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RESEARCH PAPER

A preliminary study on the diversity of termites in twin cities (Rawalpindi and Islamabad) of Pakistan

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Key Message: This preliminary study investigates termite diversity in Rawalpindi and Islamabad, identifying two species: *Coptotermes heimi* and *Odontotermes horai*. The research highlights that *Odontotermes horai* is more prevalent, with peak abundance during the humid months of June to August, and provides a foundation for understanding termite ecology and improving control strategies.

Abstract

Termites are eusocial cellulophagous isopterus insects belonging to phylum Arthopoda, class insecta and order Blattodea. They are a dominant group of invertebrate decomposers that inhabit the arid and semi-arid zone of the world. They exhibit division of labor among the individuals of their colony based on their morphology, physiology and behavior. They feed on dead and decayed wood, woody plants, animal dung, soil, timber and all the cellulosic products. They are involved in ecosystem services like nutrient cycling, enhancement of biodiversity and soil structuring etc. But on the other hand, they damage the wooden furniture, agricultural fields and all other cellulose based products. By keeping in view the ecosystem services and the economic losses rendered by them, the current study was planned to investigate the species diversity of termites in Rawalpindi and Islamabad city. The termite samples were collected from houses, animal dung, soil and trees of the study area with the help of camel hair brush, wooden sticks and X- rays sheets. Identification was done with the help of a key under the supervision of an expert entomologist. From the collected samples of termites, two species *Coptotermes heimi* (Family Rhinotermitidae) and *Odontotermes horai* (Family Termitidae) were identified. Data obtained regarding the relative abundance of termites indicated that maximum relative abundance (45.6%) of termites species was recorded during the 4th sampling period (June - August) due to higher humidity. *Odontotermes horai* (55.07%) was a more abundant termite species than *Coptotermes heimi* (44.93%). The overall diversity for termite species was 49.49% on Simpson scale while 68.80 % on Shannon diversity index. This study will provide basic knowledge regarding the abundance of termites and different habitats inhabited by termites. It is helpful for the understanding of basic eco-biology of termites. Furthermore, it will help entomologists in designing effective control measures. © 2022 The Author(s)

Keywords: Abundance, Diversity, Shannon index, Simpson index, Termites

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Introduction

Termites are taxonomically placed in phylum Arthropoda, class Insecta and order Blattodea (Osipitan et al., 2010). Approximately 3,500 species of termites are reported worldwide that have been classified in 281 genera and 7 families. Out of these, 300 species are economically significant and reported for their pest activity (Ibrahim & Adebote, 2012). In Pakistan, 53 species of termites belonging to 16 generas and 4 families (Kalotermitidae, Hodotermitidae, Rhinotermitidae and Termitidae) have been reported (Ahmad & Akhtar, 1994). Termites are pale colored, soft bodied insects that live in highly organized colonies with several hundreds to over a million individuals and show division of labor among them (Hattori et al., 2013). Termite species vary in habits, preferred food, size, body characteristics, colour and even parts of their life cycle. They completely depend on live or dead wooden material, leaf rotten litter, woody tissue of plants, soil and on animal dung (Kambhampati & Eggleton, 2000). On the basis of habitat, they are categorized into three groups (Subterranean, Dampwood and Drywood termites). Drywood and dampwood termites breed and live inside the wood that is also used for feeding. On the other hand, subterranean termites make their nests in the ground or above the ground near the sources of moisture and construct mud tubes for foraging above the ground to protect themselves from predators and dehydration (Ali et al., 2013a).

Unlike ants or bees, termites undergo incomplete metamorphosis with three different life stages: egg, nymph and adult. Termite nymphs look like small adults and typically develop into workers firstly then further molt into soldiers or alate nymphs (supplemented queens or kings). Workers are responsible for foraging for food, digesting (cellulose) and storing the food, feeding the nymphs,

tending the queen and the maintenance of the nest. They are both male and female and are usually sterile and are more likely to be found at the site of termite infestation. Soldiers are also sterile and are responsible for defending the colony and have powerful jaws. In spring, winged alates are produced for reproduction and these swarms emerge from the colony during nuptial flight. Male and female alates pair up during nuptial flights and then find out the suitable place for the establishment of a colony. After mating, both reproductives never leave the colony again. After mating, the queen can live for 30 to 50 years. Colony growth is regulated by pheromones released by queen (Su & Scheffrahn, 2000; Haifig et al., 2016).

