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Feeding preferences and responses of subterranean termite on different commercial timbers

Abstract

The purpose of this study was to find the feeding preferences of *Odontotermes obesus* termites on different types of commercial timbers along with the evaluation of different timbers and their resistance and non- resistance behavior under lab and field conditions at 100°C. There were six wood species which were evaluated regarding attack and damage which include *Azadirachta indica* (Neem), *Eucalyptus globulus* (Safaida), *Ficus religiosa* (Peeple*), Mangifera indica* (Aamb), *Dalbergia sisso* (Taali or Sheesham), *Acacia arabia* (Keekar). Two weeks' laboratory and 3 months of field trials were performed with suitable conditions. The samples of every six 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 Wagah border 30 km away from Lahore. After this time, the factors which were to be noted were wood mass loss and visual appearance of each sample. This also includes a choice and no choice feeding test. This trial is made to evaluate the nonresistance of wood to termite attack. After trials have been made, it has been noted that the most palatable wood is *M. indica, F. relgiosa* and *A. indica* and the most resistance woods are is *A. arabica, E. globulus* and *D. sisso* in no choice trials and in choice trials the most palatable wood is *M. indica* and most resistance wood is *D. sisso* and *A. arabica.*

Keywords: commercial timbers, feeding preferences, temperature impact, choice and no choice test

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Introduction

As cellulose, present in wood and wood products, is the principal food of termites, they mostly consume and destroy materials such as paper, fabrics and wood structures and hence, constant effort is directed towards their control. Field and laboratory tests have indicated that some woods are not resistant to their attack, whereas others are resistant.[1] Globally, termites are a huge problem in both agricultural and urban areas as they cause significant damage to crops, plants, buildings and woodwork and account for considerable economic loss. To make cellulose digestible and ready for assimilation, termites live in a strong mutualistic relationship with a variety of hindgut-inhabiting endomicrobes (flagellates, bacteria and archaea). Out of 2500 described species throughout the world, about 300 species are considered as pests. Damage to the wooden structures and other cellulosic materials by termites has been exceed to $3 billion per year worldwide [2]

There are many factors affecting the feeding activity of termites on woods. Wood characteristics influence the feeding activity of termites. Depending on the characteristics of the wood species, initiation, maintenance or cessation of feeding by termites may follow their exposure to a wood species. Physical, mechanical and chemical properties of the wood are probably interdependent and results in variability in wood characteristics, which will ultimately cause variability in wood resistance to termites. For example, some antitermitic chemical compounds may be found in forest species like terpenoids and quinones that act as a natural repellent for termites.[3]

In South-East Asia, termite attack is more commonly known to occur on older trees, and the termites responsible are *C. curvignathus*[4,5] and *M. dubius* (Chey, 1996; Kirton and Cheng,[5]) which have more specialized abilities to kill trees.

In Pakistan, forests are the main source of wood and wood products. Wood is a renewable natural resource, mostly used for building, construction and production. High-quality wood products are often preferred by customers, but physical or biological damage reduces their value.

Wood and wood products need to be protected during manufacture, storage and transportation and when in use.[6]

The different species of termites are found in different ecological zones of Pakistan and have different feeding preferences. For example, *Anacanthotermes vagan* does maximum damage to woodwork in buildings in Chaman, district Quetta, but is absent from the Punjab, where *Coptotermes heimi, Microcerotermes unicolar, Odontotermes obesus* and *Heterotermes indicola* play havoc.[7]

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 many cellulosic material. Termites attack had spoiled sugarcane crops in different areas of District Peshawar in 1985 and overall 90% damage was recorded in Now shera District. In 2001 Sattar and Saliha recorded 10 species of termites, which caused up to 90% of the damage to sugarcane, 43% to maize and 8-12% to wheat. Many of the orchards in Punjab will be completely devastated by termite's attack.[8] There are numerous factors that affect wood consumption by termites and these are highly interconnected. It has been of termite of termite wood consumption the natural resistance of various timbers was found to be highly resistant to attack by the termite natural resistance of the native timber species to been reported by various investigators[8] to assess the feeding preferences of termites in Pakistan is to the approaches used to determine natural different commercial woods but very little is done on Keeping in view the importance of wood and damage caused by termite species to the ecosystem of Pakistan, the present study will be carried out to evaluate the feeding preferences of termites for commercial woods.

Materials and methods

Termite collection

Large number of worker termites of *Odontotermes obesus* were collected from nests located at Wagah border that is 30 km away from Lahore. The species was dominant in soil in the month of June to mid-August in Pakistan in the rainy season.

Wood species

Commercially important wood species were selected for these trials. There were a great variety of timbers in Pakistan but for performing experiment most of wood species were taken from lumber yard. (Table 1).

