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Comparative Study of Resistance and Feeding Preference of 24 Wood Species to Attack by *Heterotermes indicola* (Wasmann) and *Coptotermes heimi* (Isoptera: Rhinotermitidae) in Pakistan

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Abstract

The present study was conducted to evaluate the laboratory and field preference of 24 Pakistani wood species by termite species *Heterotermes indicola* and *Coptotermes heimi.* The wood species evaluated, regarding attack and damage were: *Azadirachta indica* (Neem)*, Pinus roxberghii* (Chir)*, Dalbergia sissoo* (Sheesham)*, Populus deltoides* (Popular)*, Albizzia lebbeck* (Shirin)*, Abies pindrow*(fir)*, Alstonia scholaris* (Alstonia)*, Erythrina suberosa* (Gul-e-nister)*, Eucalyptus citriodora* (safaeda)*, Ficus religiosa* (Bohar)*, Heterophragma adenophyllum* (Beeri Patta)*, Melia azedarach* (Derek)*, Pinus wallichiana* (Chir)*, Terminalia arjuna* (Arjun)*, Acacia Arabica* (Kikar), *Betula utilis* (Birch) *Cedrus deodara* (Deodar)*, Cordia oblique* (Lasura), *Mangifera indica* (Aam)*,Ehretia serrata Moringa oleifera* (sohanjana)*, Putranjiva roxburghii* (Lucky bean)*, Syzygium cumini* (Jaman)and *Zizyphus jujube* (Berry). Two weeks laboratory and four weeks field feeding trials were performed as described in standards of the American Wood Protection Association. Samples of each of the 24 wood species were individually exposed to 100 termites (10% soldiers); and termite mortality, wood mass loss and visual appearance of the samples (on a scale of 0-10) were recorded. Results indicated that by no choice feeding assay, *Populus deltoides* was the most preferred and *Dalbergia sissoo* was the least preferred among the 24 wood species tested in laboratory against *Heterotermes indicola* and *Coptotermes heimi*. Field studies by no choice feeding test against mixed termites and *C. heimi* indicated *D. sissoo* the least palatable and *Mangifera indica* the most palatable wood. So it is recommended that though all 24 species evaluated in the present study differ in their susceptibility to termite attack, they would require additional protection to avoid termite attack.

Introduction

Termites are the major constituents of the forest ecosystem in the tropical and subtropical areas and they are well known for their capacity to damage and destroy wood and wood products of all kinds (Rashmi & Sundararaj, 2013). The interaction of soil type and moisture availability influences the distribution of foraging termites in microhabitats (Mary & Weste, 2010). A lot of research has been done on wood resistance against termites by using various timbers but very little on bamboos (Nirmala & Kenneth, 2011).

In Pakistan, the most common termite species causing damage to wood and wooden structures are *Coptotermes heimi* (Wasmann) and *Heteroterme indicola* (Wasmann) and *Microtermes obesi* (Holmgren) and *Odontotermes obesus* (Rambur) *Heterotermes indicola* has become major structural pest of wood and wooden structures inside houses in Pakistan and has been ranked as the most destructive termite species of the Lahore. It not only destroys wood but has been found damaging paper, clothes and any cellulosic material (Manzoor, 2010) *Coptotermes heimi* (Wasmann) is a widely distributed termite in Pakistan and causes damaging effects in standing trees (Khalid & Hina, 2014). Termites

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are often regarded as decomposers of lignocellulosic waste (Lenz, M. et al., 2011; Shaomei *et al.,* 2013). The ability of termites to degrade lignocellulose gives them an important place in the carbon cycle (Brune, 2014). Inside houses,the infestation of *H. indicola* is judged by galleries running on walls and ceilings. During survey of houses, it was also observed that it only eats softer part of wood and after attacking wood it always has connection with ground soil (its breeding place). Its tunnels can be observed as hanging food tunnels made of mud tubes (Manzoor, 2010).