Termites are one of the most destructive pests of cellulose containing materials like books and papers, wood and agriculture and cause destruction in the agricultural and commercial sector on a greater scale. They are involved in the removal of dung matter, formation of soil, emission of greenhouse gas and also used as feed for wildlife, livestock and as food for humans. They are considered as ecosystem engineers as they play a key role in nutrient fluxes by breaking down the organic matter (Lavelle et al., 2006; Rao et al., 2012; Govorushko, 2019). In Pakistan, 11 out of 53 described termite species are mainly responsible for causing damages to forest, agricultural crops, wooden buildings and furniture. The species of family Termitidae and Rhinotermitidae are mainly responsible for damage to ornamental plants, grasses, fruit trees and agricultural crops (Iqbal & Saeed, 2013). In Punjab province, two important genera (Odontotermes and Microtermes) have been reported causing damages and destruction in the wooden infrastructure near agricultural sectors (Ahmed et al., 2008a, b). In different agro-agricultural zones, genus Odontotermes is particularly responsible for structural and agricultural damages and losses. *Odontotermes obesus* cultivates a symbiotic fungus and attacks the wheat, barley, maize, pearl millet, sorghum, sugarcane, groundnut and tea crop (Luisa, 2012; Khan & Ahmad, 2017). *Coptotermes heimi* is a subterranean termite that feeds on the stem of sugarcane and on the bark and soft parts around the base of trees (Ambrose et al., 2008; Manzoor et al., 2013).

The distribution pattern and the diversity of termites mainly depend on the climatic conditions and the vegetation of the area. Pakistan is a blessed country with four seasons in a year; summer (May - August), autumn (September - early November), winter (November - mid February), spring (Februray - April). The overall climate is arid and tropical but due to diversity of landscape, different areas witness climatic changes. Termites are the most serious pest in Pakistan specifically because the hot, humid and dry climate of Pakistan is perfect for breeding of termites at a rapid pace. Termite infestation is also a major problem of study area due to suitable climatic conditions that favours the growth of termites. The summer season in Rawalpindi is hot and rainy while winter is cool and dry. On the other hand, the climate of Islamabad is more pleasant as compared to Rawalpindi city due to more vegetation. By keeping in view, the damages and destruction caused by them in the study area, termites diversity was observed in twin cities (Rawalpindi and Islamabad). Lack of information regarding the diversity and relative abundance of termites in different areas of Pakistan is another reason to conduct this research. This study will be helpful for management of termites infestation in these areas.

Materials and Methods

Description of the study area

Rawalpindi city is located at 33.57° N and 73.02° E in the Potohar region. It is an important administrative, commercial and industrial centre of Pakistan as it lies 9 miles southwest of Islamabad, the national capital. It has a warm temperate climate but due to urbanization of the city, the climatic conditions differ significantly from its twin city Islamabad (https://rawalpindi.punjab.gov.pk/climate). The level of relative humidity is maximum in August while the level of precipitation is minimum in November. Islamabad (the capital city of Pakistan) is located at 33.68° N and 73.05 °E at the northern end of Potohar Plateau and at the bottom of the Margalla Hills. The month with the highest relative humidity is August. It has a humid subtropical climate. Winters is generally characterized by dense fog in the mornings and sunny afternoons. On the other hand, Indian monsoon and western disturbance makes it hot and very rainy in summer. In this scenario, heavy showers and rains fall in Islamabad every month. The annual rainfall in Islamabad is 1142.1 mm (45 inch) (https://www.climate.top/pakistan/islamabad/precipitation/). Its annual precipitation allows the growth of lush green vegetation in the city's hills (https://en.wikipedia.org/wiki/Climate_of_Islamabad). In the present study, we observed the temperature (°C) and rainfall (mm) from September, 2021 to August 2022 as shown in Table 1 and 2.

Collection of termites

This study was conducted in Rawalpindi and Islamabad city to assess the diversity of termites. A total of 11, 350 samples of termites were collected from the urban areas of Rawalpindi (Liaquat Bagh, Shamsabad and PMAS-Arid Agriculture University, Rawalpindi) and Islamabad (I-8/1, I-10/4, F-9, G-8 Markaz, H-8, G-12). Sampling was done from September, 2021 to August, 2022. The sampling period were further categorized into four different sampling periods; 1st (September, 2021 - November, 2021), 2nd (December, 2021 - February, 2022), 3rd (March, 2022 - May, 2022) and 4th (June, 2022 - August, 2022). Termites samples were collected from the trees (50), animal dung (750 g), soil and from the houses (9) during morning and evening as termites were found mostly active at that time (Fig. 1). Houses were randomly assessed from Liaquat Bagh, Shamsabad, I-8/1 and I-10/4. Visual observation of termites infestation was made on the basis of signs that includes discarded wings during swarming season (July - September), mud tubes and tunnels on the floors and walls, roofs, damaged wooden doors and windows, damaged parts of ceilings and wood powder near tiny holes in wooden surfaces (Fig. 2). Termites were collected by

splitting infested wood, digging up the soil up to the depth of 15-25 cm, breaking termites mounds and tunnels with the help of wooden sticks. The specimens were picked up by camel hair brush and X- rays sheets. The samples were collected in plastic boxes along with the portion of termite nesting material. In order to retain moisture for termites, cotton soaked with water was placed on the perforated lid of plastic boxes and cardboard was provided as food.

