central Kolkata site altogether 17,310 ants were collected, which comprises 17 genera and 17 species from all the plots. 16,210 ants collected from North Kolkata site were distributed under 13 genera and 13 species. South Kolkata site yielded 18030 ants over 16 genera and 16 species. (Fig. 30 & Table 1)

Sitewise distribution of ants revealed that at East Kolkata site the minimum and maximum mean number of ants collected per sample varied from 1 to 150 at different plots and in different months (Table 2). In plot A this value varied between 2-15/sample while the same at plot B and C were found to be 1-80/sample and 1-105/sample respectively.

It was observed that in most of the plots at East Kolkata site *Solenopsis geminata* was present in all the months. It was widely distributed throughout the seasons, except a few months and plots.

Pheidole roberti and *Camponotus compressus* were found to be moderately distributed in different months of the seasons, though in many of the months and in many of the plots they could not be recorded. The distribution of other species were found to be very much irregular and discrete in nature, remaining absent in most of the months and in most of the plots.

Polyrhachis tubericeps, Messor barbarus, Diacamma rugosum, Anochetus graeffei, Pachycondyla rufipes, Cerapachys typhlus, Amblyopone rothneyi were recorded only once and in one plot, clearly showing their poor representation in the roadside soil at this site.

In order of dominance it was found that *S. geminata, P. roberti, Paratrechina longicornis, Tapinoma melanocephalum* and *Technomyrmex albipes* occupied first to fifth positions with a mean density in between 13.47±4.51 to 1.86±0.26 sample at East Kolkata site as a whole on an average (Table 2). Other species were found to be very poor in their density contribution in the total ant community. These species are henceforth termed as 'others'

From Table 2 it is also observed that *S. geminata* was the most dominant species at East Kolkata site and widely distributed at plot A. However, its density gradually diminished at plot B and plot C respectively. The density of *P. roberti* was found to be almost uniform in all the plots, whereas for *P. longicornis* and *T. albipes* the density was found to be more at plot A, but at plot B and C their abundance were found to be greatly reduced. However, this pattern was found to be exactly reverse for *T. melanocephalum*, where the maximum abundance was found in plot C and the same got significantly reduced at plot B and plot A. For other species no definite pattern of plotwise abundance could be established. (Table 2)

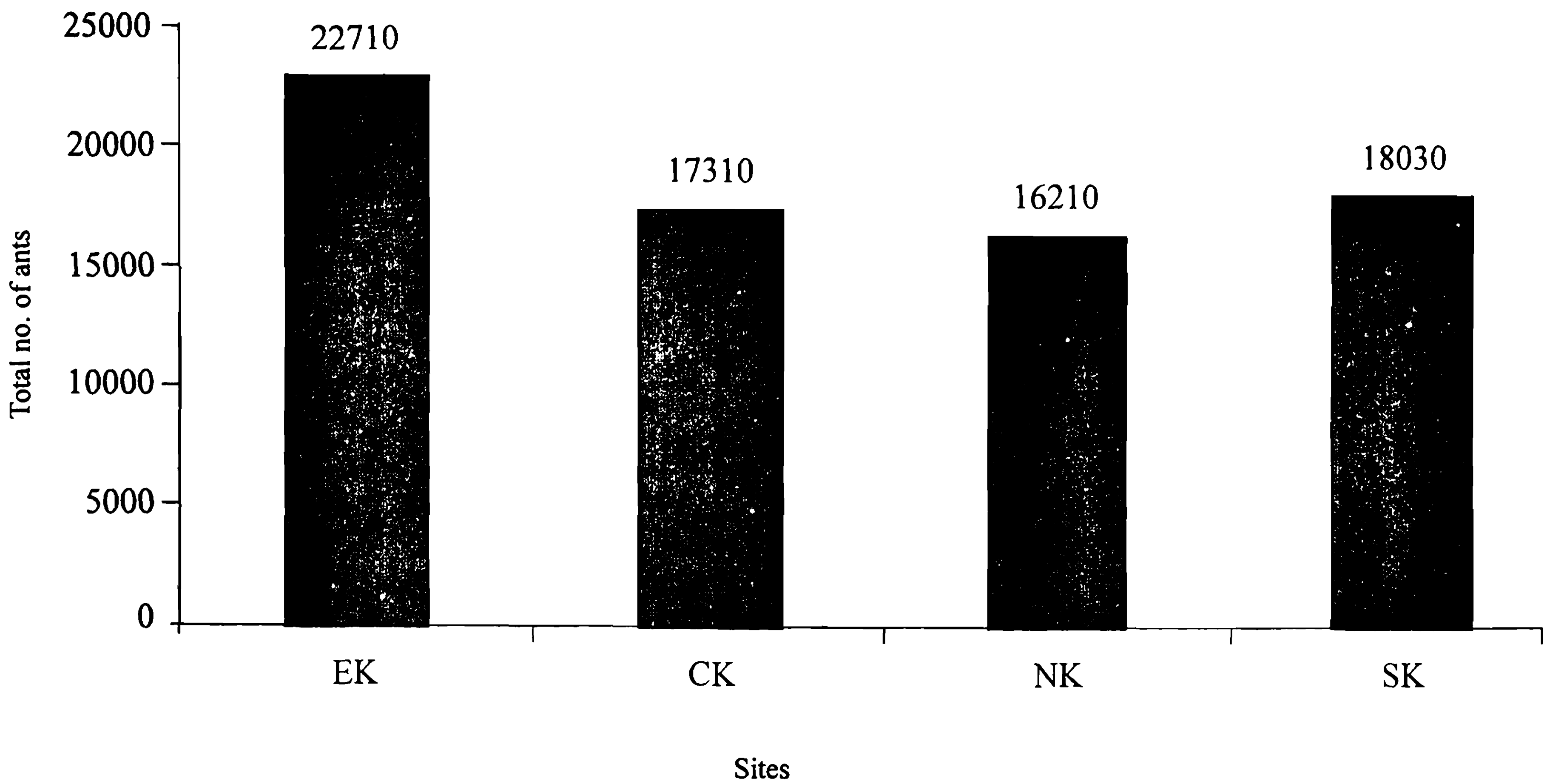


Fig. 30 : Comparison of total population of Formicidae collected from four different sites under study

Table 1 : D istribution of ant species at different sites (+ : species present; – : species absent)

Name of the Species	Sites of Collection			
	EK	CK	NK	SK
Dorylus orientalis Westwood	+	-	-	-
Amblyopone rothneyi Forel	+	-	-	-
Anochetus graeffei Mayr	+	-	+	-
Diacamma rugosum (Le Guil.)	+	-	-	-
Hypoponera truncata (Smith)	-	+		-
Pachycondyla rufipes (Jerdon)	+	-		-
Cerapachys typhlus (Roger)	+	-	-	-
Tapinoma melanocephalum (Fabr.)	+	+	+	+
Technomyrmex albipes (Smith)	+	+	+	+
Camponotus compressus (Fabr.)	+	+	+	+
Paratrechina longicornis (Latr.)	+	+	+	+
Plagiolepis jerdonii Forel	+	+	+	+
Polyrhachis tubericeps Forel	+	-	-	-
Tetraponera allaborans (Walker)	-	+	-	+
Cardiocondyla nuda (Mayr)	+	+	+	+
Carebara lignata Westwood	+	+	+	+
Crematogaster rothneyi Mayr	+	+	-	+
Lophomyrmex quadrispinosus (Jerdon)	-	+	-	-
Meranoplus bicolor (Guer.)	+	+	+	+
Messor barbarus (Linnaeus)	+	-	-	-
Monomorium floricola (Jerdon)	-	+	+	+
Oligomyrmex asinus Forel	-	+	-	-
Pheidole roberti Forel	+	+	+	+
Pheidologeton diversus (Jerdon)	-	-	-	+
Recurvidris recurvispinosa (Forel)	-	-	-	+
Solenopsis geminata (Fabr.)	+	+	+	+
Tetramorium walshi (Forel)	+	+	+	+

At Central Kolkata site the minimum and maximum mean number of ants collected per soil sample ranged between 2 to 100 at different plots in different months. This value in plot A was in between 5-100/sample. In plot B and plot C these were from 2-50/sample and 3-84/sample respectively. (Table 3)

In this site, the ant species, *Solenopsis geminata*, was found to be distributed in almost all the months of the study period with a few exceptions. Its presence in all the plots was also very evident.

On the other hand *Pheidole roberti, Meranoplus bicolor, Paratrechina longicornis* and *Carebara lignata* were found to be moderately distributed throughout the study period showing their absence in some months and some plots. The absence of other represented species in most of the months and plots were very conspicuous. The species like *Lophomyrmex quadrispinosus, Hypoponera truncata, Cardiocondyla nuda, Tetraponera allaborans, Oligomyrmex asinus* were recorded from only one plot in one month throughout the study period.

S. geminata was found to be the most dominant with a mean density of 10.02 ± 6.17 / sample. The mean density of *P. roberti, M. bicolor* and *P. longicornis* were recorded as 4.44 ± 1.42, 3.82 ± 3.44 and 1.26 ± 0.51 per sample respectively in the order of dominance. Other species were found to be very poorly represented in the share of the total ant community at this site and are henceforth termed as 'others' (Table 3)

Plotwise segregation of the dominant species reveals that the highest mean density of the most dominant species, *S. geminata* had been encountered in plot A followed by B and C. The density of *P. roberti* was also highest in plot A and lowest in plot B, in plot C the value was in between. Whereas following a reverse trend, the density of *M. bicolor* and *P. longicornis* were high in plot C; in case of the former species in plot A it was the lowest and in case of later species the lowest was in plot B. For others the plotwise distribution pattern was found very irregular. (Table 3)

At North Kolkata site the minimum value of ants collected per soil sample from different plots in different months was 3 and the maximum was 80, both were incidentally observed in plot A. In plot B these values were 4/sample and 42/sample respectively, whereas these varied from 8/sample to 60/sample in plot C (Table 4).

Distribution of *Solenopsis geminata* was found to fluctuate throughout the season, though it was found to be absent occasionally at some plots.

The distribution of *Pheidole roberti* and *Meranoplus bicolor* were found to be uniform in terms of their monthly occurrence *Tetramorium walshi* and *Monomorium floricola* were distributed poorly throughout the seasons and their absence in some plots and in some months were very conspicuous; though their number, however available, were sizeable. The other species collected from this site were found to be distributed very irregularly and in some species it was seen to be very poor.

So far the dominance of the collected species is concerned, it was found that *S. geminata, P. roberti, T. walshi, M. bicolor, Paratrechina longicornis* and *M. floricola* occupied the positions in descending order having their density per soil sample as 6.85±3.11, 4.22±1.74, 2.87±2.60, 2.56±0.09, 1.31±0.49 and 1.22±0.68 respectively (Table 4). Rests of the represented species from this site took a very negligible share of the total ant community and are threfore termed as 'others'

Plotwise mean density of the dominant species revealed that *S. geminata* was maximum in plot C followed by B and A. However, for *P. roberti, T. walshi* and *M. bicolor* the maximum density were observed at plot A followed by plot B and C. The density of *P. longicornis* was found to be maximum in plot B than in plot C and plot A. *M. floricola* exhibited a maximum density in plot A, then at plot C and plot B. For 'others' no clear plotwise density gradation could be observed. (Table 4).

At South Kolkata site the minimum and maximum number of ants collected per soil sample were 1 and 85. In plot A the minimum value was 2/sample and the same in plot B and C were 1/sample and 3/sample respectively. The maximum number of ants collected per sample in plot A, B and C were 75, 85 and 75 respectively. (Table 5).

The species, *Solenopsis geminata,* at this site also was found to be present in almost all the months throughout the study period.

Monomorium floricola and *Pheidole roberti* were distributed in months of different seasons, though in some months and in some plots they could not be recorded. The occurrence of other collected species were restricted in few months and plots. The species *Tetraponera allaborans* and *Recurvidris recurvispinosus* were recorded in two months only while *Pheidologeton diversus* was recorded from only one plot in January, 1997 indicating their very negligible presence.

S. geminata was found to be the most dominat species (10.22±4.09/sample) followed by *M. floricola, P. roberti, Plagiolepis jerdonii, Technomyrmex albipes, Paratrechina longicornis* (3.71 ± 0.25 to 1.40 ± 0.99/sample). The other species contributed a very small share of total ant community of this site and these are termed henceforth as 'others' (Table 5).

Maximum population of *S. geminata* was concentrated in plot A, and then gradually its density decreased in plot B and C. The density of *M. floricola* was found more or less uniform in all three plots. In case of *P. roberti* the maximum density was seen most in plot A and minimum in plot B, while the density of *P. jerdonii* was most in plot C and least in plot A. *P. longicornis* was seen totally absent in plot A and uniformly present in plot B and C. For others no definite pattern of plotwise abundance was found. (Table 5).

C. Seasonal Variation

Monthwise variation in the population of ants and other abiotic factors in different sites and in different plots, as observed during the study period, are as follows.

East Kolkata Site

Plot A : Throughout the study period the density of ants was found to be maximum (150±34.59) in September, 1996 and minimum (2±1.61) in the month of August, 1995. The mean value of ant population was 42.50±28.76 at this plot for the entire study period. The population density of 150±34.59 was found to be somewhat abnormal in comparison to other values, obtained throughout the period. (Table 6)

The concentration of lead (in ppm) in the roadside soil at this plot was found to be highest (210±8.48) in December, 1995 whereas the lowest was 60±6.62 in January, 1997. The mean value of concentration of lead was found to be 132.50±36.60 in the soil of this site for the entire study period. (Table 6).

The maximum temperature (34°C) recorded at this plot was in the month of May (1997) and minimum (19°C) was in December (1996). The mean temperature recorded throughout the study period was found to be 27.75°C±3.48. (Table 6)

The pH value of soil was found to be maximum in the month of September, 1996 which was 7.20±0.08 and minimum in the month of November, 1995 which was 6.59±0.07. The mean value of the pH of soil throughout the study period was found to be 6.88±0.16. (Table 6)

Plot B : In this plot of East Kolkata site the population density of ants was found maximum in the month of May, 1997 and minimum in the month of December, 1995 which were 80±25.23 and 1±1.00 respectively. The mean value of ant population density throughout the study period was found to be 27.08±22.68. (Table 7).

Concentration of lead (in ppm) was found maximum in the months of August, 1995; November, 1995 and June, 1997; which were 160±10.09, 160±4.63 and 160±6.60 respectively. Whereas the minimum was found to be 50±5.12 in the month of March, 1997. The mean concentration of lead in soil for the entire period of study was seen to be 110±34.00. (Table 7).

Temperature of soil was measured maximum in the month of May (1997) and minimum in the month of December (1996), the values were 32°C and 19.5°C respectively. The mean temperature measured throughout 24 months was found to be 27.71°C±3.93. (Table 7).

The value of pH of soil at this plot was found highest in August, 1995 and lowest in January, 1997 which were 7.15±0.08 and 6.54±0.13 respectively. The mean of the pH values of soil samples measured throughout the study period was found to be 6.92±0.16. (Table 7).

Table 2 : Mean population distribution per sample of different species of Formicidae

Name of the species	Aug,95	Sep	Oct	Nov	Dec	Jan,96	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C
Solenopsis geminata	2-0-0	4-0-0	8-5-0	19-3-4	50-0-0	55-2-105	0-50-4	25-0-0	20-0-15	52-0-0	0-40-0	18-0-10	0-0-3	0-28-0
Pheidole roberti	0	30-7-0	0	0	1-0-0	0	4-0-3	0	0	0-0-2	65-0-35	0	0	0-0-11
Paratrechina longicornis	0	0	10-0-7	0	4-0-0	0	0	0	0	0	0	4-10-0	0	150-0-0
Tapinoma melanocephalum	0-4-0	0	0	0	0	0	3-0-0	0	0-9-0	0	0	0-0-20	0-0-60	0-8-0
Technomyrmex albipes	0	0	0	18-30-0	0	0	0	0	11-0-0	0	0	0	0	0
Plagiolepis jerdonii	0	0	0-0-21	0	0	0	0	22-0-0	0-0-9	0	0	0	0	0
Camponotus compressus	0-1-1	0-1-1	2-4-0	0	0-1-0	0	0	0-0-7	0	0-4-1	0-3-3	0	0	0
Tetramorium walshi	0	0	0	0	0	0	0	0-0-33	0	0	0	0	0	0
Dorylus orientalis	0	0	0	0	0	0	0	0	0	0	0	0	38-0-0	0
Meranoplus bicolor	0	5-0-0	0	0	0	0	0-2-0	0-18-0	0-5-0	0	0	0	2-0-0	0
Carebara lignata	0-3-0	0	0	0-15-0	0	0	5-9-0	0	0	0	0	0-2-0	0-0-2	0-2-0
Cardiocondyla nuda	0	0	0	0-0-1	0	0	8-0-0	0	0	0	0	0	0	0
Polyrhachis tubericeps	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Messor barbarus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crematogaster rothneyi	0	0	0	0-0-3	0	0	0	0	0	0	0	0	0	0-0-3
Anochetus graeffei	0	0	0	0	0-0-2	0	0	0	0	0	0	0	0	0
Cerapachys typhlus	0-0-2	0	0	0	0	0	0	0	0	0	0	0	0	0
Diacamma rugosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pachycondyla rufipes	0	0	0	0	0	0	0	0	0	0	0	0	0-2-0	0
Amblyopone rothneyi	0-0-1	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 : Mean population distribution per sample of different species of Formicidae

Name of the species	Aug,95	Sep	Oct	Nov	Dec	Jan,96	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C
Solenopsis geminata	0-5-24	4-0-0	0	14-0-0	6-0-0	90-0-24	0-5-8	16-4-0	0-8-0	10-15-0	0-0-33	9-20-0	32-0-0	14-0-14
Pheidole roberti	5-31-0	0	0	18-0-0	0	0	0	0-0-2	0	0	23-0-3	0-0-3	0-0-20	0-2-0
Meranoplus bicolor	0	0-0-9	0	0-0-11	0	0-0-60	0	0	0-0-6	0	0-41-9	0	0-5-0	0
Paratrechina longicornis	0-0-5	0	0-0-8	0	0	0	14-0-0	0	19-0-8	0-0-10	0	0	0	0-11-0
Tapinoma melanocephalum	0	0	0	0-6-0	0	0	0	0	0	0	0	0	0	0
Carebara lignata	0-3-3	9-0-0	0	0	0-2-0	0	0	0	0	0	1-1-0	0	0	0
Plagiolepis jerdonii	0	0	18-0-0	0	0	0	0	0	0	0	0	0	0	0
Technomyrmex albipes	0	0	0	0	0	0	0-6-0	0	0	0	0-0-17	0	0	0
Camponotus compressus	1-0-0	0-5-0	0	0-4-0	0	0	0	0	0-4-0	0-6-0	0-8-0	0	0	0
Monomorium floricola	0	0	0-0-5	0	0	0	0	0	0	8-0-0	0	0	0	1-0-0
Tetramorium walshi	0	0	0-8-0	0	0	0	0	0	0	5-0-0	0	0	2-0-0	0
Crematogaster rothneyi	0	0	0	0-0-4	0	0	0	0	0	0	0	0	0	0
Lophomyrmex quadrispinosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypoponera truncata	0	0	0	0	0	0	0	0-0-6	0	0	0	0	0	0
Cardiocondyla nuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tetraponera allaborans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligomyrmex asinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0

at three different plots of East Kolkata site.

Oct	Nov	Dec	Jan,97	Feb	Mar	Apr	May	Jun	Jul	Mean ± SD			
A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A	B	C	A-B-C
0-0-29	33-0-0	0-34-0	0-44-0	75-0-0	0-24-0	0-17-3	37-80-11	42-0-0	8-11-0	18.67±21.96	14.08±21.06	7.67±21.36	13.47±4.51
0-0-6	0-32-43	0	0	0	0	15-0-0	0	0-60-0	0-12-0	4.79±14.17	4.63±13.39	4.17±10.85	4.53±0.26
0	0	9-0-0		0-0-6	0	0	0	0	0	7.38±29.87	0.42±2.00	0.54±1.80	2.78±3.25
0	0	0	0-28-0	0	0-1-0	0-3-0	0	0-0-13	0	0.13±0.60	2.21±5.91	3.88±12.60	2.07±1.53
0	0	0	25-0-0	0	0-0-30	15-0-0	5-0-0	0	0	3.08±6.74	1.25±5.99	1.25±5.99	1.86±0.26
3-0-0	0	0	35-0-0	0	0	0	0	0	0-0-18	2.50±8.08	0	2.00±5.59	1.50±1.08
0-8-4	0	0-0-11	0	0	0	0-0-6	0	13-0-0	0	0.63±2.61	0.92±1.91	1.42±2.78	0.99±0.33
6-0-0	0	0	0	0	0	0	0	0-0-25	0	0.25±1.20	0	2.42±8.10	0.83±1.00
0	0	0	0-0-21	0	0	0	0	0	0	1.58±7.59	0	0.88±4.20	0.82±0.65
1-0-0	0	1-0-1	0	0	0	0	0	0	12-0-0	0.88±2.55	1.04±3.69	0.04±0.20	0.65±0.44
0	0	0	0	0	0	0	0	0	0	0.21±1.00	1.29±3.43	0.08±0.40	0.53±0.54
0	0	0	0	0	0	10-5-3	0	0	0	0.75±2.50	0.21±1.00	0.17±0.62	0.38±0.26
0	0	0	0	0	24-0-0	0	0	0	0	1.00±4.80	0	0	0.33±0.47
0	0	0	0	0-23-0	0	0	0	0	0	0	0.96±4.60	0	0.32±0.45
0	0	2-0-0	0	0	0	0	4-0-0	0	10-0-0	0.67±2.13	0	0.25±0.83	0.31±0.28
0	0	0	0	0	0	0	0	0	0	0	0	0.08±0.40	0.03±0.04
0	0	0	0	0	0	0	0	0	0	0	0	0.08±0.40	0.03±0.04
0-0-2	0	0	0	0	0	0	0	0	0	0	0	0.08±0.40	0.03±0.04
0	0	0	0	0	0	0	0	0	0	0	0.08±0.40	0	0.03±0.04
0	0	0	0	0	0	0	0	0	0	0	0	0.04±0.20	0.01±0.02

at three different plots of Central Kolkata site.

Oct	Nov	Dec	Jan,97	Feb	Mar	Apr	May	Jun	Jul	Mean ± SD			
A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A	B	C	A-B-C
50-0-0	0-0-8	19-0-0	100-10-	00-19-0	0-48-0	26-0-0	0-0-8	59-19-0	0	18.71±27.86	6.38±11.00	4.96±9.22	10.02±6.17
0-5-0	50-0-6	0-0-12	0-0-25	9-0-0	5-0-0	0-0-25	33-0-0	0-0-20	0-23-0	5.96±12.45	2.54±7.54	4.83±8.39	4.44±1.42
0-0-45	0-0-1	0-0-10	0-0-18	0-0-10	0-0-6	0	1-5-6	16-0-0	0-0-16	0.71±3.19	2.13±8.22	8.63±14.45	3.82±3.44
0	0-0-9	0-2-0	0	0	0	0	0	5-0-0	0	1.58±4.66	0.54±2.22	1.67±3.34	1.26±0.51
0	0	0	0-1-17	0	0	0	0-3-7	0-24-0	0	0	1.42±4.89	1.00±3.62	0.81±0.60
12-0-0	0-8-0	0	0-15-0	0	0	0	2-0-0	0	0	1.00±2.93	1.21±3.34	0.13±0.60	0.78±0.47
0	0	0-0-8	0	0	0	0-25-0	0	3-0-0	0	0.88±3.62	1.04±5.00	0.33±1.60	0.75±0.30
0	0	0	0	0	0	0	0	0	0-0-11	0	0.25±1.20	1.17±3.97	0.47±0.50
0	0	0	0-1-0	0	0	0	0-3-0	0	0	0.04±0.20	1.29±2.30	0	0.44±0.60
0-0-5	0	0	0	0	0	0	0	0	0-12-0	0.38±1.60	0.50±2.40	0.42±1.38	0.43±0.05
0	0	0	0	0	0	0	1-0-13	0	0	0.33±1.07	0.33±1.60	0.54±2.60	0.40±0.10
0	0-0-1	0	0	0	0	0	0	0	6-0-0	0.25±1.20	0	0.21±0.82	0.15±0.11
0	0	0	0	0	0	0	0-10-0	0	0	0	0.42±2.00	0	0.14±0.20
0	0	0	0	0	0	0	0	0	0	0	0	0.25±1.20	0.08±0.12
0	0	0	0	0	0	0	0	1-0-0	0	0.04±0.20	0	0	0.01±0.02
0	0	1-0-0	0	0	0	0	0	0	0	0.04±0.20	0	0	0.01±0.02
0	0	0	0	1-0-0	0	0	0	0	0	0.04±0.20	0	0	0.01±0.02

Table 4 : Mean population distribution per sample of different species of Formicidae

Name of the species	Aug,95	Sep	Oct	Nov	Dec	Jan,96	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C
Solenopsis geminata	0-28-3	0	0-14-0	0-35-0	0-0-42	0-0-35	10-0-0	0	6-12-0	0	38-0-18	0-14-0	4-0-9	0-0-20
Pheidole roberti	0	32-0-0	0	0	25-0-0	0-0-20	15-0-0	0	7-23-0	0	0-20-0	0	15-0-0	7-0-0
Tetramorium walshi	7-0-0	0	0	0	0-15-0	0	0	0	0	28-0-0	0	0-0-18	0	0-7-0
Meranoplus bicolor	0-13-0	0	0	11-0-0	0	10-0-0	0-0-16	0-0-20	0-0-6	0	0-0-5	0	4-10-0	0
Paratrechina longicornis	0	0	0	0	0	0-8-0	0-10-0	0	0-0-12	0	0	0	8-0-0	0
Monomorium floricola	0-0-14	0	0-0-8	0	0	22-0-0	7-0-0	0	0	0	0	0	0	11-0-0
Tapinoma melanocephalum	0	0	0	0-0-14	0	0	0	27-0-0	0	0	0-0-7	0	0	0
Technomyrmex albipes	0	0	0	0	0	0-7-0	0	0	0	0-0-12	0	19-0-0	0	0
Plagiolepis jerdonii	0	16-0-0	0	0	0	0	18-0-0	0	0	0	0	0	0	0
Carebara lignata	0	0	3-0-0	0	0	0	0	0-4-0	0	0	2-0-0	0	0	0
Camponotus compressus	0	0-4-0	0	0	0	3-0-0	0	0-6-0	0	0-2-0	0	0	0	0
Anochetus graeffei	0	0	0	0	0	0	0	0	0	0-3-0	0	0	0	0
Cardiocondyla nuda	0	0	0-2-0	0	0	0	0	0-2-0	0	0	0	0	0	0

Table 5 : Mean population distribution per sample of different species of Formicidae

Name of the species	Aug,95	Sep	Oct	Nov	Dec	Jan,96	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C
Solenopsis geminata	30-18-0	0	0-4-0	0	14-20-5	65-58-0	0-0-19	0	60-0-0	6-0-0	28-0-0	3-0-2	30-0-0	20-14-0
Monomorium floricola	0	0	0	0	0	0	0	10-0-0	0-23-0	0-0-30	0-32-5	17-0-0	4-0-0	0
Pheidole roberti	0	0	0-8-0	4-0-0	0-0-4	0-0-15	75-0-0	0-12-0	0	0	0	0	0	0
Plagiolepis jerdonii	0	0	0	0	0	0	0	0	0	0-0-11	0	0	0-0-17	0-0-15
Tapinoma melanocephalum	0	0	0	0	0	0	0	0	0	0	0	0-15-0	0	0-0-5
Paratrechina longicornis	0	0	0	0	0	0	0	0	0-0-7	0-3-0	0-0-40	0	0	0
Meranoplus bicolor	0	0-0-5	0	0	0	0	0	0-14-0	0-0-4	0-5-0	0-1-0	0-0-10	0	0-1-5
Technomyrmex albipes	0	0	0-0-5	0-5-0	0	0	0	25-0-0	0	0	0	0	0	0
Tetramorium walshi	0	0	15-0-0	0	0	0	0	10-0-0	0	0	0	6-0-0	0-10-1	0
Crematogaster rothneyi	0	0	10-0-0	0	0	0	0	0	0	0	0-0-20	0	0	0
Carebora lignata	0	2-0-0	0	0	0	0	0-1-0	0-0-11	0	0	0	0-0-2	0	0-2-0
Tetraponera allaborans	0	0	0	0	0	0	0	0	0	0	0	0	0	0-11-0
Camponotus compressus	2-0-0	0-0-1	2-0-0	0	0	0	0	0	0-5-0	1-0-0	0	0	0	0
Cardiocondyla nuda	0-0-7	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvidris recurvispinosus	0	0	0	0	0	0	0	0-0-8	0	0	0	0	0	0
Pheidologeton diversus	0	0	0	0	0	0	0	0	0	0	0	0	0	0

at three different plots of North Kolkata site.

Oct	Nov	Dec	Jan,97	Feb	Mar	Apr	May	Jun	Jul	Mean ± SD			
A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A	B	C	A-B-C
8-0-0	0	6-20-50	0-0-25	11-0-18	0-0-15	8-0-9	0-0-12	0-0-13	10-0-0	4.21±8.05	5.13±9.82	11.21±14.22	6.85±3.11
0-24-0	0-0-15	0-20-0	0	23-0-0	0	0-15-0	0-20-0	15-0-0	0-0-8	5.79±9.46	5.08±8.92	1.79±5.05	4.22±1.74
0	33-0-0	0	80-0-0	0	0	0	0	0-10-0	9-0-0	5.64±17.53	1.33±3.72	0.75±3.60	2.57±2.60
22-0-0	0-3-12	0	0	0-20-0	0	0	15-0-0	0	2-15-0	2.67±5.70	2.54±5.58	2.46±5.46	2.56±0.09
0	0	0	0-23-0	0	0-6-0	11-0-0	0	0-0-7	0-0-9	0.79±2.66	1.96±5.15	1.17±3.17	1.31±0.49
0	0-12-0	0-2-0	0	0	12-0-0	0	0	0	0	2.17±5.34	0.58±2.41	0.92±3.16	1.22±0.68
0-0-13	0	0	0	0-0-17	0	0	0	0	0	1.13±5.40	0	2.13±4.98	1.09±0.87
0	0	0-0-10	0	0	0	0	0	0	0-13-0	0.79±3.80	0.83±2.90	0.92±3.05	0.85±0.05
0	0	0	0	0	0	0-0-19	0-0-7	0	0	1.42±4.71	0	1.08±3.99	0.83±0.61
0	0	0	0	3-0-0	0	0	0-10-0	0	0	0.33±0.90	0.58±2.12	0	0.30±0.24
0	0-3-0	0	0	0	0-2-0	0	0	0	0	0.13±0.60	0.71±1.54	0	0.28±0.31
0	0	0	0-2-0	0	0	0	0	0	0	0	0.21±0.71	0	0.07±0.10
0	0	0	0	0	0	1-0-0	0	0	0	0.04±0.20	0.17±0.55	0	0.07±0.07

at three plots of South Kolkata site.

Oct	Nov	Dec	Jan,97	Feb	Mar	Apr	May	Jun	Jul	Mean ± SD			
A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A-B-C	A	B	C	A-B-C
2-0-9	0-7-0	5-30-0	2-0-0	20-4-75	0-43-0	14-0-7	0-0-3	50-58-0	11-0-0	15.00±19.26	10.67±17.97	5.00±15.21	10.22±4.09
0-0-4	0	0-0-15	0	1-0-0	25-0-0	0-0-41	31-17-2	0-10-0	0	3.67±8.34	3.42±8.32	4.04±10.12	3.71±0.25
0-3-0	10-0-8	0	0	0-4-0	0-0-21	5-0-0	0	0	0-8-0	3.92±15.00	1.46±3.20	2.00±5.20	2.46±1.06
0	0-5-12	0	0-0-30	0	0	0-0-6	6-12-5	0-0-1	0	0.25±1.20	0.71±2.56	4.04±7.50	1.67±1.69
23-0-0	0-58-0	0	0	0	0	0	0	0-0-1	0	0.96±4.60	3.04±11.84	0.25±1.01	1.42±1.18
0	0	0	0-38-0	0	0	0	0	0	0-10-3	0	2.13±7.76	2.08±8.05	1.40±0.99
0	0	0	0	0	0	0	0-0-2	0-17-0	13-0-0	0.54±2.60	1.58±4.34	1.08±2.43	1.07±0.42
0	0	0	0	0	0	0	0	0	14-5-0	1.63±5.62	0.42±1.38	0.21±1.00	0.75±0.63
0	0	0	0	0	0	0	0	0	0-0-5	1.29±3.66	0.42±2.00	0.25±1.01	0.65±0.46
0	0	0	0	0	0	0	0-0-11	0	0	0.42±2.00	0	1.29±4.48	0.57±0.54
0	0	0	0-6-0	0	0	0	0	0	0	0.08±0.40	0.38±1.25	0.54±2.22	0.33±0.19
0	0	0	0-6-0	0	0	0	0	0	0	0	0.71±2.46	0	0.23±0.33
0	0	0	0	0	0	0	0	0	2-0-0	0.29±0.68	0.21±1.00	0.04±0.20	0.18±0.10
0	0	1-0-0	0	0	2-0-0	1-0-0	2-0-0	0	0	0.25±0.60	0	0.29±1.40	0.18±0.13
0	0	0	0	0	0	0	0	0-0-1	0	0	0	0.38±1.60	0.13±0.18
0	0	0	5-0-0	0	0	0	0	0	0	0.21±1.00	0	0	0.07±0.10

Plot C : The population density of ants in this plot was found maximum in January, 1996 which was 105±44.52 and minimum was found in September, 1995 which was 1±1.18. The mean population value of the whole period was found to be 25.04±23.21 at this site. Ants per sample in the month of January, 1996 (105±44.52) was found to be unusually high in comparison to that of other months throughout the study period. (Table 8).

Concentration of lead (in ppm) in soil samples was found at its maximum in the month of September, 1996 which was 190±4.79 and minimum in the months of January, 1996 and August, 1996 which were 60±4.79 and 60±5.38. The mean value of concentration of lead in soil of this plot was found to be 121.50±34.62 throughout the study period. (Table 8).

A temperature of 33.5°C was measured in the month of May, 1997 as the highest throughout the study period and the lowest one was 20.5°C in the month of December, 1996. The mean temperature of soil of this plot was found to be 27.79°C±3.25 during the entire study period. (Table 8).

The pH of soil was measured maximum as 7.16±0.05 and minimum as 6.52±0.13 from the sample collected in the months of September, 1995 and March, 1997. The mean value of pH of soil samples collected from this plot throughout the 24 months was calculated to be 6.92±0.16. (Table 8).

On an Average in East Kolkata site (including plots A, B and C) the population density was found at its peak in the month of September, 1996 which was 67.33 ± 63.30. The minimum population density was found in the month of August, 1995 which was 4.67 ± 5.82. The mean population density of ants per sample on an average of this site was found to be 31.54 ± 14.58 for the entire study period. (Table 9).

The concentration of lead (in ppm) in the soil on an average in this site were found 170 ± 30.10 and 85.00 ± 27.44 as maximum and minimum in the months of December, 1995 and March, 1997 respectively. The mean concentration of lead in the soil samples taken from this site on an average for the entire study period was found to be 121.32 ± 19.26. (Table 9).

The maximum temperature recorded in this site on an average was 33.17°C ± 0.85 in the month of May, 1997 and minimum was 19.67°C ± 0.62 in the month of December, 1996. The mean temperature of soil recorded in this site on an average was found to be 27.75°C ± 3.29. (Table 9).

The pH of soil was found at its highest and lowest level in this site on an average were 7.12 ± 0.07 and 6.69 ± 0.08 in the months of September, 1996 and November, 1995 respectively. The mean value of pH of soil of this site on an average was calculated to be 6.91 ± 0.13. (Table 9)

Table 6 : Mean value ± SD / sample of total ant population and other soil factors in plot A at East Kolkata site during the study period.

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	2 ± 1.61	115 ± 17.53	30.00	7.05 ± 0.04
September	39 ± 22.71	155 ± 13.85	29.50	7.11 ± 0.05
October	20 ± 9.43	150 ± 8.48	29.00	6.91 ± 0.05
November	37 ± 17.59	180 ± 8.48	25.00	6.59 ± 0.07
December	55 ± 22.30	210 ± 8.48	22.00	7.01 ± 0.02
January'96	55 ± 20.45	170 ± 8.48	25.00	6.87 ± 0.06
February	20 ± 9.42	100 ± 4.79	26.00	6.66 ± 0.14
March	47 ± 32.11	125 ± 4.79	31.00	6.80 ± 0.03
April	31 ± 14.57	115 ± 4.79	29.50	6.95 ± 0.05
May	52 ± 15.66	100 ± 10.30	31.50	7.03 ± 0.09
June	65 ± 22.55	125 ± 4.98	28.50	6.80 ± 0.11
July	22 ± 7.04	115 ± 4.98	29.00	6.84 ± 0.12
August	40 ± 14.16	100 ± 5.53	28.50	6.82 ± 0.15
September	150 ± 34.59	125 ± 5.78	30.00	7.20 ± 0.08
October	10 ± 5.00	160 ± 5.23	28.50	6.68 ± 0.16
November	33 ± 12.75	190 ± 10.24	22.00	6.69 ± 0.14
December	12 ± 4.90	205 ± 6.75	19.00	6.94 ± 0.09
Jannuary'97	60 ± 22.67	60 ± 6.62	22.50	6.73 ± 0.08
February	75 ± 24.85	100 ± 6.31	28.50	6.91 ± 0.05
March	24 ± 7.75	115 ± 7.56	31.50	6.77 ± 0.10
April	40 ± 14.27	100 ± 8.60	29.00	6.97 ± 0.07
May	46 ± 13.53	125 ± 6.31	34.00	7.19 ± 0.05
June	55 ± 5.78	115 ± 6.81	28.50	6.82 ± 0.08
July	30 ± 5.58	125 ± 6.06	28.00	6.88 ± 0.11
$\bar{x}$	42.50 ± 28.76	132.50 ± 36.60	27.75 ± 3.48	6.88 ± 0.16

Table 7 : Mean value ± SD / sample of total ant population and other soil factors in plot B at East Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	8 ± 8.46	160 ± 10.09	30.00	7.15 ± 0.08
September	8 ± 7.48	95 ± 6.19	29.00	7.06 ± 0.02
October	9 ± 4.98	100 ± 4.63	27.50	6.69 ± 0.10
November	48 ± 21.23	160 ± 4.63	25.00	6.70 ± 0.09
December	1 ± 1.00	140 ± 4.63	22.00	6.93 ± 0.01
Jannuary'96	2 ± 1.55	140 ± 3.77	25.50	6.92 ± 0.05
February	61 ± 26.25	90 ± 4.79	28.00	6.88 ± 0.10
March	18 ± 7.18	70 ± 4.79	30.50	6.86 ± 0.08
April	14 ± 4.58	135 ± 4.79	30.50	7.00 ± 0.04
May	4 ± 2.65	140 ± 10.30	31.00	7.09 ± 0.07
June	43 ± 18.91	150 ± 4.62	28.00	7.00 ± 0.06
July	12 ± 4.60	90 ± 7.54	28.50	6.92 ± 0.10
August	2 ± 1.48	140 ± 4.77	29.00	7.07 ± 0.08
September	38 ± 15.79	135 ± 6.07	29.50	7.02 ± 0.03
October	8 ± 3.38	80 ± 9.39	30.00	7.14 ± 0.10
November	32 ± 12.75	125 ± 7.03	23.00	6.58 ± 0.19
December	34 ± 11.73	90 ± 6.34	19.50	6.87 ± 0.06
Jannuary'97	72 ± 26.09	65 ± 6.62	21.50	6.54 ± 0.13
February	23 ± 9.27	100 ± 6.62	27.00	6.87 ± 0.03
March	25 ± 7.31	50 ± 5.12	31.00	6.83 ± 0.08
April	25 ± 6.13	65 ± 5.91	31.00	6.94 ± 0.04
May	80 ± 25.23	80 ± 5.46	32.00	7.00 ± 0.06
June	60 ± 5.78	160 ± 6.60	28.50	7.03 ± 0.03
July	23 ± 4.27	80 ± 6.56	27.50	6.92 ± 0.05
$\bar{x}$	27.08 ± 22.68	110.00 ± 34.00	27.71 ± 3.93	6.92 ± 0.16

Table 8 : Mean value ± SD / sample of total ant population and other soil factors in plot C at East Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	4 ± 2.97	125 ± 7.47	30.00	6.98 ± 0.03
September	1 ± 1.18	140 ± 6.00	29.50	7.16 ± 0.05
October	28 ± 11.50	70 ± 4.79	28.00	6.80 ± 0.11
November	8 ± 3.55	100 ± 4.79	25.50	6.78 ± 0.12
December	2 ± 1.55	160 ± 4.79	21.50	6.90 ±0.004
January'96	105 ± 44.52	60 ± 4.79	26.50	7.03 ± 0.08
February	7 ± 3.13	130 ± 4.79	28.50	6.97 ± 0.05
March	40 ± 19.05	105 ± 4.79	30.50	6.74 ± 0.04
April	24 ± 11.23	80 ± 4.79	30.50	7.10 ± 0.07
May	3 ± 1.79	130 ± 5.12	30.00	7.13 ± 0.02
June	38 ± 14.46	140 ± 4.77	28.50	6.87 ± 0.03
July	30 ± 10.29	160 ± 4.77	28.50	6.90 ± 0.02
August	65 ± 20.10	60 ± 5.38	29.50	7.08 ± 0.13
September	14 ± 6.03	190 ± 4.79	30.00	7.14 ± 0.09
October	41 ± 16.47	140 ± 7.17	29.00	7.04 ± 0.09
November	43 ± 13.64	90 ± 5.42	22.50	6.75 ± 0.07
December	12 ± 5.04	115 ± 7.25	20.50	6.88 ± 0.04
January'97	21 ± 12.34	180 ± 5.74	22.00	6.80 ± 0.05
February	6 ± 2.64	140 ± 7.39	26.00	6.73 ± 0.15
March	30 ± 8.44	90 ± 5.08	30.50	6.52 ± 0.13
April	12 ± 3.79	115 ± 7.22	31.00	7.06 ± 0.09
May	11 ± 2.05	140 ± 6.62	33.50	7.09 ± 0.07
June	38 ± 6.72	105 ± 6.16	28.00	6.92 ± 0.14
July	18 ± 4.26	150 ± 7.21	27.00	6.79 ± 0.04
$\bar{x}$	25.04 ± 23.21	121.50 ±34.62	27.79 ± 3.25	6.92 ± 0.16

Table 9 : Mean value ± SD / sample of total ant population and other soil factors on an average at East Kolkata site during the study period.

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	4.67 ± 5.82	133.33 ± 22.96	30.00 ± 0.00	7.06 ± 0.07
September	16.00 ± 21.53	130.00 ± 27.18	29.33 ± 0.24	7.11 ± 0.04
October	19.00 ± 11.94	106.67 ± 33.58	28.17 ± 0.62	6.80 ± 0.09
November	31.00 ± 23.29	146.67 ± 34.56	25.17 ± 0.24	6.69 ± 0.08
December	19.33 ± 28.34	170.00 ± 30.10	21.83 ± 0.24	6.95 ± 0.04
January'96	54.00 ± 50.69	123.33 ± 46.82	25.67 ± 0.62	6.94 ± 0.06
February	29.33 ± 28.14	106.67 ± 17.66	27.50 ± 1.08	6.84 ± 0.13
March	35.00 ± 21.73	100.00 ± 23.23	30.67 ± 0.24	6.80 ± 0.05
April	23.00 ± 12.98	110.00 ± 23.23	30.17 ± 0.47	7.02 ± 0.06
May	19.67 ± 24.66	123.33 ± 19.19	30.83 ± 0.62	7.08 ± 0.04
June	48.67 ± 22.27	138.33 ± 11.34	28.33 ± 0.24	6.89 ± 0.08
July	21.33 ± 10.64	121.67 ± 29.56	28.67 ± 0.24	6.89 ± 0.03
August	35.67 ± 29.55	100.00 ± 33.08	29.00 ± 0.41	6.99 ± 0.12
September	67.33 ± 63.30	150.00 ± 29.11	29.83 ± 0.24	7.12 ± 0.07
October	19.67 ± 18.19	126.67 ± 34.80	29.17 ± 0.62	6.95 ± 0.20
November	36.00 ± 13.97	135.00 ± 42.16	22.50 ± 0.41	6.67 ± 0.07
December	19.33 ± 13.03	136.67 ± 49.85	19.67 ± 0.62	6.90 ± 0.03
January'97	51.00 ± 30.38	101.67 ± 55.79	22.00 ± 0.41	6.69 ± 0.11
February	34.67 ± 33.07	113.33 ± 20.04	27.17 ± 1.03	6.84 ± 0.08
March	26.33 ± 8.27	85.00 ± 27.44	31.00 ± 0.41	6.71 ± 0.13
April	25.67 ± 14.70	93.33 ± 22.19	30.33 ± 0.94	6.99 ± 0.05
May	45.67 ± 32.68	115.00 ± 26.22	33.17 ± 0.85	7.09 ± 0.08
June	51.00 ± 11.22	126.67 ± 24.80	28.33 ± 0.24	6.92 ± 0.08
July	23.67 ± 6.93	118.33 ± 29.71	27.50 ± 0.41	6.86 ± 0.05
$\bar{x}$	31.54 ± 14.58	121.32 ± 19.26	27.75 ± 3.29	6.91 ± 0.13

Central Kolkata Site

Plot A : The density of population of ants in this plot was found maximum in the month of January, 1997 which was 100 ± 5.16 and minimum in the month of March, 1997 which was 5 ± 2.64. The mean density of population of ants was found to be 29.96 ± 27.03 throughout the study period. (Table 10)

The concentration of lead (in ppm) of soil of this site was found at its maximum and minimum level in the months of September, 1996 and June, 1997 which were 400 ± 5.73 and 200 ± 7.03 respectively. The mean value of concentration of lead at this plot during 24 months period was found to be 302.71 ± 47.65, which was considerably higher in comparison to the East Kolkata site. (Table 10).