Many wood species in Pakistan are utilized as food by termites and certain wood species are preferred by others. A study by Sheikh et al. (2010) showed that workers of *O. obesus* prefer *Fagus sp.* (beech) and *Pinus wallichiana* (kail) more whereas they least prefer *Abies pindrow* (pertal) and *Cedrus deodara* (diar). The importance of termite resistant (durable) timbers is environment friendly and cheap source to protect timber-in-service from attack and damage in Pakistan. Termite attack is related to the presence of resistant components which are not equally distributed to all part of plant. The occurrence of organic chemicals such as phenol, quinones, terpenoids and high concentration of lignin may also affect the areas where feeding takes place (Ayesha & Sumbal, 2012). Heartwood and sapwood contains maximum concentration of components and top of stem contains minimum (Henderson et al. 2001). Sometimes the presence of essential oils also protects plants from termite attack. Elahe et al. (2014) in their study found that *Eucalyptus* essential oil may be an effective toxicant with suitable contact and digestive toxicity on *Microcerotermes diversus*. Some of the tropical forest plantation species having natural resistance to termites may offer an alternative for the use of chemicals products (Peralta et al., 2004). Factors affecting wood consumption by termites are numerous and complexly related (Peralta et al., 2004). Most important factors are wood species, hardness, presence of toxic substances, feeding inhibitors or deterrents, presence or absence of fungi, degree of fungal decay, moisture content of wood and soil (Carter & Smythe, 1974; Nagnan and Clement, 1990). Qureshi et al. (2012) found in their study that the death of the termites is due to the mortality of their protozoan population during the period of experimentation which appears to be due to the toxic effect of corresponding wood and not because of non-feeding of the woods. It was also studied by Morales-Ramos and Rojas (2001) that different wood combinations offered to termites in laboratory trials are important in Choice feeding tests.

Keeping in view the significance of the above mentioned studies, the purpose of present study was to test the feeding preference of different wood species against two subterranean termite species in laboratory and field. The current study will also be effective in preliminary screening of naturally resistant timber species for chemical analysis in order to isolate the termite resistance components for commercial use as wood preservative and to determine which commercial species will require preservative treatment before use in regions with high termite hazard.

Materials and Methods

Laboratory bioassays

Termite source: Orphaned termite workers and third instar larvae of workers and soldiers were collected using bucket traps. The traps were brought to the laboratory, all the debris was removed and termites were kept in plastic boxes with moist filter paper. Before exposure to different wood species, termites were kept in the laboratory at (26 ± 2^{o}C, 80% R.H) to eliminate injured and inactive termites and kept in constant darkness. Only active and healthy termite workers were used for the experiments. Termites were kept in Petri-plates (90mm×15mm) containing moist filter papers until the experiments were conducted. Termite species *H. indicola* and *C. heimi* were tested for feeding preference using No-Choice feeding test in laboratory and in field conditions. All bioassay termites were collected from three colonies i.e. LCWU, Jallo park and Changamanga.

Test wood specimens: 24 important collected timber species (that were not decomposed and were dried naturally) were: *Azadirachta indica* (Neem), *Pinus roxberghii* (Chir), *Dalbergia sissoo* (Sheesham), *Populus deltoides* (Popular), *Albizzia lebbeck* (Shirin), *Abies pindrow* (fir), *Alstonia scholaris* (Alstonia), *Erythrina suberosa* (Gul- e- nister), *Eucalyptus citriodora* (safaeda), *Ficus religiosa* (Bohar), *Heterophragma adenophyllum* (Beeri Patta), *Melia azedarach* (Derek), *Pinus wallichiana* (Chir), *Terminalia arjuna* (Arjun), *Acacia Arabica* (Kikar), *Betula utilis* (Birch) *Cedrus deodara* (Deodar), *Cordia oblique* (Lasura), *Elaeis guineensis* (african palm oil), *Mangifera indica* (Aam), *Moringa oleifera* (sohanjana), *Putranjiva roxburghii* (Lucky bean), *Syzygium cumini* (Jaman) and *Zizyphus jujube* (Berry), most of these were commonly used in wood work in Pakistan. All Pakistani woods used in this study were from Heartwood.

Laboratory Preference Test

No choice laboratory tests were executed to study wood preference of two termite species *H. indicola* and *C. heimi* in the laboratory. Wooden blocks (20 x 20 x 20 mm) of each wood species were prepared, cleaned and pre weighed. Wooden blocks were dried at 100°C for 24 hours. Only one type of test or wooden block was placed in a glass Petri dish and 100 termite workers (with 10% soldiers, as naturally given in colonies) were released and kept in darkness at 26°C and 60 + 5% relative humidity for 14 days in controlled chamber. Filter paper treated with distilled water was used as control. The wooden blocks were kept suitably moist. Three replicates of wooden blocks were used for each wood. After test period the wooden blocks were recovered, dried at the same temperature at which they were dried before exposure to termite workers and the amount of wood consumed was calculated by weighing.

