EGYPTIAN ACADEMIC JOURNAL OF
# BIOLOGICAL SCIENCES
## ENTOMOLOGY

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ISSN
1687-8809

WWW.EAJBS.EG.NET

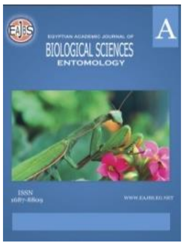
**Vol. 14 No. 4 (2021)**

**Citation**: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 14(4) pp.1-9 (2021)*
**DOI: 10.21608/EAJBSA.2021.198813**

**Egypt. Acad. J. Biolog. Sci., 14(4):1-9(2021)**

**Egyptian Academic Journal of Biological Sciences**
**A. Entomology**

**ISSN 1687- 8809**
**http://eajbsa.journals.ekb.eg/**




# Feeding Responses of Termite *Coptotermes heimi* (Blattodea: Rhinotermitidae) Against Fifteen Commercial Timbers Under Laboratory and Field Conditions

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**ARTICLE INFO**

**Article History**
Received:31/8/2021
Accepted:10/10/2021

**Keywords**:
Commercial timbers, Feeding Responses, Temperature, Choice bioassay and No choice bioassay.

**ABSTRACT**

The main purpose of this study was to investigate the feeding response of *Coptotermes heimi* termites on different commercial timbers along with the assessment of different timbers and their resistance and non-resistance behavior under lab and field conditions at 100 $^{0}$C. There were fifteen wood species that were investigated regarding attack and damage which include *Abies pindrow* (partal), *Cedrus deodara (*diar*), Acacia arabica* (keekar), *Dalbergia sisso* (tali*), Mangifera indica* (mango), *Pinus roxburghii (*Chir pine), *Populus euramericana* (Poplar), *Albizia lebbek* (Shreen), *Syzygium cumini* (Jaman), *Pongamia pinnata* (Sukh chain), *Morus nigra* (Shahtoot), *Pinus wallichiana* (Chir), *Azadirachta indica* (Neem), *Pinus ponderosa* (Yellow pine), *Ceylon cedar* (Dhraik, Bakain). Two weeks of laboratory and 3 months of field trials were performed with suitable conditions. The samples of every fifteen wood species were prepared and exposed to different species of termites by burying them in the active nests of termites. This practical was performed at the Wagah border 30 km away from Lahore. After this time, the factors which were to be noted were wood mass loss and the visual appearance of each sample. This also includes a choice and no choice feeding test. This trial is made to evaluate the non-resistance of wood to termite attack. At the end of the experiment, it has been observed that the most palatable wood is *P. euramericana* and the most resistant woods are *S. cumini* and *P. pinata* in no-choice trials and in choice trials the most palatable wood is *P. euramericana* and most resistant wood is *S. cumini.*

## INTRODUCTION

Termites are recognized as social insects living in colonies and the number of individuals ranges from several hundred up to a million. Termite colony consists of a few reproductive such as queen and king (Harris, 1957; Krishna, 1970). Termites are the major components of tropical and subtropical environments and they are reputed for their capability to damage and demolish all kinds of woods (Shanbhag and Sundararaj, 2013). Almost 3 thousand species of termites have been depicted, from these only 53 species have been identified in Pakistan and 11 species have been found to cause damage (Iqbal and

Saeed, 2013).

The preference for species of termite regarding a specified species of wood could be changed by the combination of wood given to them. (Smythe and Carter, 1970). The best test used for the determination of termite preference about wood was the choice feeding test. In case of no choice feeding test, the termite was forcefully fed on any resourced environment for ensuring their survival. (Sheikh *et al.*, 2010). The most common termite species found in Pakistan, responsible for damage in the structure of wood are *Heterotermes indicola* (Wasmann), *Microtermes obesi* (Holmgren), *Coptotermes heimi* (Wasmann), and *Odontotermes obesus* (Rambur). Since, *Heterotermes indicola* was the most popular structural pest found in Pakistan, damaging the wooden structures present inside the houses, hence become the most damaging and destructive termite species inhabited in Lahore (Walcott, 1951).

Some species of termites have the capacity to feed on living plants but few preferred to feed on the dead and decaying timber by covering them with a smooth and thin layer of mud. Some species were capable of building nests or mounds on or at the basal area of stumps, tree trunks while other species are standing freely and remote from the sites of feeding. Termites were nominated as important pests at the agricultural and domestic levels. (Logan *et al.*, 1990).