The maximum and minimum temperatures measured from the soil of this plot were 35°C in March, 1996 and 22.5°C in December, 1996; January, 1997. The mean temperature of soil recorded from this site was 29°C ± 3.32. (Table 10).

The pH value of soil at this plot was found maximum in the month of March, 1996 which was 7.15 ± 0.10 and minimum in the month of November, 1995 which was 6.57 ± 0.09. The mean value of pH of soil at this plot was found to be 6.92 ± 0.12. (Table 10).

Plot B : In this plot of Central Kolkata site the density of population of ants was found at its maximum (50 ± 4.54) in the month of June, 1996 and minimum (2 ± 1.18 and 2 ± 1.55) in the months of December of both the years 1995, 1996. The mean density of population of ants per sample was found to be 18.04 ± 14.92. However, no ant could be found in January, 1996. (Table 11).

The concentration of lead (in ppm) in the soil of this plot was found, to be maximum (590 ± 7.50) in March, 1996 and minimum (170 ± 8.69) in the month of February, 1997. The mean concentration of lead in this plot was found to be 248.17 ± 96.40. It is observed that level of maximum concentration of lead in soil is excessively high, in comparison to all other plots in all other sites. (Table 11).

In this plot the temperature of soil was recorded as maximum and minimum in the month of April, 1996 which was 32°C and in January, 1996 and 1997 which was 19.5°C. The mean temperature of the entire study period was found to be 27.29°C ± 3.39. (Table 11).

The pH value of soil samples collected from this plot was found at its highest and lowest levels as 7.14 ± 0.17 and 6.49 ± 0.20 in September, 1996 and March, 1997 respectively. The mean value of this soil pH was found to be 6.87 ± 0.17. (Table 11).

Plot C : Here, in this plot, the population density of ants was found maximum in the month of January, 1996 which was 84 ± 5.04 and minimum in the month of July, 1996 which was 3 ± 1.76. The mean population density of ants in this plot was found to be 24.13 ± 20.55. However, no ant could be found in December, 1995. (Table 12).

The concentration of lead (in ppm) of soil samples was found at its highest level as 400 ± 5.95 in the month of August, 1996 and lowest level as 120 ± 5.73 in the month of September, 1996. The mean concentration of lead at this plot was calculated to be 208.96 ± 63.61. (Table 12).

In the month of April, 1996 and January, 1997 the temperatures of soil were recorded as 32.5°C and 20.5°C respectively, which were the highest and lowest levels throughout the study period. The mean temperature of soil for the entire period of study was found to be 27.5°C ± 3.11. (Table 12).

So far the pH values of soil samples collected from this plot are concerned, the maximum and minimum levels were found to be 7.18 ± 0.05 and 6.66 ± 0.06 in May and June, 1996 respectively. The mean value of soil pH throughout the study period was calculated to be 6.83 ± 0.21. (Table 12).

On an Average of all the plots at Central Kolkata site the density of ants was found at its maximum in the month of January, 1997 (62.33 ± 30.18) and minimum in the month of December, 1995 (2.67 ± 2.97). The mean density of population of ants was found to be 24.04 ± 15.55 for the entire period of study. (Table 13).

The concentration of lead (in ppm) in soil samples at this site on an average was found maximum (375.00 ± 175.66) in the month of March, 1996 and minimum (200.00 ± 49.58) in the month of May, 1997. The mean concentration of lead in the soil samples for the entire period of study and for all the plots at this site was found to be 265.28 ± 52.21. (Table 13).

The temperature of soil recorded on an average in this site was found maximum and minimum as 32°C ± 0.82 and 20.83°C ± 1.25 in April, 1996 and January, 1997. The mean temperature of soil throughout the study period at this site as a whole was measured to be 27.91°C ± 3.09. (Table 13).

The value of pH of soil at this site on an average was found maximum (7.09 ± 0.08) in May, 1996 and minimum (6.63 ± 0.33) in the month of June., 1997. The mean value of pH of soil samples collected from this site on an average throughout the study period including all the plots was calculated to be 6.87 ± 0.14. (Table 13).

North Kolkata Site

Plot A : At North Kolkata site the density of ants was found maximum (80 ± 8.45) in the month of January, 1997 and minimum (3 ± 1.95) in the month of October, 1995. The mean population was found to be 26 ± 16.79. (Table 14).

The concentration of lead (in ppm) at this plot was found maximum in June, 1997 which was 530 ± 6.29 and minimum was found in October, 1996 which was 166 ± 6.34. The mean value of the concentration of lead in the soil of this site was found to be 286.71 ± 84.50. It is observed that the range of the concentration of lead varied very much and the maximum level was excessively high. (Table 14).

Table 10 : Mean value ± SD / sample of total ant population and other soil factors in plot A at Central Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	6 ± 2.23	320 ± 9.69	30.00	6.99 ± 0.07
September	13 ± 3.82	360 ± 7.00	29.00	7.09 ± 0.10
October	18 ± 3.92	340 ± 6.45	28.50	6.83 ± 0.03
November	32 ± 6.02	320 ± 6.07	26.50	6.57 ± 0.09
December	6 ± 2.53	280 ± 4.94	24.00	6.84 ± 0.04
January'96	90 ± 4.52	300 ± 9.15	24.50	6.90 ± 0.09
February	14 ± 3.69	360 ± 6.16	28.50	6.92 ± 0.10
March	16 ± 3.92	375 ± 6.07	35.00	7.15 ± 0.10
April	19 ± 3.10	300 ± 7.06	33.00	7.01 ± 0.02
May	23 ± 3.19	305 ± 8.11	32.00	6.98 ± 0.04
June	24 ± 3.69	240 ± 6.24	26.50	6.81 ± 0.03
July	9 ± 3.00	280 ± 6.88	31.00	6.95 ± 0.01
August	34 ± 6.94	340 ± 8.67	29.00	6.79 ± 0.02
September	15 ± 3.69	400 ± 5.73	32.00	6.98 ± 0.11
October	62 ± 4.77	350 ± 6.42	29.50	6.93 ± 0.08
November	50 ± 6.11	330 ± 5.90	26.00	6.90 ± 0.15
December	20 ± 3.92	260 ± 5.73	22.50	6.78 ± 0.07
January'97	100 ± 5.16	250 ± 7.54	22.50	6.78 ± 0.06
February	10 ± 3.16	245 ± 5.46	31.00	6.89 ± 0.08
March	5 ± 2.64	270 ± 6.75	33.00	6.93 ± 0.12
April	26 ± 3.46	280 ± 7.61	33.00	7.11 ± 0.01
May	37 ± 3.19	260 ± 6.78	30.00	7.06 ± 0.08
June	84 ± 3.90	200 ± 7.03	30.00	6.96 ± 0.09
July	6 ± 2.28	300 ± 8.01	29.00	6.91 ± 0.06
$\bar{x}$	29.96 ± 27.03	302.71 ±47.65	29.00 ± 3.32	6.92 ± 0.12

Table 11 : Mean value ± SD / sample of total ant population and other soil factors in plot B at Central Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	39 ± 6.94	300 ± 7.48	30.50	7.12 ± 0.02
September	5 ± 2.53	300 ± 9.13	29.50	6.99 ± 0.08
October	8 ± 2.61	400 ± 10.53	27.50	6.69 ± 0.13
November	10 ± 3.55	280 ± 10.14	25.00	6.67 ± 0.11
December	2 ± 1.18	200 ± 7.76	23.00	6.76 ± 0.06
January'96	0 ± 0.00	400 ± 9.57	19.50	6.71 ± 0.12
February	11 ± 3.03	450 ± 5.69	28.00	6.93 ± 0.04
March	4 ± 2.45	590 ± 7.50	30.50	6.94 ± 0.07
April	12 ± 3.55	340 ± 6.08	32.00	7.13 ± 0.08
May	21 ± 3.92	360 ± 5.90	30.50	7.10 ± 0.09
June	50 ± 4.54	200 ± 5.88	27.00	6.78 ± 0.05
July	20 ± 4.12	220 ± 6.62	28.50	6.88 ± 0.03
August	5 ± 2.14	300 ± 6.72	29.50	6.85 ± 0.02
September	13 ± 3.55	255 ± 8.01	29.00	7.14 ± 0.17
October	5 ± 1.89	280 ± 5.88	27.50	6.77 ± 0.13
November	8 ± 2.83	240 ± 11.83	22.00	6.70 ± 0.09
December	2 ± 1.55	220 ± 6.46	23.50	6.80 ± 0.02
January'97	27 ± 4.22	230 ± 7.13	19.50	6.71 ± 0.08
February	19 ± 3.10	170 ± 8.69	31.00	7.00 ± 0.02
March	48 ± 4.02	225 ± 5.64	28.00	6.49 ± 0.20
April	25 ± 3.10	230 ± 7.27	27.50	6.95 ± 0.03
May	21 ± 4.00	200 ± 7.39	28.50	7.00 ± 0.01
June	43 ± 3.66	190 ± 7.27	28.00	6.76 ± 0.25
July	35 ± 3.95	240 ± 7.72	29.50	6.95 ± 0.04
$\bar{x}$	18.04 ± 14.92	284.17 ± 96.40	27.29 ± 3.39	6.87 ± 0.17

Table 12 : Mean value ± SD / sample of total ant population and other soil factors in plot C at Central Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	32 ± 5.73	280 ± 11.99	31.00	7.10 ± 0.09
September	9 ± 4.17	185 ± 9.87	29.00	7.04 ± 0.04
October	13 ± 4.12	260 ± 8.76	28.00	6.78 ± 0.07
November	15 ± 4.17	160 ± 5.78	26.00	6.74 ± 0.05
December	0 ± 0.00	200 ± 8.81	22.50	6.80 ± 0.02
January'96	84 ± 5.04	180 ± 5.12	22.50	6.77 ± 0.07
February	8 ± 2.32	300 ± 6.08	26.50	6.98 ± 0.02
March	8 ± 3.79	160 ± 5.14	29.00	6.88 ± 0.06
April	14 ± 3.32	200 ± 6.39	32.50	7.09 ± 0.02
May	10 ± 2.76	320 ± 6.40	31.00	7.18 ± 0.05
June	62 ± 3.85	185 ± 6.28	27.50	6.66 ± 0.06
July	3 ± 1.76	160 ± 5.78	29.00	6.85 ± 0.05
August	20 ± 3.69	400 ± 5.95	28.00	6.81 ± 0.07
September	14 ± 3.95	120 ± 5.73	31.00	6.61 ± 0.07
October	50 ± 4.12	170 ± 6.26	28.00	6.80 ± 0.10
November	25 ± 4.17	200 ± 11.32	24.50	6.61 ± 0.18
December	30 ± 4.12	155 ± 6.10	22.00	6.85 ± 0.03
January'97	60 ± 3.85	160 ± 6.75	20.50	6.83 ± 0.04
February	10 ± 4.52	200 ± 7.27	27.00	6.84 ± 0.03
March	6 ± 3.16	215 ± 5.95	31.00	6.60 ± 0.16
April	25 ± 3.95	200 ± 7.20	27.00	6.98 ± 0.09
May	34 ± 3.46	140 ± 8.70	27.50	6.97 ± 0.05
June	20 ± 2.64	265 ± 6.48	29.00	6.17 ± 0.22
July	27 ± 2.97	200 ± 7.27	30.00	7.00 ± 0.01
$\bar{x}$	24.13 ± 20.55	208.96 ± 63.61	27.50 ± 3.11	6.83 ± 0.21

Table 13 : Mean value ± SD / sample of total ant population and other soil factors on an average at Central Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	25.67 ± 15.17	300.00 ± 19.09	30.50 ± 0.41	7.07 ± 0.06
September	9.00 ± 4.84	281.67 ± 73.13	29.17 ± 0.24	7.04 ± 0.04
October	13.00 ± 5.45	333.33 ± 58.01	28.00 ± 0.41	6.77 ± 0.06
November	19.00 ± 10.52	253.33 ± 68.41	25.83 ± 0.62	6.66 ± 0.07
December	2.67 ± 2.97	226.67 ± 38.42	23.17 ± 0.62	6.80 ± 0.03
January'96	58.00 ± 41.27	293.33 ± 90.31	22.17 ± 2.05	6.79 ± 0.08
February	11.00 ± 3.92	370.00 ± 61.93	27.67 ± 0.85	6.94 ± 0.02
March	9.33 ± 6.07	375.00 ±175.66	31.50 ± 2.55	6.99 ± 0.11
April	15.00 ± 4.44	280.00 ± 59.24	32.00 ± 0.82	7.07 ± 0.05
May	18.00 ± 6.61	328.33 ± 24.21	31.17 ± 0.62	7.09 ± 0.08
June	45.33 ± 16.37	208.33 ± 24.01	27.00 ± 0.41	6.75 ± 0.06
July	10.67 ± 7.69	220.00 ± 49.41	29.50 ± 1.08	6.89 ± 0.04
August	19.67 ± 12.74	346.67 ± 41.72	28.83 ± 0.62	6.82 ± 0.02
September	14.00 ± 3.82	258.33 ±114.52	30.67 ± 1.25	6.91 ± 0.22
October	39.00 ± 24.83	266.67 ± 74.34	28.33 ± 0.85	6.83 ± 0.07
November	27.67 ± 17.85	256.67 ± 55.29	24.17 ± 1.65	6.74 ± 0.12
December	17.33 ± 12.07	211.67 ± 43.70	22.67 ± 0.62	6.81 ± 0.03
January'97	62.33 ± 30.18	213.33 ± 39.24	20.83 ± 1.25	6.77 ± 0.05
February	13.00 ± 5.60	205.00 ± 31.66	29.67 ± 1.89	6.91 ± 0.06
March	19.67 ± 20.31	236.67 ± 24.69	30.67 ± 2.05	6.67 ± 0.18
April	25.33 ± 3.55	236.67 ± 33.81	29.17 ± 2.72	7.01 ± 0.07
May	30.67 ± 7.81	200.00 ± 49.58	28.67 ± 1.03	7.01 ± 0.04
June	49.00 ± 26.70	218.33 ± 33.96	29.00 ± 0.82	6.63 ± 0.33
July	22.67 ± 12.63	246.67 ± 41.81	29.50 ± 0.41	6.95 ± 0.03
$\bar{x}$	24.04 ± 15.55	265.28 ± 52.21	27.91 ± 3.09	6.87 ± 0.14

The maximum and minimum temperatures of soil were recorded as 33.5°C and 19°C in May, 1996 and December, 1996. The mean temperature of soil of this plot was found to be 27.81°C ± 3.75 (Table 14).

The pH value of soil was at its maximum (7.14 ± 0.11) in the month of January, 1997 and minimum (6.81 ± 0.05) in the month of July, 1996. The mean value of pH of soil collected throughout the study period was calculated to be 6.96 ± 0.10 (Table 14).

Plot B : The population density of ants was found maximum in the month of December, 1996 which was 42 ± 5.21 and minimum in the month of September, 1995 which was 4 ± 2.49. The mean density of population was found to be 19.13 ± 10.90 (Table 15).

In this plot the concentration of lead (in ppm) of soil sample found to be at its highest and lowest level in the months of September, 1996 and December, 1996 which were 471 ± 7.68 and 140 ± 4.88 respectively. The mean value of concentration of lead of soil throughout the study period was found to be 286.80 ± 74.16 (Table 15).

The temperature recorded as maximum and minimum throughout the 24 months were 32.5°C in both the months of May of 1996 and 1997 and 19.5°C in the month of December, 1996. The mean temperature of soil at this plot was found to be 27.52 °C ± 3.61 (Table 15).

The value of pH of the soil was found maximum (7.13 ± 0.11) in April, 1996 and minimum (6.77 ± 0.09) in July, 1996. The mean value of pH of soil throughout the study period was calculated to be 6.91 ± 0.10 (Table 15).

Plot C : The maximum (60 ± 4.60) and minimum (8 ± 3.77) density of population of ants were found at this plot in the month of December, 1996 and October, 1995. The mean population density of ants was found to be 22.42 ± 13.71. No ant could be found, however, in September, 1995 (Table 16).

The maximum and minimum concentration of lead (in ppm) of soil were 495 ± 10.35 and 180 ± 6.57 found in the month of June, 1997 and August, 1995 respectively. The mean concentration of lead in soil throughout the 24 months period was found to be 322.28 ± 89.42 (Table 16).

In this plot the maximum temperature of soil recorded was 33°C in the month of May, 1996 and minimum was 20°C in the month of January, 1997. The mean temperature of soil throughout 24 months period was found to be 27.71 ± 3.73 (Table 16).

The pH value of soil was found at its maximum level in May, 1997 which was 7.13 ± 0.15 and minimum in the month of November, 1995 which was 6.71 ± 0.07. The mean value of pH of soil samples throughout the study period was found to be 6.92 ± 0.12 (Table 16).

On an average the population density of ants in this site including all the plots was found maximum (43.33 ± 26.71) in the month of January, 1997 and minimum (9.00 ± 6.57) in the month of October, 1995. The mean density of ants was found to be 22.51 ± 7.95 (Table 17).

The concentration of lead (in ppm) in the soil sample in this site on an average was found maximum as 403.33 ± 155.24 in June, 1997 and minimum as 220.00 ± 43.67 in the month of February, 1997. The mean value of concentration of lead in this site on an average including all the plots was found to be 298.57 ± 43.79 (Table 17).

The temperature of soil on an average in this site including all the plots was found maximum in the month of May, 1996 (33.00 °C ± 0.41), and minimum in the month of December, 1996 (19.83 °C ± 0.85). The mean temperature of soil recorded throughout the two year period was found to be 27.69°C ± 3.63 (Table 17).

The pH value of soil sample at this site on an average was found at its maximum level (7.06 ± 0.06 and 7.06 ± 0.08) in May, 1996 and January, 1997; while the minimum level (6.77 ± 0.05) in November, 1995. The mean value of pH of soil at this site on an average including all the plots was found to be 6.93 ± 0.09 (Table 17).

South Kolkata site

Plot A : In this plot of South Kolkata site the density of population of ants was found maximum in February, 1996 which was 75 ± 4.69 and minimum in September, 1995 which was 2 ± 1.55. The mean density of population of ants throughout the study period was found to be 28.50 ± 19.38 (Table 18).

So far the concentration of lead (in ppm) is concerned, it was found that 330 ± 12.26 in December, 1996 and 135 ± 7.68 in March, 1997 were the maximum and minimum levels. The mean concentration of lead at this site throughout 24 months was found to be 203.38 ± 52.03 (Table 18).

The temperature of soil was recorded maximum in the month of May, 1996 which was 34°C and minimum in the month of December, 1996 and January, 1997 which was 19.5°C. The mean temperature of soil throughout the study period was found to be 27.23 ± 3.86°C (Table 18).

The value of pH of soil sample of this plot was found to be 7.07 ± 0.06 as highest in September, 1995 and 6.49 ± 0.13 as lowest in June, 1997. The mean value of pH of soil samples collected throughout the study period was found to be 6.84 ± 0.16 (Table 18).

Plot B : The population density of ants per sample was found maximum (85 ± 9.63) in June, 1997 and minimum (1 ± 1.00) in February, 1996. The mean population density of ants throughout two years was found to be 25.13 ± 22.03. It is also observed that in September 1995 and April 1997 no ant could be recorded in the soil (Table 19).

The concentration of lead (in ppm) in the soil was found maximum (300 ± 9.64) in September, 1995 and minimum (80 ± 8.85) in March, 1997. The mean concentration of lead in the soil at this plot was found to be 138.33 ± 45.06 (Table 19).

Table 14 : Mean value ± SD / sample of total ant population and other soil factors in plot A at North Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	7 ± 3.29	325 ± 18.87	29.50	6.88 ± 0.07
September	48 ± 5.76	173 ± 9.13	29.50	6.90 ± 0.04
October	3 ± 1.95	227 ± 6.03	27.50	7.00 ± 0.01
November	11 ± 5.38	428 ± 8.14	25.00	6.83 ± 0.04
December	25 ± 6.62	357 ± 6.62	21.00	6.84 ± 0.04
January'96	35 ± 5.46	340 ± 7.08	24.00	7.07 ± 0.08
February	50 ± 6.46	290 ± 6.46	28.50	7.00 ± 0.02
March	27 ± 5.42	220 ± 6.03	32.00	7.05 ± 0.07
April	13 ± 4.10	250 ± 5.49	32.00	7.00 ± 0.02
May	28 ± 6.10	178 ± 5.49	33.50	7.13 ± 0.09
June	40 ± 4.00	290 ± 2.27	28.00	6.91 ± 0.06
July	19 ± 5.48	201 ± 2.29	27.50	6.81 ± 0.05
August	31 ± 5.53	198 ± 6.05	29.00	6.83 ± 0.06
September	18 ± 5.53	348 ± 6.77	30.00	6.93 ± 0.02
October	30 ± 4.90	166 ± 6.34	29.00	6.83 ± 0.03
November	33 ± 5.36	220 ± 6.05	25.50	6.87 ± 0.07
December	6 ± 2.57	260 ± 6.29	19.00	6.93 ± 0.04
January'97	80 ± 8.45	285 ± 5.81	22.00	7.14 ± 0.11
February	37 ± 5.93	280 ± 6.29	23.50	7.03 ± 0.05
March	12 ± 5.12	285 ± 10.19	31.00	7.09 ± 0.14
April	20 ± 5.23	330 ± 8.92	31.50	7.05 ± 0.08
May	15 ± 5.73	360 ± 5.80	33.00	7.07 ± 0.10
June	15 ± 4.86	530 ± 6.29	28.50	6.85 ± 0.09
July	21 ± 6.42	340 ± 5.12	27.50	6.89 ± 0.05
$\bar{x}$	26.00 ± 16.79	286.71 ± 84.50	27.81 ± 3.75	6.96 ± 0.10

Table 15 : Mean value ± SD / sample of total ant population and other soil factors in plot B at North Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	41 ± 5.29	212 ± 6.10	30.50	6.91 ± 0.08
September	4 ± 2.49	319 ± 4.65	28.00	6.81 ± 0.06
October	16 ± 5.06	373 ± 5.66	29.00	6.84 ± 0.04
November	35 ± 5.90	279 ± 5.06	25.00	6.78 ± 0.09
December	15 ± 5.02	344 ± 4.71	21.50	6.79 ± 0.05
January'96	15 ± 6.78	300 ± 4.96	24.50	6.95 ± 0.02
February	10 ± 4.15	368 ± 5.02	29.00	6.93 ± 0.04
March	12 ± 4.19	291 ± 5.10	31.00	6.86 ± 0.09
April	35 ± 5.36	183 ± 5.16	31.50	7.13 ± 0.11
May	5 ± 2.45	268 ± 5.14	32.50	6.97 ± 0.03
June	20 ± 4.00	287 ± 5.65	29.50	6.98 ± 0.02
July	14 ± 3.52	319 ± 7.11	26.00	6.77 ± 0.09
August	10 ± 4.00	378 ± 5.88	28.00	6.93 ± 0.04
September	7 ± 3.19	471 ± 7.68	30.50	6.98 ± 0.04
October	24 ± 4.40	315 ± 5.58	28.50	6.88 ± 0.05
November	18 ± 4.77	301 ± 5.29	24.00	6.75 ± 0.09
December	42 ± 5.21	140 ± 4.88	19.50	6.88 ± 0.03
January'97	25 ± 3.22	305 ± 6.52	21.50	7.10 ± 0.08
February	20 ± 4.86	180 ± 7.20	22.00	6.98 ± 0.02
March	8 ± 3.19	305 ± 7.40	29.00	6.86 ± 0.09
April	15 ± 4.12	300 ± 6.18	29.00	7.01 ± 0.01
May	30 ± 4.96	260 ± 5.81	32.50	6.85 ± 0.04
June	10 ± 3.74	185 ± 5.85	30.00	7.01 ± 0.03
July	28 ± 5.08	200 ± 5.00	28.00	6.85 ± 0.06
$\bar{x}$	19.13 ± 10.90	286.80 ± 74.16	27.52 ± 3.61	6.91 ± 0.01

Table 16 : Mean value ± SD / sample of total ant population and other soil factors in plot C at North Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	17 ± 4.02	180 ± 6.57	30.00	6.98 ± 0.02
September	0 ± 0.00	410 ± 9.11	30.00	6.98 ± 0.02
October	8 ± 3.77	395 ± 13.12	28.00	6.80 ± 0.03
November	14 ± 4.07	255 ± 6.24	24.50	6.71 ± 0.07
December	42 ± 4.43	200 ± 5.60	20.50	6.75 ± 0.05
January'96	55 ± 4.15	220 ± 13.56	23.00	7.11 ± 0.10
February	16 ± 3.95	310 ± 9.42	28.50	6.89 ± 0.07
March	20 ± 5.06	270 ± 4.84	31.50	7.01 ± 0.03
April	18 ± 6.88	298 ± 6.60	31.00	7.02 ± 0.07
May	12 ± 3.69	364 ± 6.71	33.00	7.08 ± 0.10
June	30 ± 4.67	372 ± 6.05	31.00	6.89 ± 0.04
July	18 ± 4.51	394 ± 9.55	28.00	6.83 ± 0.07
August	9 ± 3.52	438 ± 6.66	29.00	6.98 ± 0.03
September	20 ± 3.92	284 ± 6.20	30.50	6.91 ± 0.06
October	13 ± 3.92	343 ± 6.21	28.00	6.90 ± 0.02
November	27 ± 4.73	280 ± 5.62	26.00	6.78 ± 0.10
December	60 ± 4.60	355 ± 6.78	21.00	6.79 ± 0.07
January'97	25 ± 6.48	455 ± 7.13	20.00	6.94 ± 0.04
February	35 ± 4.94	200 ± 5.51	22.50	6.93 ± 0.04
March	15 ± 4.69	455 ± 6.56	30.00	7.07 ± 0.07
April	28 ± 4.02	300 ± 5.20	29.50	7.10 ± 0.13
May	19 ± 3.71	240 ± 5.73	31.50	7.13 ± 0.15
June	20 ± 4.45	495 ± 10.35	30.50	6.79 ± 0.05
July	17 ± 4.56	220 ± 5.20	27.50	6.81 ± 0.03
$\bar{x}$	22.42 ± 13.71	322.28 ± 89.42	27.71 ± 3.73	6.92 ± 0.12

Table 17 : Mean value ± SD / sample of total ant population and Sother soil factors on an average at North Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	21.67 ± 14.89	239.00 ± 63.36	30.00 ± 0.41	6.92 ± 0.04
September	17.33 ± 22.04	300.67 ± 97.94	29.17 ± 0.85	6.89 ± 0.07
October	9.00 ± 6.57	331.67 ± 75.09	28.17 ± 0.62	6.88 ± 0.08
November	20.00 ± 11.86	320.67 ± 76.81	24.83 ± 0.24	6.77 ± 0.05
December	27.33 ± 12.40	300.33 ± 71.37	21.00 ± 0.41	6.79 ± 0.04
January'96	35.00 ± 17.25	286.67 ± 50.74	23.83 ± 0.62	7.04 ± 0.07
February	25.33 ± 18.30	322.67 ± 33.85	28.67 ± 0.24	6.94 ± 0.04
March	19.67 ± 7.85	260.33 ± 30.26	31.50 ± 0.41	6.97 ± 0.08
April	22.00 ± 10.94	243.67 ± 47.51	31.50 ± 0.41	7.05 ± 0.06
May	15.00 ± 10.56	270.00 ± 76.17	33.00 ± 0.41	7.06 ± 0.06
June	30.00 ± 9.20	316.33 ± 39.79	29.50 ± 1.22	6.93 ± 0.04
July	17.00 ± 5.06	304.67 ± 79.80	27.17 ± 0.85	6.80 ± 0.02
August	16.67 ± 11.07	338.00 ±102.17	28.67 ± 0.47	6.91 ± 0.06
September	15.00 ± 7.17	367.67 ± 77.90	30.33 ± 0.24	6.95 ± 0.03
October	22.33 ± 8.31	274.67 ± 77.92	28.50 ± 0.41	6.87 ± 0.03
November	26.00 ± 7.91	267.00 ± 34.79	25.17 ± 0.85	6.80 ± 0.05
December	36.00 ± 22.85	251.67 ± 88.18	19.83 ± 0.85	6.87 ± 0.06
January'97	43.33 ± 26.71	348.33 ± 76.14	21.17 ± 0.85	7.06 ± 0.08
February	30.67 ± 9.23	220.00 ± 43.67	22.67 ± 0.62	6.98 ± 0.04
March	11.67 ± 5.26	348.33 ± 76.31	30.00 ± 0.82	7.00 ± 0.10
April	21.00 ± 6.99	310.00 ± 15.76	30.00 ± 1.08	7.05 ± 0.03
May	21.33 ± 8.00	286.67 ± 52.81	32.33 ± 0.62	7.02 ± 0.12
June	15.00 ± 5.98	403.33 ±155.22	29.67 ± 0.85	6.88 ± 0.09
July	22.00 ± 7.06	253.33 ± 62.03	27.67 ± 0.24	6.85 ± 0.03
$\bar{x}$	22.51 ± 7.95	298.57 ± 43.79	27.69 ± 3.63	6.93 ± 0.09

The maximum and minimum temperatures of soil were recorded 33.5°C and 18°C in March, 1997 and January, 1997 respectively. The mean temperature of soil throughout two years of investigation was found to be 27.38°C ± 3.64 (Table 19).

The maximum and minimum pH of soil at this plot were 7.20 ± 0.17 and 6.03 ± 0.11 in December, 1996 and March, 1997 respectively. The mean value of pH throughout two years of investigation was found to be 6.87 ± 0.23. The range of pH value was found very wide in this plot (Table 19).

Plot C : The maximum (75 ± 6.08) and minimum (3 ± 1.90) density of population of ants were found in February, 1997 and in June, 1997. The mean population density of ants per soil sample throughout 24 months was found to be 21.50 ± 18.81. However, no ant could be recorded in November, 1995 (Table 20).

The concentration of lead (in ppm) in the soil of this plot was found maximum in the month of June, 1997 which was 135 ± 7.13 and minimum in the month of August, 1995 and March, 1997 which were 75 ± 6.77 and 75 ± 6.98 respectively. The mean concentration of lead in soil was found to be 99.58 ± 17.19 (Table 20).

The temperature of soil was found maximum in May, 1996 which was 33.5°C and minimum in December, 1996 which was 19°C respectively. The mean temperature of soil was found to be 27.21°C ± 3.59 (Table 20).

The values of pH of soil of this plot were found at their maximum and minimum levels in September, 1996 and in March, 1997 as 7.35 ± 0.19 and 5.88 ± 0.21 respectively. The mean value of pH of soil in this plot was found to be 6.85 ± 0.27 (Table 20).

On an average in this site, including all the plots, the density of ant population was found maximum (46.00 ± 22.53 and 46.00 ± 34.18) in both the months of January, 1996 and June, 1997. And minimum was 2.67 ± 3.00 in the month of September, 1995. The mean population density of ants was found to be 25.04 ± 11.32 (Table 21).

On an average in this site the concentration of lead (in ppm) of soil was found at its maximum level in (206.67 ± 83.02 and 206.67 ± 84.31) both the months of September, 1995 and December, 1995 respectively. While the minimum was 96.67 ± 28.30 in March, 1997. The mean concentration of lead in soil of this site on an average including all the plots was found to be 147.10 ± 28.42 (Table 21).

On an average the maximum and minimum temperatures in this site were recorded 33.17°C ± 0.85 and 20°C ± 1.87 in the month of May, 1996 and January, 1997 respectively. The mean temperature of soil in this site on an average including all the plots was found to be 27.27°C ± 3.62 (Table 21).

The value of pH of soil in this site, on an average, including all the plots was found at its highest in September, 1996 which was 7.13 ± 0.17 and lowest level in March, 1997 which was 6.15 ± 0.28. The mean value of pH of soil at this site, on an average, was found to be 6.85 ± 0.21 (Table 21).

Table 18 : Mean value ± SD / sample of total ant population and other soil factors in plot A at South Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	32 ± 5.85	170 ± 12.00	29.50	7.01 ± 0.01
September	2 ± 1.55	220 ± 16.22	29.00	7.07 ± 0.06
October	27 ± 5.44	180 ± 11.08	28.00	6.87 ± 0.11
November	4 ± 2.32	260 ± 11.23	25.00	6.78 ± 0.04
December	14 ± 4.12	320 ± 10.13	21.00	7.00 ± 0.02
January'96	65 ± 4.88	200 ± 10.32	23.50	6.82 ± 0.08
February	75 ± 4.69	160 ± 7.71	25.00	6.78 ± 0.05
March	45 ± 6.53	200 ± 10.26	28.00	6.94 ± 0.13
April	60 ± 4.58	230 ± 9.81	31.00	7.00 ± 0.01
May	7 ± 2.45	260 ± 10.57	34.00	7.05 ± 0.03
June	28 ± 4.22	200 ± 12.87	28.00	6.60 ± 0.15
July	26 ± 4.00	176 ± 10.05	27.00	6.69 ± 0.12
August	34 ± 4.29	170 ± 10.46	28.50	6.89 ± 0.03
September	20 ± 4.52	145 ± 9.67	31.00	6.92 ± 0.04
October	25 ± 3.66	160 ± 5.25	29.00	6.91 ± 0.05
November	10 ± 3.95	240 ± 7.00	28.00	6.85 ± 0.02
December	6 ± 2.83	330 ± 12.26	19.50	6.96 ± 0.04
January'97	7 ± 2.32	170 ± 11.80	19.50	6.61 ± 0.11
February	21 ± 3.79	150 ± 7.56	21.00	6.71 ± 0.05
March	27 ± 4.29	135 ± 7.68	33.00	6.54 ± 0.15
April	20 ± 4.88	140 ± 9.35	30.00	6.97 ± 0.02
May	39 ± 3.74	200 ± 9.81	29.50	6.95 ± 0.04
June	50 ± 4.77	205 ± 12.16	28.50	6.49 ± 0.13
July	40 ± 4.67	260 ± 9.55	27.00	6.78 ± 0.05
$\bar{x}$	28.50 ± 19.38	203.38 ± 52.03	27.23 ± 3.86	6.84 ± 0.16

Table 19 : Mean value ± SD / sample of total ant population and other soil factors in plot B at South Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	18 ± 3.43	120 ± 14.63	29.50	6.93 ± 0.05
September	0 ± 0	300 ± 9.64	28.50	7.13 ± 0.09
October	12 ± 4.02	200 ± 13.55	28.50	6.91 ± 0.06
November	5 ± 2.37	140 ± 6.81	26.00	6.73 ± 0.09
December	20 ± 4.49	180 ± 9.68	22.00	7.06 ± 0.01
January'96	58 ± 4.17	120 ± 10.47	24.00	6.85 ± 0.03
February	1 ± 1.00	140 ± 7.17	27.50	6.75 ± 0.04
March	26 ± 6.98	160 ± 8.21	29.00	6.68 ± 0.08
April	28 ± 4.45	130 ± 8.82	30.50	7.07 ± 0.05
May	8 ± 2.79	200 ± 9.37	32.00	7.18 ± 0.11
June	33 ± 4.96	100 ± 8.15	28.50	6.85 ± 0.07
July	15 ± 4.02	120 ± 9.05	27.50	6.90 ± 0.06
August	10 ± 4.31	140 ± 7.83	29.00	6.93 ± 0.04
September	28 ± 3.90	110 ± 10.69	29.00	7.11 ± 0.10
October	3 ± 1.61	120 ± 9.05	31.00	6.99 ± 0.01
November	70 ± 5.06	100 ± 10.24	27.50	6.75 ± 0.07
December	30 ± 3.79	140 ± 8.65	22.50	7.20 ± 0.17
January'97	50 ± 4.56	140 ± 10.64	18.00	6.66 ± 0.10
February	8 ± 3.19	140 ± 7.24	19.50	6.68 ± 0.07
March	43 ± 4.33	80 ± 8.85	33.50	6.03 ± 0.11
April	0 ± 0.00	90 ± 9.18	29.00	6.91 ± 0.04
May	29 ± 4.10	130 ± 8.28	28.00	6.90 ± 0.05
June	85 ± 9.63	100 ± 11.06	28.50	6.80 ± 0.07
July	23 ± 4.77	120 ± 9.16	28.00	6.85 ± 0.02
$\bar{x}$	25.13 ± 22.03	138.33 ± 45.06	27.38 ± 3.64	6.87 ± 0.23

Table 20 : Mean value ± SD / sample of total ant population and other soil factors in plot C at South Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	7 ± 2.90	75 ± 6.77	29.50	6.98 ± 0.03
September	6 ± 2.45	100 ± 7.31	28.50	7.03 ± 0.03
October	5 ± 2.61	80 ± 8.74	29.00	6.95 ± 0.02
November	0 ± 0.00	130 ± 7.65	24.00	6.68 ± 0.12
December	9 ± 3.40	120 ± 7.97	21.50	7.11 ± 0.07
January'96	15 ± 3.92	100 ± 7.00	24.50	6.95 ± 0.02
February	19 ± 3.69	100 ± 8.47	26.50	6.70 ± 0.07
March	19 ± 5.69	90 ± 7.47	28.50	6.59 ± 0.20
April	11 ± 3.97	100 ± 10.46	31.50	7.13 ± 0.08
May	41 ± 4.86	80 ± 9.12	33.50	7.12 ± 0.07
June	65 ± 4.49	120 ± 8.51	27.00	6.65 ± 0.09
July	14 ± 4.29	100 ± 8.48	28.00	6.83 ± 0.05
August	18 ± 4.07	100 ± 12.29	28.00	6.96 ± 0.06
September	25 ± 5.08	85 ± 6.51	29.00	7.35 ± 0.19
October	13 ± 3.97	90 ± 8.75	31.00	6.98 ± 0.04
November	20 ± 5.10	80 ± 9.41	26.50	6.71 ± 0.05
December	15 ± 4.88	120 ± 10.50	19.00	7.07 ± 0.08
January'97	30 ± 5.27	100 ± 8.94	22.50	6.81 ± 0.09
February	75 ± 6.08	80 ± 7.60	20.00	6.75 ± 0.04
March	21 ± 3.55	75 ± 6.98	31.50	5.88 ± 0.21
April	54 ± 4.90	110 ± 7.33	29.50	6.90 ± 0.03
May	23 ± 4.09	100 ± 11.50	28.50	6.85 ± 0.03
June	3 ± 1.90	135 ± 7.13	28.50	6.60 ± 0.08
July	8 ± 3.10	120 ± 6.35	27.00	6.83 ± 0.04
$\bar{x}$	21.50 ± 18.81	99.58 ± 17.19	27.21 ± 3.59	6.85 ± 0.27

Table 21 : Mean value ± SD / sample of total ant population and other soil factors on an average at South Kolkata site during the study period

Month	Population	Lead (ppm)	Temperature (°C)	pH
August'95	19.00 ± 11.08	121.66 ± 40.50	29.50 ± 0.00	6.97 ± 0.03
September	2.67 ± 3.00	206.67 ± 83.02	28.67 ± 0.24	7.08 ± 0.04
October	14.67 ± 10.09	153.33 ± 53.69	28.50 ± 0.41	6.91 ± 0.03
November	3.00 ± 2.89	176.67 ± 59.71	25.00 ± 0.82	6.73 ± 0.04
December	14.33 ± 6.04	206.67 ± 84.31	21.50 ± 0.41	7.06 ± 0.04
January'96	46.00 ± 22.53	140.00 ± 44.21	24.00 ± 0.41	6.87 ± 0.05
February	31.67 ± 31.70	133.33 ± 26.13	26.33 ± 0.03	6.74 ± 0.03
March	30.00 ± 12.72	150.00 ± 46.29	28.50 ± 0.41	6.74' ± 0.15
April	33.00 ± 20.77	153.33 ± 56.42	31.00 ± 0.41	7.06 ± 0.05
May	18.67 ± 16.19	180.00 ± 75.46	33.17 ± 0.85	7.12 ± 0.05
June	42.00 ± 17.01	140.00 ± 44.36	27.83 ± 0.62	6.70 ± 0.11
July	18.33 ± 6.81	132.00 ± 33.46	27.50 ± 0.41	6.81 ± 0.09
August	20.67 ± 10.84	136.67 ± 30.49	28.50 ± 0.41	6.93 ± 0.03
September	24.33 ± 5.56	113.33 ± 26.25	29.67 ± 0.94	7.13 ± 0.17
October	13.67 ± 9.56	123.33 ± 29.74	30.33 ± 0.94	6.96 ± 0.03
November	33.33 ± 26.67	140.00 ± 71.74	27.33 ± 0.62	6.77 ± 0.06
December	17.00 ± 10.65	196.67 ± 95.22	20.33 ± 1.55	7.08 ± 0.09
January'97	29.00 ± 18.07	136.67 ± 30.54	20.00 ± 1.87	6.69 ± 0.08
February	34.67 ± 29.36	123.33 ± 31.80	20.17 ± 0.62	6.71 ± 0.03
March	30.33 ± 10.14	96.67 ± 28.30	32.67 ± 0.85	6.15 ± 0.28
April	24.67 ± 22.64	113.33 ± 22.30	29.50 ± 0.41	6.93 ± 0.03
May	30.33 ± 7.71	143.33 ± 43.06	28.67 ± 0.62	6.90 ± 0.04
June	46.00 ± 34.18	146.67 ± 44.86	28.50 ± 0.00	6.63 ± 0.13
July	23.67 ± 13.75	166.67 ± 66.53	27.33 ± 0.47	6.82 ± 0.03
$\bar{x}$	25.04 ± 11.32	147.10 ± 28.42	27.27 ± 3.62	6.85 ± 0.21

D. COMPARATIVE STUDY

Plotwise comparative study at each site of the monthly variations of population of ants and concentration of soil factors revealed the following :

East Kolkata Site

Comparison of population density of ants per soil sample revealed that seasonal fluctuation of ant population were more or less same in all these plots. However, density was somewhat high in plot A. Two high peaks of population density were found, one in plot C in the month of January, 1996 and the other in plot A in the month of September, 1996 which was found abnormally high (Fig. 31).