Field Wood Preference Test against H. indicola (Wasmann) and C. heimi (Wasmann)

The field trials were conducted at sites heavily infested with termites as evidenced from previous studies and where many active nests of *H. indicola, M. obesi*, *Odontotermes obesi* and *C. heimi* were located at the workshop area of Lahore College Women University, Lahore and Jallo Forest Park, Lahore.

Three replicates of each wood were prepared and wooden blocks were tied by copper wire into a bundle. Each bundle was buried at each site, 15-20 cm deep into the soil (so that they may reach the nest) for a period of one month. Each replicate was set 2 m apart from each other. At the end of experiment, wood samples were brought back to laboratory, cleaned, oven dried and weighed to determine the amount consumed.

Upon termination of experiment, wood samples were brought back to laboratory, cleaned, oven dried and weighed to determine the amount of wood consumed. Other recorded parameters were total termite-contact, which was based on either one of the three criteria: termite feeding, deposited faecal material or mud gallery built on the wood.

In both laboratory and field trials, tested wood specimens was assessed according to the Standard Method for laboratory evaluation to determine resistance to Subterranean Termites (AWPA,1997). Visual rating of the test blocks using the scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure).

Data analyses

Data in mass loss (g) were subjected to Mean, Standard Error and Analysis of variance, and difference in mass loss for each pair of wooden block was calculated by paired comparison t-test. Means were separated using Tukey's HSD test.

Results and Discussion

Results of the no-choice laboratory evaluations of the resistance and feeding preference of 24 wood species to the subterranean termites *H. indicola* and *C. heimi* are shown in Table 1. Interpreting the objectives of the AWPA (1997) termite test relative to the present study, in No Choice feeding bioassays, the wooden blocks of *D. sissoo*, *P. wallichiana, E. deodara, P. roxberghii, C. deodara, A. indica, A. arabica* and *C. oblique* scored 10 for the mean visual rating, indicating that these woods are sound and very resistant (VR) to termite attack with only surface nibbles were permitted. *Pinus roxburghii*, *T. arjuna, A. scholaris, A. pindrow, M. azedarach,* scored 9 for the mean visual rating, showing light attack and the woods were identified as Resistant (R)*, A. lebbeck, Z. jujube, M. oleifera* scored **7** for the mean visual rating, indicating moderate attacks and were identified as Moderate resistant (MR). *F. religiosa, B. utilis, E. suberosa, P. deltoides* and *M. indica* scored 4 for the mean visual rating, indicating susceptible (S) to termite attack (Table 1). In control, no termite mortality was recorded and tunnelling pattern was observed for both species. Inside petri dish, tunnels of *H. indicola* were thin and were highly branched while tunnels of *C. heimi* were wider and less branched. *H. indicola* makes tunnel to top but *C. heimi* makes few tunnels to top.

For *H. indicola,* the woods were arranged in the following descending order of preference: *Populus deltoides* > *Mangifera indica* > *Betula utilis* > *Erythrina suberosa* > *Moringa oleifera* > *Eucalyptus citriodora* > *Syzygium cumini* > *Elaeis guineensis* > *Ficus religiosa* > *Zizyphus jujube* > *Abies pindrow* > *Melia azerdarach* > *Heterophragma adenophyllum* > *Terminalia arjuna* > *Putranjiva roxburghii* > *Acacia arabica* > *Cordia obliqua* > *Pinus wallichian* > *Albizia lebbeck* > *Alstonia scholaris* > *Cedrus deodara* > *Pinus roxburghii* > *Azadirachta indica* > *Dalbergia sissoo.* While for No Choice feeding test against *C. heimi,* in laboratory woods were arranged in the following descending order of preference: *Populus deltoides* > *Mangifera indica* > *Erythrina suberosa* > *Betula utilis* > *Elaeis guineensis* > *Ficus religiosa* > *Heterophragma adenophyllum* > *Terminalia arjuna* > *Moringa oleifera* > *Putranjiva roxburghii* > *Syzygium cumini* > *Zizyphus jujube* > *Melia azerdarach* > *Abies pindrow* > *Acacia Arabica* > *Eucalyptus citriodora* > *Azadirachta indica* > *Alstonia scholaris* > *Cordia obliqua* > *Albizia lebbeck* > *Pinus roxburghii* > *Cedrus deodara* > *Pinus wallichian* > *Dalbergia sissoo.* Mcmahan (1966) studied wood feeding preference of different woods and observed that poplar and maple both ranked as "more preferred" woods, with maple being perhaps slightly above poplar, yet incipient colonies reared on poplar strongly preferred it over maple.