Table 1 Atmospheric temperature (maximum, minimum and average) of Rawalpindi and Islamabad from September, 2021 to August, 2022

Months	Temperature (°C)					
	Rawalpindi			Islamabad		
	Max.	Min.	Average	Max.	Min.	Average
September, 2021	36	25	31	35	24	31
October, 2021	32	19	27	32	19	27
November, 2021	26	13	21	27	13	21
December, 2021	21	8	15	21	9	15
January, 2022	16	8	12	16	8	12
February, 2022	20	8	15	20	8	15
March, 2022	31	16	25	31	16	25
April, 2022	40	22	33	40	22	33
May, 2022	43	27	37	43	27	37
June, 2022	43	28	38	42	28	38
July, 2022	35	27	32	35	27	32
August, 2022	34	26	31	34	25	31

Table 2 Average rainfall (mm) of Rawalpindi and Islamabad

Time duration	Average rainfall (mm)	
	Rawalpindi	Islamabad
October, 2021 - December, 2021	4.33	5.57
January, 2022 - March, 2022	4.03	17.53
April, 2022 - June, 2022	9.03	10.73
July, 2022 - September, 2022	58.10	68.90

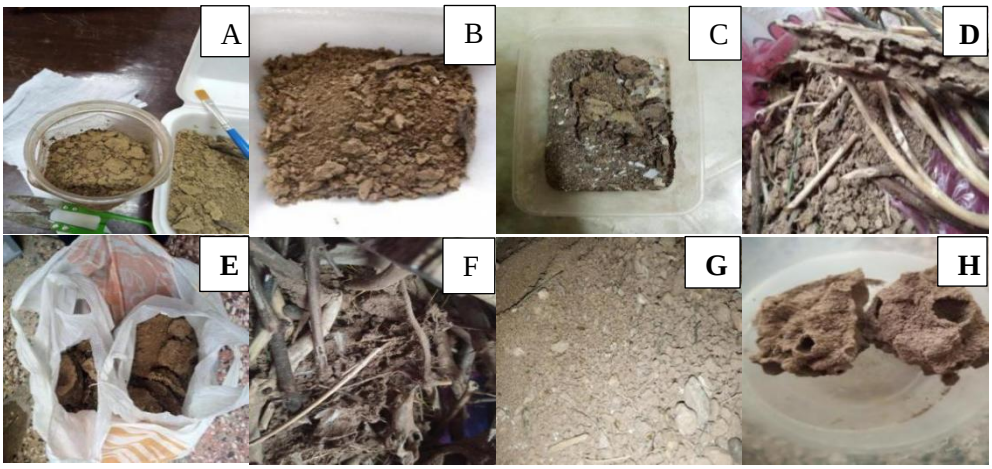

Fig. 1 Collection of termites (A) Trees (B) Soil (C) Houses (D) Wood+ Soil (E) Animal dung (F) Wood+ Soil (G) Soil (H) Mounds (Soil)

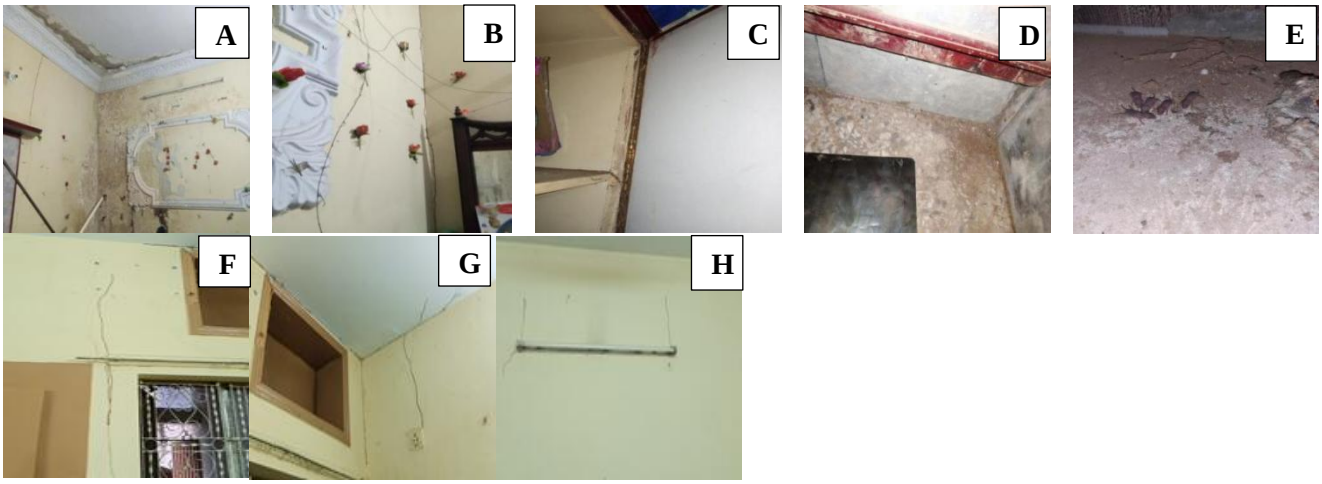

Fig. 2 Collection from houses (Rawalpindi and Islamabad)