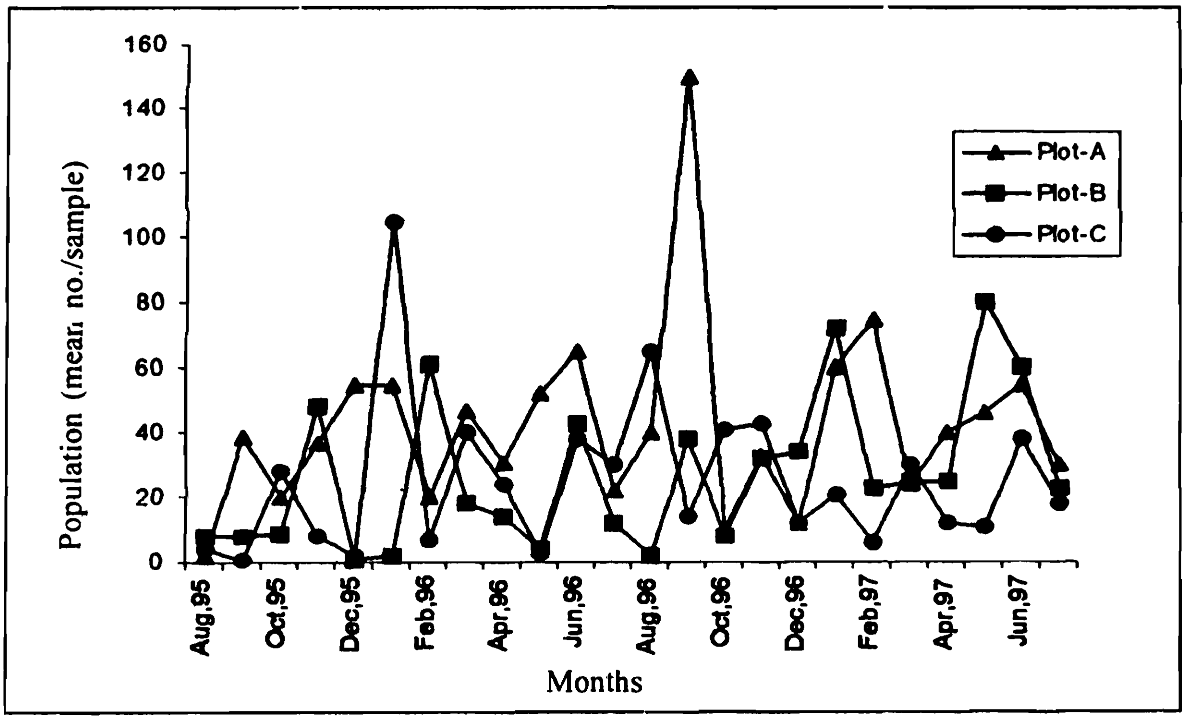


Fig. 31 : Seasonal fluctuation of population density of ants at three plots of East Kolkata site

Concentration of lead was found to (Fig. 32) have sharp fluctuations at plot C in comparison to other plots. Higher concentration of lead was observed during winter in all the plots, with a very clear winter peak at plot A. A gradual inclination and declination could be seen only in plot A.

The variation of soil temperature was seen almost similar with a definite pattern in all the three plots. The highest was noticed in the month of May and the lowest in the month of December. It was also found that extreme values of temperature in all the plots were more during the year 1996-'97 than the preceeding year (Fig. 33).

The variation of level of pH of soil at three plots at this site was found somewhat similar with very few exceptions. The highest peak was noticed in the month of September, 1996

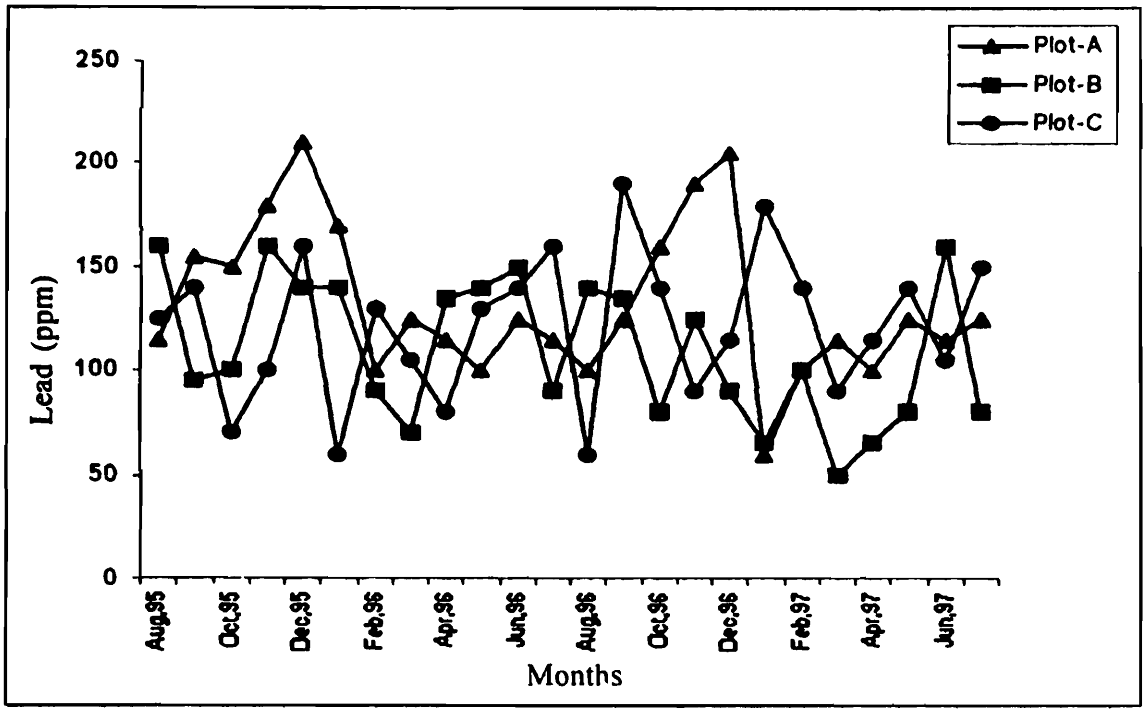


Fig. 32 : Monthwise concentration of lead in soil at three plots of East Kolkata site

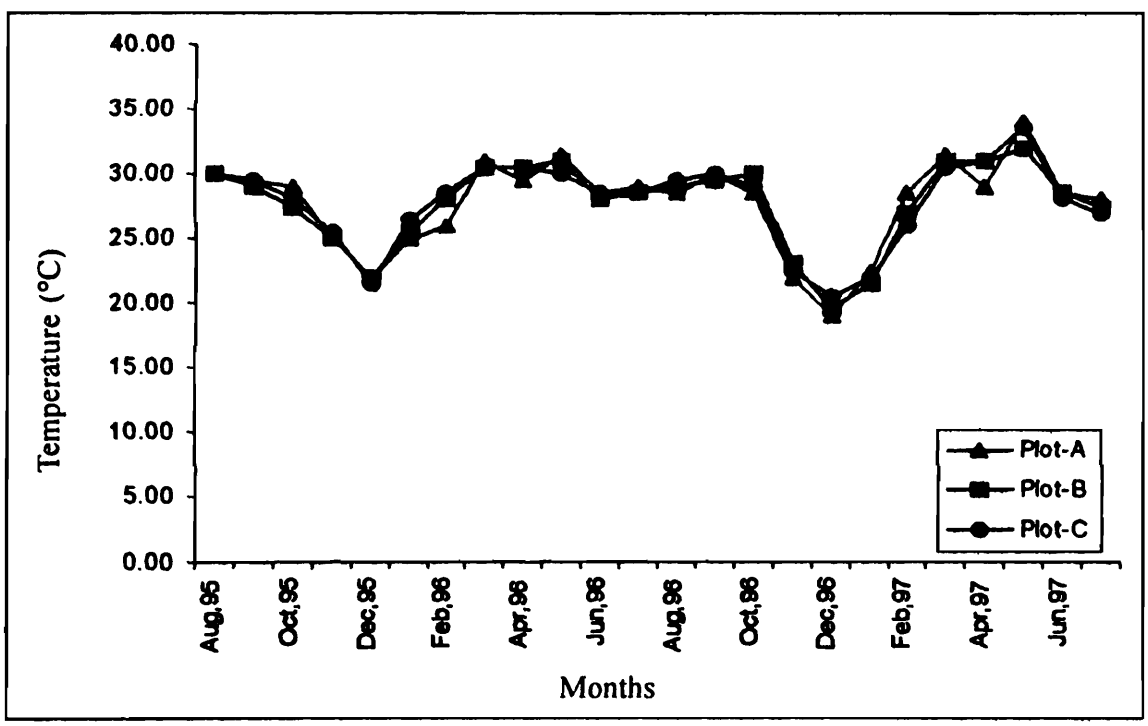


Fig. 33 : Variation of soil temperature at monthly intervals at three plots of East Kolkata site.

at plot A. The lowest was noticed in the month of March, 1997 at plot C. In all the plots for most of the study period the soil was found to be weakly acidic, however during peaks it was neutral to faintly alkaline (Fig. 34).

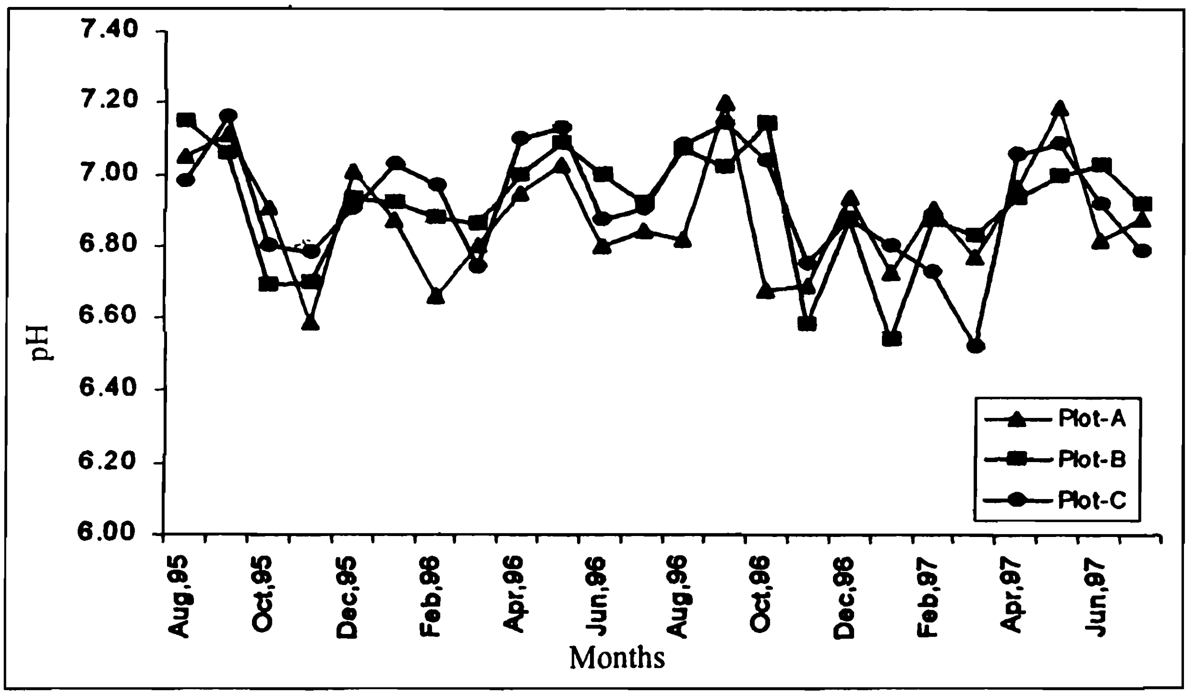


Fig. 34 : Value of pH of soil at three plots of East Kolkata site in each month

Central Kolkata Site

The trend of density of population of ants per soil sample was found higher almost throughout the period in plot A than in plot B and C. Two clear peaks in the month of January of both the years were found in plots A and C, whereas summer peaks were observed in plot B. On the other hand, the peak of plot B, though lowest in comparison to peaks of other two plots, was noticed in the month of June, 1996. The concentration of population was low in plot B in comparison to other plots almost throughout the season except at peaks (Fig. 35).

With few exceptions, the general trend of concentration of lead was observed higher in plot A than the other two plots and the variation was seen more or less even with highest and lowest concentrations in the month of September, 1996 and June, 1997. In plot B the concentration of lead was found somewhat evenly below the level of that in plot A in the later 12 months period of investigation; while in the first 12 months it was seen very uneven with an abnormal high peak in March, 1996. The same in plot C was found to be lowest in comparison to plot A and B in most of the months with a peak in August, 1996 which was highest among all the plots in that month (Fig. 36).

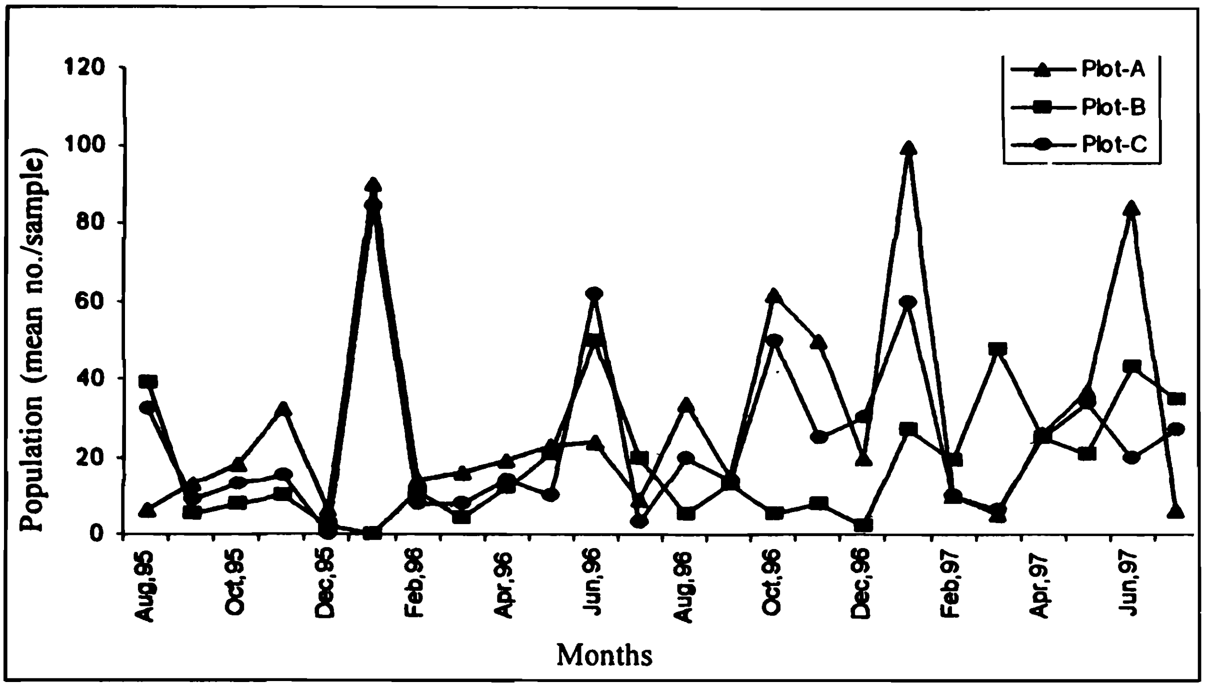


Fig. 35 : Seasonal fluctuation of population density of ants at three plots of Central Kolkata site

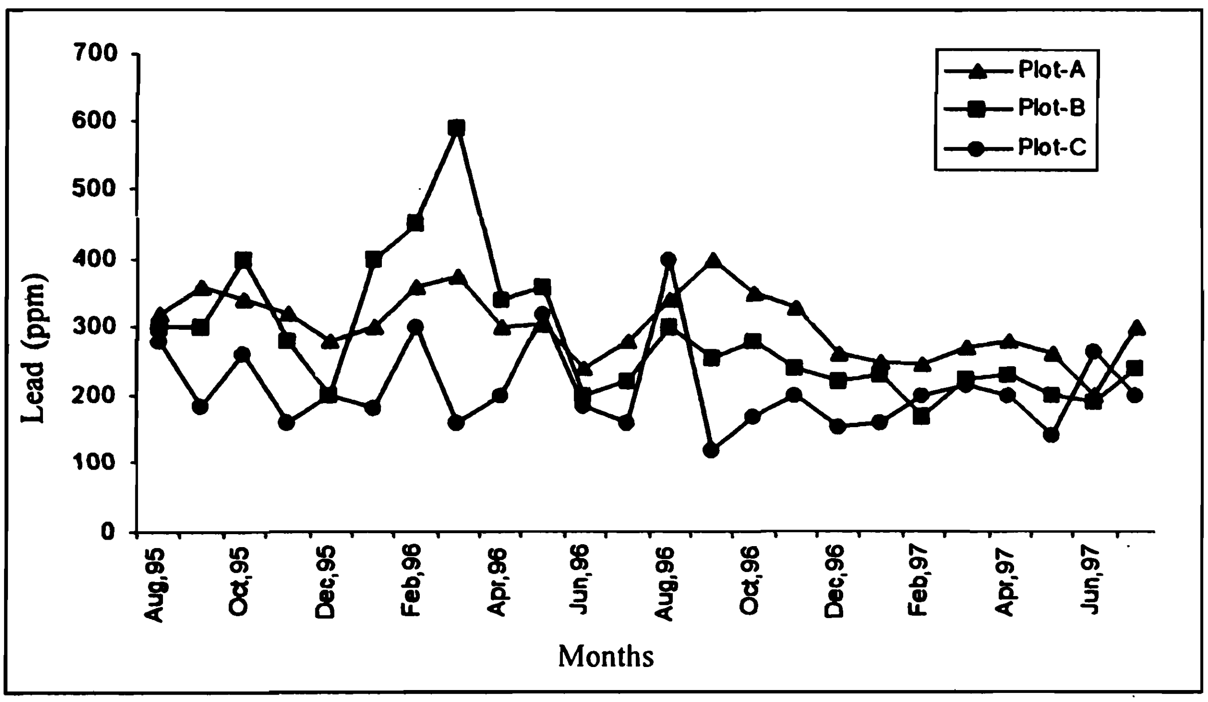


Fig. 36 : Monthwise concentration of lead in soil at three plots of Central Kolkata site

At this site the temperature of soil showed a similar trend in all the three plots with a very little variation among those in every month, with highest peaks in March-April and lowest in January. However, it was ovserved that plot A maintained a slight high soil temperature in comparison to other plots, while plot B maintained slightly low temperature during most of the study period (Fig. 37).

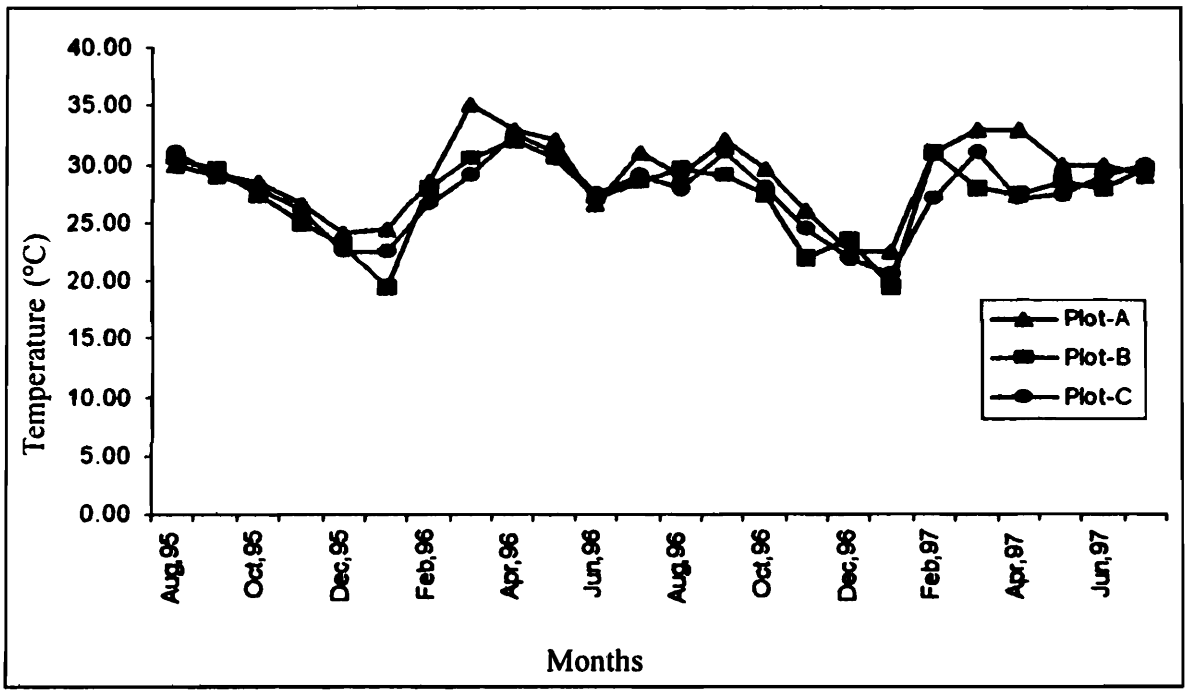


Fig. 37 : Variation of soil temperature at monthly intervals at three plots of Central Kolkata site.

The value of pH of soil was also found more or less similar trend with few exceptions. This fluctuation trend in plot A was noticed to be more even than that of other two plots. During most of the study period, in all the plots, the soil was found to be slightly acidic, with a strong exception in plot C in June 1997 when the soil was found to be moderately acidic (Fig. 38).

North Kolkata Site

The variation in seasonal fluctuation of population density of ants per soil sample in plot A throughout the period was very conspicuous with indefinite pattern at regular intervals, in comparison to the other two plots. In all the plots minimum population was observed during winter in two consequtive years. Post monsoon and summer minima of the population were also observed in both the years in all the plots. However, concentration of population was found to be more in plot A than in others during most of the study period, with an abnormally high peak in January, 1997 (Fig. 39).

So far the monthwise variation of concentration of lead in soil is concerned, it was found

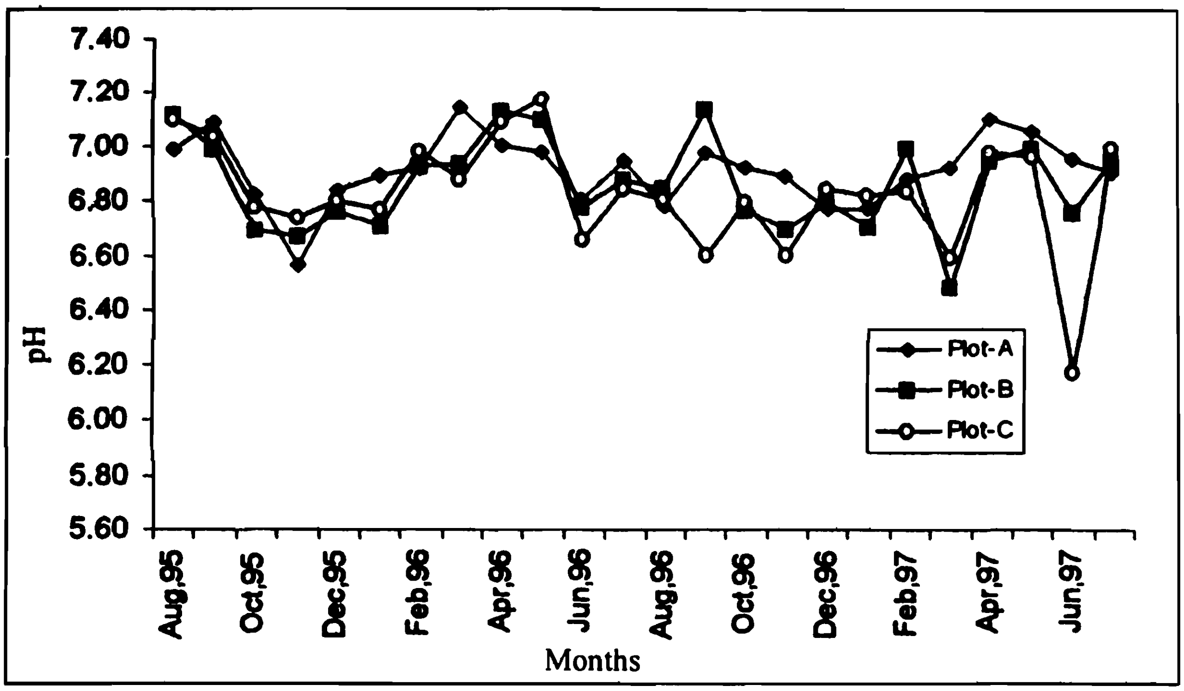


Fig. 38 : Value of pH of soil at three plots of Central Kolkata site in each month

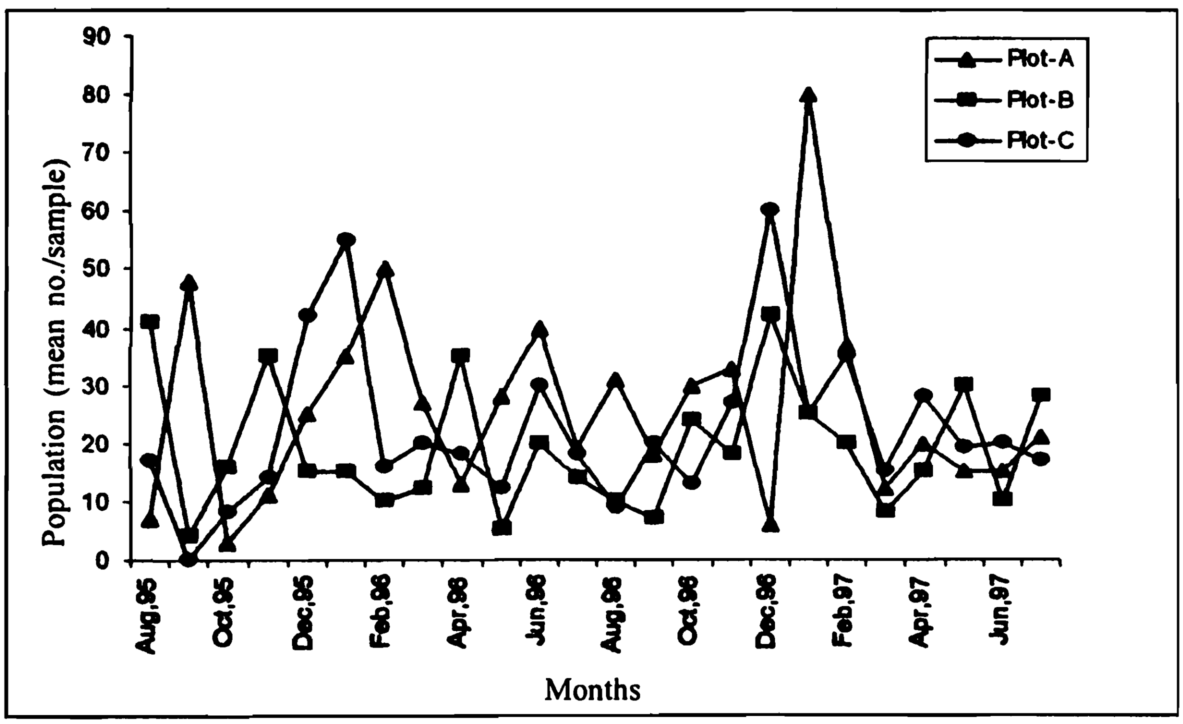


Fig. 39 : Seasonal fluctuation of population density of ants at three plots of North Kolkata site

that in plot A it varied from below 200 to above 500. The highest concentration was seen in June, 1997 in plot A in comparison to other plots though a high peak in the same month was found in plot C also. The lowest level was noticed in plot B among all three plots which was in the month of December, 1996. In most of the months concentration of lead maintained a higher trend in plot C in comparison to other plots, and plot A maintained a lower concentration of lead than plot C, with plot B lying in between (Fig. 40).

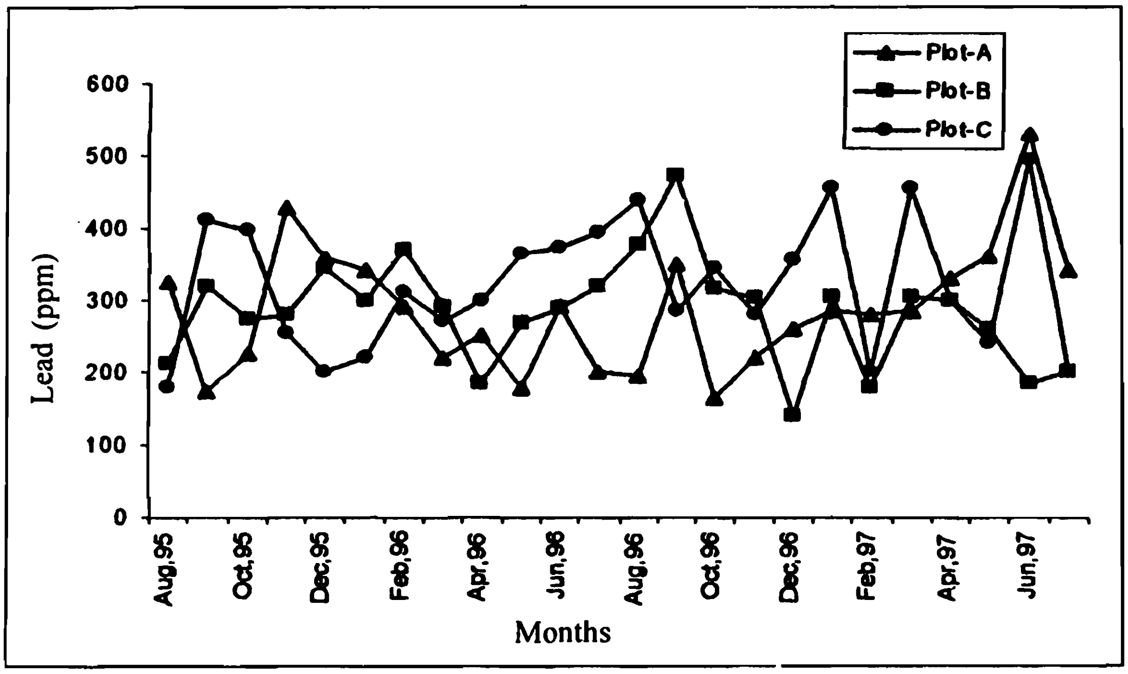


Fig. 40 : Monthwise concentration of lead in soil at three plots of North Kolkata site

The temperature of soil in all the three plots were found to follow a similar trend with very little variations. The highest peaks were found in the month of May, while the lowest were recorded in the month of January in all the plots (Fig. 41).

The soil of North Kolkata was found to be slightly alkaline during most of the study period in all the plots. The soil at plot A maintained a slightly higher pH value than other plots during most of the seasons. The lowest pH value was recorded at plot C during November, 1995 and highest at plot A in January, 1997 (Fig. 42).

South Kolkata Site

The density of population of ants in all three plots exhibited large fluctuations. In plot A population peak was observed in February, 1996. In the first 12 months period winter population peaks were observed in plots A and B, while in plot C there was summer peak. In the later 12 months, summer peaks were observed in plots A and B, and winter peak in plot C (Fig. 43).

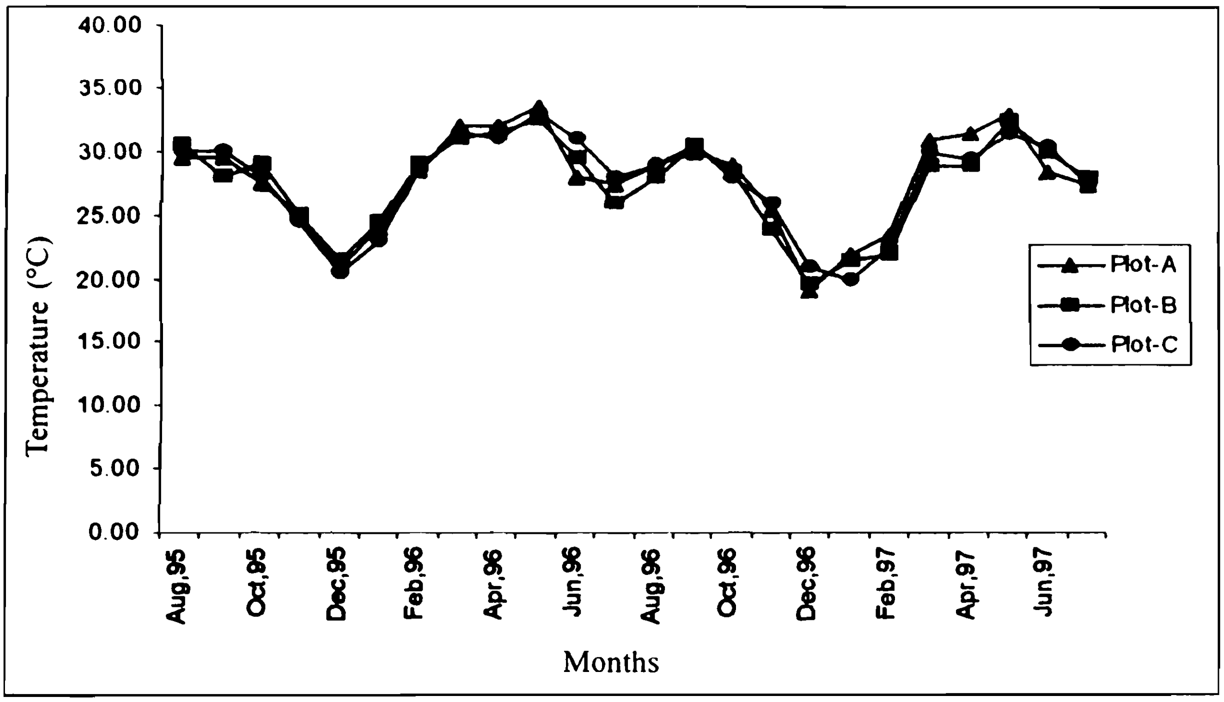


Fig. 41 : Variation of soil temperature at monthly intervals at three plots of North Kolkata site

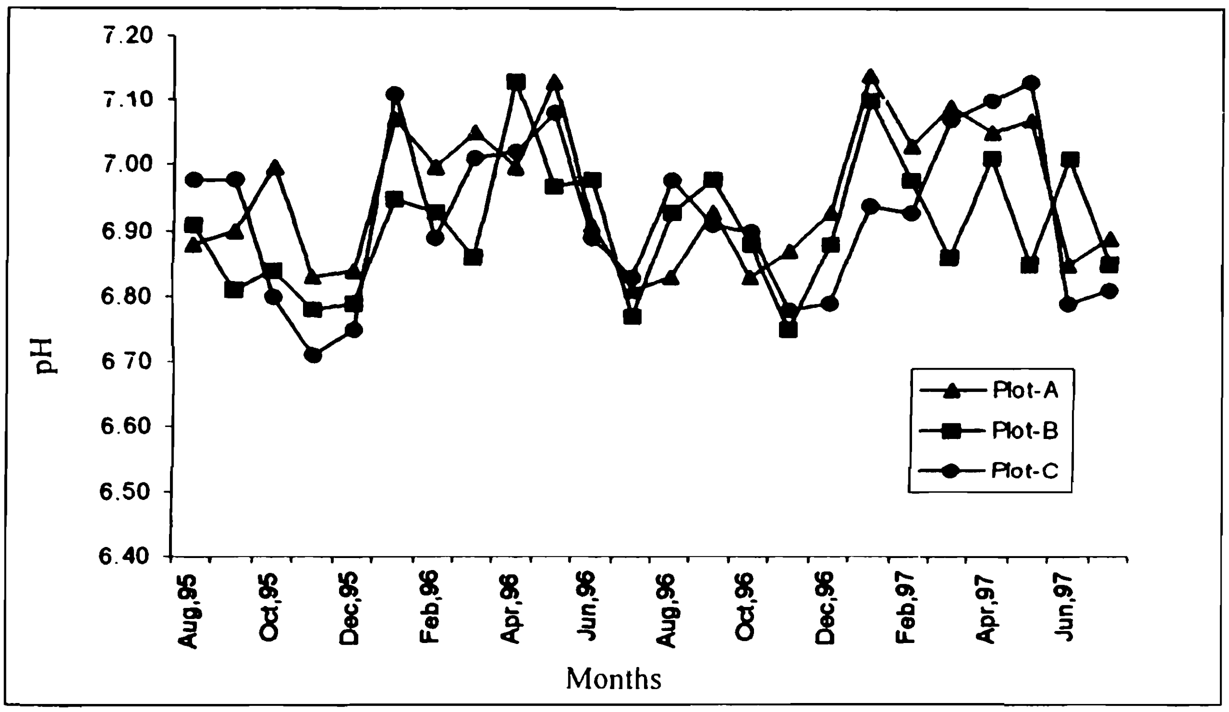


Fig. 42 : Value of pH of soil at three plots of North Kolkata site in each month

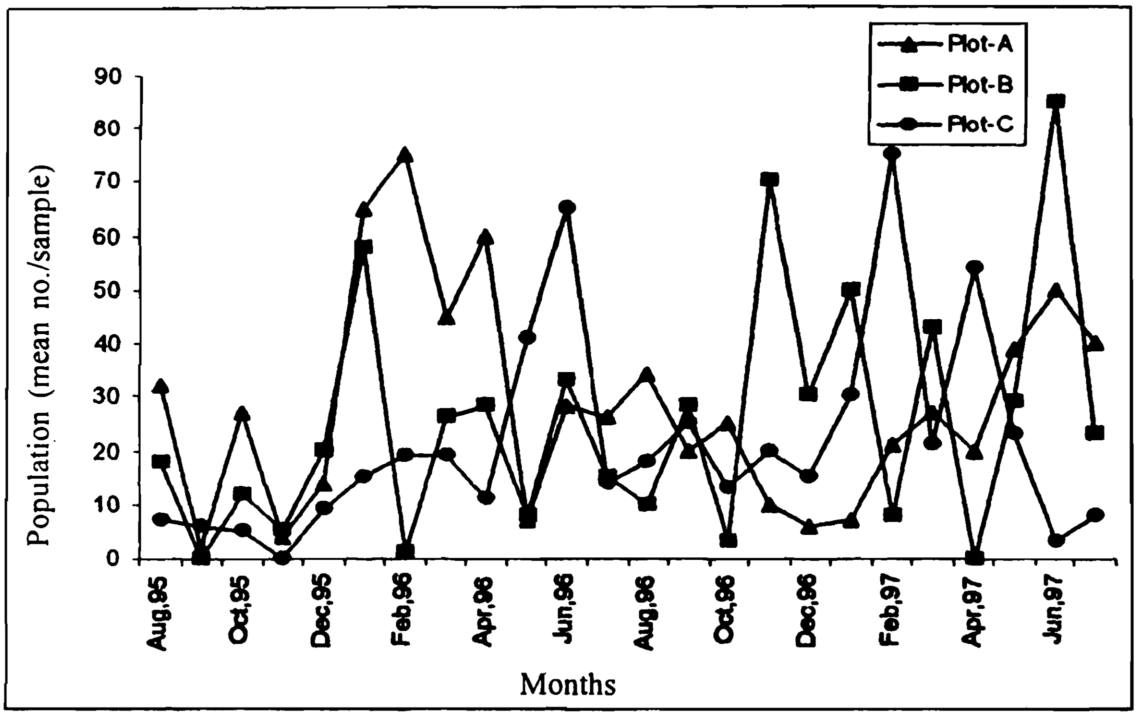


Fig. 43 : Seasonal fluctuation of population density of ants at three plots of South Kolkata site

On comparing the concentration of lead of soil at three plots it was found that the concentration in plot A was always higher in comparison to other two plots with only two exceptions. Plot C exhibited lowest concentration of lead throughout the seasons, while in plot B the concentration of lead was in between. In plot A two high peaks in winter were noticed. The peak of December, 1997 of plot A was found highest among all three plots. Plot C exhibited similar peaks like in plot A but much low in magnitude. The concentration of lead of plot B had much variations throughout the seasons without any definite pattern of fluctuations (Fig. 44).

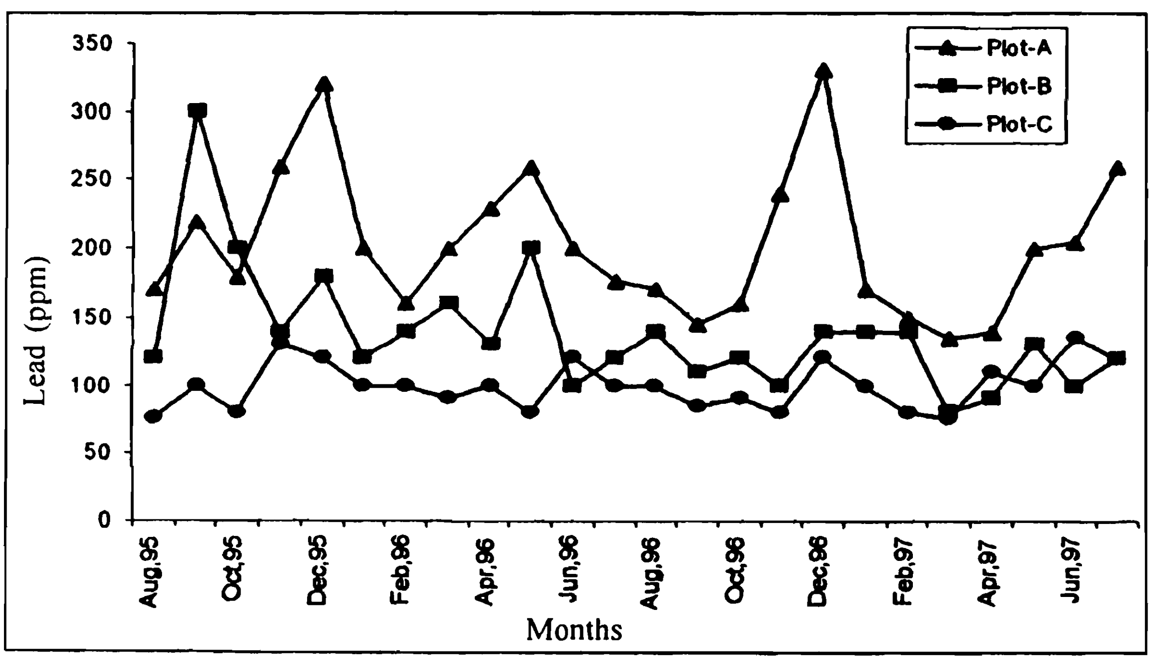


Fig. 44 : Monthwise concentration of lead in soil at three plots of South Kolkata site

Temperature of soil in all three plots showed similar trend, with lowest in winter and highest in summer. The temperature recorded in winter of 1997 was found to be lower than that of the year 1996 (Fig. 45).

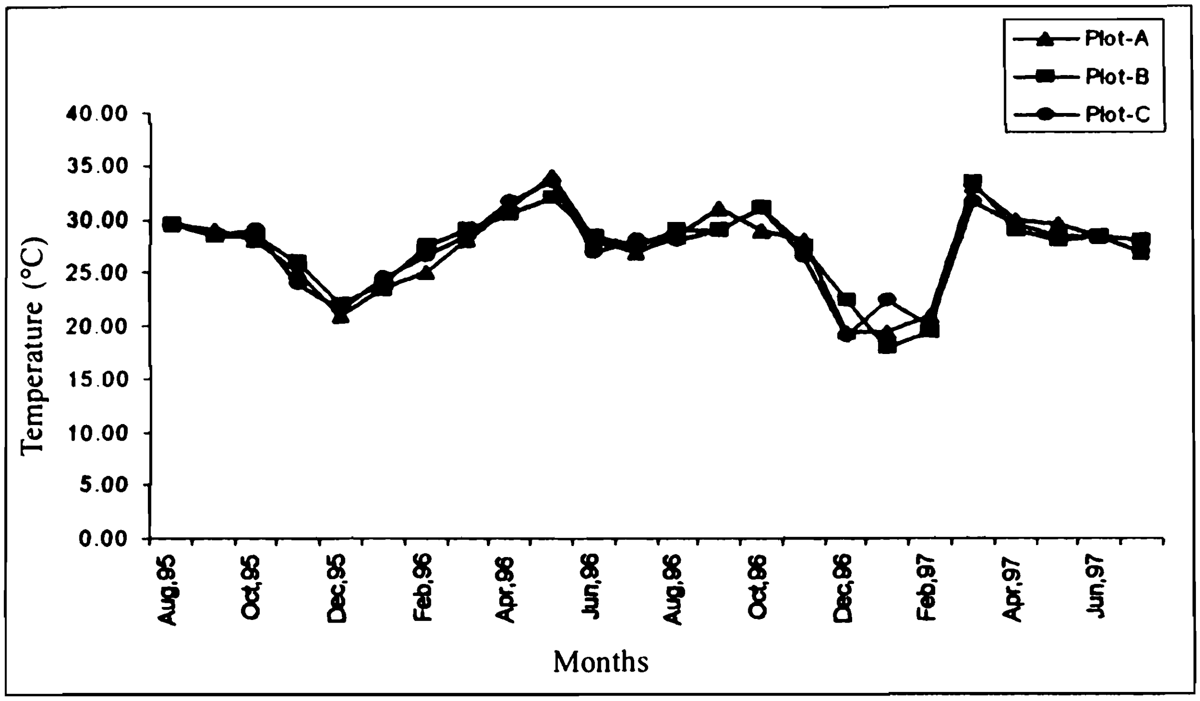


Fig. 45 : Variation of soil temperature at monthly intervals at three plots of South Kolkata site

The value of pH of soil in three plots were found to have similar trend with very little monthwise variation. A little drop in pH value was found in March, 1997 at all three plots. During the entire period of study soil in all the plots at South Kolkata was observed to be almost neutral with pH value around 7 (Fig. 46).