Results of No Choice feeding bioassay in the field for *C. heimi* confined to wooden blocks of different species of wood, the wooden blocks of the wooden blocks of *D. sissoo*, *P. wallichiana, E. deodara, Pu. Roxberghii, C. deodara, A. arabica* and *C. oblique* scored **10** for the mean visual rating, indicating that woods were sound and very resistant (VR) to termite attack with only surface nibbles were permitted. *P. roxberghii*, *T. arjuna, A. scholaris, A.pindrow, M.azedarach,* scored nine for the mean visual rating showing light attack and were identified as Resistant (R)*, A. lebbeck, Z. jujube, M. oleifera* scored 7 for the mean visual rating, indicating moderate attacks and were identified as Moderate resistant (MR). *F. religiosa, B. utilis, E. suberosa, P. deltoides* and *M. indica* scored 4 for the mean visual rating, indicating susceptible (S) to termite attack (Table 2). So, it was observed that inside laboratory and in field studies the termites species *C. heimi* had the same mean visual rating. Regarding mean wood mass loss, the lowest mean wood mass loss was for *D. sisso* which was the least preferred while *P. deltoides* was the most preferred wood by the species *C. heimi* (Wasmann).

The results of no choice field feeding test against *H. indicola* indicating that damage to wooden blocks was noted at the end of the four-week test. The loss in weight of wooden

Table 1. Mean Visual Rating, Mean Wood Mass loss and mean percentage mortality of different wood species during (No Choice feeding) bioassay against *H. indicola* (Wasmann) and *C. heimi* (Wasmann) workers exposed under laboratory conditions.

Serial No.	Wood species	Mean Visual Rating*	*H.indicola*		*C.heimi*		
			Mean Wood Mass loss (g)	Mean % Mortality	Mean visual rating	Mean Wood Mass loss (g)	Mean % Mortality
1	*Populus deltoides* (P.D)	4(S)	0.42±0.00057	18.3±0.0057	4(S)	0.48±0.006	11.66±0.577
2	*Azadirachta indica* (A.I)	10(VR)	0.0213±0.0005	55.0±0.0057	9(R)	0.078±0.006	47.49±0.577
3	*Pinus roxberghii* (Pi.R)	9(R)	0.023±0.00057	57.0±0.0005	10(VR)	0.060±0.006	57.3±0.577
4	*Dalbergia sissoo* (D.S)	10(VR)	0.019±0.00057	44.0±0.00057	10 (VR)	0.04±0.006	67.5±0.577
5	*Heterophragma adenophyllum* (H.A)	7(MR)	0.059±0.00057	29.9±0.5774	7 (MR)	0.17±0.006	26.9±0.577
6	*Ficus religiosa* (F.R)	4(S)	0.069±0.00057	29.4±0.5774	4(S)	0.23±0.006	16.88±0.577
7	*Terminalia arjuna* (T.A)	9(R)	0.055±0.00057	34.7±0.5774	7(MR)	0.15±0.006	21.77±0.577
8	*Albizia lebbeck* (A.L)	7(MR)	0.040±0.00057	27.7±0.5774	9(R)	0.065±0.006	39.7±0.577
9	*Pinus wallichiana* (P.W)	10(VR)	0.040±0.00057	29.6±0.5774	10(VR)	0.050±0.006	57.5±0.577
10	*Alstonia scholaris* (A.S)	9(R)	0.039±0.00057	29.1±0.5774	9(R)	0.074±0.006	41.50±0.577
11	*Erythrina suberosa* (E.S)	4(S)	0.037±0.00057	27.9±0.5774	4(S)	0.32±0.006	14.58±0.577
12	*Eucalyptus citriodora* (E.C)	10(VR)	0.082±0.00057	47.0±0.5774	7(MR)	0.083±0.006	40.55±0.577
13	*Abies pindrow* (A.P)	9(R)	0.071±0.00057	32.3±0.5774	9(R)	0.09±0.006	40.4±0.577
14	*Melia azedarach* (M.A)	9(R)	0.062±0.05774	47.2±0.5774	9(R)	0.10±0.006	38.9±0.577
15	*Putranjiva roxburghii* (P.R)	10(VR)	0.045±0.020	44.44±0.5774	7(MR)	0.13±0.006	56.8±0.577
16	*Cedrus deodara* (C.D)	10(VR)	0.048±0.024	38.44±0.5774	10(VR)	0.053±0.006	73.88±0.577
17	*Acacia Arabica* (A.A)	10(VR)	0.050±0.017	33.55±0.5774	9(R)	0.087±0.026	38.8±0.577
18	*Cordia oblique* (C.O)	10(VR)	0.053±0.023	33.32±0.5774	9(R)	0.070±0.026	43.7±0.577
19	*Syzygium cumini* (S.C)	4(S)	0.076±0.023	32.88±0.5774	7(MR)	0.12±0.043	26.9±0.577
20	*Zizyphus jujube* (Z.J)	7(MR)	0.072±0.028	32.44±0.5774	7(MR)	0.11±0.037	37.8±0.577
21	*Betula utilis* (B.U)	4(S)	0.070±0.023	28.55±0.5774	7(MR)	0.28±0.029	30.7±0.577
22	*Ehretia serrata* (E.S)	4(S)	0.074±0.032	27.77±0.5774	4(S)	0.24±0.043	24.6±0.577
23	*Moringa oleifera* (M.O)	7(MR)	0.086±0.032	29.33±0.5774	7(MR)	0.14±0.0.20	24.21±0.577
24	*Mangifera indica* (M.I)	4(S)	0.30±0.028	29.88±0.5774	4(S)	0.34±0.046	16.36±0.577
25	Control		0.45±0.070	0.00		0.16±0.075	0.00

