



## Termite diversity in four different areas of Namakkal, Tamilnadu

B Indhu<sup>1</sup>, S Sivanantham<sup>2</sup>, C Jayalakshmi<sup>3</sup>, S Praveen<sup>2</sup>

<sup>1</sup> Department of Zoology, Kandaswami Kandar's College, Velur, Namakkal, Tamil Nadu, India

<sup>2</sup> Department of Microbiology, Kandaswami Kandar's College, Velur, Namakkal, Tamil Nadu, India

<sup>3</sup> Department of Botany, Government Arts College for Women, Salem, Tamil Nadu, India

### Abstract

Termites are known to construct termite mounds and are known to be found all over the world when they are present. The physical, chemical, and biological characteristics of termite mounds in tropical soils are distinct from those of their parent soils. Termite mounds are a prominent feature in that soil. Termites are frequently referred to as important bioturbators, soil engineers, or even master builders due to their capabilities. Therefore, termites have an impact on the cycling and distribution of nutrients because they are believed to be the most important arthropod decomposers in tropical ecosystems. The variety of termites that can be found in Namakkal's surrounding areas (four zones). a. Puliampatti has the highest species richness, with 6 species, followed by d. Paramathi, which has 5 species, c. Vasanthapuram, which has 4 species, and b. Nadanthai, which has 3 species. In total, we are a species of termites that has been identified 9.

**Keywords:** Termite diversity, Namakkal district (4 Villages)

### Introduction

Termite workers and soldiers have white colored bodies, termites are frequently referred to as a "white ant." This is because termites have a similar appearance to ants. In one form or another, termites can be found all across the rest of the planet. In a matter of months, certain species of termites can destroy dwellings as quickly as a fire, while in a matter of years, they consume the home at a much slower pace. Holt *et al.*, (1996) [15] found that termites are so dominating that they regulate both water infiltration and the nutrient cycle, which in turn enables them to promote primary production. Within a termite colony, winged reproductive's are produced by termites, but there are an extremely small number of them.

Sugimoto *et al.*, (2000) [32] and Indhu *et al.*, (2014) [16], termites are the most significant and effective decomposers of lignocellulose, which includes material such as decaying wood. The recycling of wood and plant materials, the modification of soil conditions, the improvement of soil composition and fertility, and the provision of food for other animals are all incredibly important roles that they provide. These organisms are accountable for the redistribution of soil particles, as well as the modification of the mineral and organic content of soils, as well as the hydrology, drainage, and infiltration rates of the landscape.

SiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, and Al<sub>2</sub>O<sub>3</sub> are the components that make up the soils that are found in termite mounds (Momah and Okieimen, 2020; Indhu *et al.*, 2017) [17]. Due to the high nutrient content of the mound soil, it was observed that a large number of bacterial species were present in the soil (Enagbonma and Babalola, 2019 [12]; Indhu *et al.*, 2023) [18]. In addition, a termite mound is a significant source of soil nutrients, which are essential for the proper functioning of an ecosystem (Menichetti *et al.*, 2014 [24]; Sasikala *et al.*, 2018) [30].

(Lori *et al.*, 2017 [23] and Sivanantham *et al.*, 2023) [31] discuss the importance of microbial abundance and activity

as critical indicators for soil quality. These indicators can be assessed using a variety of techniques. According to Garau *et al.*, (2019) [14] and Thangaraj and Sivanantham (2015) [34], dehydrogenases are members of the oxidoreductase enzymes group and are utilised as an indicator of the overall microbial activity in soil. In addition to participating in the breakdown of organic matter (Wolinska *et al.*, 2015) [36], they also serve as an indication of the metabolic activities of soil microorganisms (Alef and Nannipieri, 1995) [1]. These processes take place within the cells of the microorganisms itself.

### Materials and Method

#### Study area

The diversity of termites in Namakkal is found in the following 4 areas: a. Puliampatti, b. Nadanthai, c. Vasanthapuram, and d. Paramathi. Over the course of a period of 6 months (from August 2022 to January 2023), numerous kinds of termites were observed with great variety.

#### Sampling method

##### Transect method

Samples were collected in each section for a period of thirty minutes by two individuals. Each transect was 100 metres in length and 2 metres in width. It was then divided into twenty contiguous sections, each of which measured 5 metres by 2 metres and was numbered consecutively.