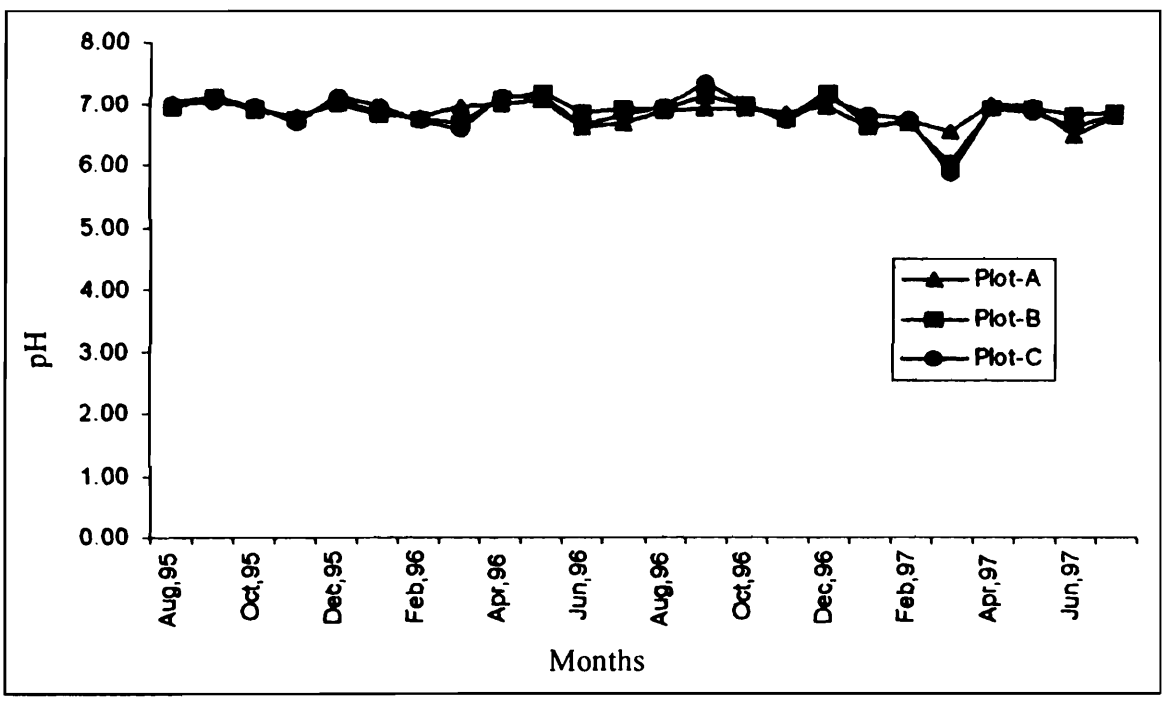


Fig. 46 : Value of pH of soil at three plots of South Kolkata site in each month

Sitewise comparative study of ant population and other edaphic factors as a whole, on an average, revealed the following facts :

Population of ants

It was observed that population of ants per sample was higher at East Kolkata site than any other three sites. It was found that the general trend in poulation, reaching peak, in all the sites was in January and June of both the year 1996 and 1997. One unusual peak at East Kolkata site only was noticed in the month of September, 1996. In most of the months population of ants was found to be low in North Kolkata site among the four sites under study (Fig. 47).

Concentration of lead

In comparison with other sites, concentration of lead was found to be more at North Kolkata site in most of the months during the study period. However, lead concentration was also found to be high at Central Kolkata site in comparison to other sites, but was less than North Kolkata site. On comparing, on the other hand at East Kolkata site, it was seen minimum during entire study period. The differences in the concentration of lead of Central and North Kolkata sites were found quite significant in comparison to East and South Kolkata sites. The concentration of lead in soil of North Kolkata site in June, 1997 was noticed to be the highest (Fig. 48).

Temperature of soil

From Fig. 49 it was found that average temperature of soil at different sites showed a regular pattern of winter minima and summer maxima. In comparison the variations in temperature at different sites, in a month, were not found to be remarkable during the entire study period.

pH of soil

Monthwise changes in pH on an average at different sites showed little variations among those and the soil was found to be weekly acidic at all the sites, almost during entire period of study, with few exceptions, when it became neutral or weekly alkaline (Fig. 50).

Sitewise species composition of ants including the plots within those, revealed the following patterns :

East Kolkata site

Solenopsis geminata was found to be the most dominant species at this site occupying about 42% of the community. *Pheidole roberti* was found to be the second dominant species with a concentration of about 14%. *Paratrechina longicornis, Tapinoma melanocephalum* and *Technomyrmex albipes* occupied third, fourth and fifth positions respectively with

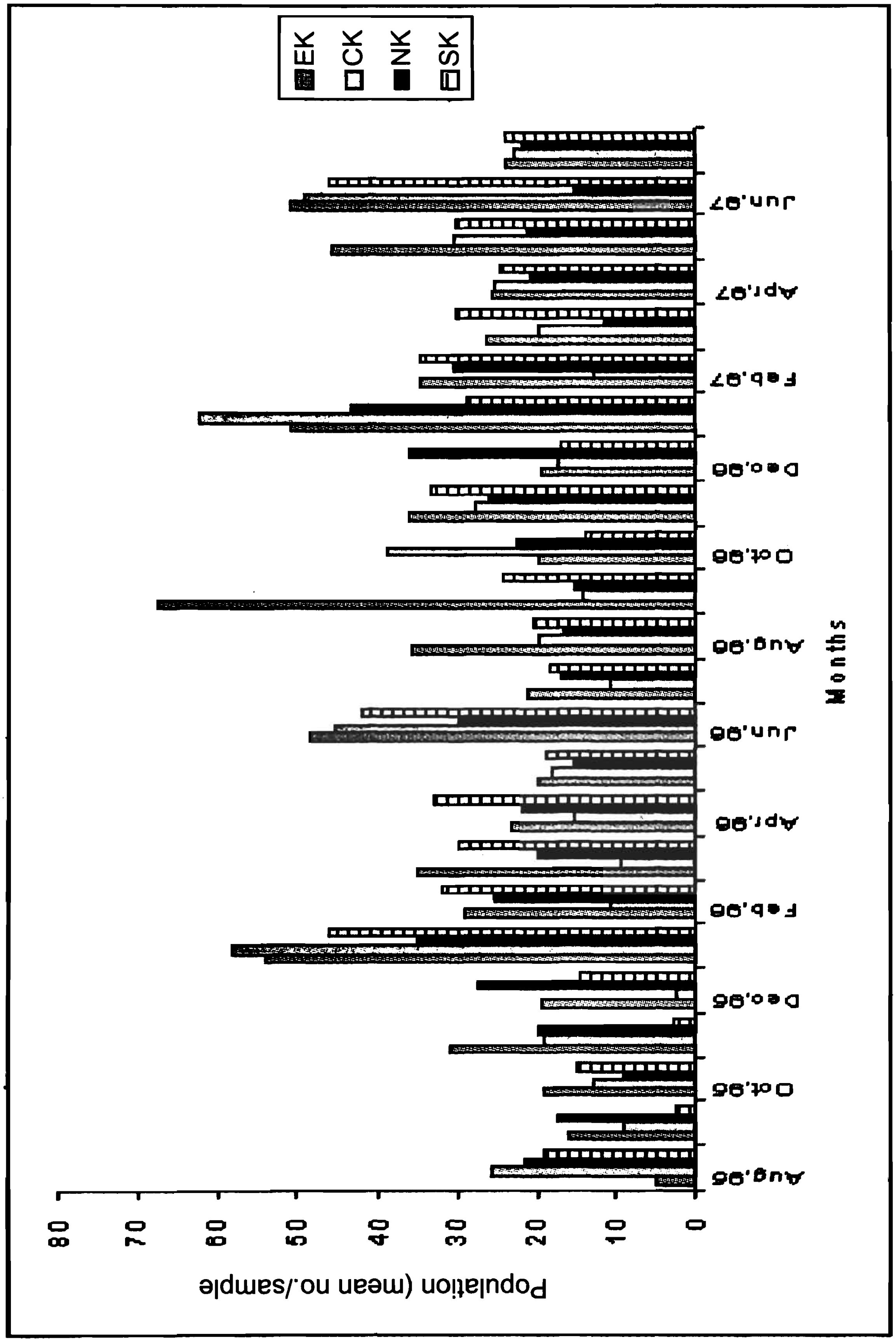


Fig 47 : Variation in population of ants on an average at different sites

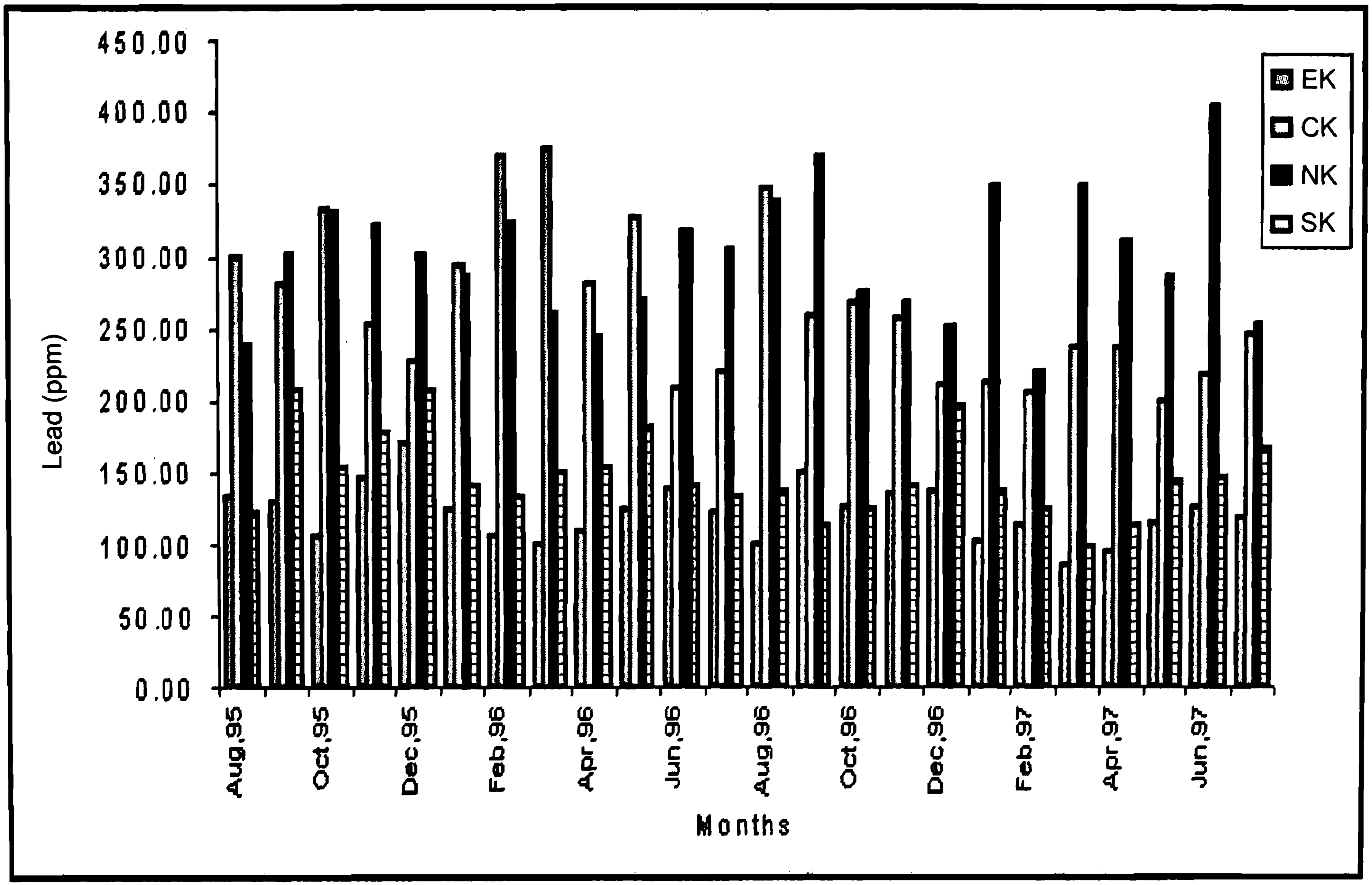


Fig 48 : Fluctuation in conecntration of lead on an average at different sites

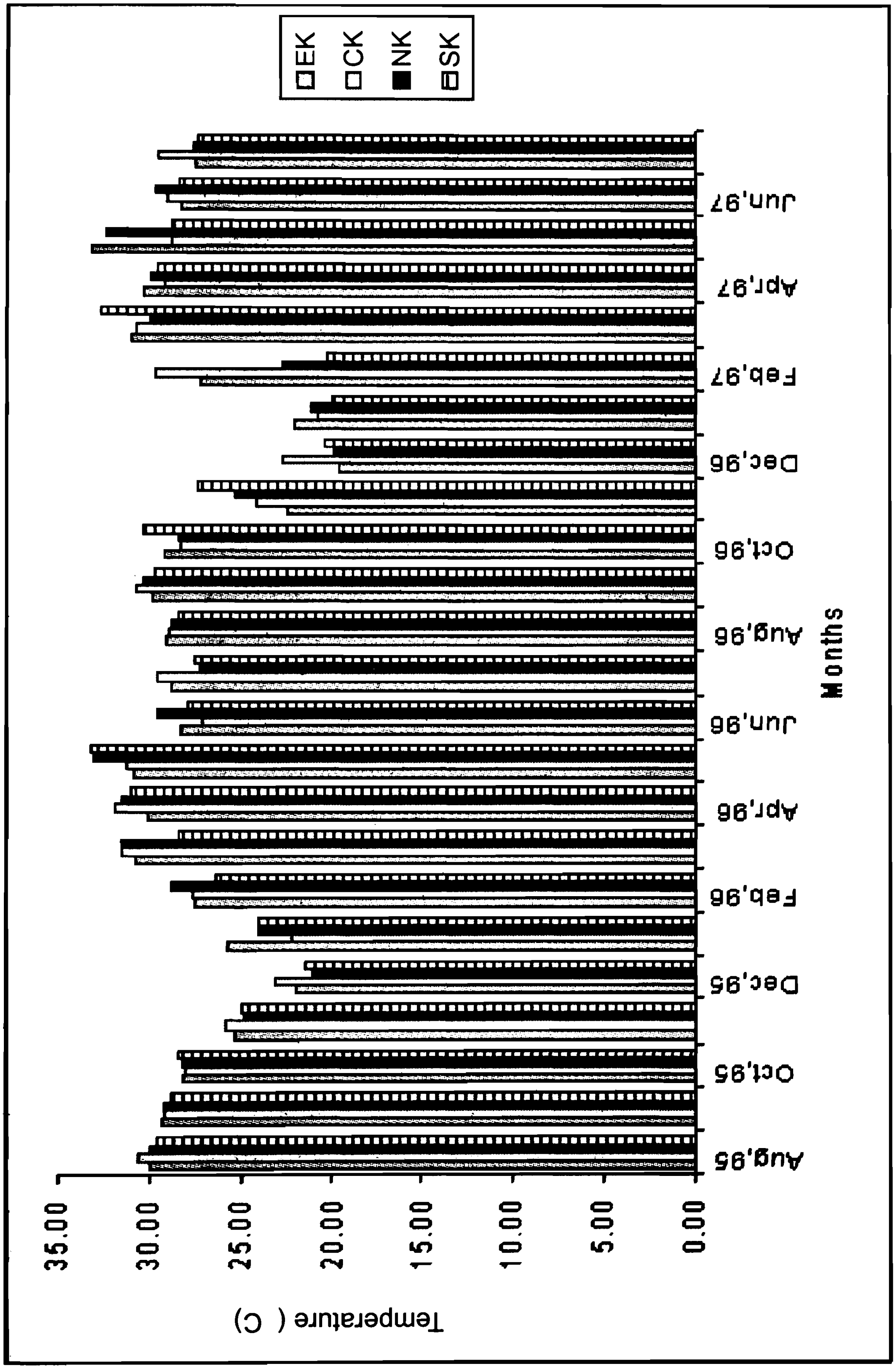


Fig 49 : Fluctuation in average temperature of soil at different sites

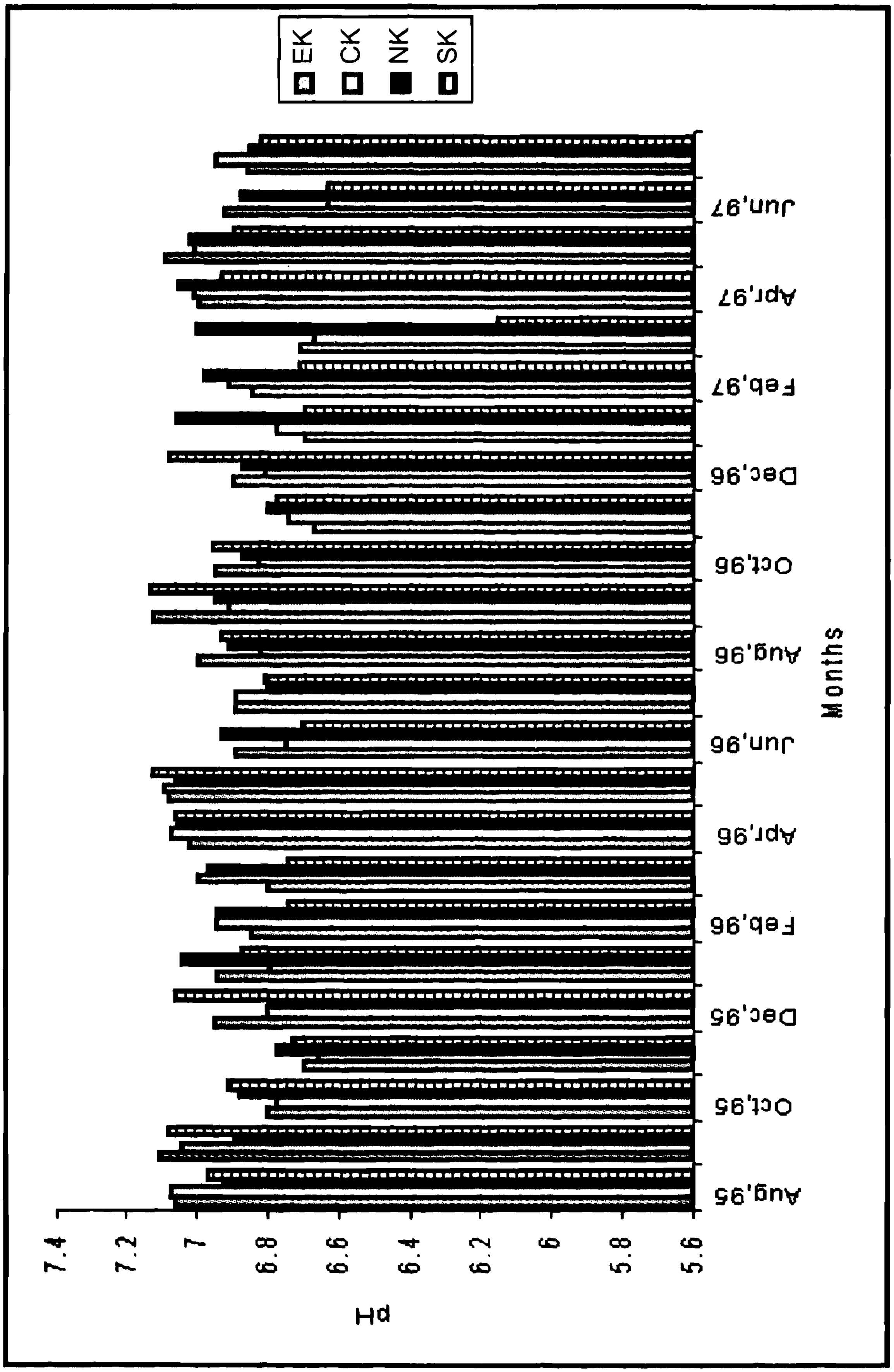


Fig 50 : Changes in average pH of soil at different sites concentration of 9%, 7% and 6% respectively. Other species in the ant community individually constituted less than 5% of the entire community and they collectively contributed 22% to whole community (Fig. 51).

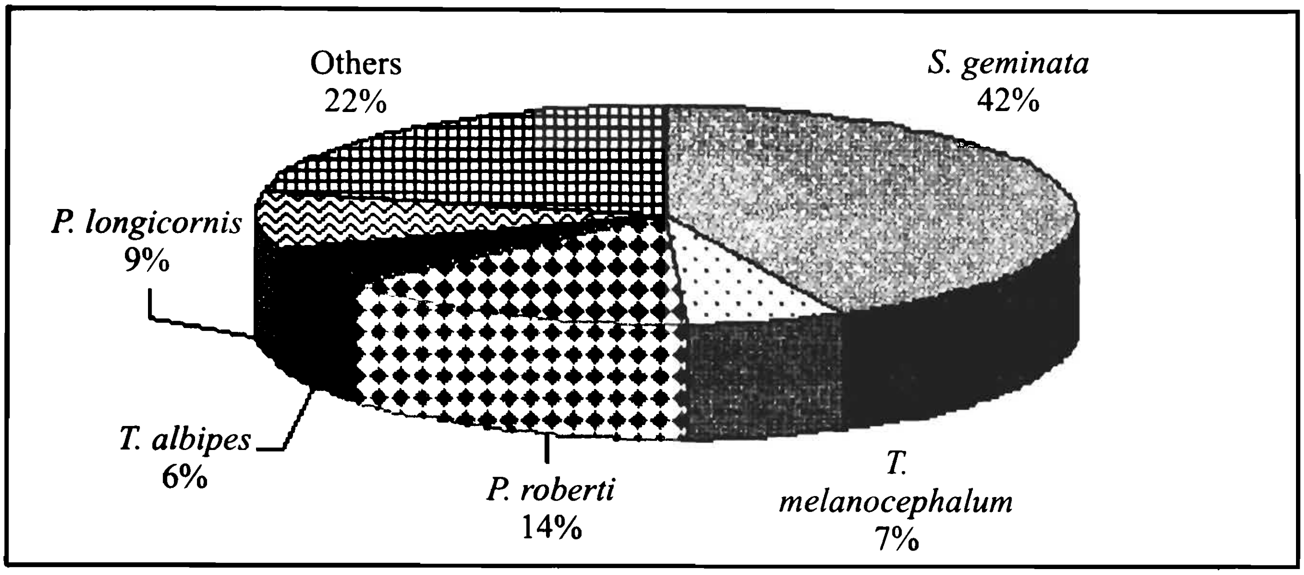


Fig. 51 : Composition of major ant species at East Kolkata site

Central Kolkata site

In this site *Solenopsis geminata* was the most dominant sharing 42% of the whole community. The shares of *Pheidole roberti, Meranoplus bicolor* and *Paratrechina longicornis* were 18%, 16% and 5% respectively in the total ant community. The others, whose individual share was less than 5% of the entire community, contributed 19% to that comminity (Fig. 52).

North Kolkata site

Solenopsis geminata was found to be the most dominant species occupying 30% of the community. *Pheidole roberti, Tetramorium walshi, Meranoplus bicolor, Paratrechina longicornis* and *Monomorium floricola* were found to secure next second to sixth positions according to their dominance in the entire community contributing 19%, 13%, 11%, 6% and 5% shares respectively. Those species, whose individual contribution was below 5%, contributed 16% to the total ant community (Fig. 53).

South Kolkata site

Contributing 40% to the total ant community, *Solenopsis geminata* occupied the first position in the dominance of species of this site. According to the contribution to the entire ant community, the next positions were found to be occupied by *Monomorium floricola*

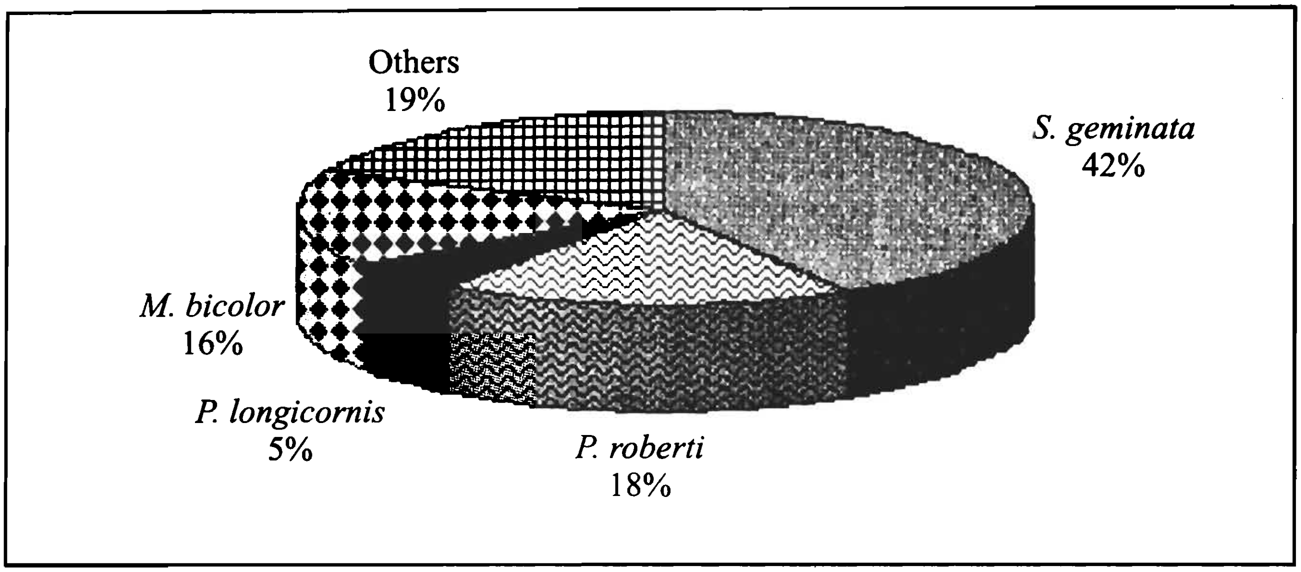


Fig. 52 : Composition of major ant species at Central Kolkata site

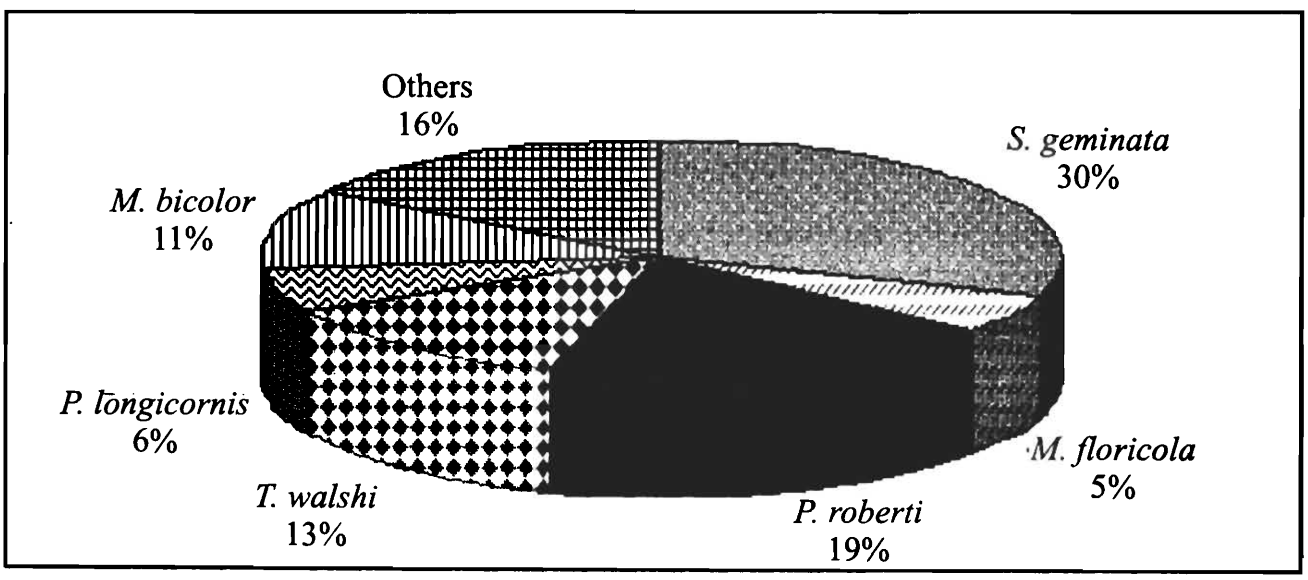


Fig. 53 : Composition of major ant species at North Kolkata site

(15%), ***Pheidole roberti*** (10%), *Plagiolepis jerdonii* (7%) and commonly by both *Paratrechina* ***longicornis*** (6%) and *Tapinoma melanocephalum* (6%). The other species, which contributed **less than** 5% individually, collectively shared 16% of the whole ant community (Fig. 54).

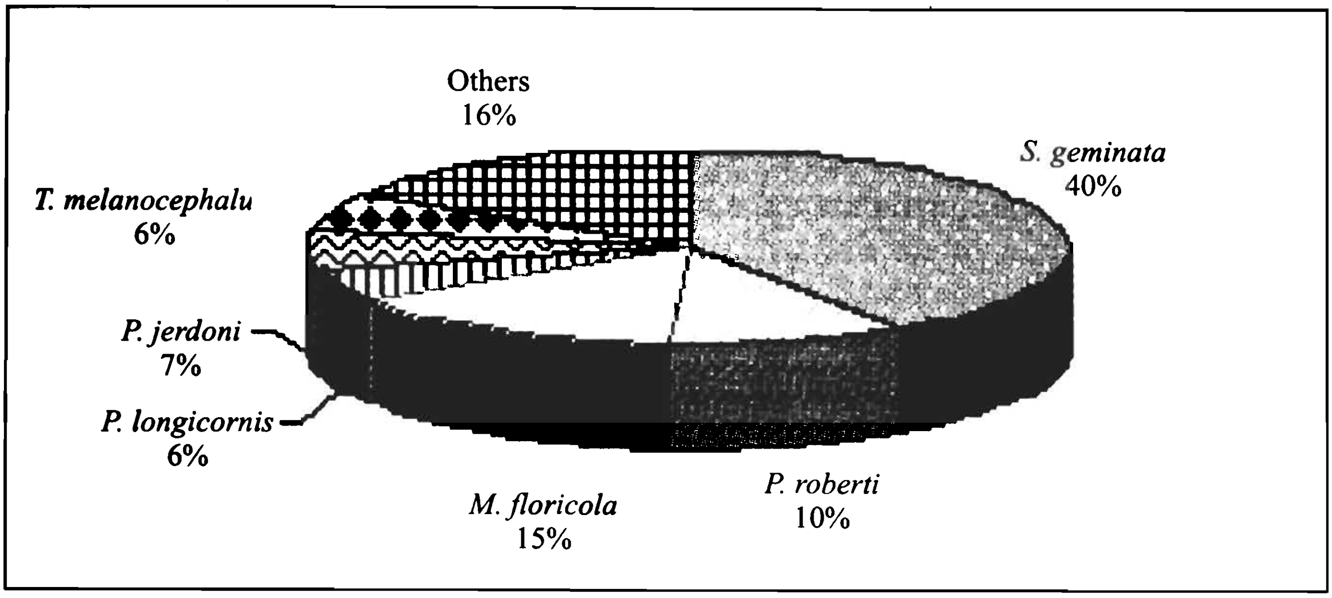


Fig. 54 : Composition of major species of ants at South Kolkata site

E. BIOASSAY

Accumulation of lead in the body tissue of ant species, which were found to be contributed at least 10% to the total ant community at each site (Figs. 51-54), were estimated. The result (Table 22) indicated that lead concentration in the body tissue ranged from 32.65 to 72.5 ppm. with two instances of lead concentration below detection level (BDL). *Solenopsis geminata* was found to have a lower accumulation of lead at all the sites in comparison to other species, while *Tetramorium walshi* had a highest concentration of 72.5 ppm. On an average it was found that *S. geminata* had the lowest deposition of lead (37.30 ± 3.34 ppm), while *Pheidole roberti* and *Meranoplus bicolor* had average lead deposition of 63.82 ± 3.48 and 54.76 ± 0.92 respectively.

Table 22. Accumulation of lead (in ppm) in the body tissue of dominant species of ants. (BDL = Below Detection Level)

Name of the species	Name of the sites				Mean ± SD
	EK	CK	NK	SK	
Solenopsis geminata	32.65	BDL	40.36	38.90	37.30 ± 3.34
Pheidole roberti	BDL	65.34	37.14	59.00	63.82 ± 3.48
Meranoplus bicolor	-	53.84	55.67	-	54.76 ± 0.92
Monomorium floricola	-	-	-	43.81	43.81
Tetramorium walshi	-	-	72.50	-	72.50

F. STATISTICAL ANALYSIS

Results thus obtained were subjected to various statistical tests to establish relationships of the abiotic factors with the population of ants as a whole both plotwise and sitewise. Relationships were also established of concentration of lead, pH and temperature of soil with the dominant ant species at different sites.

The level of significance of the correlation coefficients thus observed were also established. Regression equation of the correlationships were calculated and trendlines were drawn mainly of the significant relationships, alongwith the scattered diargam for prediction.

The differences in the mean population of ants at different plots of a site and at different sites on an average were subjected to tests of significance. The level of significance of the 't' values thus observed were also found.

The results of the statistical analysis are summarised below.

At East Kolkata site the ant population was found to have negative relationships with concentration of lead in soil at all the plots, and at plot C the negative relationship was found to be significant (Fig. 55). At other two plots the relationships were not found to be significant.

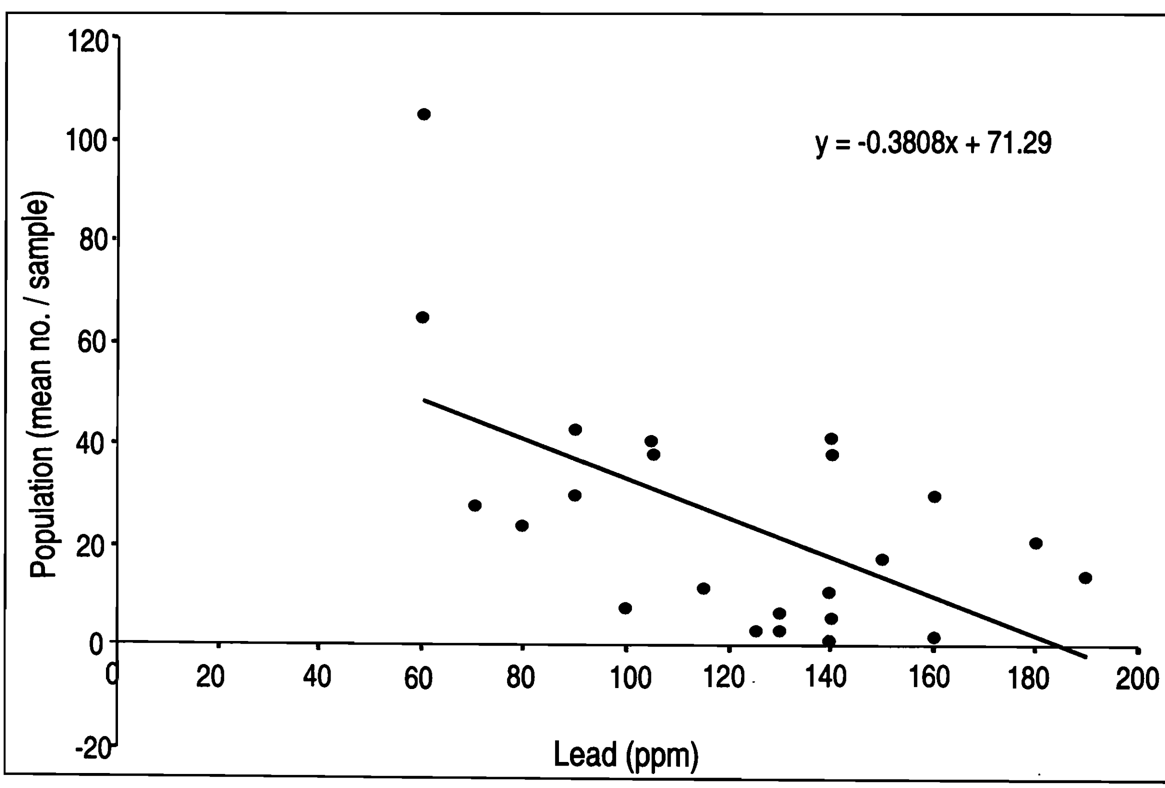


Fig. 55 : Line of regression alongwith scattered diagram of population of ants on lead at plot C of East Kolkata

However, on an average at this site, the ant population was found to have a faintly positive relationship with lead, though the relationship was not significant (Table 23).

At Central Kolkata site the relationship between ant population and concentration of lead in soil was found to be negatively significant only at plot B (Fig. 56). At other two plots the relationships were also found to be negative, but not significant. On an average in this site the relationship was found to be positive, but not significant (Table 23).

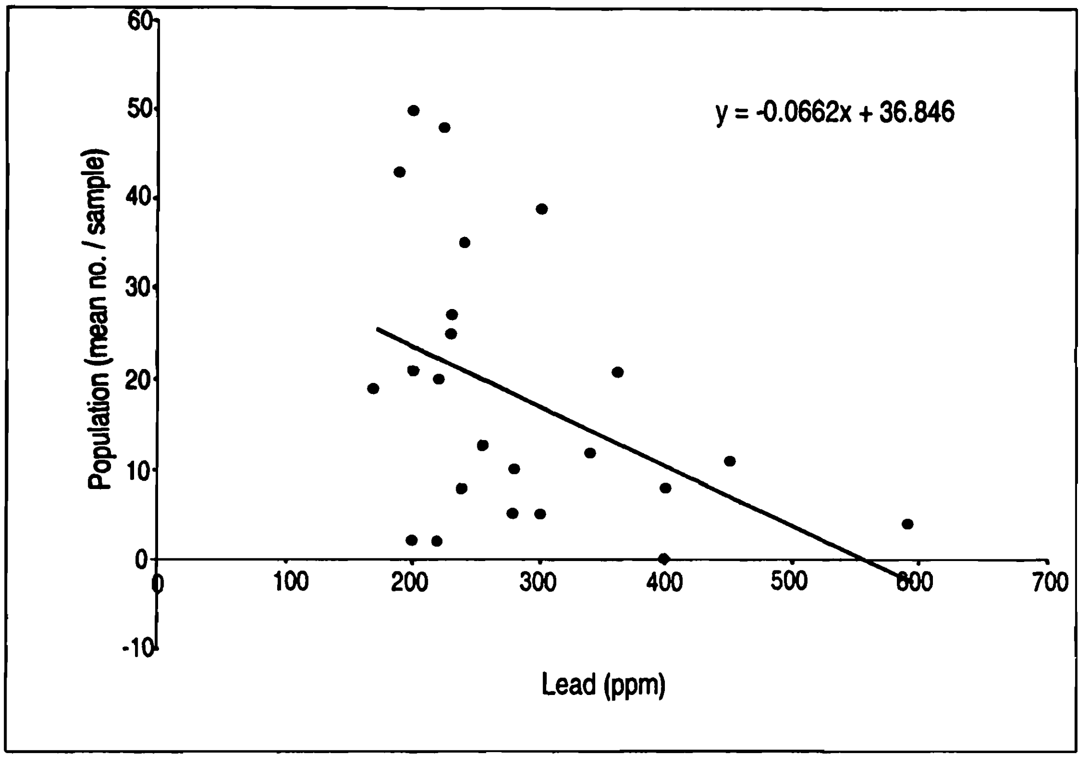


Fig. 56 : Line of regression alongwith scattered diagram of population of ants on lead at plot B of Central Kolkata

At North Kolkata site the population of ants was found to be negatively related with concentration of lead at all three plots and at the site on an average. The relationships at plot B and plot C were however found to be significant, (Figs. 57 & 58) while others found to be non-significant (Table 23).

At South Kolkata site also the population of ants at all the three plots and at the site on an average were found to be negatively related with concentration of lead in soil, with a level of significance at plot B and at the site on an average (Figs. 59 & 60). The relationships of population of ants and concentration of lead in plot A and plot C were found to be non-significant (Table 23).