Results expressed as mean±S.E (standard error).

*Visual rating according to AWPA scale 1997 of 10(sound, surface nibbles permitted), nine (light attack), seven (moderate attack), four (heavy attack), or zero (failure). Difference in mass loss for each pair of wooden block indicated by *=0.05 and **=0.01 are significantly different (paired comparison t-test).

blocks served as a measure of termite attack. Each block was then graded by the amount of termite damage by using an AWPA scale (1997). Analysis of variance also revealed mean difference were significantly different from one another (F, 7.859; d.f. 3:8:11; P<0.001).

Regarding the mean wood mass, results also indicate that the highest mean mass loss was for *H. indicola* was for *P. deltoides* (0.42±0.0005) and lowest mean mass loss was for *D. sissoo* (0.019±0.00057). Similarly, the mean wood mass, results also indicate that the highest mean mass loss was for C. *heimi* was for *P. deltoides* (0.48±0.006) and lowest mean mass loss was for *D. sissoo* (0.04±0.006). The results indicated that the wood of *D. sissoo* was the least preferred and *M. indica* was the most preferred wood used for *C. heimi*. Analysis of variance also revealed that means difference were significantly different from one another (F, 7.617; d.f., 3:8, P<0.001).

Regarding feeding preferences of *H.indicola* and *C. heimi*, the basic purpose was to know which species of local timbers possesses natural resistance against termites and which timber species are palatable. Various researchers in Pakistan had studied the feeding preference of *C. heimi, O.obesus* and *B.beesoni* (Akhtar & Jabeen, 1981). Akhtar and Ali (1979) studied feeding preference of *O. obesus* and arranged the woods in the following descending order of preference: *Populus eur-americana* (S.W), *Abies pindrow* (H.W), *Acacia arabica* (H.W), *Cedrus deodara* (H.W), *Mangifera indica, Morus alba* (H.W), *Pinus roxburghii* (H.W) and *Dalbergia sissoo* (H.W). However, no comprehensive data on the feeding preferences of different wood species was available. Mcmahan (1966) studied wood feeding preference of different woods and observed that poplar and maple both ranked as "more preferred" woods, with maple being perhaps slightly above poplar, yet incipient colonies reared on poplar strongly preferred it over maple.