A search for termites was conducted in each of the following microhabitats and sections: 12 samples of surface soil (each 12 cm X 12 cm, to 10 cm depth); accumulations of litter and humus at the base of trees and between buttress roots; the inside of dead tree stumps, logs, branches, and twigs; the soil within and beneath rotten logs; all mounds and subterranean nests encountered; arboreal nests, carton runways, and sheeting on vegetation up to a height of 2 m above ground level.

### Quadrat method

A site measuring 100 m by 100 m was chosen at random and marked. In this procedure, five sub-sections measuring 2 m by 2 m were randomly designated, and termites were sampled in the same manner as for the transect-based method.

Both early in the morning, between the hours of 6:00 and 7:00, and late in the evening, between 5:00 and 6:00, were the times when transects were monitored. On the other hand, the surveys were only carried out when the weather conditions were favorable (that is, when there was neither rain nor high temperatures). In addition, there were sporadic reports of witnessing butterflies. The Panasonic FZ 300 camera was utilized in order to obtain the photographs.

### Identification

Using a key that we had compiled from a variety of Zoological Survey of India (ZSI) sourcebooks (Chhotani 1997<sup>[9]</sup>; Kumar and Thakur 2013)<sup>[22]</sup>, we were able to identify the termites. Through the use of morphological characteristics of various body components, including as the head, eyes, antennae, pronotum, mesonotum, metanotum, legs, rostrum, cerci, and so on, they were able to be identified up to the genus level. The mandible, the labrum, and the postmentum were all mounted. The identification of species was accomplished by obtaining measurements of various sections and comparing them to the keys that were compiled.

### Result

The findings of the investigation showed that there were ten different species of termites present across the entire region between the months of August 2022 and January 2023. a. Puliampatti, b. Nadanthai, c. Vasanthapuram, and d. Paramathi are the four locations that make up the termite diversity located in Namakkal. It was found that there were many different types of termites in the termites during the course of 6 months (August 2022 to January 2023). One of the highest species richnesses is found in Puliampatti, which has 6 species, followed by Paramathi, which has 5 species. There were less termites found in Nadanthai, which had 3 species, compared to the number of termites found in Vasanthapuram, which had 4 species.

#### 1. *Cryptotermes brevis* – West Indian dry wood termite

This termite is also known as the powder post termite or the West Indian dry wood termite. Without access to any external supply of water, it is able to complete its life cycle entirely within wooden structures or items made of wood, such as furniture. Damage is caused to the structural timbers of buildings as well as wooden goods such as furniture when it is accidentally brought into new sites. This occurs rather regularly.

West Indian dry wood termites are eusocial insects that construct a colony nest and reside inside timbers. They do this by building chambers designed for the raising of larvae as well as short galleries. They are similar to other dry wood species in that they are larger and have deeper bodies than termites that live underground, they have shorter limbs, and they move more slowly. All of the other members of the colony, with the exception of those in the reproductive class, are blind. It is their strong jaws that allow them to chew wood fibre, their claws that allow them to grab wooden surfaces, and their antennae that resemble the beads of a necklace that are linked together.

#### 2. *Incisitermes minor* - western dry wood termite

The western region of North America, which includes the western United States and northern Mexico, is its natural state of origin. There have been numerous other locations in the United States where it has been discovered, all the way up to the East Coast. According to reports, it originated in Toronto. This has been brought to the state of Hawaii. There have been reports of it in China, and it is not an unusual occurrence in Japan. The economic significance of this insect lies in the fact that it attacks timber structures, especially homes. Only in the states of California and Arizona is it estimated that it has an annual impact on the economy of approximately \$250 million. There are three distinct varieties of termites that can be found inside a single colony: the alates, the soldier, and the worker. The color of this eusocial species is dark brown, and it has an orange pattern on its head. Additionally, the colonies are most active throughout the spring and summer months, and they like to be active when temperatures are greater.

#### 3. *Coptotermes formosanus* – super termite

A species of termite that is native to southern China and has been introduced to Taiwan (which was once known as Formosa, which is whence it gets its name), Japan, South Africa, Sri Lanka, Hawaii, and the continental United States is called the Formosan termite (*Coptotermes formosanus*). It is common practice to refer to the Formosan termite as the "super-termite" due to the destructive nature of its behavior, which is characterized by the vast size of its colonies and its capacity to consume wood at a tremendous rate. Large enough populations of these termites have reached the point where they may be detected by weather radars in New Orleans.