Termites are responsible for causing damage to the wood. The number of harmful species of termites in different areas of the world is recorded as Australia has 16, In North America number is 9, in Indian Subcontinents about 26, Tropical Africa has 24 and West Indies and Central Asia have 17. Among the reported genera of termite, the *Coptotermes* has the highest range of pest species found in any genus, along with 28 species able to invoke the damage. (Su and Scheffrahn 2000). The estimations about the economic damage of termites are quite rare globally as well as in some regions. The most damaging and destructive species found in the world is *Mastotermes darwiniensis* commonly named as giant northern termite. (Buczkowski and Bertelsmeier, 2017). Ten species of termites were recorded, which were responsible for the 90% destruction of sugarcane, 43% in maize and 8-12% in case of wheat. Many orchard plants were completely destructed by the attack of termites in Punjab (Akhtar and Shahid, 1989).

Control measures for different species of termites are different because of their life histories. Different insecticides are available for removing subterranean termites. Other slow-acting treatments are also used for the exclusion of colonies of subterranean termites. Other treatments like whole structure treatments like heat and fumigation, compartmental treatments like heat or cold, and local treatments like wood surface treatments or insecticide introductions are primary tools for dry wood termite control (Abe *et al.*, 2000).

The present study was conducted to understanding subterranean termite resistance and feeding preferences on different commercial timbers is a demand of the time.

## MATERIALS AND METHODS

**Termite Collection:**

Termites are the small ant-like insects that were found in mounds, trees and even on the walls of our houses. A large number of termites workers of *Coptotermes heimi* collected from nests situated in Wagah border that is 30 km away from Lahore.

**Wood Species**:

There were fifteen wood species that were selected regarding attack and damage which include *Abies pindrow* (partal), *Cedrus deodara (*diar*)*, *Acacia arabica* (keekar), *Dalbergia sisso* (tali*)*, *Mangifera indica* (mango), *Pinus roxburghii (*Chir pine), *Populus euramericana* (Poplar), *Albizia lebbek* (Shreen), *Syzygium cumini* (Jaman), *Pongamia* *pinnata* (Sukh chain), *Morus nigra* (Shahtoot), *Pinus wallichiana* (Chir), *Azadirachta indica* (Neem), *Pinus ponderosa* (Yellow pine) and *Ceylon cedar* (Dhraik, Bakain). Most of the wood species were taken from the lumber yard.

**No Choice Laboratory Trials:**

Wooden blocks (4x2x1 cm) of all the woods used in experiments were prepared and dried at suitable 100$^{o}$C temperatures for 48 hours. One block from each type of wood species was put in a glass petri dish with a suitable diameter and height and 50 worker termites of *C. heimi* were added to Petri dish. The wooden blocks have been kept suitably damp. For each wood three replicates of each wooden block have been used. For two weeks, Petri dish was kept at an acceptable temperature. In the end, the wooden pieces were dried at the same temperature as they dried before being exposed to termites, and the amount of wood consumed was calculated.

**No Choice Field Trials:**

In this experiment, wooden blocks of fifteen different wood species measuring (4x2x1 cm) were made and dried for 48 hours at a suitable 100$^{o}$C temperature. Each kind of wood species' block was tied individually. Nests of termites *C. heimi* were found near Wagah border Lahore. Each tied block of wood was placed at a distinct location of the nest, which was buried 30cm deep into the soil. The blocks were removed from the soil after three months and reweighed.

**Choice Laboratory Trials:**

Choice lab tests were also carried out to compare feeding responses of termites *C. heimi* on *A. pindrow vs C. deodara, A. arabica vs D. sisso, P. euramericana vs P. roxburgi, M. indica vs A. arabica, P. wallichiana vs M. nigra, C. cedar vs P. ponderosa, A. indica vs P. pinnata, S. cumini vs A. lebbek.* This feeding comparison was considered more accurate than no-choice laboratory trials. The methodology was the same as in the no-choice laboratory trials but in this, the wooden blocks were placed side by side with other wood of different species in the form of pairs to determine feeding preference and resistance of each species of wood. The wooden blocks of fifteen different wood species measuring (4x2x1 cm) were prepared and dried at a suitable 100$^{0}$C temperature for 48 hours. The time period was also the same as in no-choice laboratory trials, after that time period data will be analyzed.