The present study was carried out to compare the feeding preference of two important species of termites. Regarding mean percentage mortality in laboratory trials, the highest mean percentage mortality (57.0±0.0005) for *H.indicola* was for the wood *Pinus roxberghii* and lowest mean percentage (0.045± 0.020) mortality was for *Putranjiva roxburghii*. For *C.heimi*, the mean percentage mortality in laboratory trials was highest for *Cedrus deodara* (73.88± 0.577) and lowest mean percentage (11.66±0.577) mortality was for *Populus deltoids* (Table 1).

According to the results of field no choice feeding test for *C.heimi,* it was revealed from results that wood of *Dalbergia sissoo*, *Azadirachta indica, Eucalyptus citriodora, Pinus wallichiana, Acacia arabica* were very resistant (VR) and had 10 mean visual rating showing only nibbles of termite attack, the wood of *Pinus roxberghi, A. pindrow, Ficus religiosa, Alstonia scholaris, Melia azerdarach,* and *Terminalia arjuna* were resistant (R), to termite attack showing minimum wood mass loss and no significant portion of wood was eaten by *C. heimi*. The woods of *Albizia lebbeck*, *H. adenophyllum, M. olifera* and *Z. cumini*were moderately resistant (MR) indicating that some portion of wood is eaten by them. *Populus deltoids, Erythrina suberosa, Betula utilis* and *Mangifera indica* were susceptible (S) to termite attack and some portion of wood was significantly eaten by *C. heimi* (Table 2). So 24 tested woods were arranged in following descending order of preferences: *Populus deltoides* > *Mangifera indica* > *Moringa oleifera* > *Elaeis guineensis* > *Erythrina suberosa* > *Syzygium cumini* > *Heterophragma adenophyllum* > *Cordia oblique* > *Ficusreligiosa* > *Pinus roxburghii* > *Alstonia scholaris* > *Terminalia arjuna* > *Albizia lebbeck* > *Pinus wallichiana* > *Melia azerdarach* >*Betula utilis* > *Abies pindrow* > *Zizyphus jujube* > *Eucalyptus citriodora* > *Putranjiva roxburghii* > *Acacia arabica* > *Azadirachta indica* > *Cedrus deodara* > *Dalbergia sissoo*. As far as mean wood mass loss is concerned, the maximum mean wood mass loss (0.40± 0.0152) is for *Populus deltoids* wood and minimus wood mass loss is for *Dalbergia sisso*(0.013±0.0057).

If we compare laboratory and field wood preference for *C.heimi* results are almost similar, under field conditions three woods i.e. *Populus deltoid*s, *Elaeis guineensis* and *Mangifera* are susceptible to termite attack and maximum mean wood mass loss is observed for them.

It is quite obvious that *D. sisso* is having high specific gravity as compared to *Populus* and is hard in nature, one factor may be it is less eaten by both termite species in the laboratory and in field also (Table 3-Appendix). Chaudhry *et al.,* (1978) also studied natural resistance of twelve timbers to the attack of *C. heimi* and found that *Cedrus deodara* and *Tectona grandis* were resistant to termite attack, while *Salmalia malabarica*, *Abies pindrow* and *Picea smithiana* were the most susceptible. Akhtar (1981) reported that *A. pindrow* is resistant to *C. heimi*. In this study, our main question, to know which species of local timber was palatable but which possesses natural resistance against termites, was answered, and there is a need to further investigate the nature of compounds having anti-termitic properties within these woods. Manzoor *et al.* (2009) studied the comparative studies on two Pakistani subterranean termitespecies i.e. *Coptotermes heimi* and *Microcerotermes championi* (Rhinotermitidae, Termitidae) for Natural Resistance and feeding Preferences in Laboratory and field trials and the results of present study are in conformity with the previous ones so there is dire need to develop wood rating scales in Pakistan also. Similarly Rasib and Hina (2014) studied the feeding preferences of *Coptotermes heimi* and the feeding preference of *C. heimi*in descending order based on wood consumption as a quantitative parameter were as follows: *P. euramericana* > *Ailanthus excelsa* > *Azadirachta indica* > *P. roxburghii* > *Butea monosperma* > *Morus alba* > *Bauhinia variegata* > *Albizia lebbeck* > *Dalbergia sissoo* > *Heterophragma adenophyllum* > *Erythrina suberosa* > *Cassia fistula* > *T. grandis* > *Mangifera indica* > *Eucalyptus camaldulensis* > *Jacaranda mimosifolia* > *Bambusa bamboo* > *S. cumini*.