#### 4. *Reticulitermes flavipes* - Eastern subterranean termite

The eastern subterranean termite, also known as *Reticulitermes flavipes*, is the termite that comes into contact with the most people in North America. These termites are considered to be pests since they are the most economically significant insects in the United States that destroy wood. Cellulose is the material that they consume, which includes things like the structural timber in houses, wooden fittings, paper, books, and cotton textiles. Within a mature colony, the number of workers can range anywhere from 20,000 to as high as 5 million, and the principal queen of the colony will lay between 5,000 and 10,000 eggs annually, adding to the overall number of workers. In the same way that other social insects do, eastern subterranean termites divide labor and share resources according to a caste structure. Their communities, which are referred to as colonies, are made up of both men and females and are loosely affiliated with one another. The worker caste, the military caste, and the reproductive caste are the three primary categories that are used to classify the termites that are found in the colony.

#### 5. *Hypotermes obscuriceps* – Pest termite

Termites belonging to the genus *Hypotermes* include the species known as *Hypotermes obscuriceps*. Its natural habitats are in Vietnam, Sri Lanka, and India. The termitaria that it creates is a pest that is found in tea.

### 6. *Macrotermes convulsivarius* – Pest termite

Termite belongs to the family Termitidae, and one of its species is called *Macrotermes convulsivarius*. A native of India and Sri Lanka, it is a pest. Mandibles are developed to a high degree in soldiers, who are particularly huge. This bug is a significant problem for many wood works in buildings. In the gut of *M. convulsivarius*, there is a high concentration of flagellated bacteria, including *Bacillus*, *Acinetobacter*, *Salmonella*, *Enterobacter*, and *Enterococcus*.

### 7. *Odontotermes globicola* – Small termite

*Odontotermes globicola* belonged to the genus *Odontotermes* and was classified as a species of tiny termite. It is indigenous to the people of India, Malaysia, and Sri Lanka. It is discovered behind flower pots and logs that have rotted away. In order to construct their little chambered nest, they need termitaria that are spherical and combed.

### 8. *Microtermes obesi* - wheat termite

The termite species known as *Microtermes obesi*, sometimes known as the wheat termite, is a tiny member of the genus *Microtermes*. It is indigenous to the countries of India, Sri Lanka, Pakistan, and Vietnam. Additionally, it is a minor problem of sugarcane, but it is a serious pest of wheat. The termites in question have a dark head and a cream-colored body. Both in the morning and in the evening, workers are more active. It is a significant pest that affects wheat. Wheat is harmed by them shortly after it is planted and in the early stages of maturity. Those plants that are heavily infected may wilt and be easily removed from the ground. Utilising natural predators like *Metarhizium anisopliae* and *Beauveria bassiana* is one method that termites might use to limit their population.

### 9. *Trinervitermes biformis* - snouted harvester termite

*Trinervitermes biformis*, often known as the snouted harvester termite, is a species of mound-building termite that belongs to the genus *Trinervitermes* and is considered to be indigenous to India and Sri Lanka. Bandarawela, which is located in Sri Lanka, was the location where the type species was described. Brinda and sugarcane are both susceptible to this insect.

### Discussion

The hazards that termites represent to the production of food and industrial crops are extremely obvious, despite the fact that India may not have access to reliable statistics regarding economic losses. A loss of 15–25% of corn yield and around 1478 million Rupees is attributed to termites in India, according to (Joshi *et al.*, 2005) [19]. In the Northeastern region of Puducherry, (Anantharaju *et al.*, 2014) [3] discovered 10 different species of termites, which belonged to eight different genera and three different families. Samples of termites taken from the Islamia University of Bahawalpur in Pakistan were used by (Ali *et al.*, 2013) [2] to determine the existence of six different species of termites. In a university campus in Indonesia, (Primanda *et al.*, 2003) [27] detected six different species of termites in an area that was sixteen thousand square metres in size and was divided into quadrates of ten metres by ten metres. The Vadodra district of Gujarat was the location where (Kumar and Pardeshi 2011) [21] discovered fifteen different species of termites.

(Dawes 2010) [11], the majority of termite assemblages have a more broad range of food resources, including a variety of cropping patterns (such as wood, soil, and leaf litter), as well as different types of soil for nesting methods (mound, arboreal nests, and nests of wood). Edible insects offer a novel and sustainable source of protein for human consumption, and they have a tremendous amount of promise as ingredients for food products. Therefore, there is a consensus in favor of "the use of insects for foods" (Sun-Waterhouse *et al.*, 2016) [33]. The application of insects for therapeutic purposes is referred to as entomotherapy (Costa-Neto 2005) [10]. Termites have been consumed for millennia in various regions of the world, and the practise of hunting termites has become more common in recent years (Figueiredo *et al.*, 2015) [13]. Irulars of Red hills (Bosco and Arumugam 2012) [5], Pillur valley (Rasingam 2012) [28], and Erode district (Revathi and Parimelazhagan 2010) [29] in Tamil Nadu have been found to hold a wealth of ethnobotanical knowledge, according to research.