**Choice Field Trials:**

Choice field tests were also carried out to compare feeding responses of termites *C. heimi* on *A. pindrow vs C. deodara, A. arabica vs D. sisso, P. euramericana vs P. roxburgi, M. indica vs A. arabica, P. wallichiana vs M. nigra, C. cedar vs P. ponderosa, A. indica vs P. pinnata, S. cumini vs A. lebbek.* These pairs were joined side by side in a bundle using copper wire. The location of the nest and the methodology of the test were the same as in no choice field Trials. In this experiment, wooden blocks of fifteen different wood species measuring (4x2x1 cm) were made and dried for 48 hours at a suitable 100$^{o}$C temperature. The time period is also the same as bundles were buried for 3 months and after 3 months the wooden blocks were reweighed again and the wood consumption was calculated.

**Statistical Analysis**:

On the conclusion of the no-choice laboratory trials, data on wood consumption, percentage of wood consumption and percentage of survival were subjected to one-way analysis of variance. Data obtained in the choice laboratory and field trials were statistically analysed using a paired comparison t-test. Similarly, the percentage of mass loss in wood species in the no-choice field trials was analysed.

## RESULTS

Choice and no-choice bioassays were conducted to evaluate the feeding preference of *C. hemi.* In both choice and no choice bioassay, 15 different wood species were offered to termite to check the most palatable wood under different environmental conditions. For a successful bait station, knowledge of more susceptible wood is necessary.

**No Choice Lab Trials:**

In a no-choice Laboratory bioassay, 15 different wood species were exposed to termite *C. hemi*. Among these species, minimum mass loss was recorded in *P. pinata* (5%) and *S. cumini* (5%). Maximum consumption was noted in *Populus euramericana* (78%) after 2 weeks. Current results revealed that *P. pinata* and *S. cumini* are not preferred wood by termite *C. hemi* and were found to be highly resistant wood. Whereas, *P. euramericana* was extremely susceptible to termite attack. The mean wood consumption values noted for *A. pindrow* 10.7mg, *C. deodara* 3.12mg, *A. arabica* 3.5mg, *D. sisso* 2.03mg, *P. euramericana* 15.6mg, *P. roxburgi* 1.33mg, *M. indica* 3.07mg, *Pinus wallichiana* 1.67mg, *M. nigra* 7.9mg, *C. cedar* 4.3mg, *Pinus ponderosa* 2.1mg, *Azadirachta indica* 6.57mg, *Pongamia pinnata* 1 mg, *Syzygium cumini* 1.03mg, *Albizia lebbek* 2.3mg. Mean followed by same letter show non-significant difference (P>0.05) and mean followed by different letter show a significant difference (P<0.05). (Table 1).

**Table 1:** Amount of wood consumption (Mean±SE) and wood consumption (%) in blocks of 15 different wood species exposed to the workers of *C. heimi* for 2 weeks under no-choice laboratory conditions.

| Wood species | Mean Wood consumption (mg) Mean±S.E | Percentage Wood consumption |
|---|---|---|
| *P. euramericana* | $15.6 \pm 0.25^{i}$ | 78% |
| *A. pindrow* | $10.7 \pm 0.12^{h}$ | 54.5% |
| *D. sisso* | $3.12 \pm 0.14^{cde}$ | 16% |
| *C. deodara* | $2.03 \pm 0.26^{abc}$ | 10.4% |
| *A. arabica* | $3.5 \pm 0.24^{de}$ | 17.9% |
| *A. lebbek* | $2.3 \pm 0.07^{bcd}$ | 11.7% |
| *S. cumini* | $1.03 \pm 0.07^{a}$ | 5% |
| *P. pinnata* | $1.0 \pm 0^{a}$ | 5% |
| *M. nigra* | $7.9 \pm 0.33^{g}$ | 40% |
| *P. wallichiana* | $1.67 \pm 0.27^{ab}$ | 8.6% |
| *M. indica* | $3.07 \pm 0.19^{cde}$ | 15.3% |
| *A. indica* | 6.57± 0.24f | 33.7% |
| *P. roxburghii* | $1.33 \pm 0.07^{ab}$ | 6.6% |
| *P. ponderosa* | $2.1 \pm 0.08^{abc}$ | 10.4% |
| *C. cedar* | $4.2 \pm 0.16^{e}$ | 21% |