Table 2. Mean Visual Rating and Mean Wood Mass loss of various wood species during No Choice feeding bioassay against *C. heimi* (Wasmann) in the field.

S. No.	Wood Species	Mean Visual Rating	Mean Wood Mass loss (g) (Mean±S.E)
1.	*Dalbergia sisso*	10 (VR)	0.013a±0.0057
2.	*Pinus roxburghii*	9(R)	0.026b±0.0115
3.	*Azadirachta indica*	10 (VR)	0.053c±0.0378
4.	*Populus deltoides*	4 (S)	0.40d±0.0152
5.	*Albizia lebbeck*	7(MR)	0.03±0.00632
6.	*Abies pindrow*	9(R)	0.08±0.00632
7.	*Pinus wallichiana*	10(VR)	0.12±0.00632
8.	*Alstonia scholaris*	9(R)	0.13±0.00632
9.	*Melia azerdarach*	9(R)	0.14±0.00632
10.	*Terminalia arjuna*	9(R)	0.17±0.00632
11.	*Eucalyptus citriodora*	10(VR)	0.18±0.00632
12.	*Heterophragma adenophyllum*	7(MR)	0.20±0.0632
13.	*Ficus religiosa*	4(MR)	0.21±0.00632
14.	*Erythrina suberosa*	4(S)	0.28±0.00632
15.	*Moringa oleifera*	7(MR)	0.19±0.003
16.	*Cedrus deodara*	10(VR)	0.014±0.026
17.	*Cordia oblique*	10(VR)	0.23±0.026
18.	*Acacia Arabica*	109(VR)	0.11±0.033
19.	*Betula utilis*	4(S)	0.16±0.025
20.	*Zizyphus jujube*	7(MR)	0.16±0.026
21.	*Syzygium cumini*	4(S)	0.19±0.069
22.	*Putranjiva roxburghii*	10(VR)	0.28±0.075
23.	*Elaeis guineensis*	4(S)	0.41±0.120
24.	*Mangifera indica*	4(S)	0.42±0.153

Conclusion

The present study was performed to determine the natural wood preferences of two subterranean species of termites *C. heimi* and *H. indicola*. Subterranean termites cause extensive damage to wood and cellulose products in temperate and tropical climates. Some wood species are preferred by termites over other species due to many factors e.g. palatability and digestibility of wood, essential oils and chemicals. Twenty four commonly used woods were tested in laboratory and field by choice and no choice feeding tests. So it was concluded that *Populus deltoids* and *Mangifera indica* were most preferred along with highest mass loss ratio, whereas *Dalbergia sisso* and *Cedrus deodara* were least preferred by the both termite species in laboratory and field tests.

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Appendix. Table showing Density, Strength and uses of different wood species used in the study.