Table 1 Wood used in experiment with scientific and common names

Plant species	Scientific name of plant	Local name
1	*Azadirachta indica*	Neem
2	*Eucalyptus globulus*	Safaida
3	*Ficus religiosa*	Peeple
4	*Mangifera indica*	Mango
5	*Dalbergia sisso*	Shisham
6	*Acacia arabia*	Keekar

Laboratory trials

Two experiments were done on the pre-heated wooden blocks from different species to determine resistance and feeding preferences of *O. obesi* on different commercial timber.

a. No Choice Laboratory Trials

b. Choice Laboratory Trials

No choice laboratory trials

Wooden blocks (4.2x2.5x1cm) of all the woods used in experiments were prepared and dried at suitable 100°C temperatures for 48 hours. One block from each type of wood species was put in a glass petri dish with suitable diameter and height and 50 worker termites of *O. obesus* were added in 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 the acceptable temperature. At the end the wooden blocks were dried at the same temperature at which they were dried before being exposed to termites and measured the amount of wood consumed (Figure 1).

Figure 1 Wood used in Lab Trial.

Choice laboratory trials

Choice laboratory tests were also conducted to compare feeding preferences and resistance of *O. obesus* on *A. indica* (Neem) vs *E. globulus* (Safaida) AI/EG, *F. religiosa* (Peeple) vs *M. indica* (Aamb) FR/MI, *D. sisso* (Taali or Seesham) vs *A. arabia* (Keekar) DS/AA, *A. indica* (Neem) vs *M. indica* (Aamb) AI/MI, *E. globulus* (Safaida) vs *D. sisso* (Taali or Seesham) EG/ DS, *F. religiosa* (Peeple) vs *A. arabia* (Keekar) FR/AA. This feeding comparison were considered more accurate than no choice laboratory trials. The methodology was 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 pair to determine feeding preference and resistance of each species of wood. The wooden blocks of six different wood species measuring (4.2x2.5x1cm) were prepared and dried at suitable 100°C temperature for 48 hours. The time period was also same as in no choice laboratory trials, after that time period data will be analyzed.

Field trials

Two experiments were done on the pre-heated wooden blocks from different species to determine resistance and feeding preferences of *O. obesus* on different commercial timber

a. No Choice Field Trials

b. Choice Field Trials

No choice field trials

In this the wooden blocks of fifteen different wood species measuring (4.2x2.5x1cm) were prepared and dried at suitable 100°C temperature for 48 hours. Blocks of each type of wood specie were tied separately. Nests of termites *O. obesus* were found near Wagah border Lahore. Each tied block of wood was placed at different sites of nest buried 30cm deep into the soil. The blocks were removed from the soil after 3 months and reweighed (Figure 2).

Figure 2 Wood species placed in termite's nest.

Choice field trials

Choice laboratory tests were also conducted to compare feeding preferences and resistance of termites *O. obesus* on *A. indica* (Neem) vs *E. globulus* (Safaida) AI/EG, *F. religiosa* (Peeple) vs *M. indica* (Aamb) FR/MI, *D. sisso* (Taali or Seesham) vs *A. arabia* (Keekar) DS/AA, *A. indica* (Neem) vs *M. indica* (Aamb) AI/MI, *E. globulus* (Safaida) vs *D. sisso* (Taali or Seesham) EG/ DS, *F. religiosa* (Peeple) vs *A. arabia* (Keekar) FR/AA. These pairs were tie side to side with the help of copper wire in a bundle. The location of nest and the methodology of the test were same as in no choice field Trials. The wooden blocks of six different wood species measuring (4.2x2.5x1 cm) were prepared and dried at suitable 100°C temperature for 48 hours. The time period is also same as bundles were buried for 3 months and after 3 months the wooden blocks were reweighed again and the wood consumption was calculated.

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Statistical analysis

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

Results

Choice and no choice bioassays were conducted to evaluate the feeding preference of *O. obesus*. In both choice and no choice bio assay, six different wood species were offer to termite to check the most palatable wood under different environmental conditions. For successfully bait station, the knowledge of more susceptible wood is necessary.

No choice lab trials

In no choice Laboratory bioassay, six different wood species were exposed to termite *O. obesus*. Among these species, minimum mass loss was recorded in *A. arabica* (7.2%) and *E. globulus* (9.5%). Maximum consumption was noted in *M. indica* (42.8%) after 2 weeks. Current results revealed that, *A. arabica* and *E. globulus* is not preferred wood by termite and found to be resistant wood (Table 2). Whereas, *M. indica* was susceptible to termite attack. The mean wood consumption values noted for, *A. arabica* 1.4g, *D. sisso* 3.06g, *M. indica* 8.06g, *Azadirachta indica* 6.8g, *E. globulus* 1.9g, *F. religiosa* 5.07g.

No choice field trials

In no choice field bioassay, six different wood species were exposed to termite *O. obesus*. Among these species, minimum mass loss was recorded in *D. sisso* (7.1%) and *E. globulus* (11.7%). Maximum consumption was noted in *F. religiosa* (37.1%) after 3 months. Current results revealed that, *D. sisso* and *E. globulus* is not preferred wood by termite and found to be resistant wood (Table 3). Whereas, *F. religiosa* was susceptible to termite attack. The mean wood consumption values noted for, *A. arabica* 10.2g, *D. sisso* 3.06g, *M. indica* 11.07g, *Azadirachta indica* 13.5g, *E. globulus* 5.8g, *F. religiosa* 18.06g.