Table 23. Relationship between concentration of lead (ppm) and population of ants (mean no./sample) at different plots and at different sites. (NS - Not Significant)

X : Lead		Mean		Correlation coefficient (r)	P	Regression equation of ant (y) on lead (x). y = ax+b
		Lead	Population			
East Kolkata	Plot-A	132.50	42.50	-0.168	NS	y = -0.1323x+60.036
	Plot-B	110.00	27.08	-0.158	NS	y = -0.1054x+38.678
	Plot-C	121.50	25.04	-0.568	<0.01	y = -0.3808x+71.29
	Average	121.32	31.54	0.032	NS	y = 0.0242x+28.602
Central Kolkata	Plot-A	302.71	29.96	-0.282	NS	y = -0.1599x+78.35
	Plot-B	284.17	18.04	-0.427	<0.05	y = -0.0662x+36.846
	Plot-C	208.96	24.13	-0.212	NS	y = -0.0685x+38.44
	Average	265.28	24.04	0.091	NS	y = -0.091x+48.19
North Kolkata	Plot-A	286.70	26.00	-0.239	NS	y = -0.0475x+39.632
	Plot-B	286.80	19.13	-0.61	<0.001	y = -0.0924x+45.244
	Plot-C	322.28	22.42	-0.331	<0.10	y = -0.0502x+38.562
	Average	298.57	22.51	-0.297	NS	y = -0.054X+38.63
South Kolkata	Plot-A	203.38	28.50	-0.279	NS	y = -0.104x+49.65
	Plot-B	138.33	25.13	-0.433	<0.05	y = -0.2119x+54.433
	Plit-C	99.58	21.50	-0.182	NS	y = -0.1994x+41.358
	Average	147.10	25.04	-0.471	<0.02	y = -0.1876x+52.636

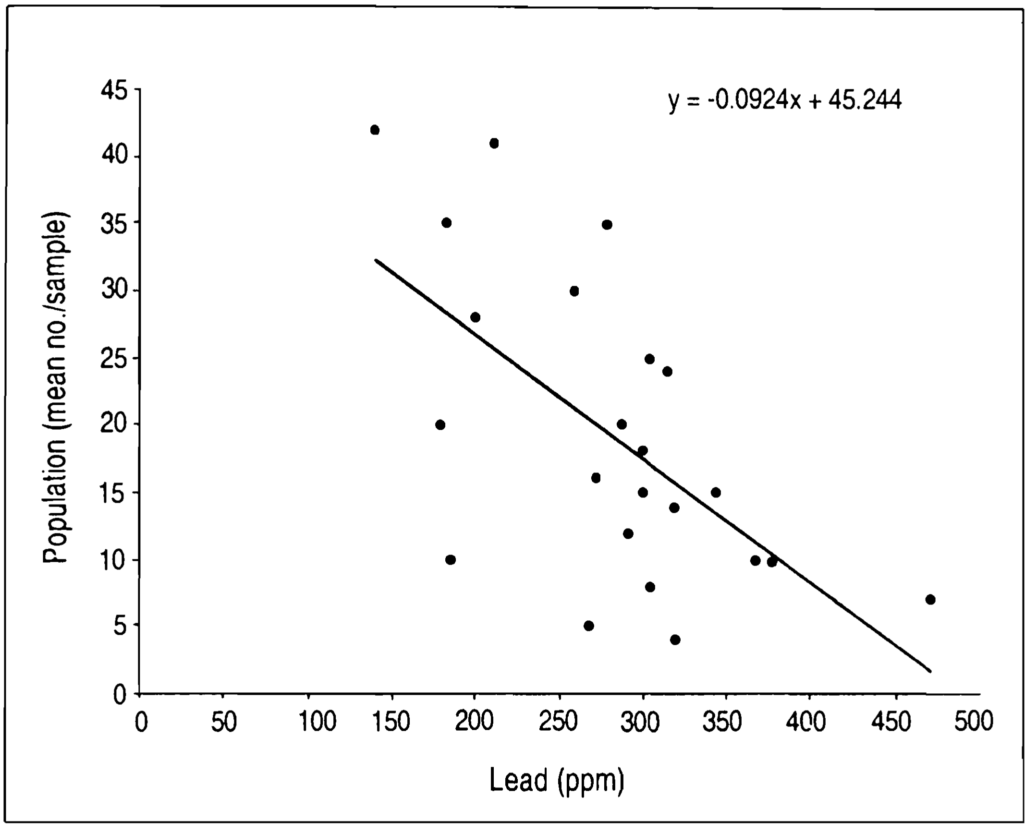


Fig. 57 : Line of regression alongwith scattered diagram of population of ants on lead at plot B of North Kolkata

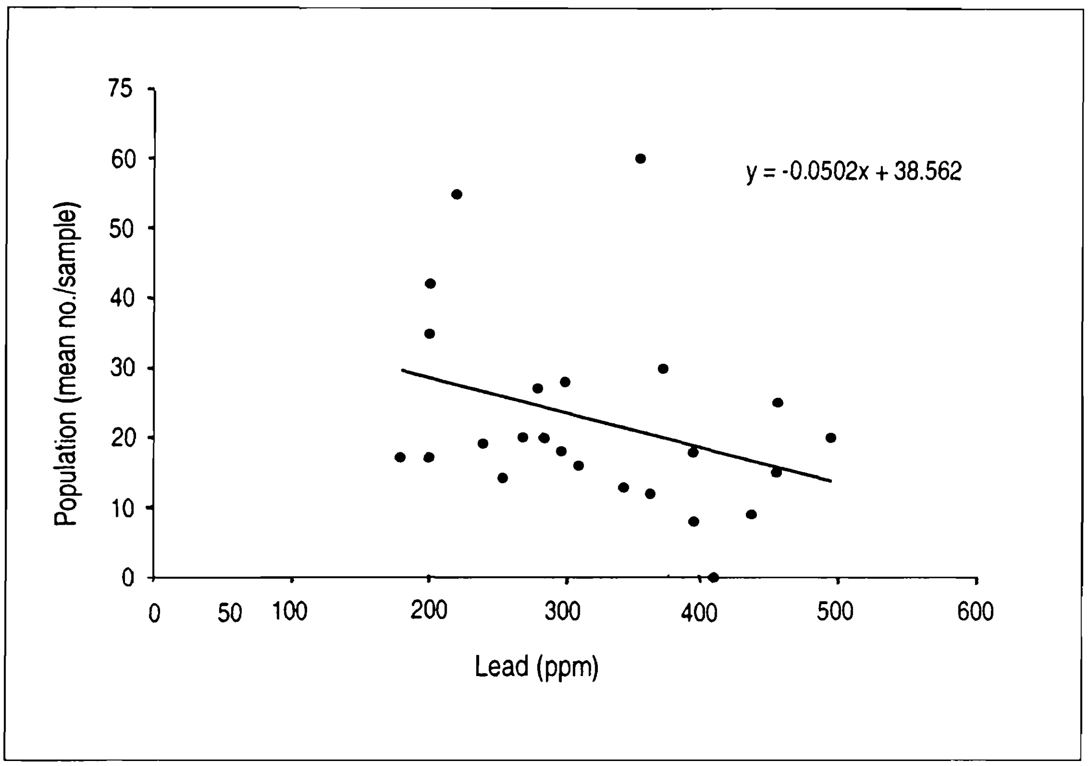


Fig. 58 : Line of regression alongwith scattered diagram of population of ants on lead at plot C of North Kolkata

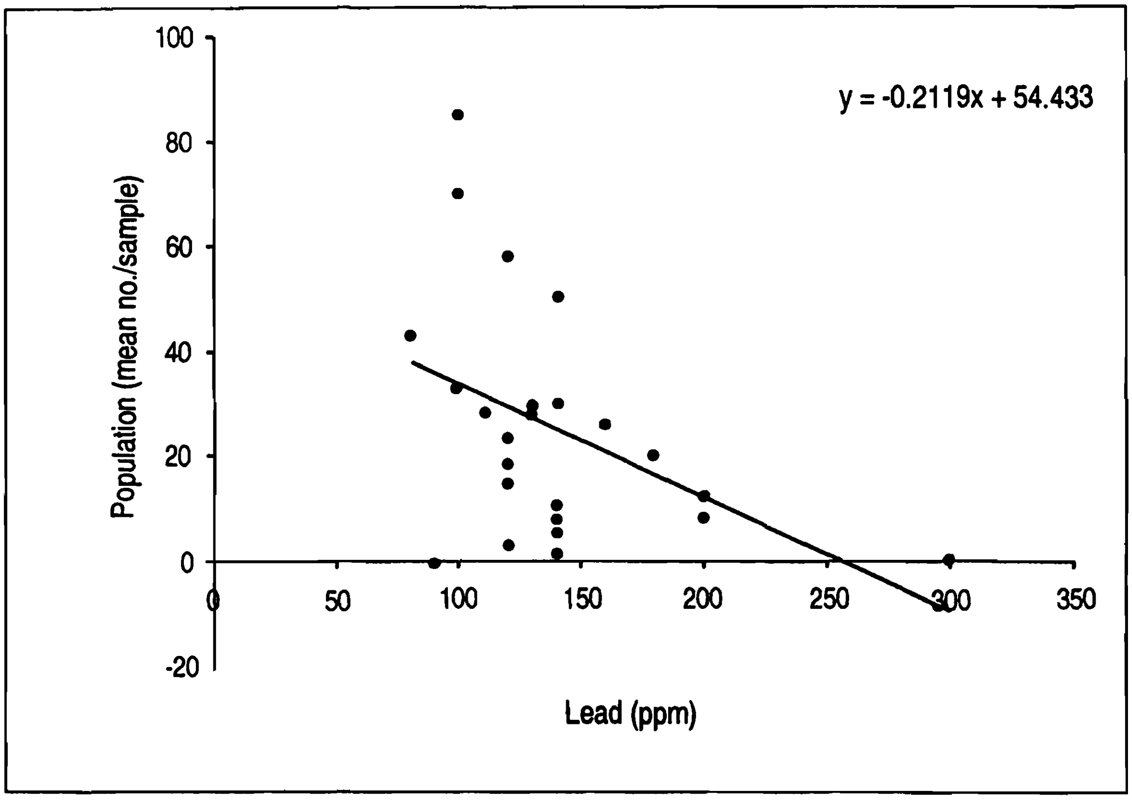


Fig. 59 : Line of regression alongwith scattered diagram of population of ants on lead at plot B of South Kolkata

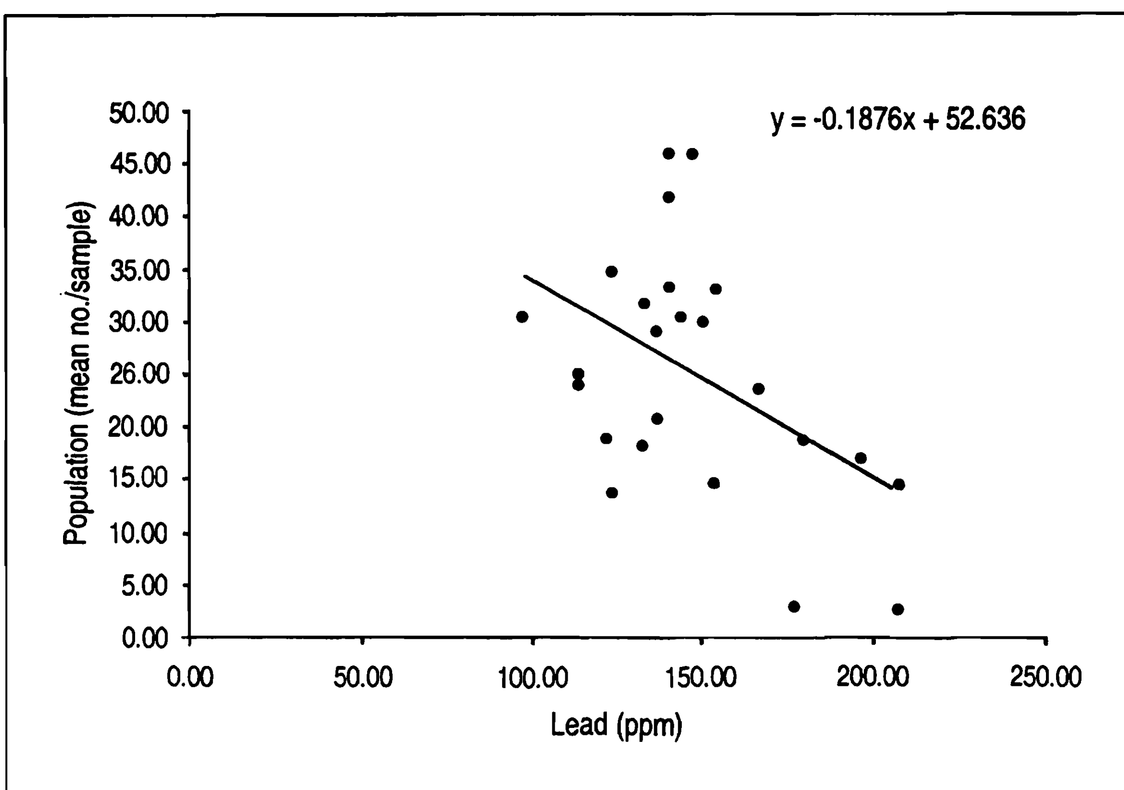


Fig. 60 : Line of regression alongwith scattered diagram of population of ants on lead, on an average of South Kolkata.

So far the populaiton of ants and temperature of soil is cencerned, at East Kolkata site no significant relationship could be observed though the relationships were found to be positive at plot A and plot C, and negative at plot B and at the site on an average (Table 24).

At Central Kolkata site the population of ants and the temperature of soil were found to be positively correlated only at plot B and negatively in other two plots and at the site on an average. The relationships were found to be significant at plot A and plot C (Figs. 61 & 62) whereas the relationship at plot B and at the site on an average were not significant (Table 24).

At North Kolkata site the relationships between population of ants and temperature of soil were found to be negative in all the three plots and at the site on an average. Among those, the relationships were found to be significant at plot C and at the site on an average (Figs. 63 & 64). However, the negative relationships were found to be non-significant at plot A and plot B (Table 24).

At South Kolkata site no significant relationship could be established between population of ants and temperature of soil. Though at plot A the relationship was found to be positive; whereas in plot B, plot C and at the site on an average the relationships were found to be negative (Table 24).

On the other hand, at East Kolkata site the population of ants and the pH of soil were found to be related negatively at plot B, plot C and at the site on an average; whereas at plot A it was found to be positive. The relationships at plot A and B were found to be significant (Figs. 65 & 66). But there was no significant relationship between these two parameters in plot C and at the site on an average (Table 25).

At Central Kolkata site the relationships of population of ants with pH of soil were found to be negative and not significant in all the plots A, B, C and at the site on an average (Table 25).

At North Kolkata site the relationship between population of ants and pH of soil was found to be non-significant in any of the plots and at the site on an average. This relationship was found to be negative only at plot C whereas in others the relationships were positive. (Table 25).

At South Kolkata site the population of ants was found to be negatively related with the pH of soil in all three plots and at the site on an average. The relationships were found to be non-significant in all three plots whereas at the site on an average it was found to be significant (Table 25, Fig. 67).

At East Kolkata site the population of *Solenopsis geminata*, *Pheidole roberti* and *Paratrechina longicornis* were found to be positively related with concentration of lead in soil whereas that of *Tapinoma melanocephalum* and *Technomyrmex albipes* were found to be negative. These relationships were found to be non-significant (Table 26). The lines of

Table 24. Relationship between temperature (°C) of soil and population of ants (mean no./sample) at different plots and at different sites. (NS - Not Significant)

X : Temperature		Mean		Correlation coefficient (r)	P	Regression equation of ant (y) on temperature (x) y = ax+b
		Temperature	**Population**			
East Kolkata	Plot-A	27.75	42.50	0.112	NS	y = 0.9293x+16.712
	Plot-B	27.71	27.08	-0.126	NS	y = -0.8683x+51.142
	Plot-C	27.79	25.04	0.002	NS	y = 0.0127x+24.69
	Average	27.75	31.54	-0.024	NS	y = 0.1046x+34.444
Central Kolkata	Plot-A	29.00	29.96	-0.424	<0.05	y = -3.4528x+130.09
	Plot-B	27.29	18.04	0.228	NS	y = 1.0027X-9.324
	Plot-C	27.50	24.13	-0.438	<0.05	y = -2.8966x+103.78
	Average	27.91	24.04	-0.216	NS	y = -2.2777x+87.613
North Kolkata	Plot-A	27.81	26.00	-0.218	NS	y = -0.975x+53.119
	Plot-B	27.52	19.13	-0.241	NS	y = -0.7265x+39.118
	Plot-C	27.71	22.42	-0.646	<0.01	y = -2.3727x+88.161
	Average	27.69	22.51	-0.702	<0.001	y = -1.5376x+65.088
South Kolkata	Plot-A	27.23	28.50	0.116	NS	y = 58.23x+12.644
	Plot-B	27.38	25.13	-0.134	NS	y = -0.8086x+47.259
	Plot-C	27.21	21.50	-0.130	NS	y = -0.6824x+40.068
	Average	27.27	25.04	-0.037	NS	y = -0.1151x+28.18

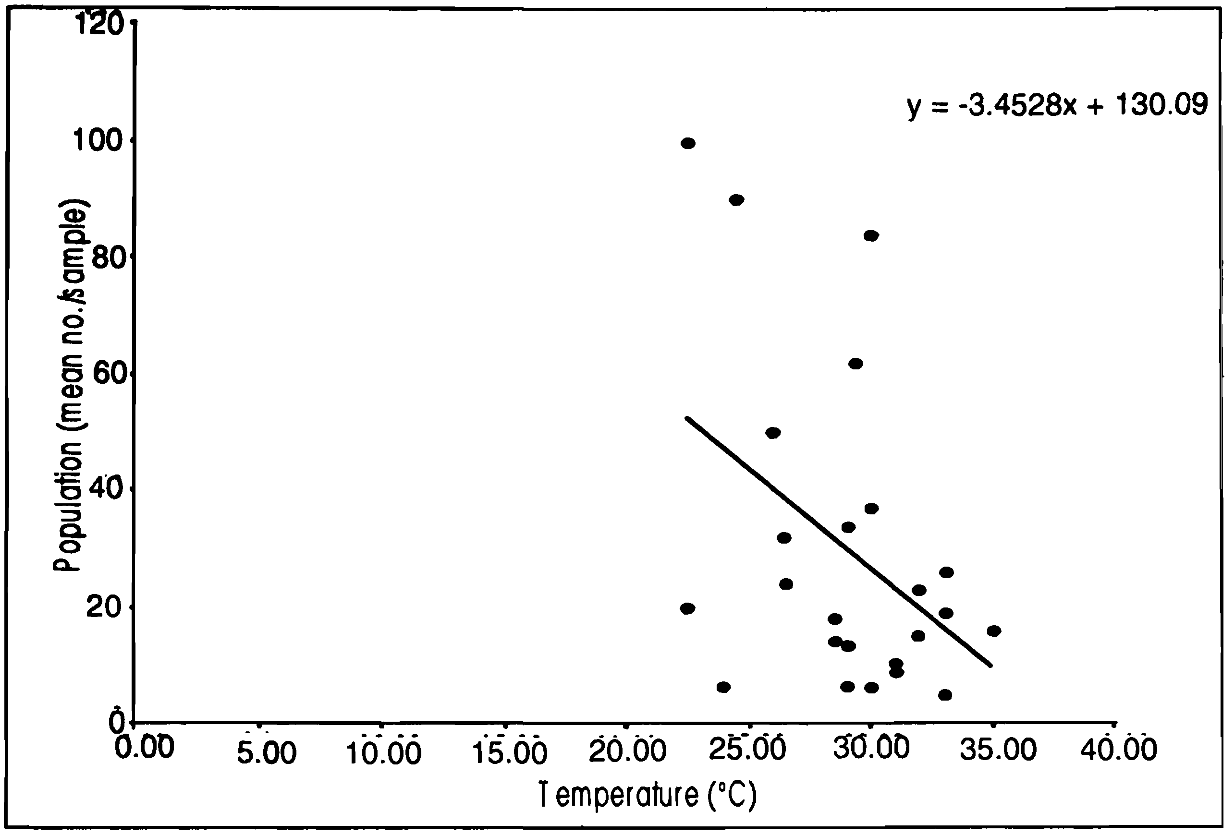


Fig. 61 : Line of regression alongwith scattered diagram of population of ants on temperature at plot A of Central Kolkata

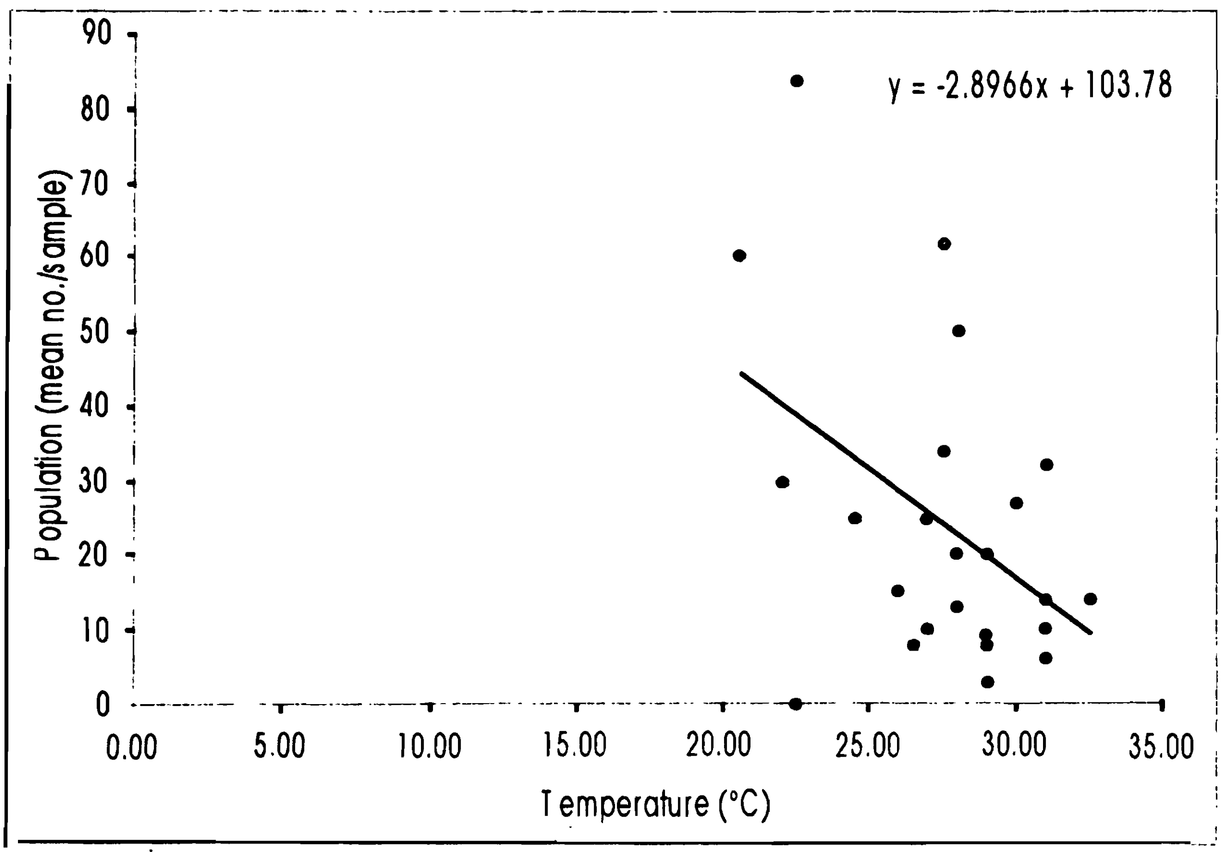


Fig. 62 : Line of regression alongwith scattered diagram of population of ants on temperature at plot C of Central Kolkata

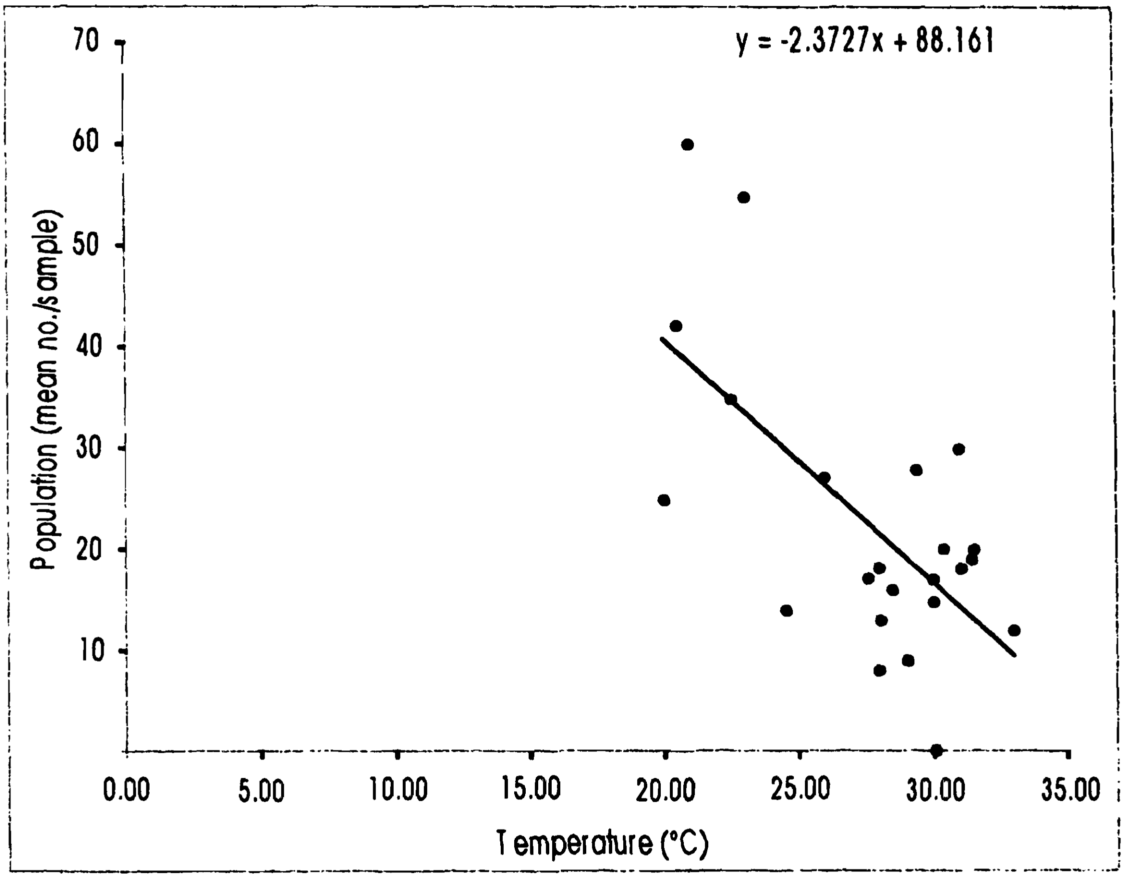


Fig. 63 : Line of regression alongwith scattered diagram of population of ants on temperature at plot C of North Kolkata

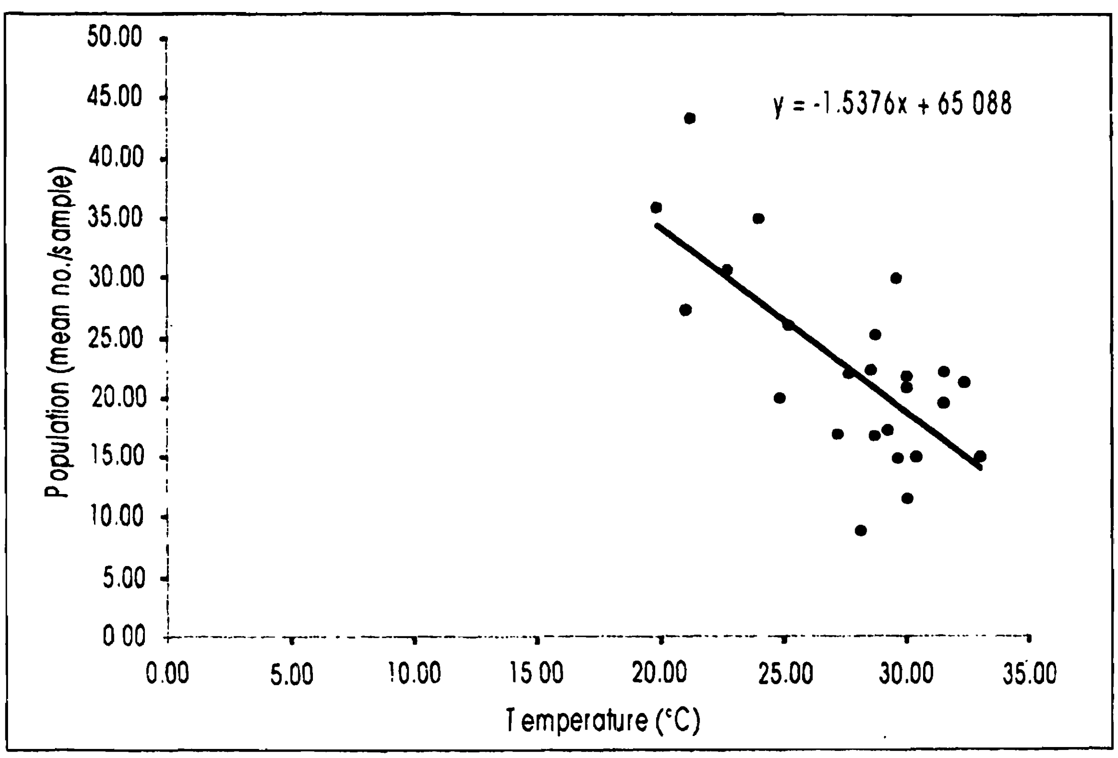


Fig. 64 : Line of regression alongwith scattered diagram of population of ants on temperature, on an average of North Kolkata site

Table 25. Relationship between pH of soil and population of ants (mean no./sample) at different plots and at different sites. (NS - Not Significant)

X : pH		Mean		Correlation coefficient (r)	P	Regression equation of ant (y) on pH (x) y = ax+b
		pH	Population			
East Kolkata	Plot-A	6.88	42.50	0.370	<0.1	y = 67.177x–419.96
	Plot-B	6.92	27.08	-0.351	<0.1	y = -50.589x+377.01
	Plot-C	6.92	25.04	-0.031	NS	y = -4.4334x+55.736
	Average	6.91	31.54	-0.063	NS	y = -6.8947x+79.172
Central Kolkata	Plot-A	6.92	29.96	-0.187	NS	y = -40.832x+312.48
	Plot-B	6.87	18.04	-0.059	NS	y = -5.2512x+54.104
	Plot-C	6.83	24.13	-0.098	NS	y = -9.6585x+90.1
	Average	6.87	24.04	-0.293	NS	y = -43.782x+324.9
North Kolkata	Plot-A	6.96	26.00	0.267	NS	y = 43.486x–276.46
	Plot-B	6.91	19.13	0.044	NS	y = 4.9234x–14.887
	Plot-C	6.92	22.42	-0.078	NS	y = -8.872x+83.848
	Average	6.93	22.51	0.163	NS	y = 14.507x–77.995
South Kolkata	Plot-A	6.84	28.50	-0.168	NS	y = -20.32x+167.51
	Plot-B	6.87	25.13	-0.303	NS	y = -28.593x+221.53
	Plot-C	6.85	21.50	-0.092	NS	y = -6.2979x+64.644
	Average	6.85	25.04	-0.416	<0.1	y = -22.605x+179.97

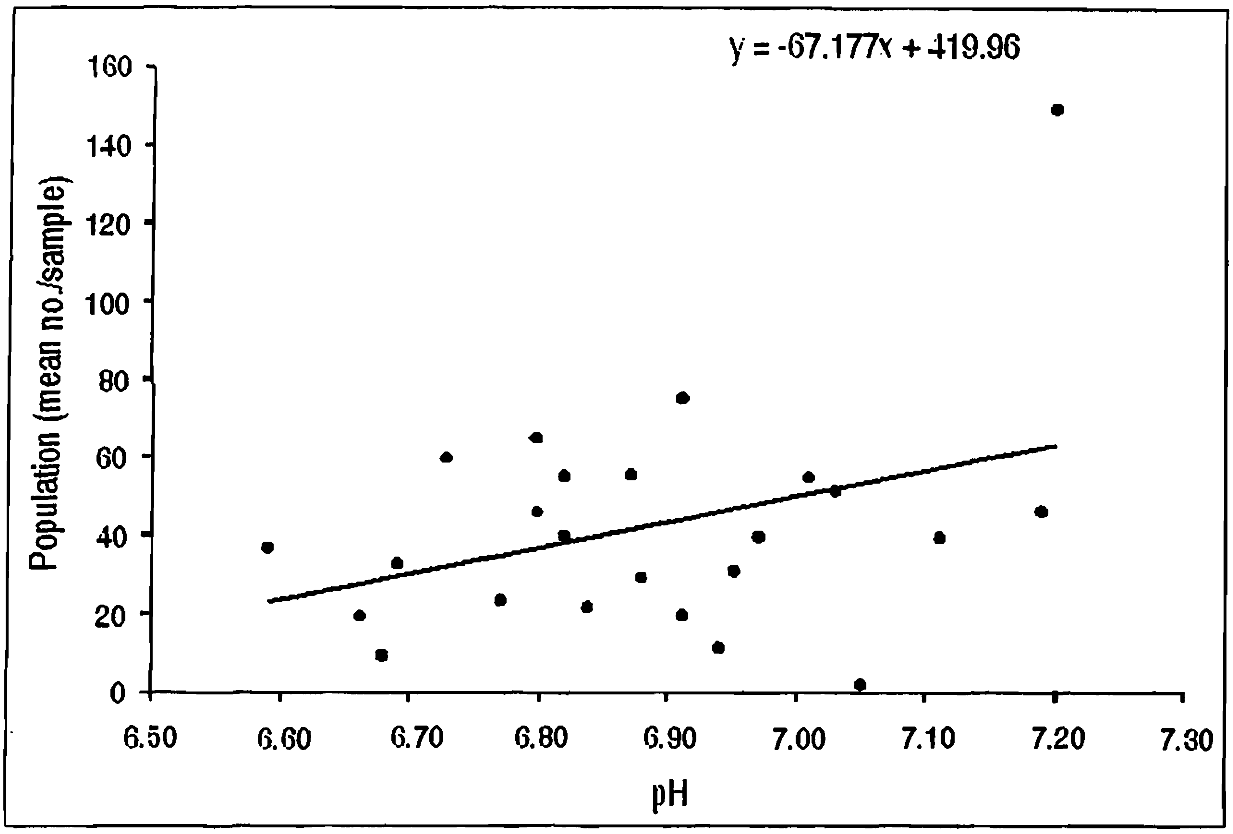


Fig. 65 : Line of regression alongwith scattered diagram of population of ants on pH at plot A of East Kolkata

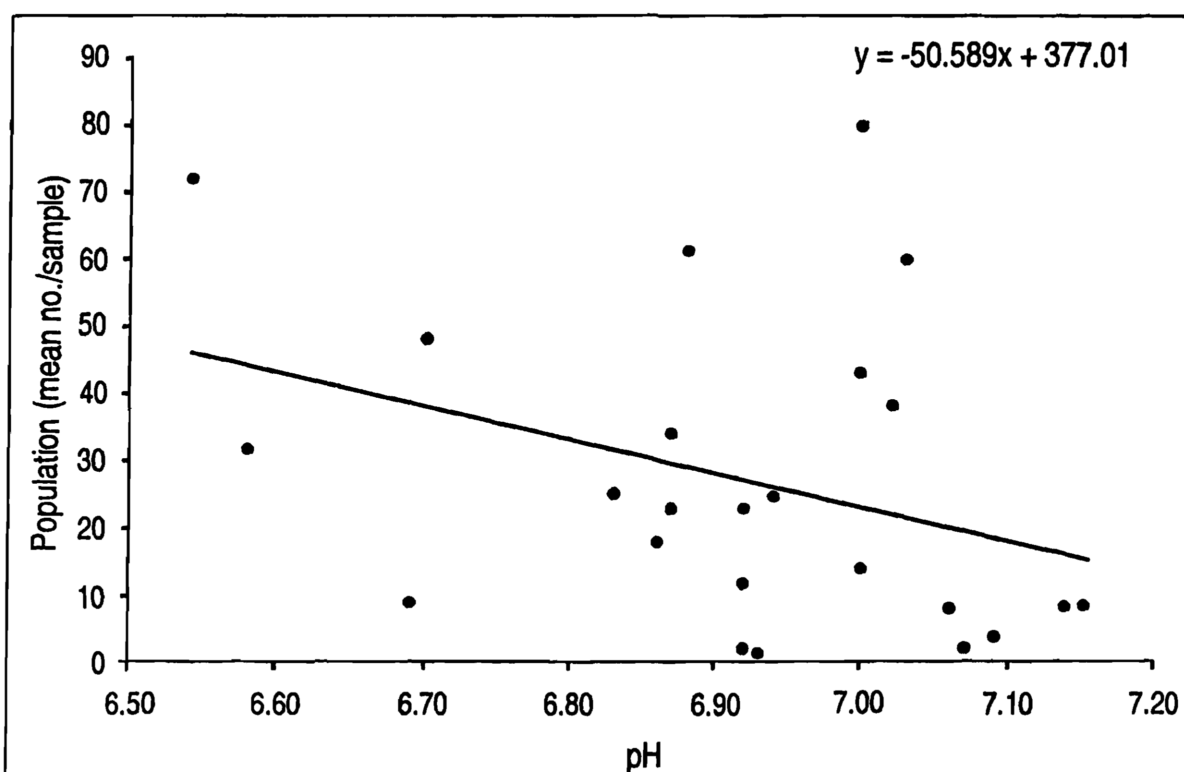


Fig. 66 : Line of regression alongwith scattered diagram of population of ants on pH at plot B of East Kolkata

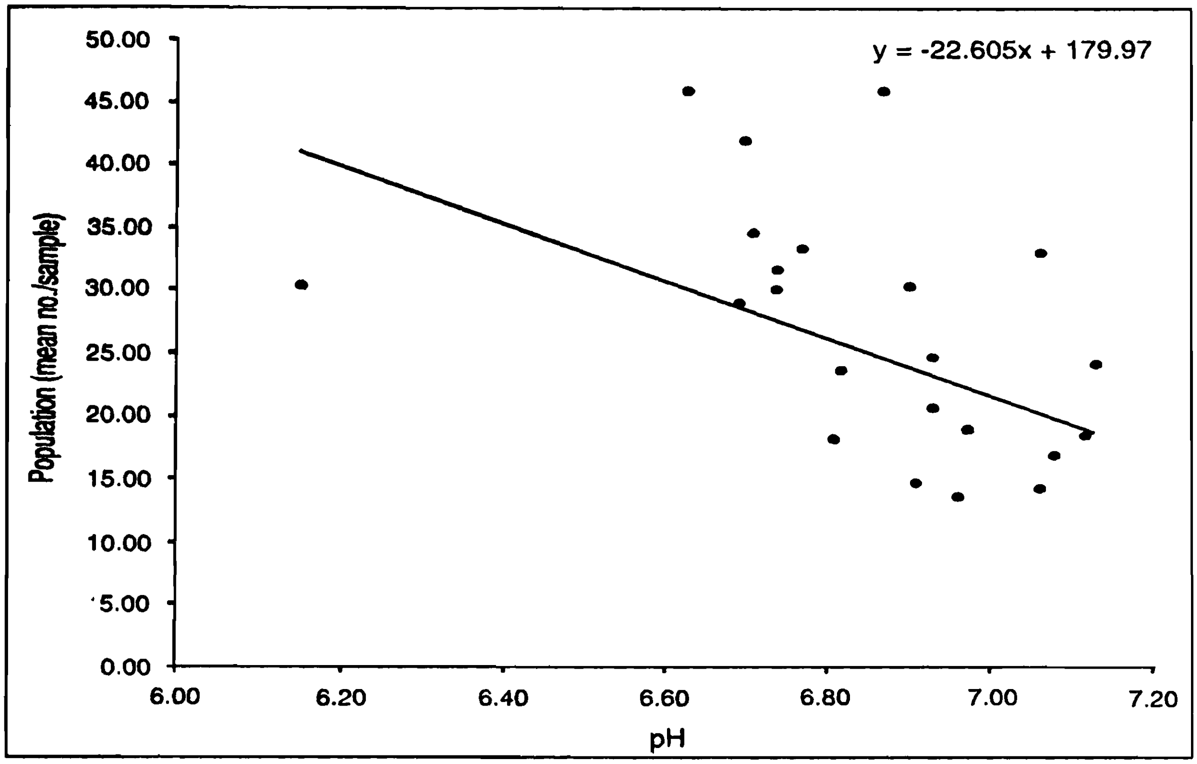


Fig. 67 : Line of regression alongwith scattered diagram of population of ants on pH, on an average of South Kolkata.

regression alongwith scattered diagram of population of all major species on concentration of lead in soil were drawn (Figs. 68-72).

At Central Kolkata site the population of *Solenopsis geminata, Pheidole roberti, Meranoplus bicolor* were found to be related negatively with concentration of lead in soil; whereas that of *Paratrechina longicornis* with lead was found positively related, which was found significant also. The relationship between population of *P. roberti* with concentration of lead was also found to be significant. In case of other two species the relationships were not significant (Table 26). The lines of regression alongwith scattered diagram of population of these major species on concentration of lead in soil were drawn (Figs. 73-76).

At North Kolkata site the relationships of population of *Tetramorium walshi, Paratrechina longicornis* and *Monomorium floricola* with concentration of lead in soil were found to be positive, but not at significant level. The population of *Solenopsis geminata, Pheidole roberti* and *Meranoplus bicolor* with concentration of lead were found to be negative. The relationship of *M.bicolor* with concentration of lead in soil was found to be at significant level, other two were at non-significant level (Table 26). The lines of regression of population of major species of ants on concentration of lead in soil are being represented in Figs. 77-82.

At South Kolkata site the individual population of all major species *viz. Solenopsis geminata, Monomorium floricola,Pheidole roberti, Plagiolepis jerdonii, Tapinoma*

Table 26. Relationship between concentration of lead (ppm) and population of major species of ants (mean no./sample) at different sites. (NS - Not Significant)

Site X : Lead	Name of the Species	Mean Population	Correlation coefficient (r)	P	Regression equation of ant species (y) on lead (x) y = ax+b
East Kolkata	*Solenopsis geminata*	13.47	0.042	NS	y = 0.026x+10.323
	Pheidole roberti	4.53	0.263	NS	y = 0.1202x–10.059
	Paratrechina longicornis	2.78	0.314	NS	y = 0.1626x–16.952
(Mean of Lead : 121.32)	*Tapinoma melanocephalum*	2.07	-0.284	NS	y = -0.0652x+9.9789
	Technomyrmex albipes	1.86	-0.170	NS	y = -0.0352x+6.1322
Central Kolkata	*Solenopsis geminata*	10.02	-0.154	NS	y = -0.0298x+17.908
	Pheidole roberti	4.45	-0.332	<0.1	y = -0.031x+12.672
(Mean of Lead : 256.28)	*Meranoplus bicolor*	3.82	-0.227	NS	y = -0.0238x+10.138
	Paratrechina longicornis	1.26	0.336	<0.1	y = 0.0138x–2.4074
North Kolkata	*Solenopsis geminata*	6.85	-0.095	NS	y = -0.0131x+10.757
	Pheidole roberti	4.23	-0.239	NS	y = -0.0191x+9.9182
	Tetramorium walshi	2.87	0.163	NS	y = 0.0216x–3.5739
	Meranoplus bicolor	2.56	-0.507	<0.02	y = -0.0307x+11.717
(Mean of Lead : 298.57)	*Paratrechina longicornis*	1.31	0.276	NS	y = 0.0123x–2.3638
	Monomorium floricola	1.22	0.035	NS	y = 0.0016x+0.7421
South Kolkata	*Solenopsis geminata*	10.22	-0.214	NS	y = 0.0879x+23.21
	Monomorium floricola	3.71	-0.166	NS	y = -0.0294x+8.042
	Pheidole roberti	2.46	-0.203	NS	y = -0.0368x+7.8905
	Plagiolepis jerdonii	1.67	-0.187	NS	y = -0.0191x+4.4821
(Mean of Lead : 147.47)	*Tapinona melanocephalum*	1.43	-0.141	NS	y = -0.0208x+4.4953
	Paratrechina longicornis	1.40	-0.044	NS	y = -0.0056x+2.2329

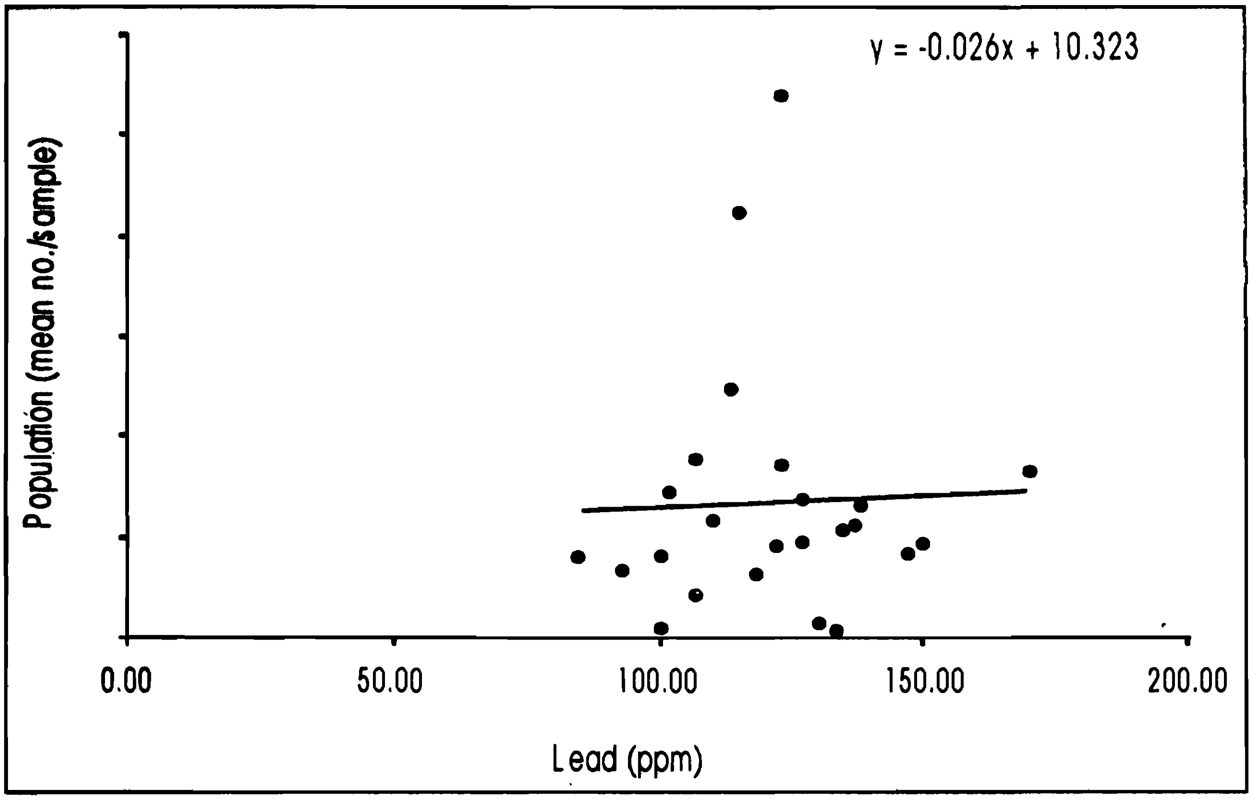


Fig. 68 : Line of regression alongwith scattered diagram of population of *S. geminata* on lead at East Kolkata