**No Choice Field Trials:**

In a no-choice Field bioassay, 15 different wood species were exposed to termite *C. hemi*. Among these species, minimum mass loss was recorded in *S. cumini* (8.3%) and *P. pinata* (8.9%). Maximum consumption was noted in *Populus euramericana* (82.6%) after 12 weeks. Current results revealed that *P. pinata* and *S. cumini* are not highly preferred wood by termite *C. hemi* and were found to be highly resistant wood. Whereas, *P. euramericana* was extremely susceptible to termite attack. The mean wood consumption values noted for *A. pindrow* 17.1mg, *C. deodara* 5.6mg, *A. arabica* 8.3mg, *D. sisso* 9.6mg, *P. euramericana* 28.1mg, *P. roxburgi* 18.7mg, *M. indica* 8.3mg, *P. wallichiana* 5.0mg, *M. nigra* 12.6mg, *C. cedar* 6.8mg, *P. ponderosa* 4.4mg, *A. indica* 10.1mg, *P. pinnata* 3.0 mg, *S. cumini* 2.8mg, *A. lebbek* 11.7mg. Mean followed by same letter show non-significant difference (P>0.05) and mean followed by different letter show a significant difference (P<0.05) (Table 2).

**Table 2:** Amount of wood consumption (Mean±SE) and wood consumption (%) in blocks of 15 different wood species exposed to the workers of *Coptotermes heimi* for 12 weeks under no-choice Field conditions.

| Wood species | Mean Wood consumption(mg) Mean±S.E | Percentage Wood consumption |
|---|---|---|
| *P. euramericana* | 28.1± 0.40$^{j}$ | 82.6% |
| *A. pindrow* | 17.1± 0.52$^{i}$ | 50.2% |
| *D. sisso* | 9.6± 0.28$^{f}$ | 28.3% |
| *C. deodara* | 5.6± 0.17$^{cd}$ | 16.5% |
| *A. arabica* | 8.3± 0.12$^{ef}$ | 24.3% |
| *A. lebbek* | 11.7± 0.52$^{gh}$ | 34.5% |
| *S. cumini* | 2.8± 0.14$^{a}$ | 8.3% |
| *P. pinnata* | 3.0± 0.45$^{ab}$ | 8.9% |
| *M. nigra* | 12.6±0.19$^{h}$ | 37% |
| *P. wallichiana* | 5.0± 0.31$^{bcd}$ | 14.6% |
| *M. indica* | 8.3± 0.24$^{ef}$ | 24.4% |
| *A. indica* | 10.1± 0.05$^{fg}$ | 29.6% |
| *P. roxburghii* | 18.7± 0.22$^{i}$ | 55.1% |
| *P. ponderosa* | 4.4±0.25$^{abc}$ | 12.9% |
| *C. cedar* | 6.8±0.32$^{de}$ | 19.9% |

## Choice Lab Trials:

In these trials the wooden blocks were dried at temperature 100 $^{0}$Cand then the blocks were tie in group form with alternate wood species and offer to the worker of *Coptotermes heimi* in petri plates. Maximum feeding was observed in *P. euramericana* (13.6 mg) and *P.roxburghi (*1.17 mg) and minimum feeding was observed in *S. cumini* (1.3 mg) and *A. lebbek* (9.2 mg). The feeding rate observed in other wooden blocks combination in descending order is as follows, PE/PR> AI/PP> AP/CD> AA/DS> CC/PP> PW/MN> MI/AA> SC/AL. The difference in the amount of wood consumed was statistically significant ($P < 0.05$) (Table 3).

**Table 3.** Mean wood consumption (X±SD) workers of *C. heimi* in "mg" AP/CD (*A. pindrow* vs *C. deodara*), AA/DS (*A.arabica* vs *D.sisso*), PE/PR (*P.euramericana* vs *P. roxburgi*), MI/AA (*M. indica vs A. arabica*), PW/MN (*P. wallichiana vs M. nigra),* CC/PP (*C. cedar vs P. ponderosa*), AI/PP (*A. indica vs P. pinnata*), SC/AL (*S. cumini vs A. lebbek*) dried at 100$^{0}$C temperatures in 2-week "CHOICE" trial under laboratory condition.

| Temperature | Comparison[a] | Wood mass loss(mg) | | Probability[b] |
|---|---|---|---|---|
| | | Wood1 | Wood2 | |
| 100$^{0}$C | *AP/CD* | *7.9± 0.10* | *1.9± 0.34* | *0.000**** |
| | *AA/DS* | *7.1 ±0.38* | *2.1±0.05* | *0.003*** |
| | *PE/PR* | *13.6±0.24* | *1.17±0.07* | *0.001*** |
| | *MI/AA* | *2.9±0.07* | *2.2±0.07* | *0.05** |
| | *PW/MN* | *3.3±0.12* | *6.9±0.05* | *0.002*** |
| | CC/PP | 4.5±0.07 | 2.0±0.57 | 0.003** |
| | AI/PP | 7.9±0.03 | 2.3±0.12 | 0.003** |
| | SC/AL | 1.3±0.12 | 9.2±0.09 | 0.000*** |

a: Each wooden block was paired with a wooden block of other species (wood 1/wood 2) in Petri plate containing 100 termites (n=3).
b: Difference in mass loss for each pair of wooden blocks indicated by ** = 0.05, are significantly different (paired comparison t-test).