The termite, *Odontotermes formosanus*, has been utilized by a number of south Indian tribes, including the Kanikaran, Paniyan, Sholaga, Irula, and Kota, for the treatment of viral infections and asthma (Wilson 2005) [35]. According to (Khare 2007) [20], the most important chemical components that are active in *A. indica* are aristolochic acid and aristolactams. According to (Chander *et al.*, 2015) [8], Nicobarese groups of indigenous populations make extensive use of *C. cathartica* as a treatment for a variety of ailments, including bodily pain, earache, fever, and joint pain. It has also been found that the methanol extract of the plant's seeds that have been roasted and fermented is efficient in suppressing cancer cell lines (Niveditha *et al.*, 2013) [25]. According to Ayyanar (2008) [4], Kani tribal people in the Tirunelveli hills of southern India utilize the leaves of *G. mauritiana* to treat fever, cough, and cold.

In the majority of countries in Asia and Africa, termites are regarded as a gastronomic delicacy, particularly among economically disadvantaged societies that are residents of forest regions. According to (Paul 2011) [26], edible termites could be a good staple diet for pregnant women, children, and other primates because they provide a significant amount of protein, carbs, and fat in addition to a large number of necessary amino acids. According to (Chakravorty *et al.*, 2016) [7], a number of *Odontotermes* species include a high concentration of minerals such as zinc and iron, which are considered to be among the most significant threats to public health in the majority of developing and underdeveloped nations. According to (Figueiredo *et al.*, 2015) [13], there have been reports of 29 countries across three continents using termite species as the basis for their medicinal applications.

### Conclusion

a. Pulliyampatti, b. Nadanthai, c. Vasanthapuram, and d. Paramathi are the subject of the current research project, which aims to investigate the termite diversity in the Namakkal region. It was found that there were many different types of termites in the termites during the course of six months (August 2022 to January 2023). The highest number of species was found in Puliampatti, which had six species, followed by Paramathi, which had five species, Vasanthapuram, which had four species, and Nadanthai, which had three species. b. Nadanthai had the fewest number of termites as well.

1. *Cryptotermes brevis* – West Indian dry wood termite,
2. *Incisitermes minor* - western dry wood termite,
3. *Coptotermes formosanus* – super termite,
4. *Reticulitermes flavipes* - Eastern subterranean termite,
5. *Hypotermes obscuriceps* – Pest termite,
6. *Macrotermes convulsionarius* – Pest termite,
7. *Odontotermes globicola* – Small termite,
8. *Microtermes obesi* - wheat termite,
9. *Trinervitermes biformis* - snouted harvester termite

Termites are the most significant and effective decomposers of lignocellulose, which includes decaying wood and other similar materials. The recycling of wood and plant materials, the modification of soil conditions, the improvement of soil composition and fertility, and the provision of food for other animals are all incredibly important roles that they provide. These organisms are accountable for the redistribution of soil particles, as well as the modification of the mineral and organic content of soils, as well as the hydrology, drainage, and infiltration rates of the landscape. When it comes to the ecological processes that occur in the soil, termites are extremely important mediators.

The termites are effective decaying organisms. In a great number of nations, the materials that have disintegrated are utilized by certain species of termites. Additionally, certain indigenous peoples consume termites due to the presence of certain nutrients in the materials. Termites are a common ingredient in treatments for certain populations.