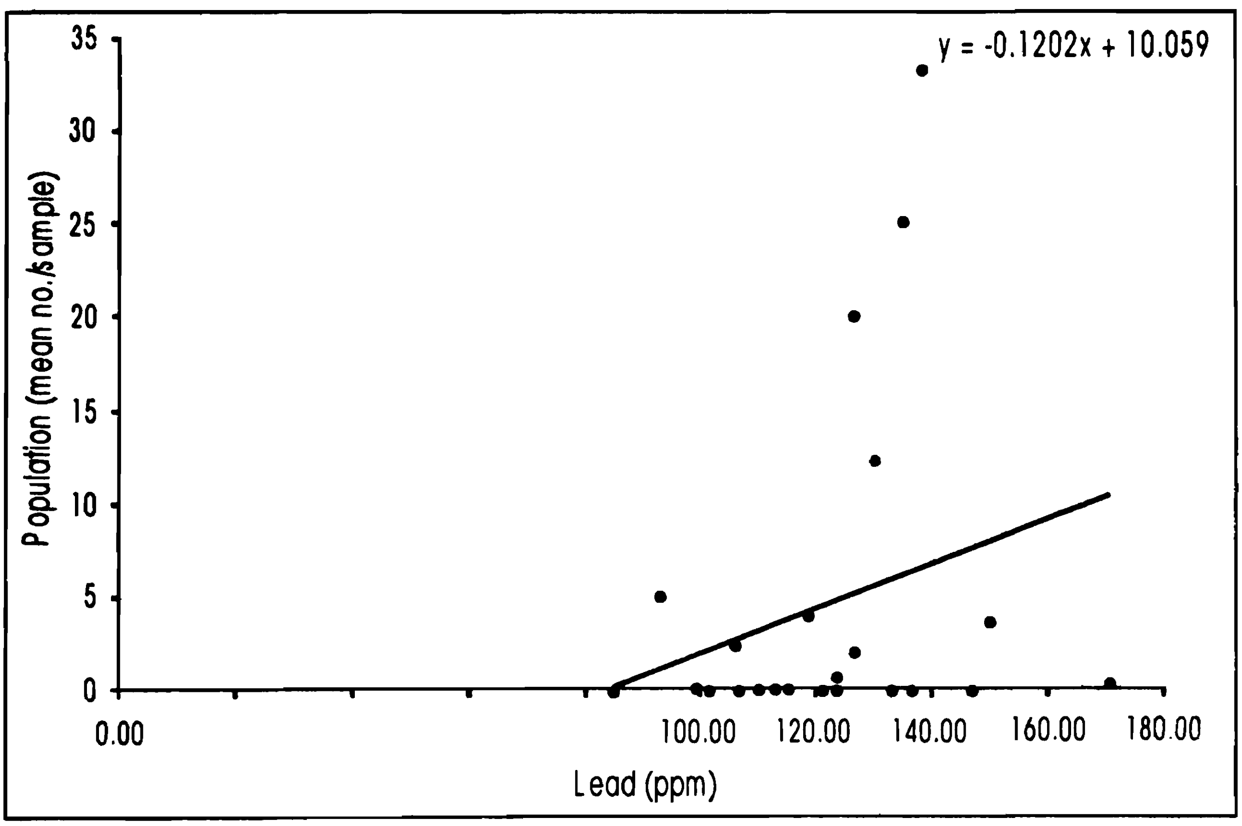


Fig. 69 : Line of regression alongwith scattered diagram of population of *P. roberti* on lead at East Kolkata

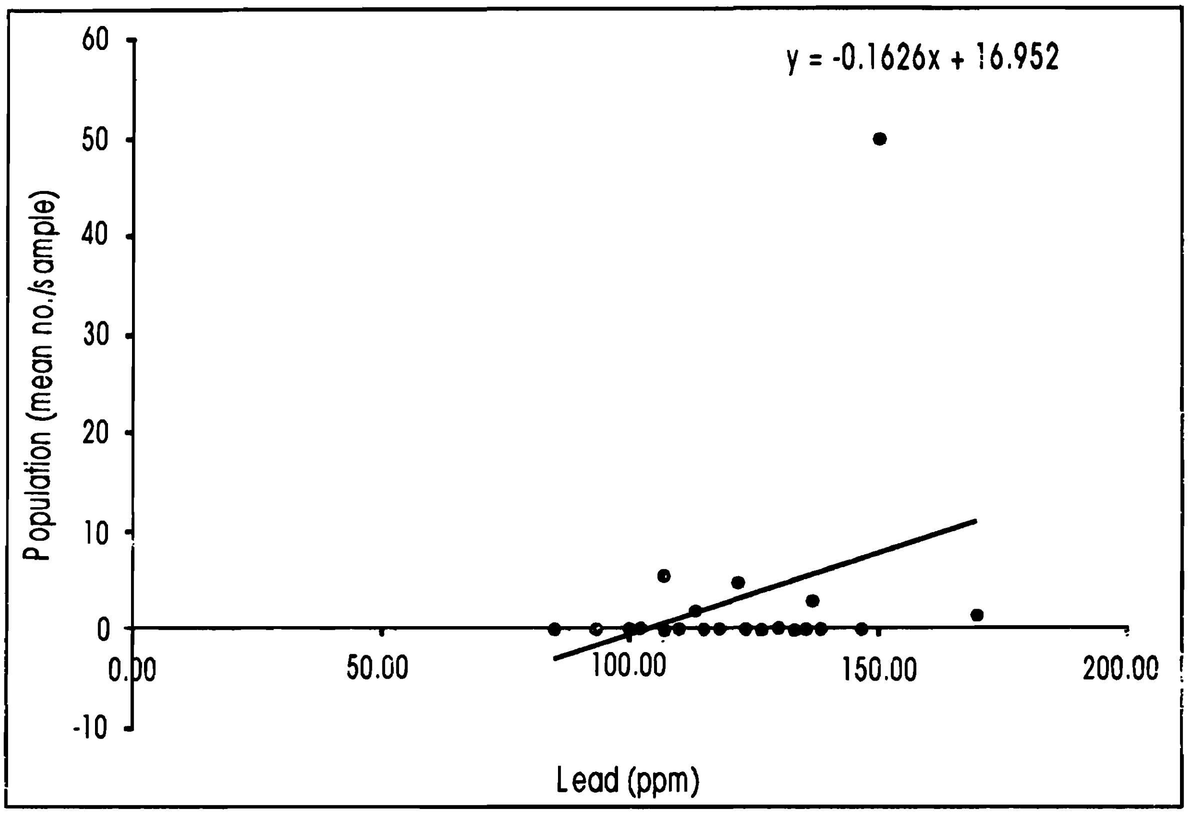


Fig. 70 : Line of regression alongwith scattered diagram of population of *P. longicornis* on lead at East Kolkata

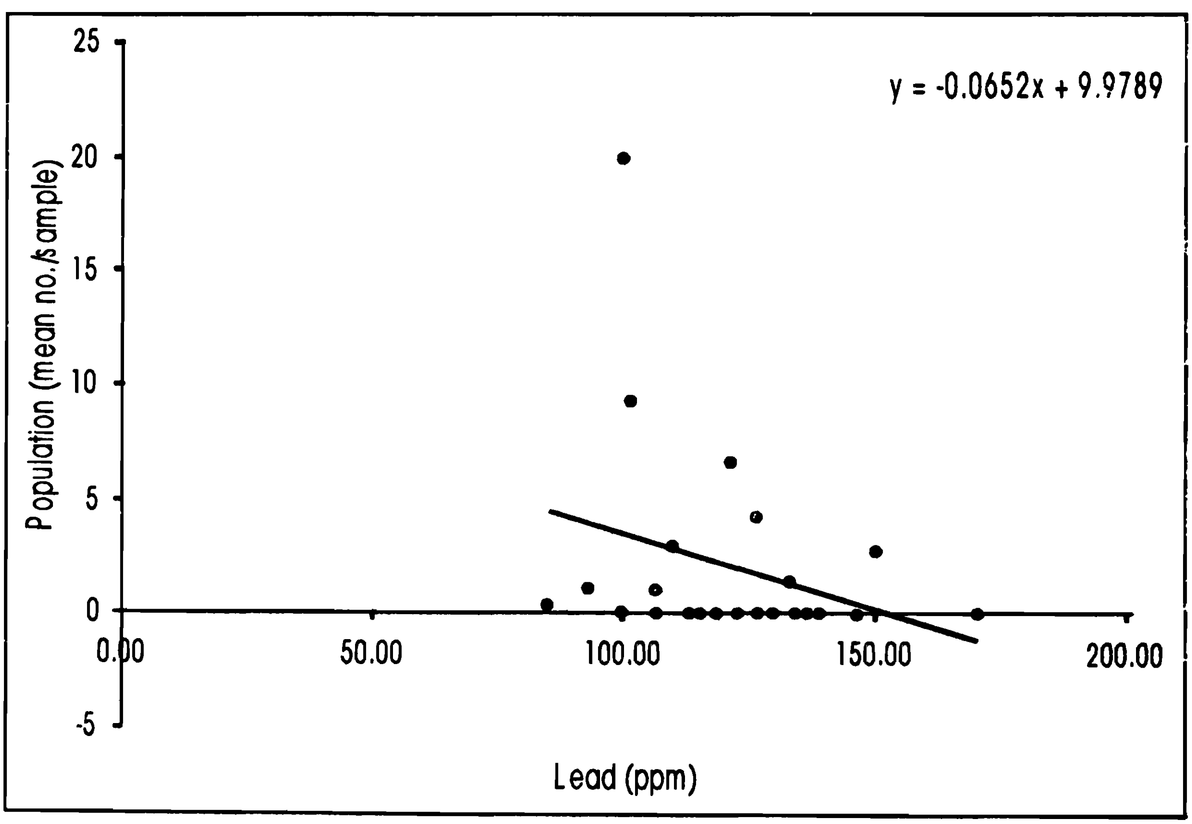


Fig. 71 : Line of regression alongwith scattered diagram of population of *T. melanocephalum* on lead at East Kolkata

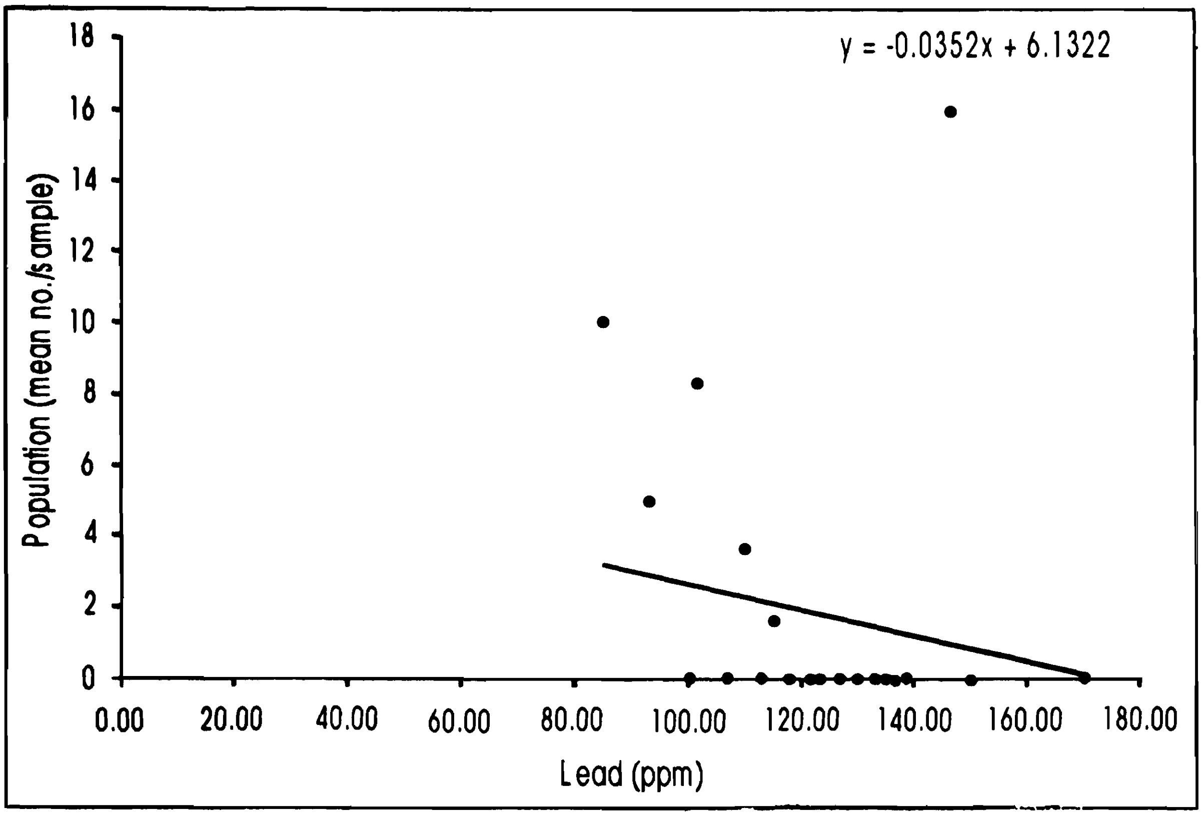


Fig. 72 : Line of regression alongwith scattered diagram of population of *T. albipes* on lead at East Kolkata

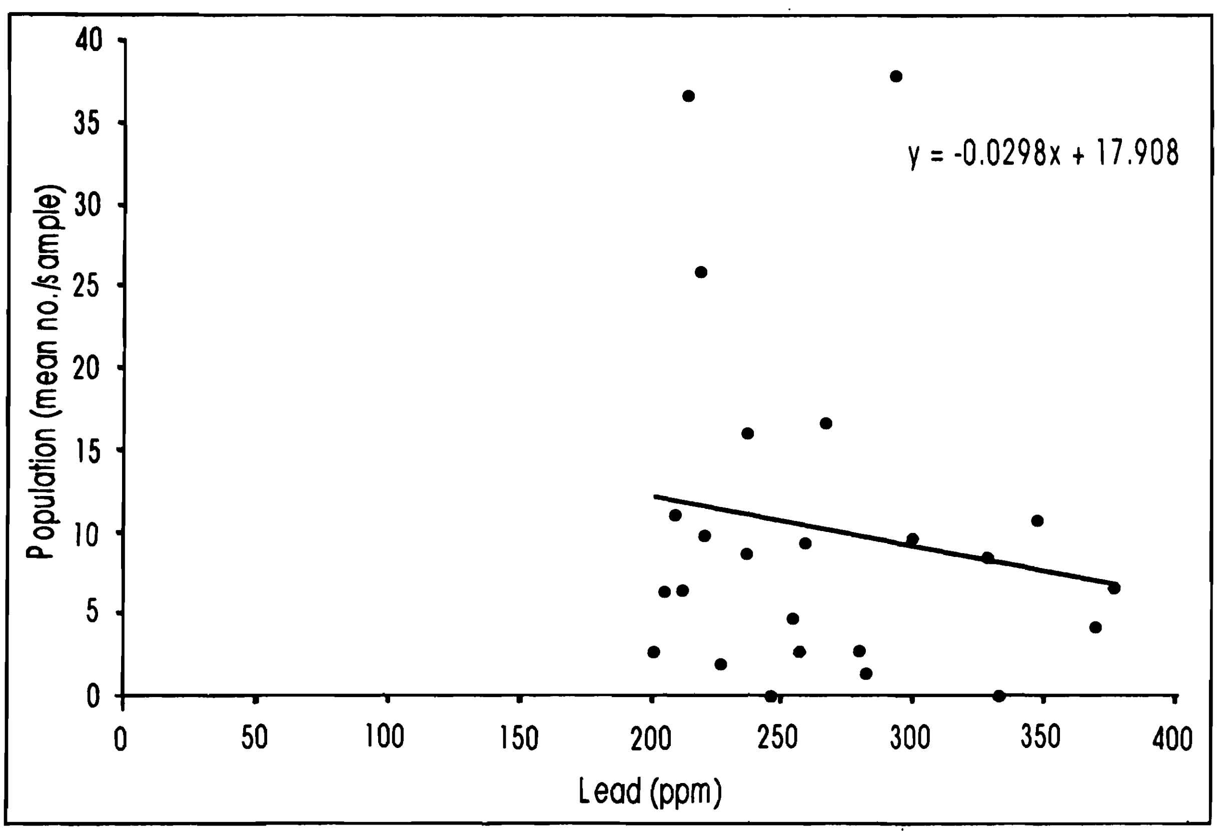


Fig. 73 : Line of regression alongwith scattered diagram of population of *S. geminata* on lead at Central Kolkata

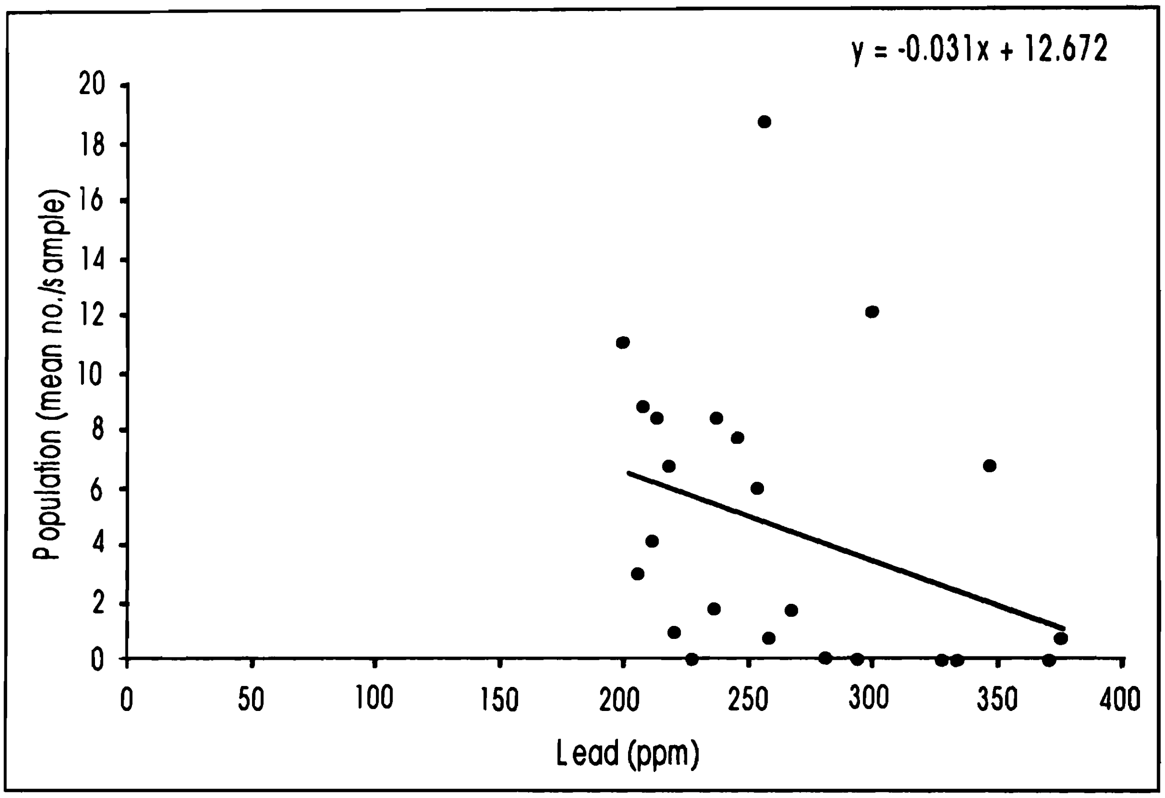


Fig. 74 : Line of regression alongwith scattered diagram of population of *P. roberti* on lead at Central Kolkata

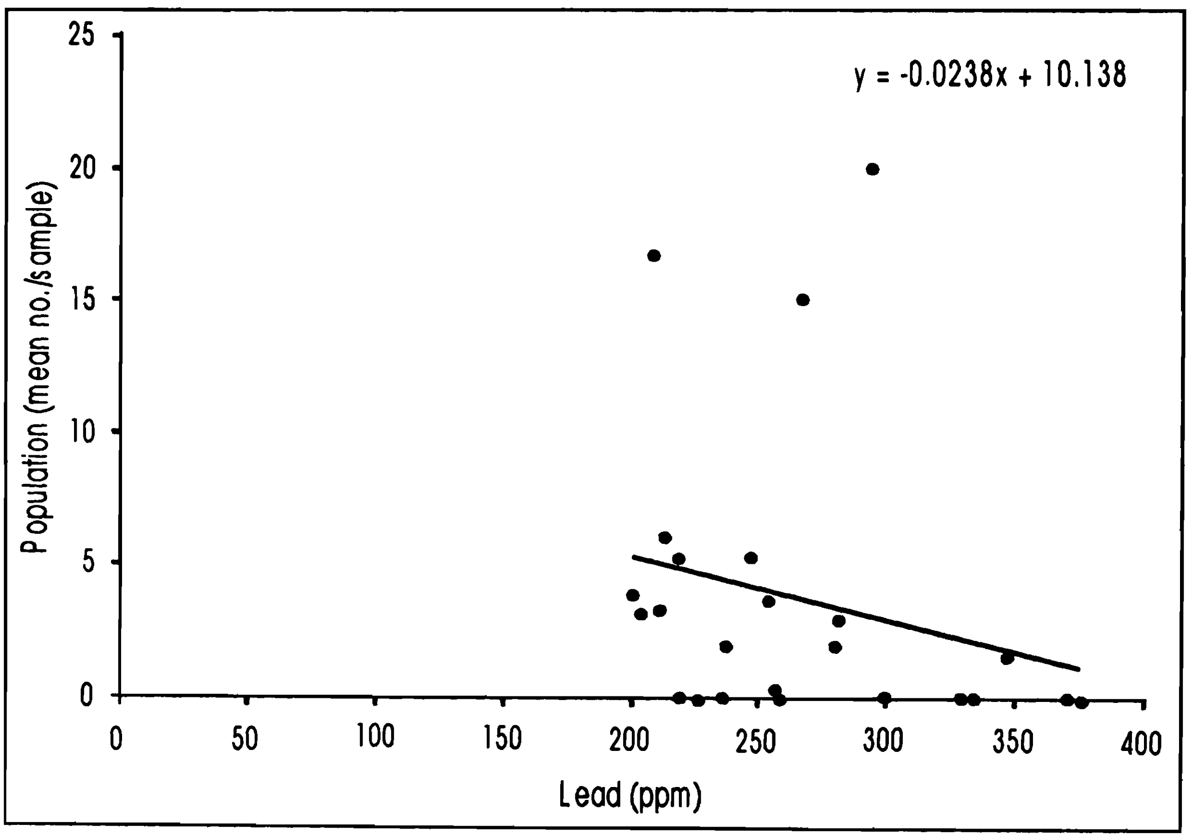


Fig. 75 : Line of regression alongwith scattered diagram of population of *M. bicolor* on lead at Central Kolkata

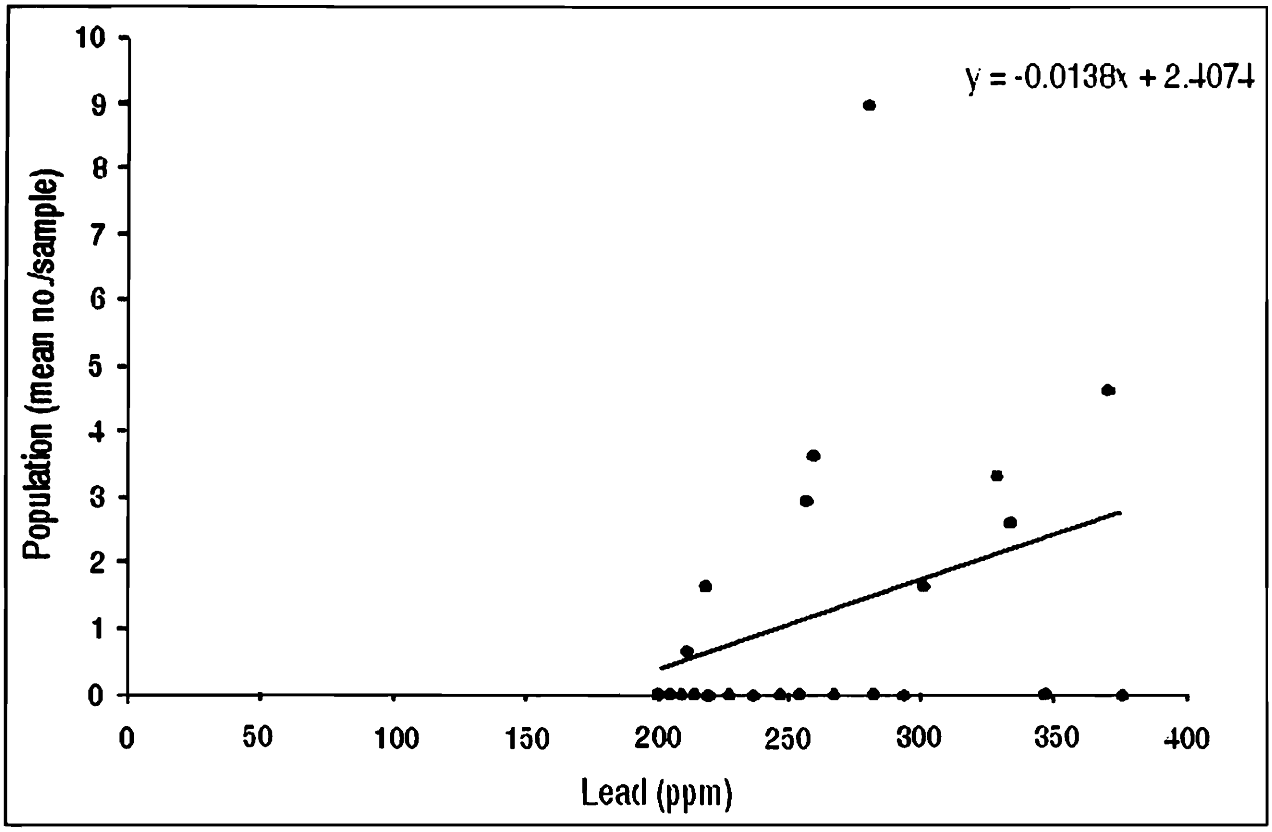


Fig. 76 : Line of regression alongwith scattered diagram of population of *P. longicornis* on lead at Central Kolkata

melanocephalum and *Paratrechina longicornis* was found to be negatively related with the concentration of lead in soil; though none at significant level (Table 26). The lines of regression of population of major species of ants on concentration of lead in soil are being represented in Figs. 83-88.

The relationship between temperature of soil and individual population of *Solenopsis geminata*, *Pheidole roberti*, *Tapinoma melanocephalum* and *Technomyrmex albipes* at East Kolkata site was found to be negatively related but the population of *Paratrechina longicornis* was found to be positively related. However, none of these relationships was found to be at significant level (Table 27).

At Central Kolkata site the relationship between the population of *Solenopsis geminata*, *Pheidole roberti* and *Meranoplus bicolor* with the temperature of soil was found to be negative; whereas population of *Paratrechina longicornis* was found positively related with the temperature in soil. The relationships of *S. geminata* and *M. bicolor* were found to be at significant level (Figs. 89 & 90). The other two relationships were found to be non-significant (Table 27).

At North Kolkata site the individual population of *Solenopsis geminata*, *Pheidole roberti*, *Tetramorium walshi*, *Paratrechina longicornis* and *Monomorium floricola* was found to be negatively related with the temperature in soil but the population of *Meranoplus bicolor* was

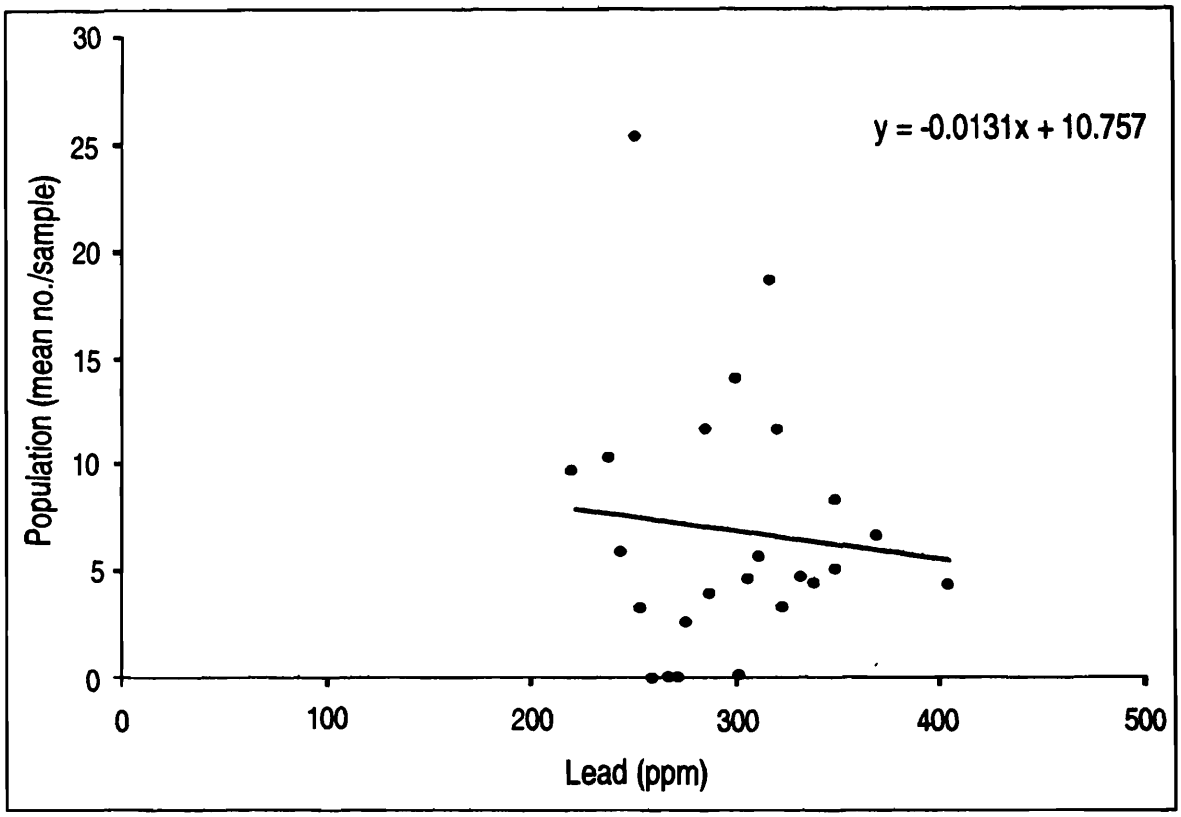


Fig. 77 : Line of regression alongwith scattered diagram of population of *S. geminata* on lead at North Kolkata

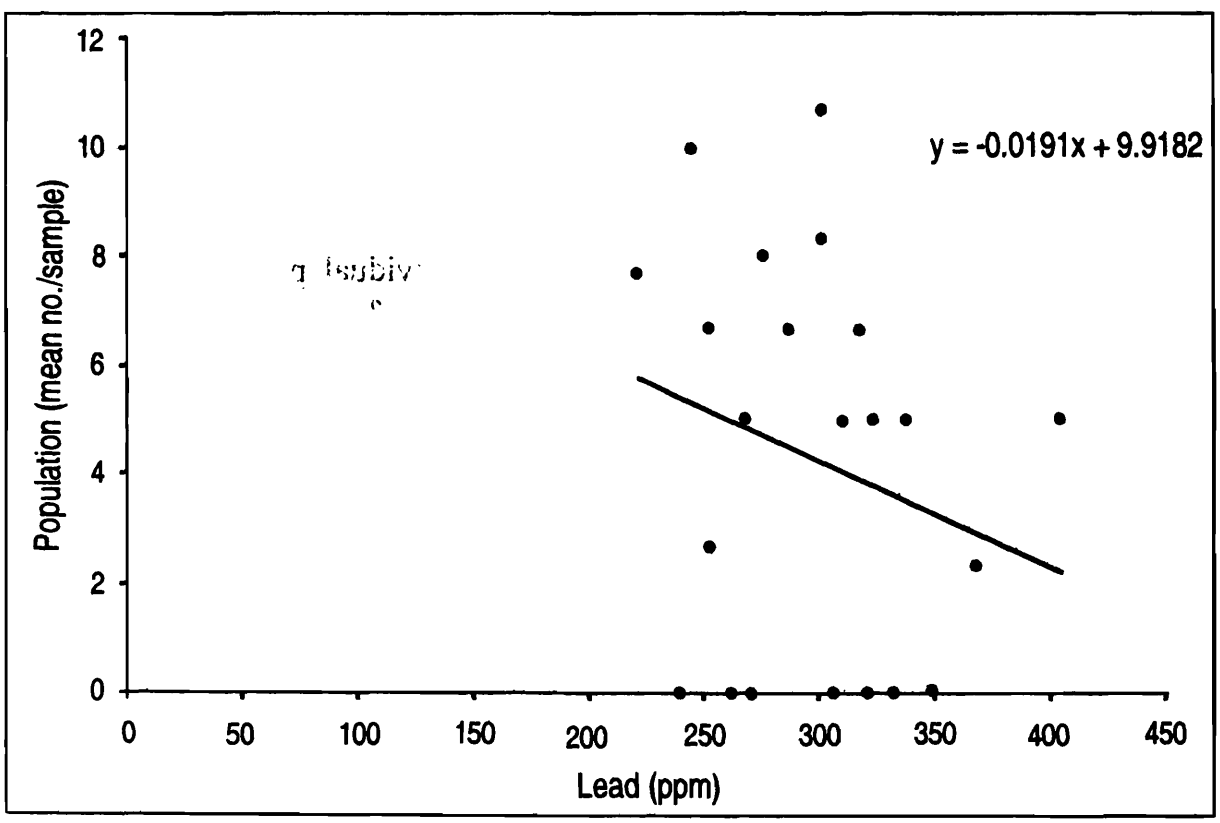


Fig. 78 : Line of regression alongwith scattered diagram of population of *P. roberti* on lead at North Kolkata

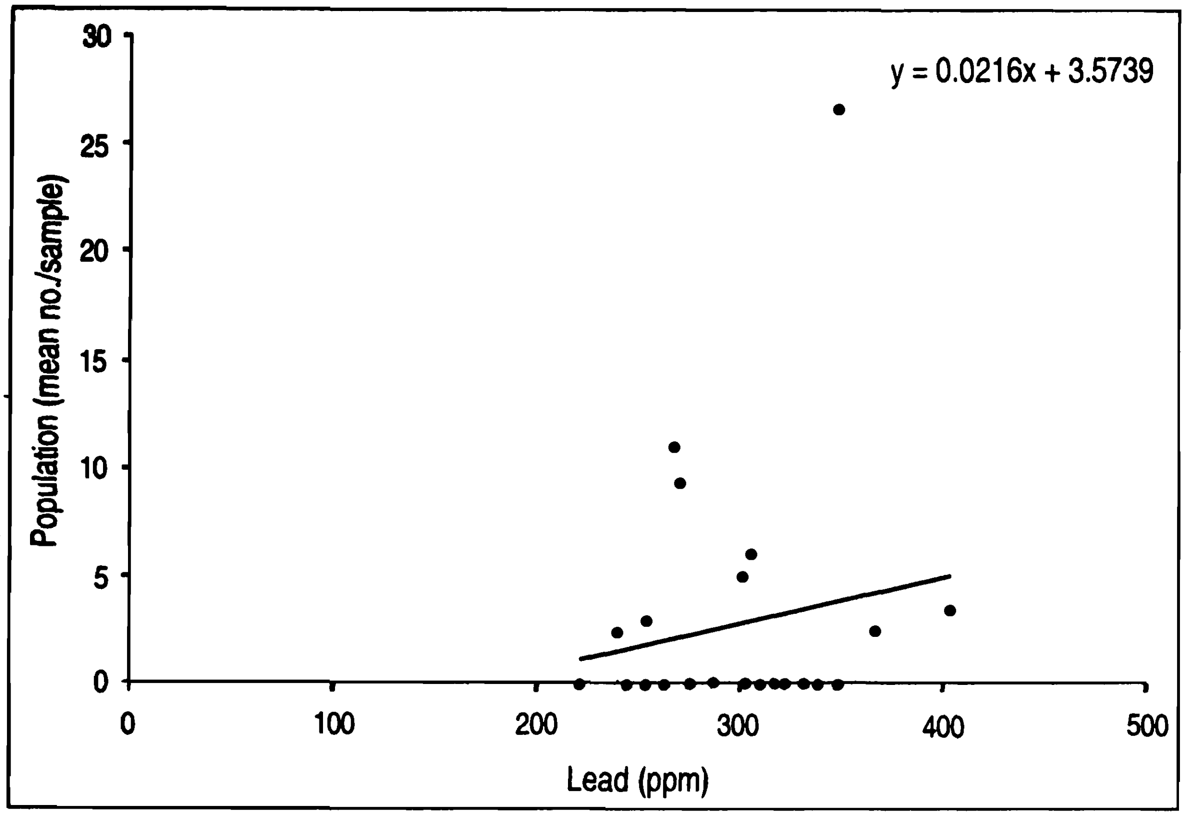


Fig. 79 : Line of regression alongwith scattered diagram of population of *T. walshi* on lead at North Kolkata

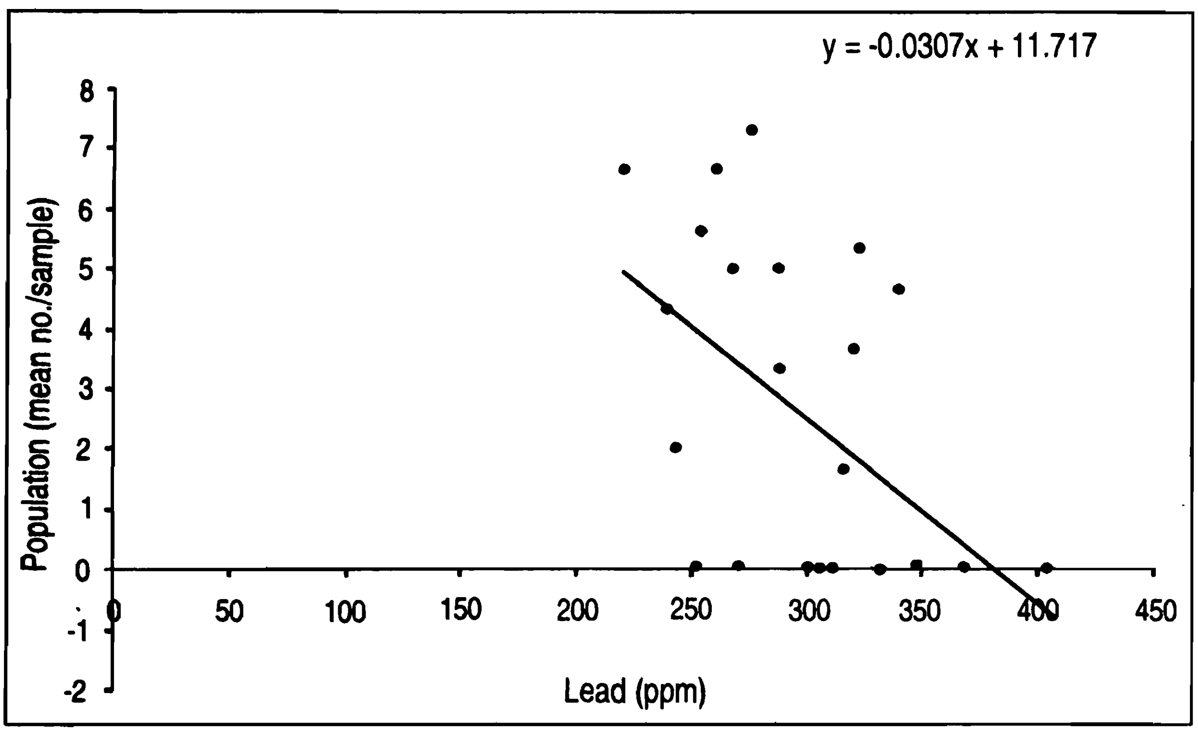


Fig. 80 : Line of regression alongwith scattered diagram of population of *M. bicolor* on lead at North Kolkata

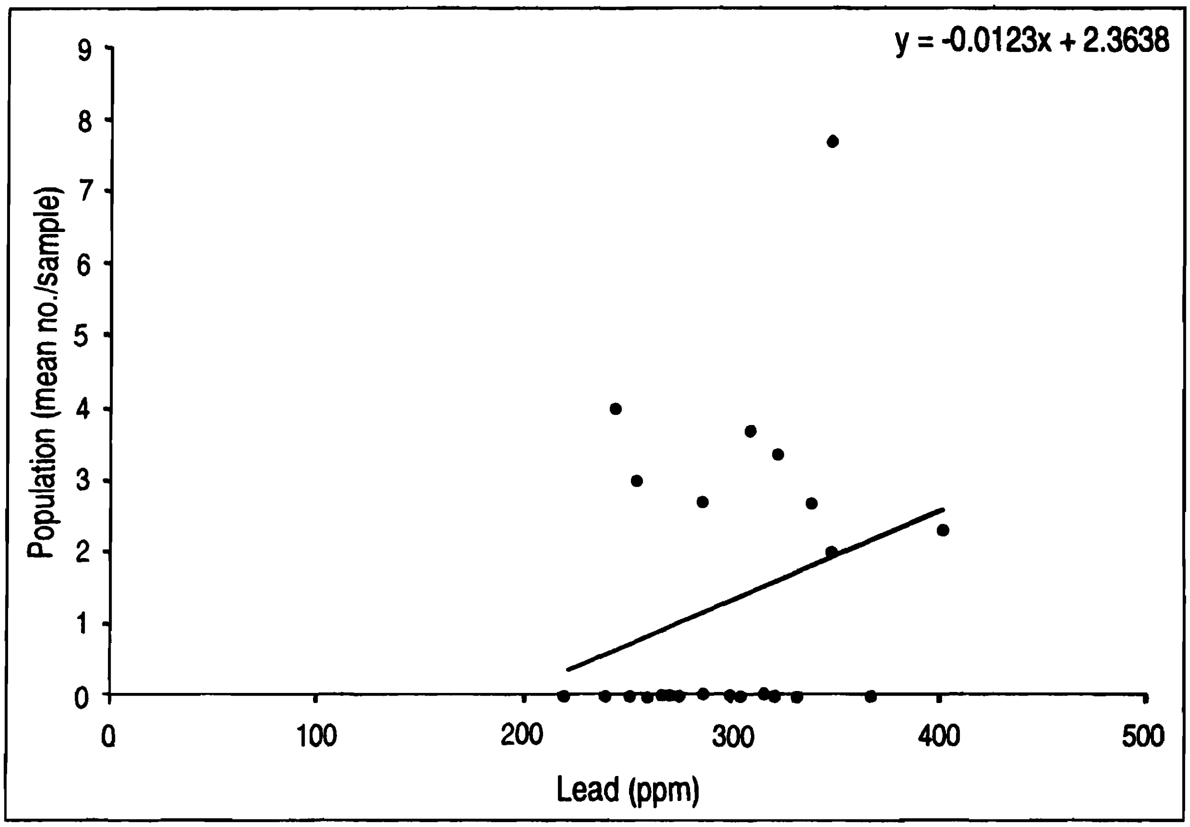


Fig. 81 : Line of regression alongwith scattered diagram of population of *P. longicornis* on Lead at North Kolkata

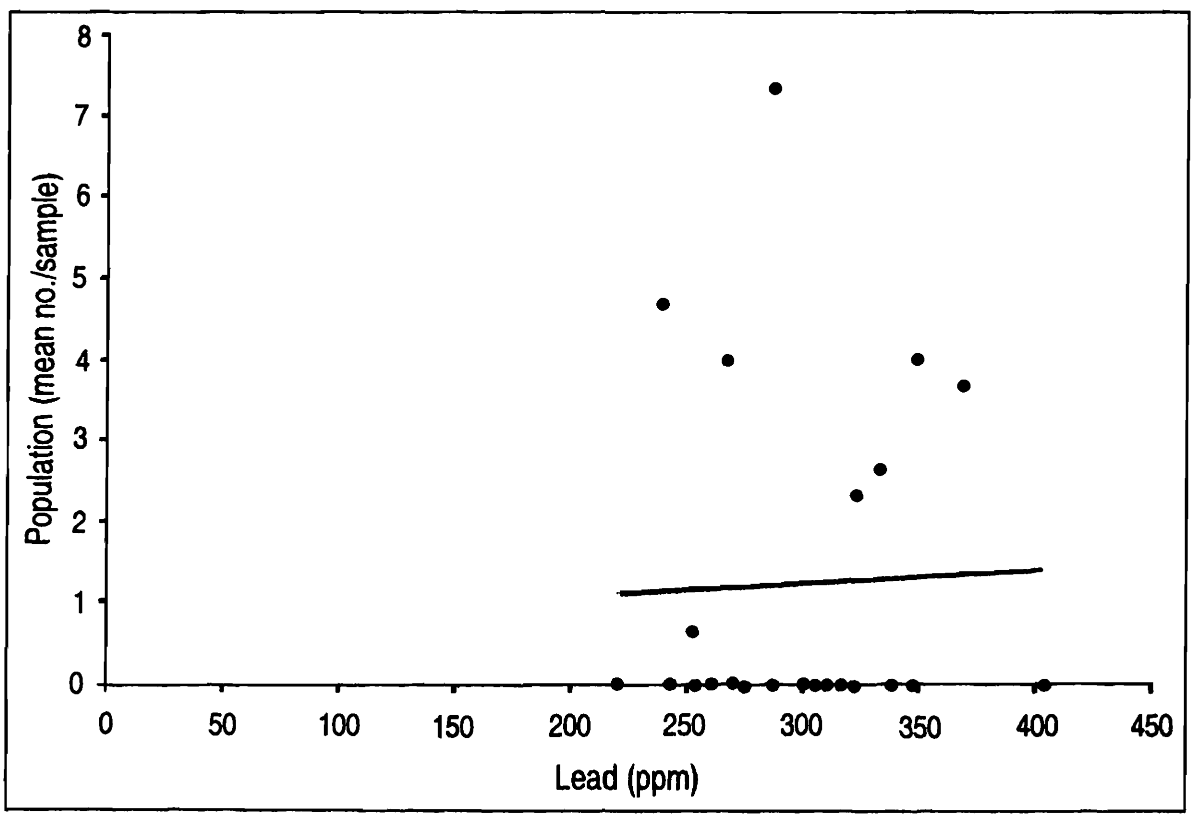


Fig. 82 : Line of regression alongwith scattered diagram of population of *M. floricola* on Lead at North Kolkata