**Choice Field Trials**:

In these trials, the wooden blocks were dried at temperature 100 $^{0}$C and then the blocks were tie in group form with alternate wood species and offer to the worker of *C. heimi* under field conditions. Maximum feeding was observed in *P. euramericana* (14.90 mg) and *P.roxburghi* (2.43 mg) and minimum feeding was observed in S. cumini (2.93 mg) and *A. lebbek* (9.13 mg). The feeding rate observed in other wooden blocks combination in descending order is as follows, PE/PR> AI/PP> AP/CD> AA/DS> CC/PP> PW/MN> MI/AA> SC/AL. The difference in the amount of wood consumed was statistically significant (P< 0.05) (Table 4).

**Table 4.** Mean wood consumption (X±SD) workers of *C. heimi* in "mg" AP/CD (*A. pindrow* vs *C. deodara*), AA/DS (*A.arabica* vs *D.sisso*), PE/PR (*P.euramericana* vs *P. roxburgi*), MI/AA (*M. indica vs A. arabica*), PW/MN (*P. wallichiana vs M. nigra),* CC/PP (*C. cedar vs P. ponderosa*), AI/PP (*A. indica vs P. pinnata*), SC/AL (*S. cumini vs A. lebbek*) dried at 100$^{0}$C temperatures in 12-week "CHOICE" trial under Field condition.

| Temperature | Comparison[a] | Wood mass loss(mg) | | Probability[b] |
|---|---|---|---|---|
| | | Wood1 | Wood2 | |
| **100$^{0}$C** | *AP/CD* | *8.27± 0.12* | *2.67± 0.36* | *0.010* |
| | *AA/DS* | *6.47±0.24* | *3.53±0.24* | *0.001***|
| | *PE/PR* | *14.90±0.40* | *2.43±0.23* | *0.004***|
| | *MI/AA* | *3.33±0.17* | *5.27±0.12* | *0.001***|
| | *PW/MN* | *4.43±0.24* | *7.13±0.15* | *0.025* |
| | CC/PP | 5.53±0.12 | 2.70±0.33 | 0.034 |
| | AI/PP | 8.63±0.26 | 3.27±0.12 | 0.007** |
| | SC/AL | 2.93±0.28 | 9.13±0.11 | 0.003** |

a: Each wooden block was paired with a wooden block of other species (wood 1/wood 2) in the field (n=3).
b: The difference in the mass loss for each pair of wooden blocks indicated by ** = 0.05 are significantly different (paired comparison t-test).

## DISCUSSION

Feeding preferences of *C. heimi* subterranean termites on fifteen wood species at fixed temperature were studied for having knowledge about feeding preferences and responses toward certain wood species. The result indicated that the feeding preference of *C. heimi was P. euramericana> A. pindrow > M. nigra> A. indica>C. cedar> A. arabica> D. sisso> M. indica > A. lebbek > C. deodar >P. ponderosa> P. wallichiana> P. roxburgi> P. pinnata> S. cumini* when all wooden blocks were dried at 100'C. The current study found that *P. euramericana* and *A. pindrow* woods were the favorite food source to termite *C. heimi*. Maximum feeding and mass loss were observed in these two kinds of wood in the no-choice test and *A. lebbek* and *A. indica* were also most favorite. Softening of *P. euramericana* makes it palatable to termites. More than 70% consumption was noted in case of *P. euramericana* in both sites.

Our results match with the *Peralta et al., (2004)* who observed that wood hardness is a key factor in wood-feeding by subterranean termites with maximum mass consumption rates for softwood compared to hardwood species. In other studies, Iqbal *et al.*, (2015) observed the opposite relationship between wood hardness and consumption of wood by *C. formosanus* and *R. flavipes* and stated that softwood species are preferred by termites and heavily damaged than harder and heavier wood species. Furthermore, the wood of *P.*