Identification of termites

Trees, soil, cow dung and houses are the sites from where the termites were collected. Nearly 100 individuals of termites from each sampling site were used for identification. Identification was done on the basis of morphological characters (colour, size and shape of head, antennae etc.). Termites were picked up from the specimen by using camel hair brush. They were then preserved in a sampling vial having absolute ethanol for identification and labeling was done with all the required information (location, collector name and date of collection) (Fig. 3). The collected specimens of termites were identified from Department of Entomology, PMAS - Arid Agriculture University, Rawalpindi. Taxonomic key proposed by Akhtar (1983) was used for identification of termite species.

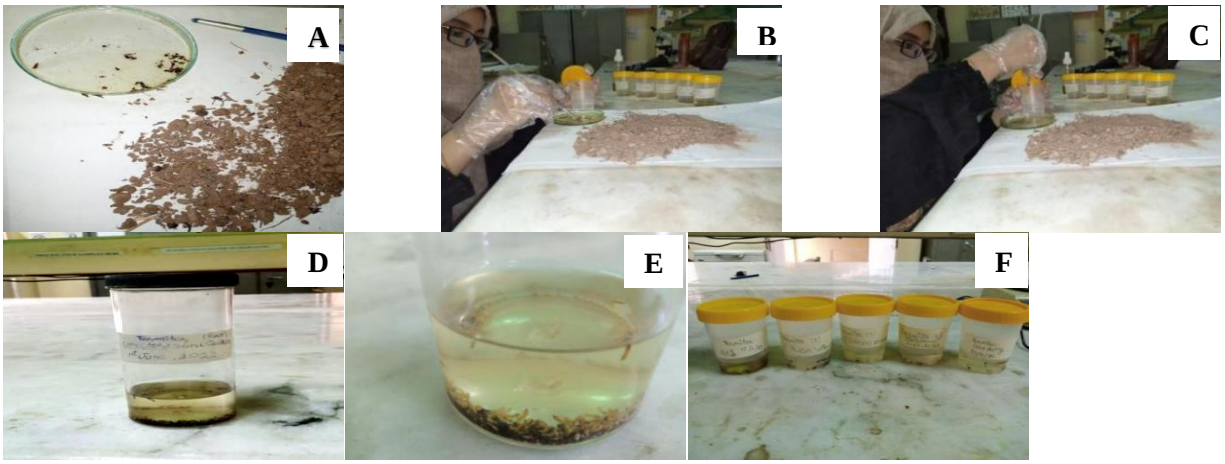

Fig. 3 Identification of termites (A) Separation of termites from debris; (B, C) Transfer of termites into plastic bottles for preservation in absolute ethanol; (D, E, F) Sampling vials containing termites for identification

Statistical analysis

Relative abundance and diversity indices of termites

The number of individuals of termites collected were used for the calculation of relative abundance of termites. Relative abundance (RA) of termites was calculated by using the following formula:

$$Relative\ Abundance = \frac{Population\ of\ individual\ species}{Total\ population\ of\ species} \times 100$$

Termite diversity was calculated by Simpson and Shannon diversity indices (Simpson, 1949; Odum, 1975).

Simpson diversity index (D) is a measure of diversity that is used to measure community diversity and it report both the number of species present per sample as well as the relative abundance of different species.

$$D = 1 - \frac{\sum n\,(n-1)}{N(N-1)}$$

Where
D = Dominance index
n = Number of individuals of each species
N = Total number of individuals of all the species

Shannon Diversity Index (H) was used for species diversity measurement within a community and to characterize both the abundance and the evenness of the species present.

$$H = -P_i\, ln\, P_i$$

Where
H = Shannon diversity index
ln = natural logarithm
P_i = Proportion of number of individuals of each species by total number of individuals of all species

Results

Identification of termites

From the collected samples, two species of termites were identified representing two families belonging to two different generas; Odontotermes and Coptotermes. Results indicated that the two species of termites *Coptotermes heimi* (Family Rhinotermitidae) and *Odontotermes horai* (Family Termitidae) were identified from the samples collected from houses, animal dung, soil and trees of the study area (Table 3). These two species were also reported in Taxila along with two other species i.e., *Odontotermes obesus* and *Microtermes unicolor* (Nazir et al., 2016). These two species were also reported from houses infested with termites in different areas of Punjab (Manzoor & Mir, 2010).