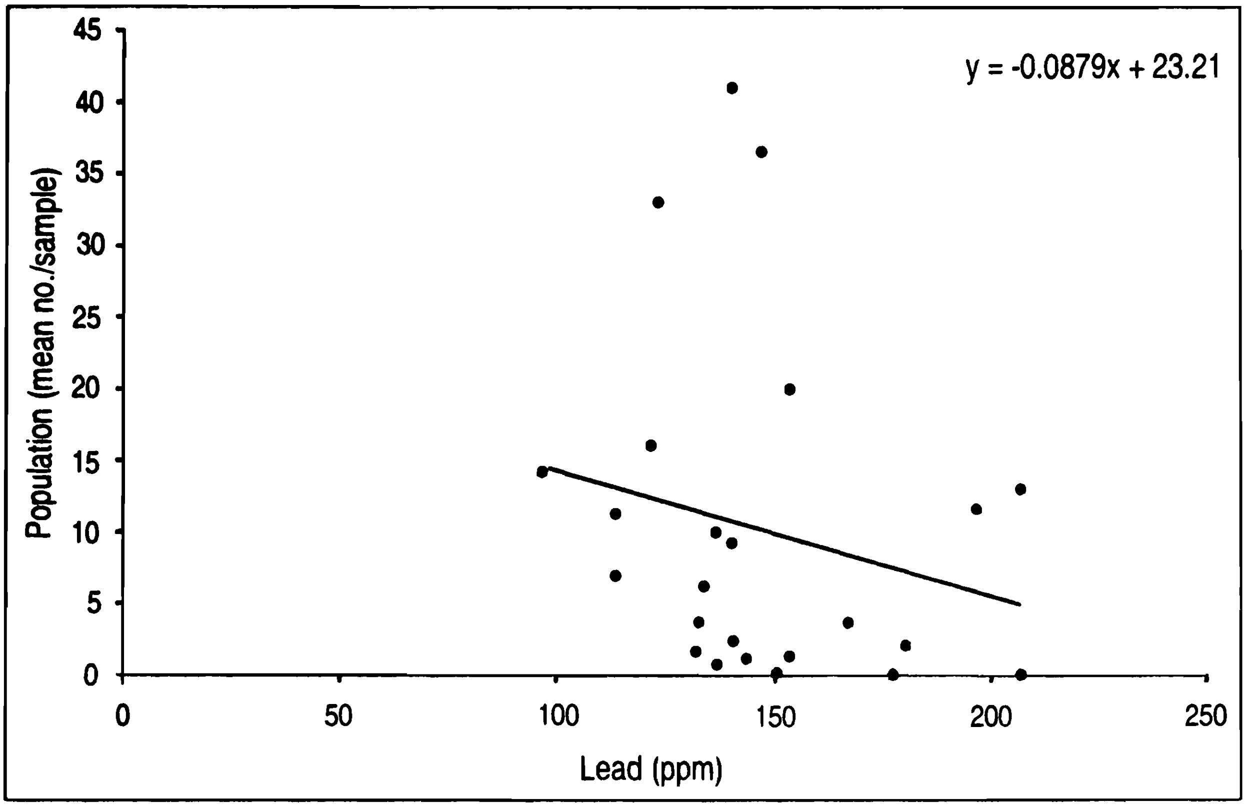


Fig. 83 : Line of regression alongwith scattered diagram of population of *S. geminata* on lead at South Kolkata

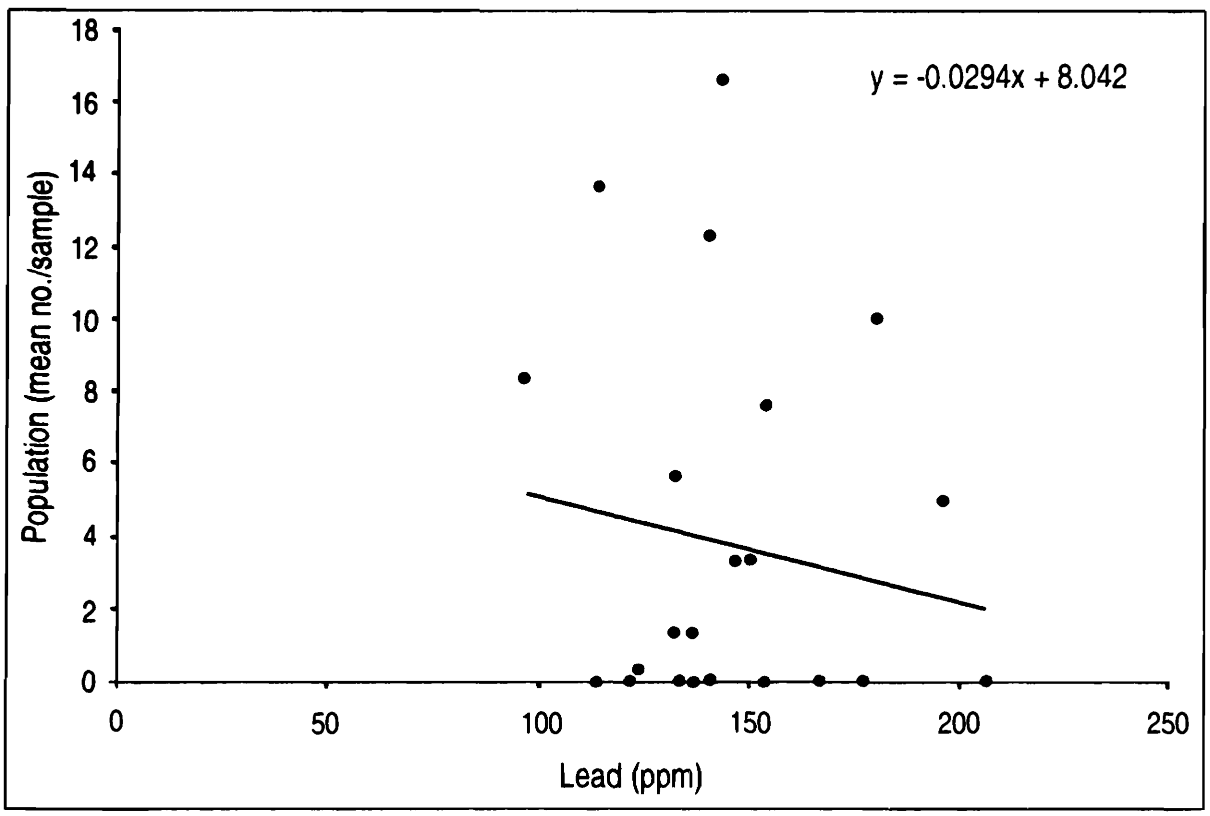


Fig. 84 : Line of regression alongwith scattered diagram of population of *M. floricola* on lead at South Kolkata

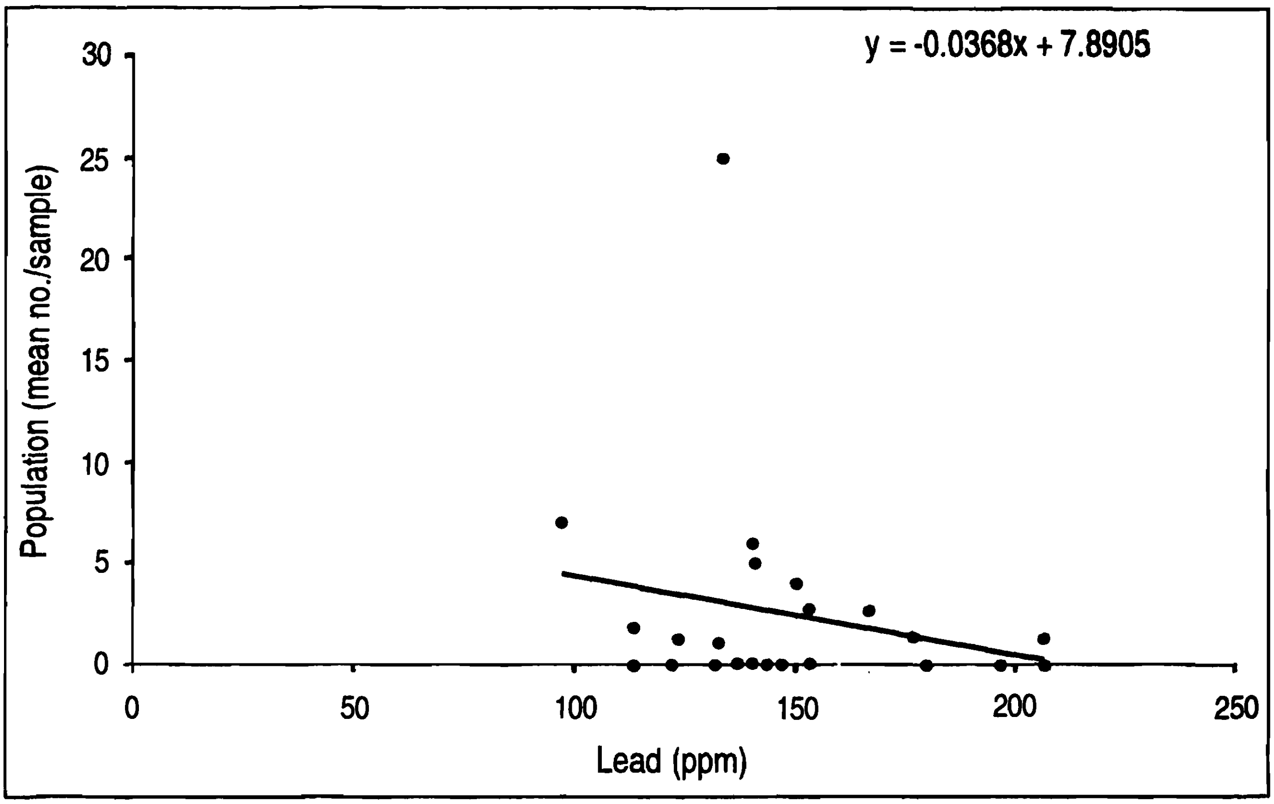


Fig. 85 : Line of regression alongwith scattered diagram of population of *P. roberti* on lead at South Kolkata

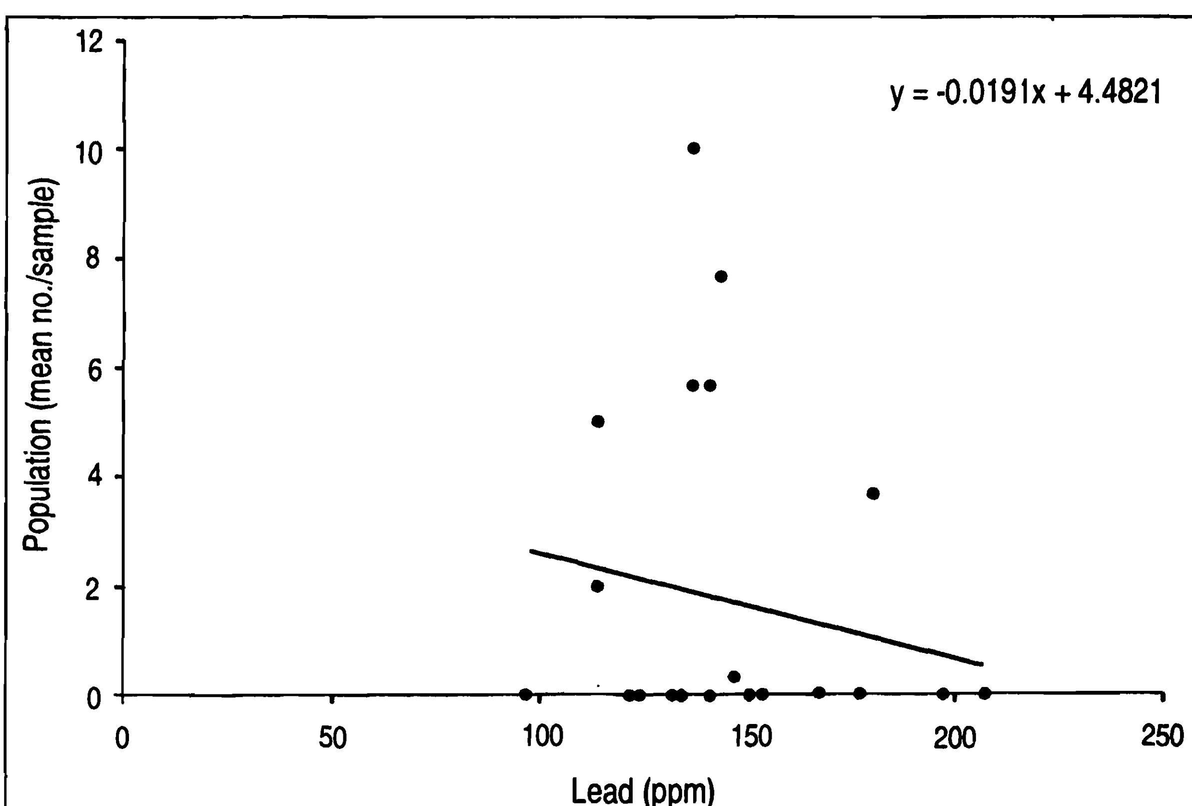


Fig. 86 : Line of regression alongwith scattered diagram of population of *P. jerdonii* on lead at South Kolkata

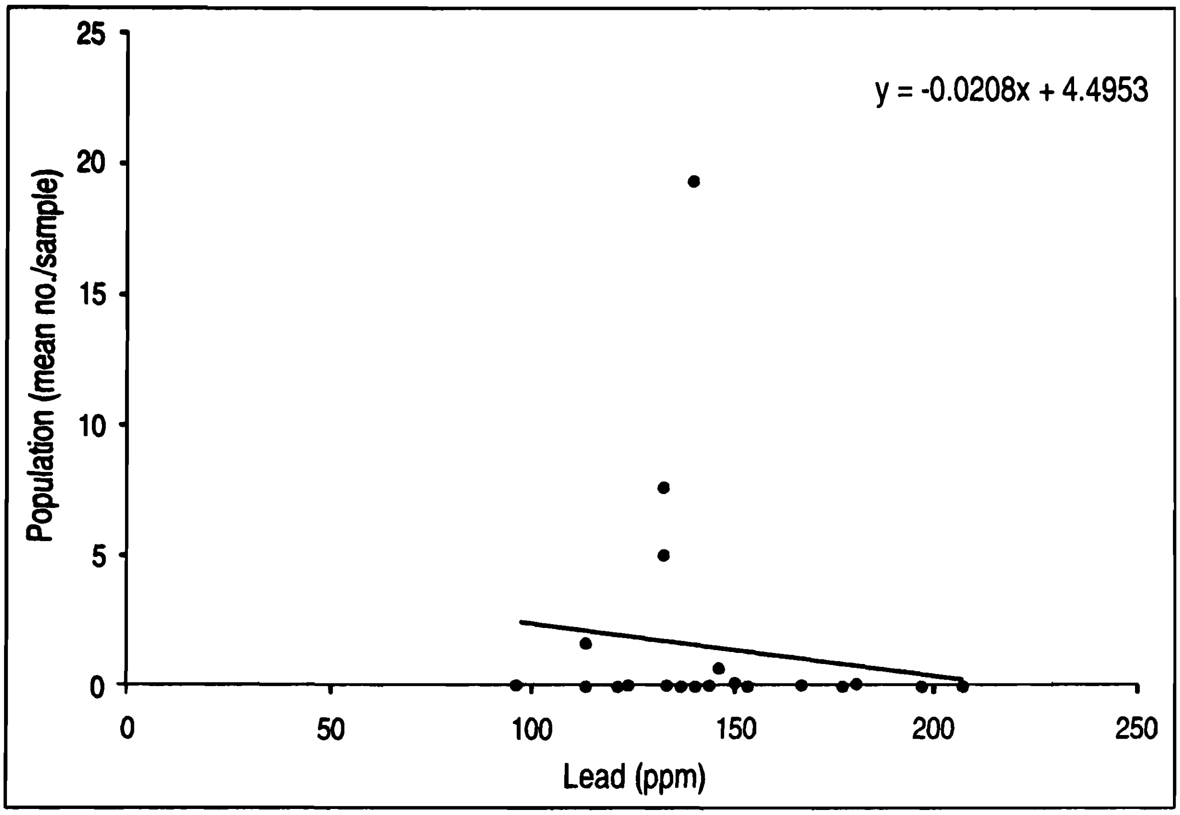


Fig. 87 : Line of regression alongwith scattered diagram of population of *T. melanocephalum* on lead at South Kolkata

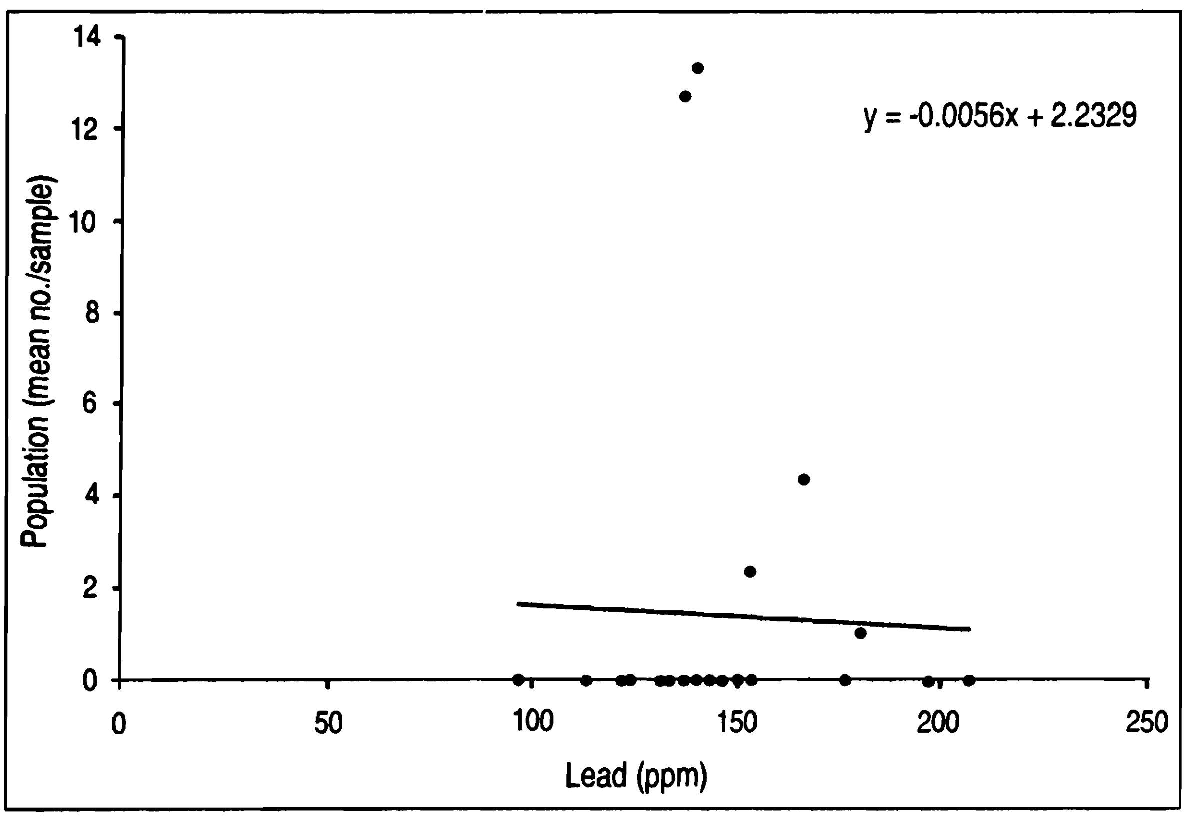


Fig. 88 : Line of regression alongwith scattered diagram of population of *P. longicornis* on lead at South Kolkata

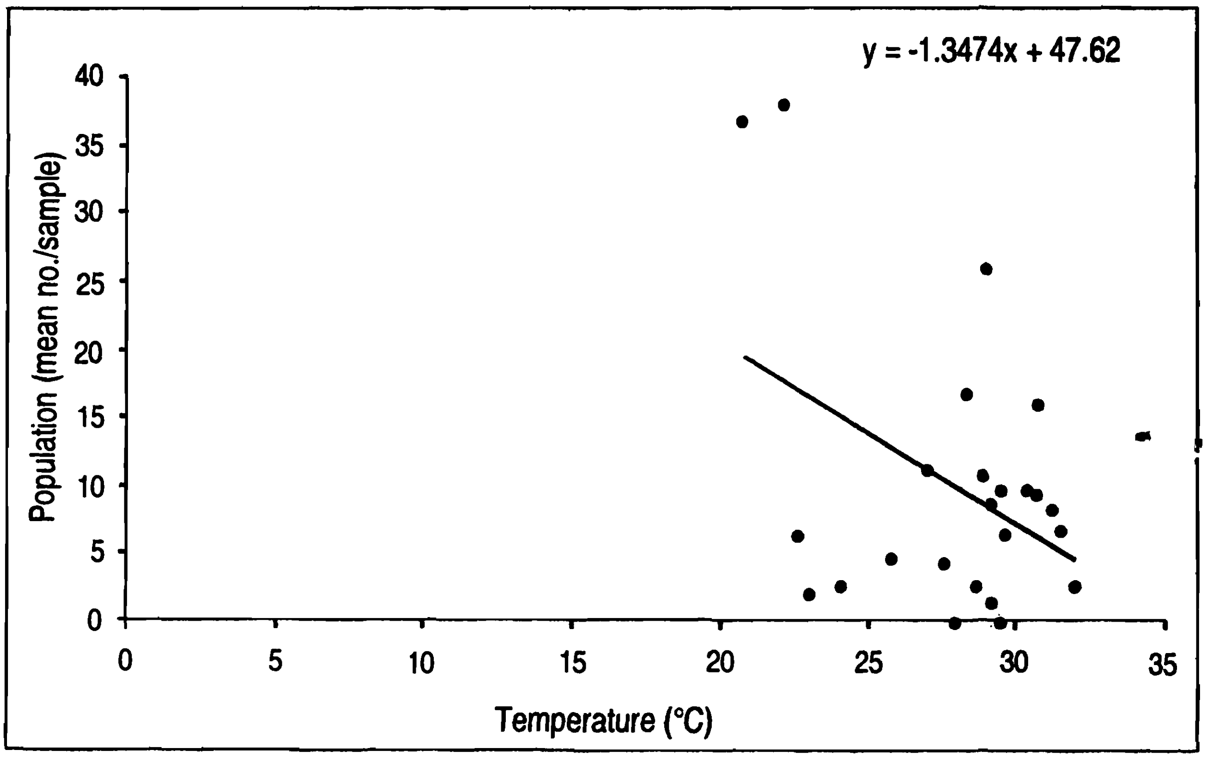


Fig. 89 : Line of regression alongwith scattered diagram of population of *S. geminata* on temperature at Central Kolkata

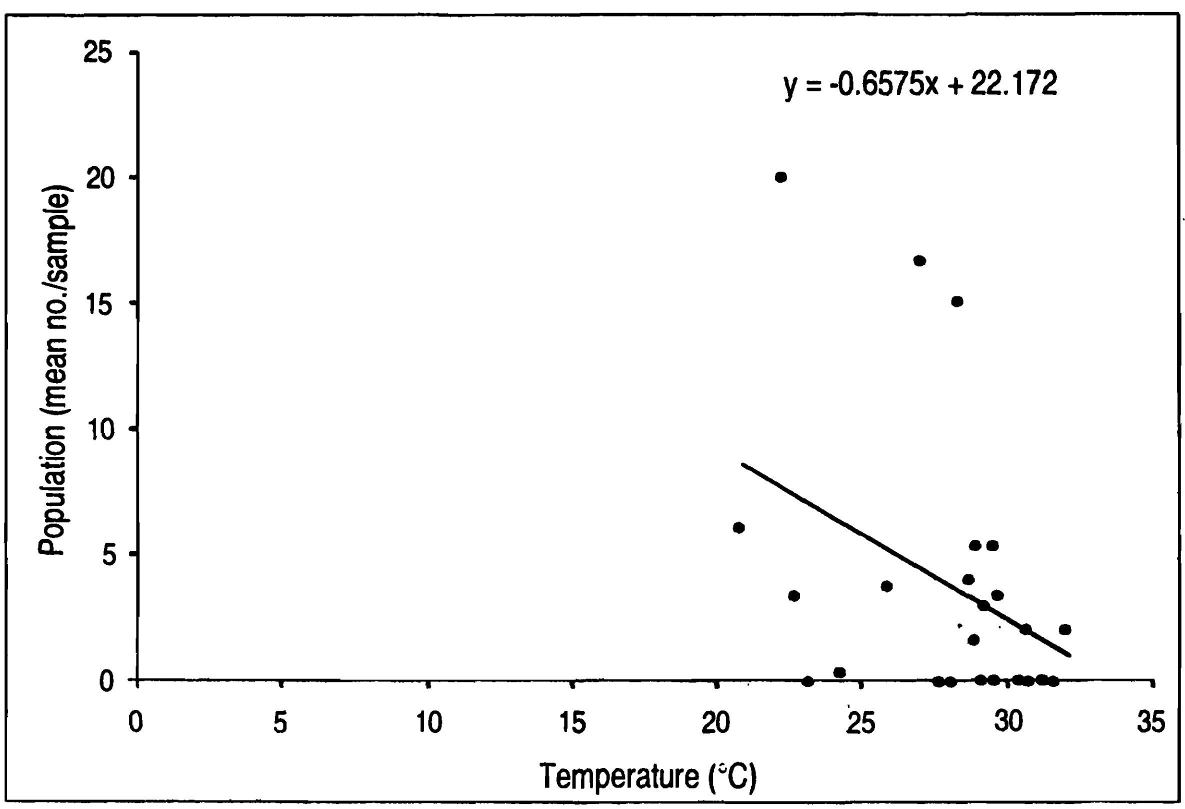


Fig. 90 : Line of regression alongwith scattered diagram of population of *M. bicolor* on temperature at Central Kolkata

Table 27. Relationship between temperature (°C) of soil and population of major species of ants (mean no./sample) at different sites. (NS - Not Significant)

Site X : Temperature	Name of the Species	Mean Population	Correlation coefficient (r)	P	Regression equation of ant species (y) on temperature (x) y = ax+b
East Kolkata	*Solenopsis geminata*	13.47	-0.045	NS	y = -0.1656x+18.067
(Mean of Temperature : 27.75)	*Pheidole roberti*	4.53	-0.085	NS	y = -0.2279x+10.824
	Paratrechina longicornis	2.78	0.098	NS	y = 0.2976x–5.798
	Tapinoma melanocephalum	2.07	-0.002	NS	y = -0.0031x+2.1558
	Technomyrmex albipes	1.86	-0.082	NS	y = -0.0995x+4.6214
Central Kolkata	*Solenopsis geminata*	10.01	-0.413	<0.1	y = -1.3474x+47.62
(Mean of Temperature : 27.91)	*Pheidole roberti*	4.45	-0.217	NS	y = -0.3429x+14.017
	Meranoplus bicolor	3.82	-0.371	<0.1	y = -0.6575x+22.172
	Paratrechina longicornis	1.26	0.303	NS	y = 0.2112x–4.6312
North Kolkata	*Solenopsis geminata*	6.85	-0.596	<0.01	y = -0.9869x+34.174
(Mean of Temperature : 27.69)	*Pheidole roberti*	4.23	-0.141	NS	y = -0.1357x+7.9801
	Tetramorium walshi	2.87	-0.336	<0.1	y = -0.5384x+17.782
	Meranoplus bicolor	2.56	0.070	NS	y = 0.0509x+1.1463
	Paratrechina longicornis	1.31	-0.124	NS	y = -0.0664x+3.1457
	Monomorium floricola	1.22	-0.051	NS	y = -0.0286x+2.0152
South Kolkata	*Solenopsis geminata*	10.25	-0.214	NS	y = -0.6839x+28.9
(Mean of Temperature : 27.27)	*Monomorium floricola*	3.71	0.395	<0.1	y = 0.5449x–11.152
	Pheidole roberti	2.46	-0.015	NS	y = -0.0217x+3.0504
	Plagiolepis jerdonii	1.67	-0.065	NS	y = -0.0517x+3.0778
	Tapinona melanocephalum	1.43	0.083	NS	y = 0.0955x–1.1724
	Paratrechina longicornis	1.40	-0.221	NS	y = -0.2217x+7.4484

positively related with temperature in soil. The relationships of temperature in soil with *S. geminata* and *T. walshi* were found to be at significant level (Figs. 91 & 92). The population of other species was found to be insignificantly related with temperature in soil (Table 27).

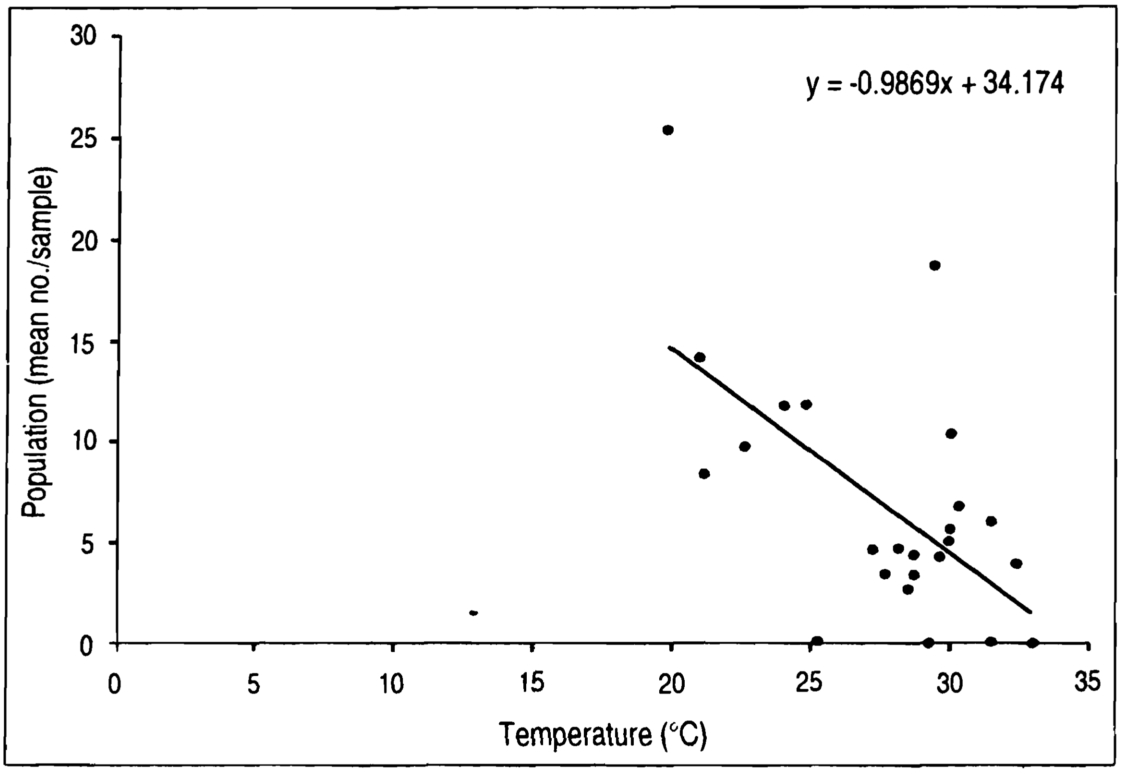


Fig. 91 : Line of regression alongwith scattered diagram of population of *S. geminata* on temperature at North Kolkata

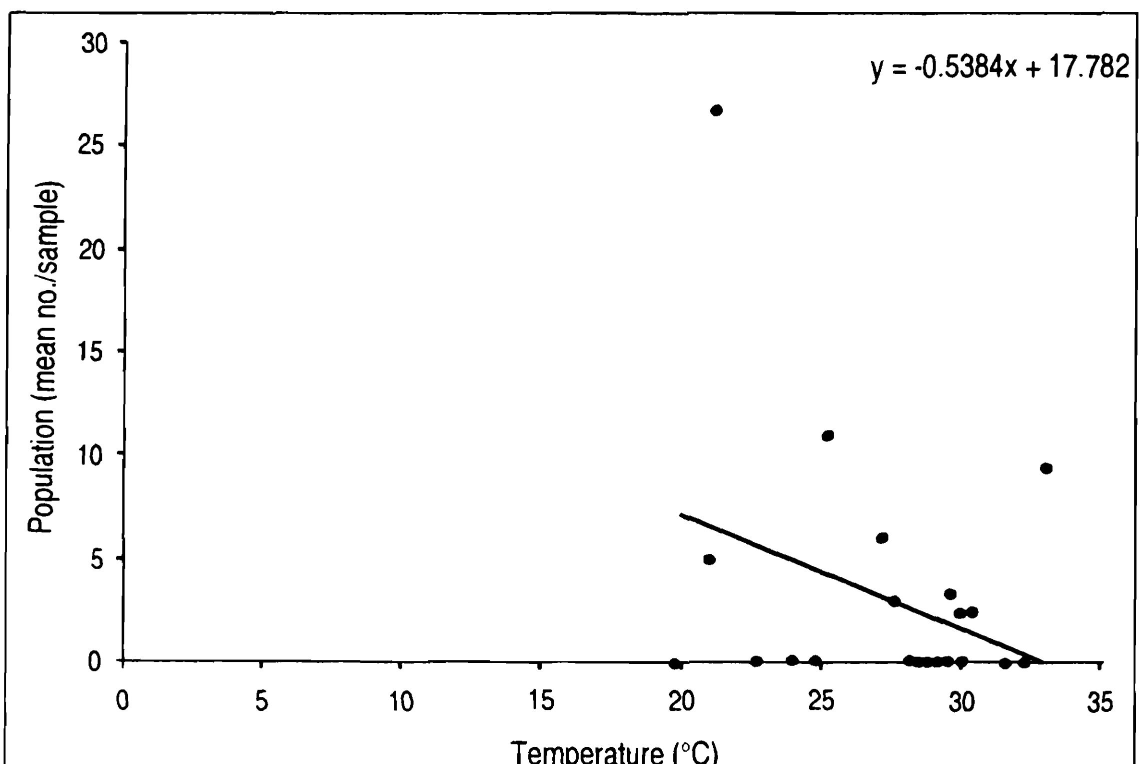


Fig. 92 : Line of regression alongwith scattered diagram of population of *T. walshi* on temperature at North Kolkata

At South Kolkata site the population of *Solenopsis geminata, Pheidole roberti, Plagiolepis jerdoni* and *Paratrechina longicornis* were found to be negatively related with the temperature in soil but not at significant level. The population of *Monomorium floricola* and *Tapinoma melanocephalum* were found to be positively related with temperature in soil; the former at significant level and the later at non-significant level (Table 27). The line of regression alongwith scattered diagram of populaiton of *M. floricola* on temperature in soil is represented in Fig. 93.

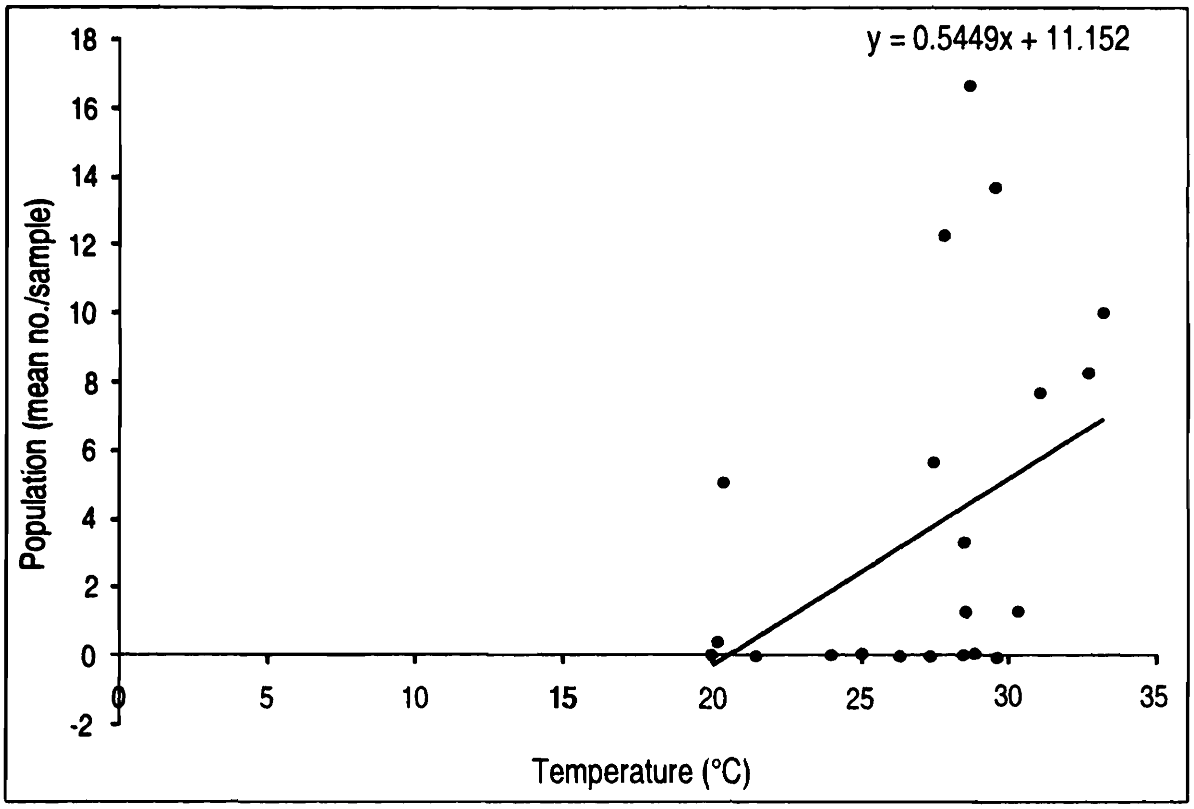


Fig. 93 : Line of regression alongwith scattered diagram of population of *M. floricola* on temperature at South Kolkata

he relationships of pH of soil and the individual population of *Solenopsis geminata, Paratrechina longicornis* and *Tapinoma melanocephalum* at East Kolkata site were found to be positive. but not at significant level but the population of *Pheidole roberti* and *Technomyrmex albipes* was found to be negatively related with the pH of soil. The former relationship was found to be non-significant (Table 28). while the later was at significant level (Fig. 94).

At Central Kolkata site the population of *Solenopsis geminata. Pheidole roberti* and *Meranoplus bicolor* was found to be negatively related with the pH of soil. Of these. the first one was found to be at significant level (Fig. 95). The other two relationships were found non-significant. The population of *Paratrechina longicornis* was found to be positively related. though non-significantly. with pH of soil (Table 28).

At North Kolkata site the population of *Solenopsis geminata* and *Meranoplus bicolor* was found to be related with pH of soil negatively. both were non-significant. Whereas. the

Table 28. Relationship between pH of soil and population of major species of ants (mean no./sample) at different sites. (NS Not Significant)

Site X : pH	Name of the Species	Mean Population	Correlation coefficient (r)	P	Regression equation of ant species (y) on pH (x) y = ax+b
East Kolkata	*Solenopsis geminata*	13.47	0.092	NS	y = 8.266x–43.632
(Mean of pH : 6.91)	*Pheidole roberti*	4.53	-0.099	NS	y = -6.547x+49.756
	Paratrechina longicornis	2.78	0.306	NS	y = 22.805x–154.77
	Tapinoma melanocephalum	2.07	0.041	NS	y = 1.3394x–7.1842
	Technomyrmex albipes	1.86	-0.481	<0.05	y = -14.4x+101.34
Central Kolkata	*Solenopsis geminata*	10.01	-0.394	<0.10	y = -29.419x+212.18
(Mean of pH : 6.87)	*Pheidole roberti*	4.45	-0.149	NS	y = -5.3604x+41.28
	Meranoplus bicolor	3.82	-0.322	NS	y = -13.021x+93.294
	Paratrechina longicornis	1.26	0.314	NS	y = 5.007x–33.142
North Kolkata	*Solenopsis geminata*	6.85	-0.126	NS	y = -8.4378x+65.308
(Mean of pH : 6.93)	*Pheidole roberti*	4.23	0.013	NS	y = 0.5013x+0.7497
	Tetramorium walshi	2.87	0.120	NS	y = 7.8245x–51.336
	Meranoplus bicolor	2.56	-0.080	NS	y = -2.3715x+18.986
	Paratrechina longicornis	1.31	0.485	<0.05	y = 10.56x–71.858
	Monomorium floricola	1.22	0.113	NS	y = 2.5608x–16.519
South Kolkata	*Solenopsis geminata*	10.25	-0.143	NS	y = -7.8969x+64.373
(Mean of pH : 6.85)	*Monomorium floricola*	3.71	-0.070	NS	y = -1.6715x+15.164
	Pheidole roberti	2.46	-0.329	<0.10	y = -8.0758x+57.808
	Plagiolepis jerdonii	1.67	0.077	NS	y = 1.0645x–5.629
	Tapinona melanocephalum	1.43	-0.034	NS	y = -0.6811x+6.0987
	Paratrechina longicornis	1.40	-0.194	NS	y = -3.3739x+24.526

population of *Pheidole roberti, Tetramorium walshi, Paratrechina longicornis* and *Monomorium floricola* were found to be positively related with pH of soil. All the relationships were found to be non-significant, except that of the population of *P. longicornis* with pH of soil which was found to be significant (Fig. 96).

At South Kolkata site the individual population of *Solenopsis geminata, Monomorium floricola, Pheidole roberti, Tapinoma melanocephalum* and *Paratrechina longicornis* was found to be negatively related with pH of soil. Whereas, the population of *Plagiolepis jerdoni* was found to be positively related with pH of soil. The relationship between population of *P. roberti* and pH of soil was found to be significant (Fig. 97), while the other relationships were found to be non-significant (Table 28).

At East Kolkata site the differences of mean population of ants between plots A and B and between plots A and C were found to be significant. Whereas, the difference in mean population between plot B and plot C was found to be non-significant (Table 29).

At Central Kolkata site the difference of mean population of ants between plot A and plot B was found to be significant. Whereas, the differences in mean population between plots B and C and between plots A and C were found to be non-significant (Table 30).

At North Kolkata site no significant difference of mean population of ants was found in between any two plots (Table 31).

At South Kolkata also the observation was same, *i.e.*, no significant difference of mean population of ants was found between any two plots (Table 32).

When the differences of mean population of ants of different sites on an average was considered, significant difference was found only between East Kolkata and North Kolkata. No significant difference in the mean population of ants was found between any other sites (Table 33).