*euramericana* populous is more susceptible to degradation by the microorganism i.e., fungus and the wood degraded by the fungus is usually preferred by termite workers (*Little et al.*, 2013). Our results also follow the results of Rasib *et al*., (2014) who reported that the woods of P. *euramericana* populous and *M. indica* mango were the most palatable and favorite food source to termite *O. obesus* in both choice and no choice bioassay. Both wood species are soft and easily consumable. Farkhanda *et al.*, (2015) reported that *P. euramericana* populous and *M. indica* mango was most palatable and preferred woods along with more mass consumption whereas *Dalbergia sisso* least preferred and less mass consumed by termites *C. heimi* and *H. indicola*. Rasib and Ashraf (2014) also reported that *P. euramericana* populous was highly preferred wood to *Coptotermes heimi* in both laboratory and field bioassay. Therefore *P. euramericana* populous can be used in the bait station and termite trapping. Our results relate to these studies.

Afzal, Rasib, and Hussain (2017) also studied the feeding preferences of *Heterotermes indicola* (Wasmann). *D. sissoo* and *S. cumini* were more resistive to the termite attack. *P. euramericana* and *B. monosperma* were more consumed by termites. Dugal and Latif (2015) studied the laboratory and field feeding preferences of by termite species *Heterotermes indicola* and *Coptotermesn heimi.* The result revealed that *Populus deltoides* was most consumed and *Dalbergia sissoo* was the least consumed wooden block by termites. In field, *D. sissoo* was the least consumed and *Mangifera indica* was the most consumed wooden block by the termites.

Rasib, Ashraf, and Afzal (2014) studied the feeding preference of *O. obesus.* The study revealed the most consumed was *P. euramericana* > *C. fistula* > *A. excelsa* > *A. indica* > *H. adenophyllum* > *B. variegata* > *E. camaldulensis* > *P. roxburghii* > *S. cumini* > *A. lebbeck* > *B. monosperma* > *M. indica* > *M. alba* > *D. sissoo* > *J. mimosifolia* > *E. subrosa* > *B. bamboo* > *T. grandis*, respectively. Sheikh *et al.* (2010) work on the termite species of *O.obesus* and its feeding habitat this species prefers *Fagus sp* (beech) and *Pinus wallichiana* (kail) and whereas the least preferred wood is *Abies pindrow* (pertal) and *Cedrus deodara* (diar). The resistant chemicals in trees are not present in all trees, which makes some trees more resistant and some trees more vulnerable to termite attack, according to Akhtar in 1980, *A. pindrow* is considered a highly resistant wood species towards termites.

The result indicated that *P. euramericana* following *A. pindrow* was most consumed and less resistant toward the attack of *C. heimi termites*. Present study results were not consistent with the previous researches about the resistance of wood protection from termite attacks. Ijaz and Aslam (2003) also revealed that *O. obesus* infestation increases with the increase in the humidity level in Lahore, Pakistan. The *Phyllanthus emblica* and *Cupressus sempervirens* are more palatable for the termites because of the presence of dense shelter. The alteration in the resistance of wood is because of changes in the chemical constitution (phenol, terpenoids, and quinines) of wood, the PH level of wood and the hardness of the wood, which makes the wood more palatable to *O. obesus* termites.

## Conclusion

The present study indicated that the feeding preference of *C. heimi* was *P. euramericana*> *A. pindrow* > *M. nigra*> *A. indica*>*C. cedar*> *A. arabica*> *D. sisso*> *M. indica* > *A. lebbek* > *C. deodar* >*P. ponderosa*> *P. wallichiana*> *P. roxburgi*> *P. pinnata*> *S. cumini* when all wooden blocks were dried at $100^0$C. *P. euramericana, A. pindrow, M. nigra and A. indica* are the most palatable wood species for the *C. heimi* termites, when wooden blocks were dried at $100^0$C *S. cumini*, *P. pinnata* and *P. roxburghii* wood species were most resistant to terminate attack and durable in the long run that can be used for making building materials and wooden structure. Termites consumed more wooden blocks in the no-choice field and choice field Trials than no-choice lab Trials and choice lab Trials when wooden blocks were dried at $100^0$C. Termite feeding depends on the moisture content and temperature of wood species. So wooden species treated at $100^0$C temperature became more palatable for termites. This study does not illustrate which chemical prevents the attack of termites. Contrary to all the previous researches, *P. euramericana* in this research was most palatable to *C. heimi* maybe because the wooden blocks were dried at $100^0$C but further research in the future is needed to know exact factors that turn most resistant species to most palatable species to *C. heimi.*

**Acknowledgement:**

We are very thankful to Dr. Khalid Zamir Rasib, Associate Professor, The University of Lahore, for supporting us in this research.

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