**Table 1:** List of Termite in Namakkal district during August, 2022 to January, 2023

S.No	Family	Scientific Name	Common Name
1	Kalotermitidae	<i>Cryptotermes brevis</i>	West Indian dry wood termite
2	Kalotermitidae	<i>Incisitermes minor</i>	Western dry wood termite
3	Rhinotermitidae	<i>Coptotermes formosanus</i>	Super termite
4	Rhinotermitidae	<i>Reticulitermes flavipes</i>	Eastern subterranean termite
5	Termitidae	<i>Hypotermes obscuriceps</i>	Pest termite
6	Termitidae	<i>Macrotermes convulsionarius</i>	Pest termite
7	Termitidae	<i>Odontotermes globicola</i>	Small termite
8	Termitidae	<i>Microtermes obesi</i>	Wheat termite
9	Termitidae	<i>Trinervitermes biformis</i>	Snouted harvester termite

**Table 2:** List of Species (family) Richness in Four Different areas around Namakkal District

S No	Name of the Place	No. of Species (Family)
1	Puliyampatti	6
2	Paramathi	5
3	Vasanthapuram	4
4	Nadanthai	3



**Fig 1:** Map showing the study area (Namakkal district of Tamil Nadu)

**Acknowledgement**

The writers would like to extend their gratitude to the management of Kandasawami Kandari's College in Velur,

Namakkal, Tamilnadu, India, for providing the necessary facilities. The college is responsible for providing these facilities.

## References

- Alef K, Nannipieri P. Protease activity In: Methods in Applied Soil Microbiology and Biochemistry, Elsevier Publishing Pvt.Ltd, 1995, 608.
- Ali M, Sial N, Ashraf S, Hasanat A. A survey of subterranean Termite (isoptera) Fauna and its population diversity in district Bahawalpur. *Standard Scientific Research and Essays*,2013;1(11):289-293.
- Anantharaju T, Gurjeet K, Gajalakshmi S, Abbasi SA. Sampling and identification of termites in Northeastern Puducherry. *Journal of Entomology and Zoology Studies*,2014;2(3):225-230.
- Ayyanar M. Ethnobotanical wealth of Kani tribe in Tirunelveli hills. Ph.D. Dissertation, University of Madras, Chennai, India, 2008.
- Bosco FG, Arumugam R. Ethnobotany of Irular tribes in Redhills, Tamil Nadu, India. *Asian Pacific Journal of Tropical Biomedicine*, 2012, 874 - S877.
- Brown KS, Kard BM, Doss MP. Oklahoma termite survey (Isoptera). *J. Kans. Entomol. Soc*,2004;77:1-9.
- Chakravorty J, Ghosh S, Megu K, Jung C, Meyer-Rochow VB. Nutritional and anti-nutritional composition of *Oecophylla maragdina* (Hymenoptera: Formicidae) and *Odontotermes* sp. (Isoptera: Termitidae): Two preferred edible insects of Arunachal Pradesh, India. *Journal of Asia-Pacific Entomology*,2016;19:711-720.
- Chander PM, Kartick C, Vijayachari P. Herbal medicine & healthcare practices among Nicobarese of Nancowry group of Islands - an indigenous tribe of Andaman & Nicobar Islands. *Indian Journal of Medical Research*,2015;141:720-744.
- Chhotani OB. The Fauna of India and The adjacent countries. Isoptera (Termites), Zoological Survey of India, 1997, 1.
- Costa-Neto EM. Entomotherapy or the medicinal use of insects. *Journal of Ethnobiology*,2005;25:93-114.
- Dawes TZ. Impacts of habitat disturbance on termites and soil water storage in the tropical Australian Savanna. *Pedobiologia*,2005;53:241-246.
- Enagbonma BJ, Babalola OO. Potentials of termite mound soil bacteria in ecosystem engineering for sustainable agriculture. *Annals of Microbiology*,2019;69:211-219.
- Figueiredo RECR, Vasconcellos A, Policarpo LS, Alves RRN. Edible and medicinal termites: a global overview. *Journal of Ethnobiology and Ethnomedicine*,2015;11:29.
- Garau G, Porceddu A, Sanna M, Silvetti M, Castaldi P. Municipal solid wastes as a resource for environmental recovery: Impact of water treatment residuals and compost on the microbial and biochemical features of As and trace metalpolluted soils. *Ecotoxicology and Environmental Safety*,2019;174(15):445-454.
- Holt JA, Bristow KL, McIvor JG. The effects of grazing pressure on soil and litter animals and some hydraulic properties of two soils in semi-arid tropical Australia. *Aust. J. Soil Res*,1996;34:69-79.
- Indhu B, Muthusami S, Thirunavukkarasu N. "Studies on microflora and their role on egg shell contamination and infection." *International Journal of Pharmaceutical, Chemical and Biological Sciences*,2014;4(3):518-521.