Abundance of termites

The data regarding the number of individuals of termite's species collected in different sampling period was evaluated to calculate the relative abundance of various termite species. From the data presented in Fig. 4, it was noted that minimum percentage abundance (13.39%) was recorded due to low temperature in 1st sampling period (September, 2021 - November, 2021). While maximum abundance (45.6%) of termites was recorded in summer season (June - August) due to higher percentage of relative humidity and maximum atmospheric temperature. These two factors are necessary for termite's survival, growth and development.

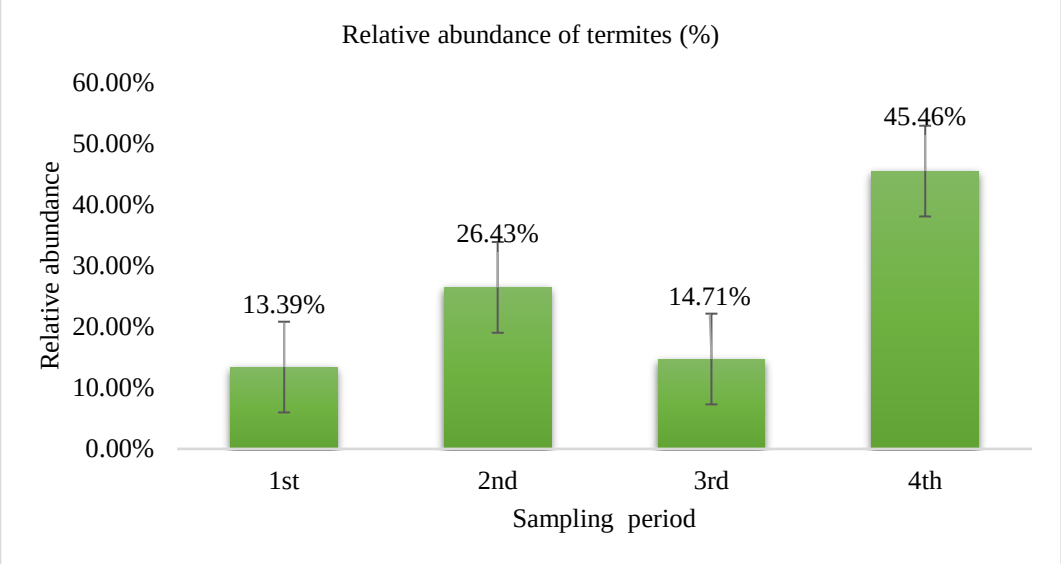

Fig. 4 Relative abundance of termites (%) in different sampling period

It was noted that the temperature was low in first and second sample collection period respectively with minimum rainfall. These two periods were characterized by dry climatic conditions. In the 4th sampling period, nuptial flights of winged alates of termites were observed because this was the breeding season of termites. Therefore, maximum number of termites was collected in this season. The atmospheric temperature and relative humidity were also high, due to heavy rainfall in monsoon season. This was in accordance with the findings of Fatima et al. (2020) that reported the maximum activity of termites in summer season. From the data presented in Table 3, it has been noted that maximum number of individuals of *Coptotermes heimi* were reported during September, 2021 to November, 2021 with percentage abundance of 73.68%. On the other hand, *Odontotermes horai* was more dominant species (61.5%) reported during December to August.

In order to compare the abundance (%) of termites collected from different sites from June - August, data was presented in Fig. 5. In case of the termite diversity from the soil, out of 5160 collected samples of termites, 1000 (19.38%) were collected from the soil while 2110 (41.89%) individuals were collected from infested trees. The least number of individuals 530 (10%) were collected from the houses and 1520 (29.46%) individuals were collected from animal fecal material.

Diversity indices of termites

The results on the diversity of termites from different areas of Rawalpindi and Islamabad, shown in Table 4 indicated that a total of 11,350 individuals of termites were collected from Rawalpindi and Islamabad during the sampling period. Simpson and Shannon diversity indices reflected that maximum value of diversity was observed from March to May. In 3rd sampling period, overall diversity (1-D = 0.497) was 49.70% on Simpson index and on Shannon scale, it was 69.01% (Table 4). The lowest value

for *Odontotermes obesus* was recorded in 1st sampling period (September - November) with 0.0693 (Simpson index) and 0.3513 (Shannon index). The value of diversity index observed during December to February for termites was D (Dominance index) = 0.5200; 1-D (Simpson diversity index) = 0.4800 on Simpson scale and H (Shannon diversity index) = 0.6730 on Shannon scale. From March to May, similar trend was observed for termites diversity with D = 0.5030; 1-D = 0.4970 and H = 0.6901 values for diversity indices. During 4th sampling period, *C. heimi* and *O. horai* were prevalent with D = 0.5244; 1-D = 0.4756 and H = 0.6685 according to Simpson and Shannon diversity indices. Results have shown that the lowest value for species diversity was observed from September to November whose value was 38.78% according to Simpson index and 57.63% on Shannon index. In order to compare the evenness of the individuals among species collected during different sampling period, maximum value of equitability (0.9956) was reported from March to May that means number of individuals of both reported species were nearly same. The minimum value of equitability of 0.8315 was recorded during September to November according to Table 4.