S. No.	Wood species	Density	Strength	Use
1	*Abies pindrow* (A.P)	Specific gravity of 0.48 with a calorific value of 4500 kcal/kg	Light, soft	Construction, fuel, fodder, watershed protection, packing cases, and plywood.
2	*Azadirachta indica* (A.I)	Specific gravity of 0.68 and a calorific value of 4990 kcal/kg.	Heavy, hard, resilient.	Furniture, fodder, wood carving, timber, agriculture implements and tannin.
3	*Pinus roxberghii* (Pi.R)	Specific gravity of 6.48 and a calorific value of 4995 kcal/kg.	Moderately hard, moderately heavy	Construction, and various wood products (furniture, match sticks, window frames, etc.
4	*Dalbergia sissoo* (D.S)	Wood is heavy with a specific gravity of 0.85 and a calorific value of 5000 kca1/kg.	Hard and strong, resilient	Fodder, furniture, fuel and charccal, medicinal (roots and bark), railway carriages, sporting goods, farm implements, and shade.
5	*Heterophragma adenophyllum* (H.A)	Calorific value of 4800 kcal/kg.	Hard, strong resilient	Furniture, fuel, and ornamental
6	*Ficus religiosa* (F.R)	Medium	Soft	Ornamental, fodder, food (figs), small timber, and medicinal.
7	*Terminalia arjuna* (T.A)	Specific gravity of 0.9 and a calorific value of 5000 kcal/kg.	Hard, heavy, resilient.	Fuel, implements, erosion control, wheels, spokes and axles, fodder, medicinal (bark is a astringent and cardiac stimulant), timber and ornamental.
8	*Albizia lebbeck* (A.L)	Densewith a specific gravity between 0.55 and 0.64, and a calorific value of 5100 kcal/kg.	Very strong, resilient	Fodder, fuel, land stabilization, nitrogen fixing, poles, agricultural implements, shade, and apiculture
9	*Pinus wallichiana* (P.W)	Specific gravity of 6.48 and a calorific value of 4995 kcal/kg.	Moderately hard, moderately heavy	Construction, fuel, sleepers, and various wood products (furniture, match sticks, window frames, etc.)
10	*Alstonia scholaris* (A.S)	Heavy	Hard, Brittle	Ornamental and medicinal
11	*Erythrina suberosa* (E.S)	Wood is light and has a calorific value of 4800 kcal/kg.	Soft and not durable, but fibrous and tough	Fuel, nitrogen fixing, ornamental and medicinal bark as a fabrifuge).
12	*Eucalyptus citriodora* (E.C)	Specific gravity of 0.78 and a calorific value of 4800 kcal/kg.	Hard, elastic and resilient	Fuel, charcoal, furniture, perfume (leaves), shelterbelt, apiculture, pulp, fiber board and tool handles
13	*Populus deltoides* (PD)	Specific gravity of 0.46 and a calorific value of 5900 kcal/kg.	Moderately light, soft	Fuel, packing cases and crates, matches, erosion control and reforestation, plywood, pulp, fodder, and roadside tree
14	*Melia azedarach* (M.A)	Specific gravity of 0.56 and a calorific value of 5100 kcal/kg.	Light, moderately hard, resilient	Furniture, fodder, ornamental, timber, construction, agricultural implements, boxes and packing crates, sports equipment, veneer and plywood and medicinal (flowers and leaves)poultice for headaches
15	*Putranjiva roxburghii* (P.R)	Specific gravity of 0.47 and a calorific value of 5800 kcal/kg.	Light, soft	Construction, fuel, railway sleepers, watershed protection, packing cases and medicinal (aromatic wood juice ia a carminative, diuretic).
16	*Cedrus deodara* (C.D)	Specific gravity of 0.57 with a calorific value of 5200 kcal/kg	Wood is light and not strong	Fuel and timber (construction)
17	*Acacia Arabica* (A.A)	Wood is soft, with a specific gravity of 0.59 and a calorific value of 4910 kcal/kg	Hard, moderately strong	Fuel, fruit, implements, erosion control and medicinal (fruit for cough, chest diseases)

Appendix. Table showing Density, Strength and uses of different wood species used in the study (Continuation).

S. No.	Wood species	Density	Strength	Use
18	*Cordia oblique* (C.O)	A calorific value of 4900 kcal/kg	Hard, heavy and resilient	Construction, fuel, fruit, medicinal (fruit is a carminative, seed for treatment of diabetes), tannin, shelterbelts, apiculture, paper pulp, shade, fodder and roadside planting
19	*Syzygium cumini* (S.C)	Specific gravity of 0.70 and a calorific value of 4800 kcal/kg.	Hard, heavy and resilient	Construction, fuel, fruit, medicinal (fruit is a carminative, seed for treatment of diabetes), tannin, shelterbelts, apiculture, paper pulp, shade, fodder and roadside planting
20	*Zizyphus jujube* (Z.J)	Specific gravity of 0.93 and a calorific value of 5900 kcal/kg.	Hard, heavy, strong	Fuel, charcoal, agricultural implements and fruit
21	*Betula utilis* (B.U)	Heavy	Strong but low as compared to yellow birch	Fuel, fodder and furniture
22	Ehretia serrata Roxb	Specific gravity of 0.59.	Hard, strong	Fuel, fruit, implements, erosion control, furniture,
23	*Moringa oleifera* (M.O)	Medium	Soft, spongy, weak	Ornamental, fodder, food (leaves, flowers and fruits), seed oil (lubrication and perfume), and gum (bark).
24	*Mangifera indica* (M.I)	Dense, with a specific gravity of 0.55 and a calorific value of 4600 kcal/kg.	Strong and durable	Fruit, lumber and construction, chipboard, ornamental, medicinal (ripe fruit is a laxative, seeds are astringent and vermifuge) and food pickels