- Indhu B, Muthusami S Thirunavukkarasu N. Study of Plankton Diversity of Cauvery River from Jedarpalayam to Velur, Namakkal District,2017;5(1):28-30.
- Indhu B, Sivanantham S, Thangaraj N, Thirunavukkarasu N. "Effect of different levels of cow manure on phytoplankton productivity in culture." *International Journal of Zoology Studies*,2023;8(4):32-35.
- Joshi PK, Singh NP, Singh NN, Gerpacio RV, Pingali PL. Maize in India: Production Systems, Constraints, and Research Priorities. D.F. CIMMYT, Mexico, 2005, 22.
- Khare CP. Indian Medicinal Plants – An illustrated dictionary. Springer Science + Business Media, LLC, Spring Street, New York, USA, 2007.
- Kumar D, Pardeshi M. Biodiversity of termites in agro ecosystem and relation between their niche breadth and pest status Gujarat Institute of Desert Ecology Bhuj Gujarat India. *Journal of Entomology*,2011;8(3):250-258.
- Kumar S, Thakur RK. Termites (Insecta: Isoptera) from Punjab with new distributional records (Accepted in *The Indian Forester*),2013;139(6):553-558.
- Lori M, Symnaczik S, Ma'eder P, De Deyn G, Gatteringer A. Organic farming enhances soil microbial abundance and activity—A meta analysis and meta-regression. *PLoS One*,2017;12(7):e0180442. <https://doi.org/10.1371/journal>.
- Menichetti L, Landi L, Nannipieri P, Katterer T, Kirchmann H, Renella G. Chemical properties and biochemical activity of colonized and abandoned litter-feeding termite (*Macrotermes* spp.) mounds in chromic Cambisol Area on the Borana Plateau, Ethiopia. *Pedosphere*,2014;24:399-407.
- Niveditha VR, Venkatramana DK, Sridhar KR. Cytotoxic effects of methanol extract of raw, cooked and fermented split beans of *Canavalia* on cancer cell lines MCF-7 AND HT-29. *The IIOAB Journal*,2013;4(4):20-23.
- Paul D. Nutrient content of sexual and worker forms of the subterranean termite, *Reticulitermes* sp. *Indian Journal of Traditional Knowledge*,2011;10(3):505-507.
- Primanda A, Ischak TM, Basukriadi A. Termite Species Richness on the Campus of Universities Indonesia, Depok. Department of Biology, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok 16424, Indonesia. *MAKARA SAINS*,2003;7:9-14.
- Rasingam L. Ethnobotanical studies on the wild edible plants of Irula tribes of Pillur Valley, Coimbatore District, Tamil Nadu, India. *Asian Pacific Journal of Tropical Biomedicine*, 2012, 1493-1497.
- Revathi P, Parimelazhagan T. Traditional Knowledge on Medicinal plants used by the Irulas Tribes of Hasanur Hills, Erode District, Tamil Nadu, India. *Ethnobotanical Leaflets*,2010;14:136-60.
- Sasikala P, Indhu B, Pugazhendy K, Sattanathan G. "Freshwater plankton culture using different organic and inorganic fertilizer." *Indo American Journal of Pharmaceutical Sciences*,2018;05(07):6275-6282.
- Sivanantham S, Thangaraj N, Indhu B, C Jayalakshmi C. Efficacy of *Glycyrrhiza glabra* as an antibacterial agent against isolates that produce biofilm and beta-

- lactamases.” *International Journal of Multidisciplinary Education and Research*,2023:8(4):81–86.
32. Sugimoto A, Bignell DE, MacDonald JA. Global impact of termites on the carbon cycle and atmospheric trace gases. In: *Termites: Evolution, Sociality, Symbioses, Ecology*. [Abe, T., Bignell, D.E., Higashi, M. (Eds.)], Kluwer, Netherlands, 2000, 409–435.
  33. Sun-Waterhouse D, Waterhouse GIN, You L, Zhang J, Liu Y, Ma L, *et al*. Transforming insect biomass into consumer wellness foods: A review. *Food Research International*,2016:8(1):129-151.
  34. Thangaraj N, Sivanantham S. Phytochemical Screening, Characterization, compound identification and separation from *Daucus carota*. *INT. JI. Curr. Res. Biosci. Plant. Biol*,2015:2(7):168–172.
  35. Wilsanand V. Utilization of termite *Odontotermes formosanus* by tribes of south India in medicine and food. *Natural Product Radiance*,2005:4(2):121-125.
  36. Wolinska A, Stepniewska Z, Pytlak P. The effect of environmental factors on total soil DNA content and dehydrogenase activity. *Archives of Biological Sciences Belgrade*,2015:67(2):493–501.