Table 3 Relative abundance of individuals of each termites species

Sampling period	Species	No. of individuals	Relative Abundance (RA)	P_i
September, 2021 to November, 2021	*Coptotermes heimi*	1120	73.68	0.7368
	Odontotermes horai	400	26.32	0.2632
		1520	100	1
December, 2021 to February, 2022	*Coptotermes heimi*	1200	40.00	0.4000
	Odontotermes horai	1800	60.00	0.6000
		3000	100	1
March, 2022 to May,2022	*Coptotermes heimi*	770	46.11	0.4611
	Odontotermes horai	900	53.89	0.5389
		1670	100	1
June, 2022 to August, 2022	*Coptotermes heimi*	2010	38.95	0.3895
	Odontotermes horai	3150	61.05	0.6105
		5160	100	

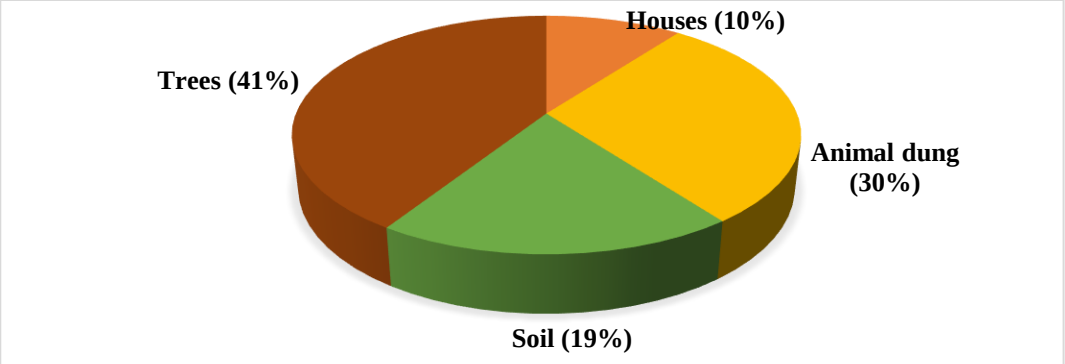

Fig. 5 Occurrence (%) of termites at various collection sites (June - August)

Table 4 Diversity indices of each termite species in different sampling period

Sampling period	Name of species	No. of individuals (n)	Simpson index $D = \sum Pi^2$	Shannon index $H = -\sum Pi ln(Pi)$	Equitability
1st	*Coptotermes heimi*	1120	0.5429	- 0.2250	0.8315
	Odontotermes horai	400	0.0693	- 0.3513	
		1520	D=0.6122; 1-D=0.3878	H = 0.5763	
2nd	*Coptotermes heimi*	1200	0.1600	-0.3665	0.971
	Odontotermes horai	1800	0.3600	-0.3065	

		3000	D=0.5200; 1-D=0.4800	H = 0.6730	
3rd	*Coptotermes heimi*	770	0.2126	-0.3570	0.9956
	Odontotermes horai	900	0.2904	-0.3332	
		1670	D= 0.5030; 1-D=0.4970	H = 0.6901	
4th	*Coptotermes heimi*	2010	0.1517	-0.3673	0.9645
	Odontotermes horai	3150	0.3727	0.3012	
		5160	D=0.5244; 1-D=0.4756	H = 0.6685	

The data regarding the overall diversity of different termite species was given in Table 5. The overall diversity of termites from Rawalpindi and Islamabad was recorded 49.49% on Simpson diversity index. But on Shannon scale a value of 68.80% was observed. In terms of evenness among individuals of species, a value of 0.9926 was obtained for Shannon equitability factor. Relative abundance of different termite species revealed that *Odontotermes horai* (55.07%) was more abundant termite species in the current study area, followed by *Coptotermes heimi* (44.93%).