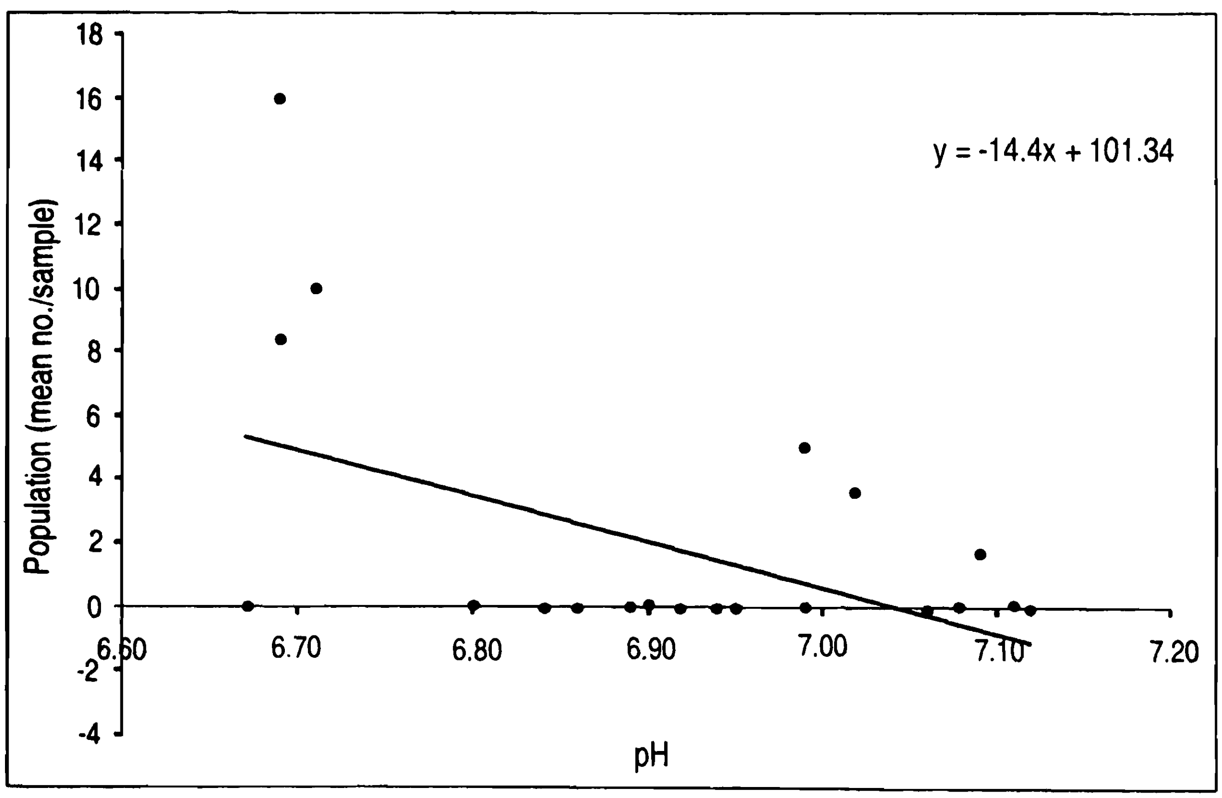


Fig. 94 : Line of regression alongwith scattered diagram of population of *T. albipes* on pH at East Kolkata

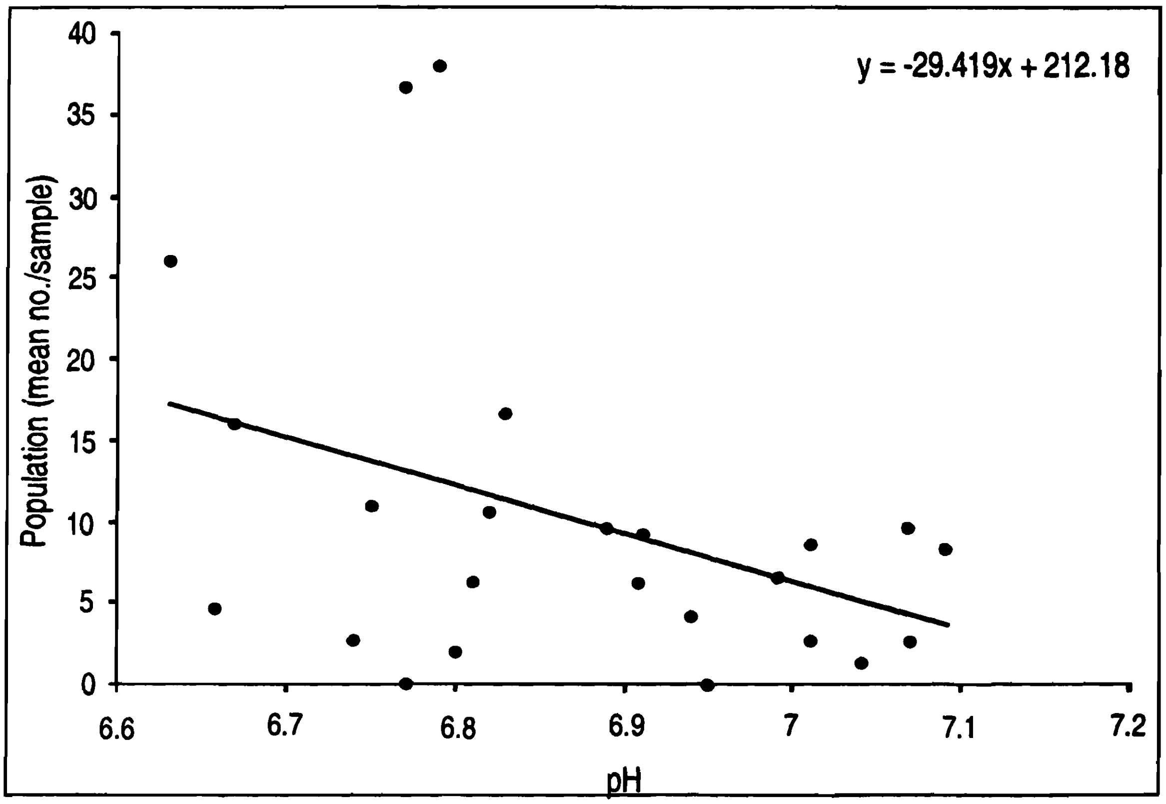


Fig. 95 : Line of regression alongwith scattered diagram of population of *S. geminata* on pH at Central Kolkata Kolkata

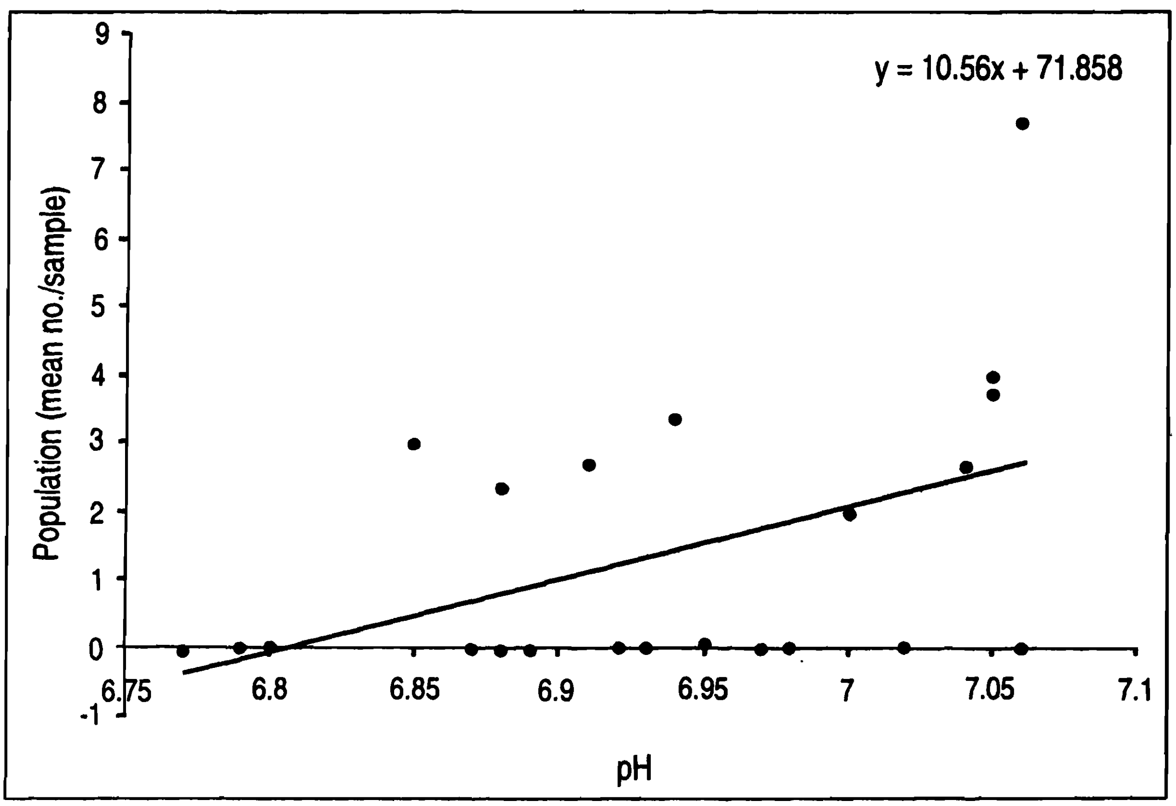


Fig. 96 : Line of regression alongwith scattered diagram of population of *P. longicornis* on pH at North Kolkata

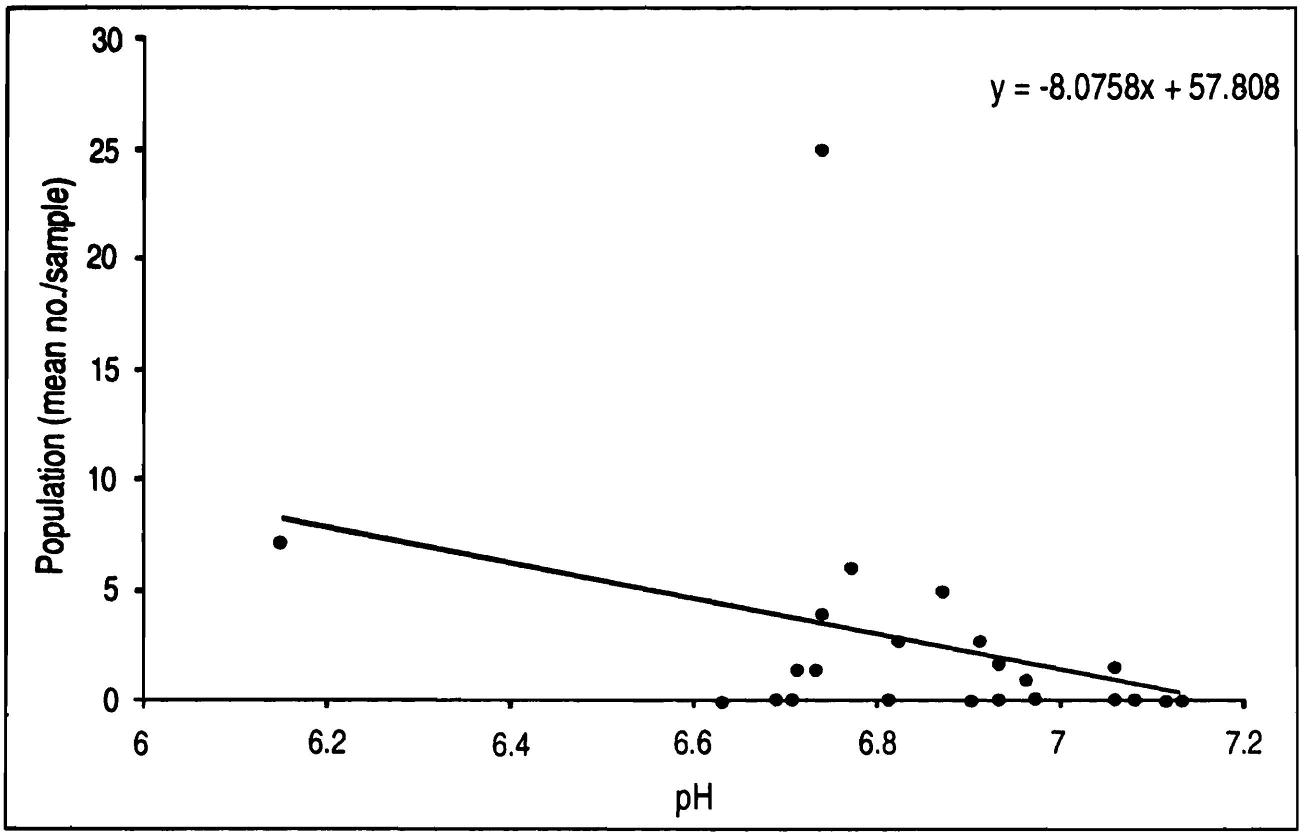


Fig. 97 : Line of regression alongwith scattered diagram of population of *P. roberti* on pH at South Kolkata

Table 29 : Level of significance of differences of mean population of ants at different plots of East Kolkata

	B	C
A	2.02	2.26
B		0.30

Table 30 : Level of significance of differences of mean population of ants at different plots of Central Kolkata

	B	C
A	1.85	0.82
B		1.15

Table 31 : Level of significance of differences of mean population of ants at different plots of North Kolkata

	B	C
A	1.66	0.79
B		0.90

Table 32 : Level of significance of differences of mean population of ants at different plots of South Kolkata

	B	C
A	0.55	1.24
B		0.60

Table 33 : Level of significance of differences of mean population of ants at different sites under study

	CK	NK	SK
EK	1.69	2.61	1.69
CK		0.42	0.25
NK			0.88

DISCUSSION

In this study, altogether 27 species of ants belonging to 27 genera distributed over 7 subfamilies were observed to occur in the roadside soil of different selected sites of Kolkata city. Earlier, Bingham (1903) reported 14 species of ants under 8 genera from Kolkata. However, Tiwari *et al.* 1998 reported a total of 28 formicid species belonging to 18 genera from Kolkata.

Though the occurrence of all the species encountered in this study were reported from India, 7 genera, out of 27 genera and 8 species of a total of 27 species collected during this study are reported for the first time from Kolkata (Table 34). Genus *Cerapachys* and the species *Cerapachys typhlus* (Roger) are recorded for the first time from the state of West Bengal. The findings therefore suggest that species diversity of ants of Kolkata and of West Bengal are yet to be fully explored and further study is required for establishment of total ant fauna of these zones.

Table 34 : Genera and species of ant recorded for the first time from Kolkata, as well as from West Bengal (Marked with *)

Name of the Genus	Name of the Species
1. *Amblyopone* Erichson	1. *Dorylus orientalis* Westwood
2. *Anochetus* Mayr	2. *Amblyopone rothneyi* Forel
3. *Hypoponera* Santschi	3. *Anochetus graeffei* Mayr
*4. *Cerapachys* Smith	4. *Hypoponera truncata* (Smith)
5. *Polyrhachis* Smith	*5. *Cerapachys typhlus* (Roger)
6. *Messor* Forel	6. *Polyrhchis tubericeps* Forel
7. *Oligomyrmex* Mayr	7. *Messor barbarus* (Linnaeus)
	8. *Oligomyrmex asinus* Forel

Regarding food habits of the species of ants encountered in this study, it was found that almost equal number of species (11 to 12) were either carnivorous or omnivorous and rest 4 species were aphidocolous and harvester (Table 35). It is significant to note that the species like *Tapinoma melanocephalum, Technomyrmex albipes, Paratrechina longicornis, Meranoplus bicolor, Monomorium floricola, Solenopsis geminata, Tetramorium walshi* were all found to be dominant species, observed in this study at different sites, which were species omnivorous and of non-specialised type, as reported by Hölldobler and Wilson (1990).

The species of ants as reported to be carnivorous (Hölldobler and Wilson, 1990) were found to be sparsely distributed and their numerical dominance were also found to be very low. It therefore appears that the ant species which were adapted to utilise all available food resources had succeeded better in establishing themselves in the road side soil, characterised

Table 35 : Food habit of ant species collected from the study sites.

Carnivorous (Specially entomophagous)	Aplidocolous (taking honey dew)	Harvester	Omnivorous (non-specialised)
1. *Dorylus orientalis*	1. *Camponotus compressus*	1. *Messor barbarus*	1. *Tapinoma melanocephalum*
2. *Amblyopone rothneyi*	2. *Plagiolepis jerdonii*		2. *Technomyrmex albipes*
3. *Anochetus graeffei*	3. *Crematogaster rothneyi*		3. *Paratrechina longicornis*
4. *Diacamma rugosum*			4. *Tetraponera allaborans*
5. *Hypoponera truncata*			5. *Cardiocondyla nuda*
6. *Pachycondyla rufipes*			6. *Meranoplus bicolor*
7. *Cerapachys typhlus*			7. *Monomorium floricola*
8. *Carebara lignata*			8. *Pheidologeton diversus*
9. *Lophomyrmex quadrispinosus*			9. *Solenopsis geminata*
10. *Oligomyrmex asinus*			10. *Tetramorium walshi*
11. *Pheidole roberti* (also granivorous)			11. *Recurvidris recurvispinosa*
			12. *Polyrhachis tubericeps*

by various adverse factors like non-availability of adequate green covers, load of vehicular pollution and probably a lower concentration of the susceptible prey species. As reported by Wheeler (1913) the ants are capable of changing their food habits when required; the dominant species, as observed here, which were non-specialised omnivorous in nature had probably adapted themselves to utilise whatever food resources available for their better sustenance. Findings of the earlier workers like Chattopadhyay and Hazra (1983, 2000) suggested a declination in the soil arthropods under heavy metal pollution including lead. Therefore, poor distribution and dominance of the carnivorous species (specially entomophagous) had probably resulted from the non-availability of adequate other insect prey species. However, this aspect requires to be studied thoroughly before arriving into any conclusion.

As par as the habitat of most of the ant species recorded in this study are concerned, they are known to be surface dwellers, as reported earlier by Wheeler (1913). Since the samples were collected from the upper layer of soil, the pollution estimates may therefore be considered as reasonable. It is therefore also expected that the population dynamics with reference to different abiotic soil factors including lead, as observed in this study, was also a reasonable estimate. Some of the deep burrowing forms are represented by only about 10% of the total population on the surface for foraging (Golley and Gentry, 1964; Krzysztofiak, 1991). Therefore, for these species like *Pheidole roberti, Pheidologeton diversus, Messor barbarus, Cerapachys typhlus, Pachycondyla rufipes, Anochetus graeffei*, the absolute effect of lead pollution on the total population might not be available in this study. Dominant species like *S. gemitata, T. melanocephalum, T. albipes, P. longicornis, M. bicolor, M. floricola, T. walshi*, collected in this study were mainly found to be surface dwellers. Thus the effect of lead pollution were best studied here for these surface dwelling species, because the effect of lead pollution on the population as a whole was best exhibited in these species only.

The characteristics of the soil was found to be almost similar at all the sites. However, the presence of vegetation varied largely. A good vegetal growth at EK and SK probably accounts for maximum population of ants at both these sites. (Fig. 30). An extremely poor vegetation at NK might have resulted into a poorly developed ant community at NK and with an intermediary community at CK where the vegetation was found to be not having much variations (Fig. 30). Such an influence of vegetation cover on the ant community at different sites corroborated the findings of earlier workers who observed that the vegetation directly or indirectly influence the population of soil arthropods (Buckle, 1921; Sheals, 1957.

Since the ant species recorded in this study are mostly carnivorous or omnivorous in nature, their popualtions are directly dependant on their prey species, which in most cases are phytophagous in nature and are thereby dependant on the vegetation itself. Thus it can be assumed that the vegetation cover on soil might have played indirect influence on the community structure of ants.

Altogether 74260 ants were collected during the entire period of study from all the sites. EK contained 30.58% (22710), while at NK the occurrence was minimum with **21.83%** (16210) (Table 36, Fig. 30).

Table 36 : Percentagewise distribution of different species of ants at different sites.

Name of the species	**EK**	**CK**	**NK**	**SK**	**Total**
Dorylus orientalis West.	0.80	–	–	–	**0.80**
Amblyopone rothneyi Forel	0.01	–	–	–	0.01
Anochetus graeffei Mayr	0.03	–	0.07	–	0.10
Diacamma rugosum (Le Guil.)	0.03	–	–	–	0.03
Hypoponera truncata (Sm.)	–	0.08	–	–	0.08
Pachycondyla rufipes (Jerd.)	0.03	–	–	–	0.03
Cerapachys typhlus (Roger)	0.03	–	–	–	0.03
Tapinoma melanocephalum (Fabr.)	2.01	0.78	1.05	1.37	5.21
Technomyrmex albipes (Sm.)	1.80	0.46	0.82	0.73	3.81
Camponotus compressus (Fabr.)	0.96	0.43	0.27	0.18	1.84
Paratrechina longicornis (Latr.)	2.69	1.23	1.26	1.36	6.54
Plagiolepis jerdonii Forel	1.45	0.73	0.81	1.62	4.61
Polyrhachis tubericeps Forel	0.32	–	–	–	0.32
Tetraponera allaborans (Walk.)	–	0.01	–	0.23	0.24
Cardiocondyla nuda (Mayr)	0.36	0.01	0.07	0.18	0.62
Lophomyrmex quadrispinosus (Jerd.)	–	0.14	–	–	0.14
Meranoplus bicolor (Guer.)	0.63	3.70	2.48	1.04	7.85
Messor barbarus (Linn.)	0.31	–	–	–	0.31

It is indicated that at EK site the physico-chemical conditions were most favourable for the growth of ant community. Presence of more vegetation, faintly acidic soil and presence of lowest lead load (121.32±19.26 ppm) (Table 9) probably triggered favourable growth of the ant community at EK. While, at NK the lead load was maximum (298.57±43.79 ppm) with a similar temperature and pH value as that of EK (Table 17). At NK the total population of ants was lowest which provokes to infer that presence of more lead either singly or conjointly exerted a negative effect on the population growth at NK where vegetations were also minimum in comparison to other plots.

It appears that soil at NK was most polluted by lead and this pollution load gradually decreased at CK and SK, while at EK the lead pollution was found to be lowest. Such a difference in the lead load in the soil at different sites might be attributed to density of the traffic – a lower traffic density had probably caused a lower lead load in the soil. However, vegetation factor also might have played a role in determining the lead content of the soil. As reported by Goldshmidt and Scanlon (1977), Bahlsberg-Phalsson (1989), Migula and Binkowska (1993) the uptaking of lead from the soil by plants is quite considerable. Very poor vegetation and highest lead load at NK and good vegetation and lowest soil lead concentration probably support the observation of earlier workers. Further, as suggested by Moore and Moore (1976), the variation in the amount of heavy metals in different polluted plots and also in different months is due to various types and properties of soil and also due to soil's unique and inherent ability for detoxification of pollutants.

At CK and SK the average lead load got reduced in comparison to NK (265.28±52.22 ppm and 147.10±28.42 ppm) and also the vegetation factor improved, it was found that the population of ants gradually increased from NK to CK and SK. Though the pH and temperature factors at these two sites did not exhibit any major differences in comparison to NK.

Thus, it appears that presence of vegetation, which auguments the food resources of phytophagous ant species and controls the growth of soil entomofauna which in turn act as the prey species for the carnivorous ants, and the lead concentration of soil contributed their effects, might be in collaboration, on the population growth of soil ants. This finding agrees with the observations of earlier workers (Buckle, 1921 and Sheals, 1957) who noted the large contribution of vegetations directly or indirectly towards the growth of healthy soil fauna. Petal (1974, 1976); Vespalainen and Wuorenrinne (1978); Nuorteva (1990); Nuorteva *et al.* (1991) observed that presence of different pollutants in soil including the heavy metals largely affected the total population of soil ants.

From tables 9, 13, 17 and 21 it is evident that there were differences in the average population of ants, where the values being 31.54±14.58, 24.04±15.55, 22.51±7.95 and 25.04±11.32 respectively at EK, CK, NK and SK. The differences in these mean values on being subjected to statistical tests (Table 33) showed that the difference in the population of EK and NK was quite significant and was a true difference.

It is very clear from Tables 6-21 that there are differences in mean population of ants at different plots in all the sites. The mean population was found highest in plot A which were 42.50±28.76, 29.96±27.03, 26.00±16.79 and 28.50±19.38 at EK, CK, NK and SK respectively. While the lowest concentration of mean population was found in plot C at EK and SK which were 25.04±23.21 and 21.50±18.81 respectively and in plot B at CK and NK which were 18.04±14.92 and 19.13±10.90 respectively. On being subjected to statistical tests (Tables 29-32) the differences of mean population between plots A and B and plots A and C at EC were found to be quite significant. Significant difference of mean population of ants was also found between plots A and B at CK, which suggested that these significant differences in mean population of ants were probably real and considerable.

Total ant population at different sites varied considerably at different seasons. However, in most of the sites winter peaks of population were visible with semipeaks during premonsoon (Fig. 47). The general tendency of soil arthropods to attain maximum population during monsoon and minimum during summer are reported by some workers (Roy and Ghatak, 1977; Hazra and Choudhuri, 1981). But Dethier (1971), Petal (1994) observed that soil arthropods had the capability to augment their population in accordance with the available physico-chemical conditions of soil. Thus, winter maxima and premonsoon semipeaks of the population of ants, observed in this study, is corroborative with the findings of Ford (1935), Macfadyen (1952), Murphy (1953).

In addition to temperature, both lead concentration and pH exhibited random fluctuation at all the sites (Figs. 48-50) and did not follow any particular seasonal maxima or minima. Since lead load in the road side soil is related with the automobile exhausts the minimum seasonal effect on the same is therefore quite justified, because fluctuation of automobile density is a random phenomenon.

The roadside soil at most of the sites during most of the months of the study period was found to be slightly acidic which is corroborative with the earlier findings of Anderson (1979) and as such acidity of the soil being largely contributed by the automobile exhausts. The random fluctuation of pH value was also therefore dependant on the fluctuation of the vehicular density in a random manner. Thus it can be concluded that seasonal variations of the concentration of lead in soil and its pH probably did not have much significance on the seasonal fluctuation of the ant population at different sites.

The concentration of lead (on an average) being quite high at different sites (85.00±27.44 to 403.33±155.22 ppm) as observed in this study was obviously found to be a determining factor of the quantum of the ant population. Under this extreme condition the surviving ant species with a high tolerance level utilised whatever available resources for their sustenance and developed maximum population at opportune season which was found here to be during winter when the temperature at all the sites were found to be minimum. This prompts to infer of the possible prevalence of low-temperature preferring forms in the ant population. Presence of such low-temperature preferring soil insects in predominance has also been reported earlier by Mitchel (1979).

The results of the seasonal variations at different sites on being subjected to statistical tests proved that on an average, ant population was positively correlated with lead at EK and CK, though such correlationships were not significant. On the other hand, at NK and SK they were negatively related and at SK this relationship was quite significant (Table 23). This suggests that low lead concentration promoted the growth of ant population at EK and CK, though such promotion was not significant. The significant negative relationship of lead and ant population at SK substantiated the negative effect of lead on the population, though the mean concentration of lead at this site on an average was 147.10 ppm and was considerably less in comparison to NK and CK. The vegetation at SK were also much diversified in comparison to other sites. Therefore the possibility of involvement of some other abiotic factors as well as anthropogenic activities conjointly with lead in bringing about such a strong negative relationship could not be ruled out.

Temperature had negative relationship with average ant population at all the sites (Table 24). The relationship was observed to be highly significant only at NK. Thus it can be said that low-temperature preferring forms predominated the ant population at NK.

Soil pH, on the other hand, exhibited non-significant negative relatiohship at EK and CK, but positive relationship at NK (Table 25). However, at SK the significant negative relationship of pH with the ant population suggests presence of more acidophilic forms. The acidulation of the roadside soil due to deposition of the automobile exhausts would obviously promote the harbouring of acidophilic forms probably resulting into obtaining a negative relationship.

Plotwise seasonal variations in the mean population of ants (Figs. 31, 35, 39, 43) at different sites exhibited winter population peaks at most of the plots of EK, CK and NK, though at EK the fluctuations were found not to follow any definite pattern. At SK no clear population peaks were available at any of the plots. On comparison with the seasonal fluctuation of lead concentration in the soil (Figs. 32, 36, 40, 44), it is evident that the ant population tried to increase whenever the concentration of lead was low at all the sites. A higher concentration of lead in plot A of all the sites and a corresponding higher mean population of ants in plot A at most of the sites apparently reflected that concentration of lead have a positive effect on the growth of ant population. However, on comparison to the seasonal fluctuations both of population of ants and concentration of lead, this relationship was found to be somewhat different. From Table 23 it is evident that ant population as a whole had negative relationship with lead concentration and such relationship was also found to be statistically significant at plot B of all the sites except EK where the significance was observed at plot C. It therefore seems that there were some lead pollution tolerant species which aggregated in the soil adjacent to the roadside, thus increasing the mean population of ants in plot A of all the sites. And in fact the species *Solenopsis geminata* (Fabricius) were found to get concentrated more towards plot A at all the sites except at NK (Tables 2-5). This finding has received support of Chattopadhyay and Hazra (1983) who observed that some ants thrived better in polluted environment.

Temperature in all the plots at all the sites were found to be low in winter and high in summer months (Figs. 33, 37, 41, 45). Increase of ant population at different plots of different sites during winter therefore suggests the possibilities of the presence of more low-temperature tolerant species in the ant community.

Wide range of fluctuation of pH values were observed in all the plots of EK, CK, and NK but did not follow any particular pattern at EK and at CK. However, at NK during winter the soil pH was found to be higher in comparison to the summer months, where the population were also found to be higher during winter. At SK the soil was found to be almost neutral with pH values around 7 and with very little seasonal fluctuation (Figs. 34, 38, 42, 46). Therefore the effect of pH on the population was not very clear from the study of seasonal fluctuation.

On being subjected to statistical tests, it was observed that (Table 24, 25) in most of the plots the ant population had negative relationship with both temperature and pH and some of these relationship were found to be significant. Strong negative correlation between temperature and the ant population at plot C and on average at NK and a same trend at plots A and C of CK suggests the negative influence of temperature on the population at these plots due tc probable presence of low-temperature tolerant forms. A similar phenomenon was also observed by Paclt (1956), Pryor (1962) in case of collembolan fauna. Chattopadhyay and Hazra (1983) also observed a negative relationship of temperature with soil dwelling coleopteran insects. Since the relationship of ant population and soil pH was found to be mostly non-significant, the effect of pH on the ant populaion were perhaps minimum. This confirmed the observations of Dhillon and Gibson (1962) and Davis (1963). Chattopadhyay and Hazra (1983) also observed that direct influence of pH on the soil arthropods were little, but it might have contributed to the fluctuation of soil arthropod population by indirectly influencing vegetation and other physico-chemical properties of the soil.

The regression analysis alongwith trendlines of the significant relationship (Figs. 55-67) of ant community with lead concentration, temperature and pH would be helpful for predictions on their effects on ant community.

The study also suggests the possibility of the presence of low-temperature preferring forms of ants in the roadside soil. Concentration of lead and soil pH probably, either singly or conjointly, produced a negative effect on the total population of ants. The ant species which got adopted in the road side soil with such enormous amount of lead load seemed to have utilised whatever resources available for their sustenance and growth.

These findings are in confirmity with the observations of the earlier workers (Vanek, 1967; Keeney and Walsh, 1975; Petal, 1976, 1978; Anderson, 1980; Bhattacharya *et al.* 1980). However, the findings of Gorny (1976), Chattopadhyay and Hazra (2000) that the ant population may increase in the polluted soil – are not truely reflected in this study due to establishment of negative relationships between ant population and soil lead which were found to be significant at many plots; though the population were high in road-adjacent soil, where the concentration of lead was also high.

While considering the species composition of ant community it is found that altogether 27 species of ants belonging to 27 genera were recorded from all the experimental sites. EK exhibited the largest species diversity with 20 species, while at NK it was minimum with an occurrence of 13 species only (Table 1).

It is therefore clear that favourable condition for growth and colony formation of maximum number of ant species were available at EK, while ecological conditions like various edaphic and vegetal factors were not ideally favourable for flourishing of all the species at NK site. The species distribution of ants was found to be almost similar at CK and SK, each having a distribution of 17 and 16 species though the quality of the species varied at these two sites to some extent (Table 1).

Solenopsis geminata was observed to be the most dominant species occurring at all the sites and throughout the entire study period and it occupied a maximum perecentage of

39.32 of all the ants at all the sites on cumulative basis. Sitewise also, it was found that *S. geminata* was dominating with a percentage occurrence of 13.06, 9.71, 6.64 and 9.91 at EK, CK, NK and SK respectively (Table 36). Thus it may be stated that *S. geminata* has the capability of exploring various ecological conditions for their sustenance and also ideally suited to withstand various ecological constraints. Widespread presence of *S. geminata* at all the plots of different roadside soil is supported by the earlier observation of Wheeler (1913).

From Table 1 it is evident that species *like Dorylus orientalis, Amblyopone rothneyi, Diacamma rugosum, Pachycondyla rufipes, Cerapachys typhlus, Polyrhachis tubericeps, Hypoponera truncata, Lophomyrmex quadrispinosus, Oligomyrmex asinus, Pheidologeton diversus* and *Recurvidris recurvispinosa* remain restricted only at a particular site The first 6 species were recorded only from EK with a very low numerical strength and occasional appearances in a few months. The same was true in case of *H. truncata, O. asinus* and *L. quadrispinosus* which were restricted at CK only and *P. diversus* and *R. recurvispinosa* were restricted only at SK. The possibility therefore emerges that these species, becoming very sensitive, probably could not adapt themselves well in the polluted roadside soil. At NK no such sensitive and low tolerant species was aparently available as because none of the species available there were found restricted at that site only, and except *Anochetus graeffei* all other species were found to be well distributed at other sites also. Since, the concentration of lead was found to be maximum at NK (upto 530 ppm) in comparison to other sites, the species available at NK may be considered as well tolerant to lead pollution. However, the species diversity at NK was much less than other sites probably due to the negative effect of very high concentration of lead at this site.

Though only 6 to 7 species were found to be dominating the ant community in the soil at different sites (Figs. 51-54), it is very clear that *S. geminata* is by far the only species which dominated the soil ant community. The contribution of this species in the ant community to the tune of around 40% is quite considerable and significant and which suggests that this species is by far the most suitable one for better survival in the roadside soil, heavily polluted by lead. The dominance of *Pheidole roberti* at EK, CK, NK and SK; of *Paratrechina longicornis* at EK; of *Meranoplus bicolor* at CK and NK; of *Tetramorium walshi, Monomorium floricola* at NK and SK respectively are also considerable (Figs. 51-54). These species also adapted themselves well to survive in such extreme condition. However, they remained lagging far behind the capability of *S. geminata*.

It therefore appears that all these dominating species have the capabilities of changing their living environments when they have to survive in a difficult ecological condition. That the ants are having the capabilities of changing their environment for their better sustenance and development have also been reported by Gorny (1976), Gadagkar *et al.* (1993), Migula *et al.* (1993) and Petal (1994).

Fangmeyer and Steubing (1986), Stary and Kubiznakova (1987) and Krzysztofiak (1991) reported high tolerance level of *Formica* spp. and *Lasius niger (L.)*. However, in this study, instead of these species *S. geminata* has established itself to be another species of ant well tolerant to high level of lead pollution.

Plotwise distribution of species reveals (Tables 2-5) that at site EK maximum diversity of species was available at plot C where the mean concentration of lead was very low and minimum at plot A where the lead load was comparatively higher.

The same trend was also found at SK. It is to note that both at EK and SK the vegetal growth was comparatively better, the mean lead concentration in soil was also comparatively lower. Thus it can be inferred that the low tolerant species drifted towards plot C, away from the road, where the effect of lead was comparatively less and such a tendency probably resulted into better diversity of species at plot C.

At NK, though the spçcies found are assumed to be well tolerant to lead pollution, as discussed earlier, all the species except *A. graeffei* represented at plot A where the lead pollution was found to be lower in comparison to plots B and C.

However, at CK incidental occurrence of species *Cardiocondyla nuda, Tetraponera allaborans* and *Oligomyrmex asinus* at plot A had resulted into the exhibition of maximum species diversity at plot A, where the concentration of lead was maximum. From Table 3 it is evident that all these 3 species occurred only in one month during the entire 24 months study period and their concentration was 1 number / soil sample only. Ignoring such absolute insignificant presence of these species it gets established that the species diversity is better at plot C where the concentration of lead was low.

At all the sites, except NK, it is evident (Tables 2-5) that the density of *S.geminata* was more at plot A where the lead concentration was more. The same trend was also found true at NK, where this species occurred maximum at plot C where the lead concentration was more. The sharp decline of the density of this species at plots with lower concentration of lead also suggests that *S. geminata* can withstand lead polluting soil very efficiantly. The relationship of *S. geminata* with the lead concentration of soil on plotwise average of those plots was calculated and it was found that the correlation coefficient values were 0.404, 0.721, 0.993 ($P<0.05$) and 0.957 ($P<0.05$) at EK, CK, NK and SK respectively. Thus the affinity of *S. geminata* towards the soil with high lead load has also confirmed through statistically established positive relationship, at all the sites, with lead which are found to be significant both at NK and SK. For other dominant species the pattern of larger occurrence at plots with higher lead and lower at other plots are not very distinctly displayed.

Statistical analysis (Table 26) reveals that *S. geminata* had a negative relationship with the concentration of lead at all the sites, but at EK the relationship was positive; though none of these relationships was significant. All other major species mostly exhibited negative relationship with lead. *M. bicolor* was found to be significantly affected at NK.

It is therefore apparent that the seasonal distribution of the population of different species of ants bore an inverse relationship with the seasonal variations of the soil lead concentration, on an average, at different sites and such a distribution did not obey the larger accumulation of the ants in the adjacent roadside soil. It therefore seems that though the dominant species of ants including *S. geminata* are tolerant to lead pollution, their affinity towards the lead rich soil was only exhibited on an average basis. In spite of the efficient physiological mechanism to combat the lead, its effect, which was negative in nature, could not be overcome absolutely by these dominant ant species. But since the negative relationships were not significant, the negative effects could not get settled. Such negative effects of pollutants on beneficial organism like ants were also observed by Nuorteva (1990) and Nuorteva *et al.* (1991).

Both temperature and pH had negative relationship with the dominant species. In most of the cases however no significance in such relationship could be established.

The regression analysis and the trendlines of all the dominant species on lead and only of significant relationship on temperature and pH (Figs. 68 - 97) could help in prediction of their effects on the population.

This study of species diversity therefore reveals that the diversity is more in soil where the pollution load is less. The species which are less tolerant to higher concentration of lead migrated to the soil with lower concentration of pollutants. The result thus corroborates with the findings of Edwards (1969), Ghilarov (1973), Dindal *et al.* (1975) and Petal (1978) who also observed a decline species diversity of microarthropods in polluted soil. Vanek (1967), Edward and Lofty (1969), Dindal *et al.* (1975), Gorny (1975), Bhattacharya *et al.* (1980), Bhattacharya and Bhattacharya (1981) have also observed that pollutants in the soil including heavy metals exerted considerable negative effects on soil arthropods and these negative effects not only caused a reduction in the populaion but also reduced the species diverstity; only those species which possessed higher tolerance level could survive well in such extreme soil conditions. Chattopadhyay and Hazra (2000) were of the view that when the concentration of heavy metals was low, the pollution tolerant species took the opportunity to utilise whatever resources available at that time and augmented their population growth and this eventually resulted into development of significant or non-significant relatiohship of the population with various edaphological parameters.

Inspite of the probability of the dominant species being well-tolerant to lead pollution, their negative relationship, depicted in the distribution pattern of these species, pointed out that such pollution tolerant species also get adversely affected by the concentration of soil pollutants. This finding is supported by earlier observations of Edwards (1969) and Anderson (1980).

From the account of biochemical estimation of deposition of lead (Table 22) in the body of different species of ants, it appeared that the concentration of lead in the body was much below the concentration of lead in the soil. Such a phenomenon was earlier observed by Krzysztofiak (1991) where concentration of copper and lead were found to be lower in the body of *Lasius niger* (L.) than the soil along traffic arteries in Poland. From Table 22 it is also evident that concentration of lead in the body of different species of ants was minimum at EK and maximum at NK, thereby suggesting a positive relationship between the degree of soil habitat pollution with lead and its content in the body of different dominant species of ants. This is also corroborative with the findings of Krzysztofiak (1991). However, Krzysztofiak (1991) observed a maximum concentration of lead upto 8.6 ppm only in the body of *L. niger,* whereas in this study the lead content was found to be much higher in comparison. On the other hand, Stary and Kubiznakova (1987) observed lead content in the range of 6.65 - 374.09 ppm in the body of four different species of *Formica*. While, in this study the lead content remained within the range of 32.65-72.50 ppm in different dominant species. Such differences in concentration of heavy metal in different species of ant bodies seems to be quite interesting and remains to be found.

As observed by Atkinson (1977), Prestwich (1983), Migula (1985) and Migula *et al.* (1993) the crucial dysfunction caused by heavy metals is to deplete energy rich ATP molecules which act as activators of various metabolic pathways and creates important physiological constraints for ants.

It also appeared that *Solenopsis geminata* had the lowest concentration of lead in body tissue in comparison to other dominant species. Migula and Binkowska (1993) observed that in insects most of the heavy metals were not taken up by intestines and those were easily lost from the gut with the excrements, so there was no significant increase in lead and cadmium content in insects. Thus it seems that *S. geminata* is having more efficient excretory mechanism in comparison to other species of ants, resulting into substantial reduction in their body lead load. This mechanism probably helped this species to flourish largely in such highly polluted soil and proved itself to be the most dominent species in the roadside soil of Kolkata by adopting better physiological nechamism.

The results in this study corroborated mostly the findings of earlier workers with few exceptions. The discrepancies thus noted might be due to the contributions of local environmental factors which were likely to exert its influence on the community structure of soil animals.

Soil represents a very complex habitat with various factorial components interwoven together. Therefore, it would be difficult to consider the effect of these soil components separately in nature. It might therefore be opined that the factorial components, studied here, in collaboration with other components, not considered in this study, collectively contributed towards the population dynamics of the soil dwelling ants.

SUMMARY

It can be summarised from the above account that the roadside soil of Kolkata is polluted by lead emitted from the automobile exhaust. The level of such pollution was maximum at North Kolkata where the vegetation on soil was very poor, but at East Kolkata and South Kolkata the soil vegetation was comparatively better and soil lead load was also comperatively much low; thereby indicating a possible role of vegetation in lowering soil lead concentration by uptaking lead from the soil.

A total of 27 species of ants belonging to 27 genera under 7 subfamilies obtained from the soil of all the roadside experimented sites of Kolkata in this study. Of these, 8 species and 7 genera are being reported for the first time from Kolkata. Therefore, altogether 56 species of ants under 33 genera are recorded so far from the city of Kolkata, including this study.

It was also evident that soil ant fauna was maximum at EK where the lead pollution was minimum and the minimum was at NK where the lead concentration was maximum, thereby suggesting a negative effect of lead on the soil ant community.

At most of the sites the concentration of lead in soil was maximum at plot A which lay adjacent to the road and decreased gradually away from the road suggesting poor drifting of lead from the roadside. A corresponding increase in ant population at plots rich with lead load suggested the presence of well tolerant species in the ant community at those areas.

Solenopsis geminata (Fabricius) was found to be the most dominant species occurring throughout the time and space of this study and occupying about 40% of the total ant community. This species also exhibited positive relationship with lead content of the soil of each site and the relationship was found to be quite significant at two sites at, *viz.*, North Kolkata and South Kolkata. This species may therefore be considered as a well tolerant species. However, for designating this species as an index organism for soil lead pollution, further studies are suggested, particularly under controlled laboratory condition. Considerable low deposition of lead in the body tissue of *S. geminata*, in comparison to other dominant species, suggests probable better excretory functioning and thereby supporting their best physiological adaptation in such extreme soil condition. Such processes of physiological adaptation of *S. geminata* also require further elaborate study.

In addition to *S. geminata*, only four other species namely *Pheidole roberti, Meranoplus bicolor, Tetramorium walshi and Monomorium floricola* were recorded to be dominant by individual contribution of 10% or more to the total ant community; but their degree of dominance varied at different sites. These species were also supposed to be well tolerant to lead pollution but they had a comparatively high deposition of lead in their body tissue, thereby suggesting their less physiological adaptability in comparison to *S. geminata* in such a polluted environment. None of these species is likely to be considered as a real competitor of *S. geminata*. This aspect also requires to be studied in more detail.

Species diversity of ants was found to be inversely related with soil lead pollution level; maximum 20 species were found at East Kolkata site where lead pollution were minimum and only 13 species were recorded from North Kolkata site where the lead pollution was maximum.

Seasonal variation of ant population did not show any regular pattern of fluctuation, which varied considerably from plot to plot and also from site; to site therefore suggesting the concept that the species with high tolerance level utilised whatever resources available at opportune seasons to sustain their population.

Lead concentration in the soil being dependant on the automobile density did not exhibit any distinct seasonal variation.

Population of ants, on an average, was found to be related inversely with the temperature of the soil.

Soil at all the sites exhibited a low acidic character except at South Kolkata where it was found to be almost neutral, which probably exerted its effects on the growth of soil vegetation and development of phytophagous soil organisms, thus affecting the ant community in an indirect manner and also might have played an intrinsic role in conjugation with some other soil factors.

This study would therefore provide a baseline data of species composition of ants of Kolkata, so far, with their habit and habitat.

Effects of lead pollution on species diversity and population structure of soil ants and establishment of lead pollution tolerant species would serve as useful information for future study.

Further, emergence of *Solenopsis geminata* as most tolerant species to lead pollution might be useful to establish it as an index species and as a biomonitoring agent for effective environmental management.

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