Table 5 Overall diversity index of termites species collected from Rawalpindi and Islamabad (September, 2021 - August, 2022)

Species	No. of individuals (n)	Percentage (%)	Simpson index $D = \sum Pi^2$	Shannon index $H=-\sum Pi ln(Pi)$	Equitability
Coptotermes heimi	5100	44.93	0.2019	-0.3595	0.9926
Odontotermes horai	6250	55.07	0.3032	-0.3285	
Total	11350	100	D= 0.5051; 1-D=0.4949	H = 0.6880	

Discussion

Termites are edaphic fauna of isopteran insects that are placed in Blattodea order of phylum Arthopoda. Caste system is present in termites colony and show division of labour among the members (workers, soldiers and reproductives) of their colony. General characteristics of termites include straight antennae, equal length of front and rear wings that are longer than the body, straight waist between the thorax and have blunt end abdomen. The workers and soldiers have beige or tan colored and alates have brown colored bodies. They feed on dead and decayed wood, soil rich in humus, the plant waste product and cellulosic material. They are the dominant group of invertebrate decomposers and play a major role in nutrient recycling but are also of momentous menace to timber-in-service in Pakistan. They are one of the major structural pests and pose a serious economic burden due to damages caused by them. In urban areas and agricultural fields of Pakistan, *Coptotermes heimi* has been reported for its pest activity (Manzoor & Mir, 2010; Manzoor et al., 2011). In various areas of Peshawar and Nowshera, the crop of sugarcane was reported devasted by termites (Salihah et al., 1988). Sattar and Saliha (2001) also reported that termites attack on wheat, sugarcane and maize crop. By taking into consideration the damages caused by them, this research study was planned. As it is important to determine which termite specie is present to design the most effective plan of action for their management and control.

Termites samples were collected to find out the diversity and relative abundance in Rawalpindi and Islamabad. Results showed that two species of termites *Odontotermes horai* (Family Termitidae) and *Coptotermes heimi* (Family Rhinotermitidae) were reported from the study area. Both species were also reported in taxila along with *Odontotermes obesus* and *Microtermes unicolor* (Nazir et al., 2016). Taxila is the tehsil of district Rawalpindi, due to same climatic condition the reported species were also present there. Azam et al. (2015) have explored six termite species (*Coptotermes heimi*, *Microcerotermes championi*, *Odontotermes obesus*, *Microtermes obesi*, *Microtermes mycophagus* and *Odontotermes guptai*) foraging in houses and different portions of garden trees of Gujranwala district. Similarly thirteen species including *Coptotermes heimi* amd *Odontotermes horai were* reported from houses infested with termites in different localities of Punjab (Manzoor &

Mir, 2010). *Coptotermes heimi* were also reported along with sixteen other species of termites in Mianwali (Nasir, 2006).

Results obtained regarding the relative abundance of termites samples collected round the year indicated that maximum number of termites was collected in the summer season (June - August) because ground and atmospheric temperature is suitable for termites foraging activities. During the monsoon season, rainfall makes soil moist and the higher atmospheric temperature making the favourable conditions for termites survival. On the other hand, during the 2nd sampling period, less number of termite species were collected as the temperature was low. Termites remain active during the whole year even during winter. However, low temperature brings changes in the daily routines as subterranean termites moves deeper into the ground to gain the warmth they need to survive. The termites do not swarm in low temperature and in winter season there is a less chance that they are making new colonies. Instead of that, they prefer to live in the colony in which they already exist. In the spring and summer season, most species of subterranean termites show swarming behaviour and create new colonies. Therefore, maximum amount of termites were collected in this sampling period.

There exist a relation between temperature and average rainfall with species richness of termite species and their foraging activities (Jones & Eggleton, 2000). The atmospheric temperature is negatively related with abundance of termite species while humidity is positively related with abundance of termites (Sattar & Saliha, 2001). Temperature and humidity play a vital role in swarming and colony formation so maximum termite activity was observed during July to September when both temperature and humidity were high. Puche & Su (2001) observed that tunnelling activity dependent upon the moisture content. In addition to moisture, decayed wood is also a major attractant. Temperature plays a key role in the foraging activity of termites and daily fluctuations in temperature affect the termite activity. A research was conducted on the study of foraging behavior of *Coptotermes heimi* by using Mark-Release-Recapture method. It was observed that there exist a positive but non-significant correlation between soil temperature and relative humidity and the total population of *C. heimi*. On the other hand, negative and non-significant correlation exists between atmospheric temperature and total population of termites (Manzoor et al., 2013). Seasonal fluctuations affect the termites population and its activity. Similar observations were made by Haverty et al. (1999).

During the 4th sampling period, when the maximum samples of termites were collected, the abundance (%) of termites was compared at various collection sites. Maximum termite individuals were collected from trees (41.89%). Collection was done in accordance with Trees > Animal dung > Soil > Houses. The highest infested tree species observed were *Acacia nilotica* and *Ziziphus maurtitius* followed by *Acacia modesta*, *Melia azedarach* and *Dalbergia sissoo*. In taxila, Rawalpindi, *Dalbergia sissoo* was the most dominant specie reported infested with termites. Mostly the wooden trash, bark and dead part of trunk were found to be infested with termites (Nazir et al., 2016). Different types of habitat were inhabited by termites. Mostly the bark and dead part of trunk and the wooden trash was found to be infested with termites. *Coptotermes heimi* was the significant specie inhabited the tree and soil habitat (Manzoor & Mir, 2010). It was also observed that different termite's species preferred to inhabit different trees.

Coptotermes heimi and *Odontotermes horai* preferred to dwell the bark and trunk of *Dalbergia sissoo, Ziziphus mauritius* and *Acacia nilotica*. *C. heimi* species made its dwellings on the bark and wooden debris of *Dalbergia sissoo*. These termite habitats were also reported by Azam et al. (2015) who also reported that *O. guptai* made nest in the bark and on the trunk of *Magnifera indica* while *O. obesus* inhabited the trunks and the fallen twigs of *Dalbergia sissoo*. *Coptotermes heimi*, *Eremotermes paradoxalis*, *Heterotermes indicola*, *Odontotermes guptai*, *Odontotermes gurdasurensis*, *Odontotermes horai*, *Odontotermes obesus*, *Microtermes obesi* and *Microtermes mycophagus* were identified during a survey of termites infested houses. These species are responsible for the damage and destruction to wooden structures and buildings with around 34.32% damage was detected on door frames, 33.13% to window frames, 15.97% to timber frame, 10.05% to wall stud, 4.73% to walls and 20.71% damage was detected outside the houses by tree stumps etc. (Manzoor & Mir, 2010). This is due to lack of resources and the unawareness of community about termites. It was also observed that termites mostly favoured damp soil for its maturation as compared to dry soil. It was also reported by Nazir et al. (2016). Although many species of termites make their nests or colonies underground (subterranean termites), there are some that build their colonies in the trees, within the walls or sides of buildings. These termites don't require their connection with soil for moisture. They fulfil their moisture requirement needed, from the wood they infest. They are called drywood termites. Termites are soft shelled insects, that absorbs the moisture necessary for their existence through their exoskeleton. It doesn't means that they depend on damp wood or soil. They may be found on dry walls and soil but favor damp environments either soil or wood.

A total of 11,350 termite individuals were collected from September, 2021 to August, 2022. Simpson and Shannon diversity indices were used to calculate the diversity of termites. From June to August, *Odontotermes horai* was more dominant than *Coptotermes heimi***.** It was also observed that *Odontotermes horai* was predominant in May, June and July. Similar results were reported by Manzoor & Mir (2010). Overall diversity of termites calculated from Simpson index and Shannon diversity index was 49.49% and 68.80% respectively. Six species of termites (*Microtermes unicolor*, *Eramotermes paradoxalis*, *Microtermes mycophagus*, *Psammotermesrajasthanicus*, *Odontotermes obesus* and *Coptotermes heimi*) were reported from Bahawalpur district in a survey conducted on subterranean termite fauna and its population diversity. The overall values for diversity were recorded 68% and 66% on Simpson dominance index and Shannon-Weiner function, respectively. Maximum termites diversity was observed in August due to heavy rains of moonsoon season (Ali et al., 2013b). Data regarding the

relative abundance of both termite species showed that *Odontotermes horai* with 55.07% was more abundant termite species as compared to *Coptotermes heimi* with 44.93%. These findings were in accordance with the research done in taxila, Rawalpindi where the relative abundance of termite species indicated that *Odontotermes horai* is the most prevalent reported species in Taxila with 45.88% value of percentage abundance (Nazir et al., 2016).

This study will provide us the knowledge regarding the diversity of termites in Rawalpindi and Islamabad. It provides us knowledge about the abundance of termites round the year which may give better idea regarding its management. Based on gathered information on the diversity and relative abundance of termites in Rawalpindi and Islamabad, the present findings will be evaluated for comparison with other ecological regions of Pakistan. This research is helpful for management of termites in urban ecosystem. Further studies should also be conducted in Islamabad and Rawalpindi on morphometric analysis and the distribution pattern of termites. In future, a comparative analysis on relative abundance and diversity of termite species should be done on other species reported there. A detailed study will also be conducted to investigate the basic biology of termites of Pakistan with respect to varying climatic conditions in future.

Conclusion

In the present study, two species of termites i.e., *Odontotermes horai* and *Coptotermes heimi* were reported. Among them, the *Odontototermes horai* was common termite species in the Rawalpindi and Islamabad. It was distributed widely at various sites such as animal dung, trees, soil and in the houses. It is helpful for the identification of pest species responsible for losses in the agricultural fields, forest plantation and to the wooden infrastructure to a great extent. This type of research on termites survey and identification may be done on other areas of Pakistan to cover untouched areas of countries. Identification of species is helpful in planning and designing most effective control methods and strategies. In future, it is recommended that identification may be done on the basis of molecular aspects along with morphological characteristics.

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