Choice lab trials

In these trials the wooden blocks were dried at temperature 100°C and then the blocks were tie in group form with alternate wood species and following result were obtained (Table 4).

i. Each wooden block was paired with a wooden block of other species (wood 1/wood 2) in Petri plate containing 100 termites (n=3).

ii. 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 100C and then the blocks were tie in group form with alternate wood species and following result were obtained (Table 5).

a. Each wooden block was paired with a wooden block of other species (wood 1/wood 2) in field (n=3).

Difference in mass loss for each pair of wooden blocks indicated by ** =0.05, are significantly different (paired comparison t-test).

Table 2 Amount of wood consumption (Mean±SE) and wood consumption (%) in blocks of six different wood species exposed to the workers of *Odontotermes obesus* for 2 weeks under no-choice laboratory conditions

Wood species	Mean Pre weight (g)	Mean wood consumption (g) Mean±S.E	Percentage wood consumption
A. indica	20	6.8±0.42	34%
E. globulus	19.7	1.9±0.12	9.50%
A. arabica	19.8	1.4±0.24	7.20%
D. sisso	19.6	3.06±0.26	17.80%
F. religiosa	19.5	5.7±0.32	28.70%
M. indica	20	8.6±0.37	42.80%

Table 3 Amount of wood consumption (Mean±SE) and wood consumption (%) in blocks of six different wood species exposed to the workers of *Odontotermes obesus* for 12 weeks under no-choice Field conditions

Wood species	Mean Pre weight (g)	Mean wood consumption (g) Mean±S.E	Percentage wood consumption
A. indica	50	13.5± 0.66	27%
E. globulus	50.7	5.8±0.36	11.70%
A. arabica	50.8	10.2±0.32	20.50%
D. sisso	50.6	3.06±0.26	7.10%
F. religiosa	50	18.6±0.71	37.10%
M. indica	50	11.7±0.52	23.50%

Table 4 Mean wood consumption (X **Local name** SD) workers of *O. obesus* in "g" AI/EG (*A. indica* vs *E. globulus*), FR/MI (*F. religiosa* vs *M. indica*), DS/AA (*D. sisso* vs *A. arabica*), AI/MI (*A. indica vs M. indica*), EG/DS (*E. globulus vs D. sisso),* FR/AA (*F. religiosa vs A. arabica* dried at 100°C temperatures in 2-week "CHOICE" trial under laboratory condition

Temperature	Comparison[a]	Wood mass loss(g)		Probability[b]
		Wood 1	Wood 2	
100C	AI/EG	6.6± 0.10	2.5± 0.34	0.000***
	FR/MI	5.5±0.38	7.3±0.05	0.003**
	DS/AA	2.1±0.11	4.00±0.07	0.001**
	AI/MI	5.0±0.12	7.43±0.05	0.002**
	EG/DS	3.4±0.17	1.3±0.57	0.003**
	FR/AA	4.0±0.09	2.0±0.12	0.003**

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Table 5 Mean wood consumption (X±SD) workers of *O. obesus* in "g" AI/EG (*A. indica* vs *E. globulus*), FR/MI (*F. religiosa* vs *M. indica*), DS/AA (*D. sisso* vs *A. arabica*), AI/MI (*A. indica vs M. indica*), EG/DS (*E. globulus vs D. sisso)*, FR/AA (*F. religiosa vs A. arabica* dried at 100°C temperatures in 12-week "CHOICE" trial under Field condition

Temperature	Comparison[a]	Wood mass loss(g)		Probability[b]
		Wood 1	Wood 2	
100C	AI/EG	8.27±0.10	3.50±0.34	0.000***
	FR/MI	6.47±0.38	7.77±0.05	0.003**
	DS/AA	4.10±0.11	3.43±0.07	0.001**
	AI/MI	7.30±0.12	6.0±0.05	0.002**
	EG/DS	7.13±0.17	4.33±0.57	0.003**
	FR/AA	5.33±0.09	2.70±0.12	0.003**

Discussion

Current study found that *M. indica* and *A. indica* woods were the favorite food source to termite *O. obesus*. Maximum feeding and mass loss was observed in these two woods in both tests. Softening of *M. indica* makes this wood palatable to termite. More than 42% consumption was noted in case of *M. indica.*

Visually, it was found that both woods were heavy attacked, even the woods were collapsed. Termites were penetrated inside the woods and maximum wood was consumed. In comparison, woods of *A. arabica, E. globulus, F. religosa* and *D. sisso* were not desired wood species. Minimum wood consumed in case of these woods and fall under the category of "slight to superficial attack. Strategies that promote the use of biodegradable-renewable-carbon materials, such as wood, require species with considerable natural durability for decay and insects or the use of environmentally benign preservatives.[9] The use and availability of the durable commercial tropical timbers are restricted by certification schemes for sustainable management of timber resources. Lesser-known timbers are important[10] as potential commercial timber alternatives. However, if the impact of lesser-known timbers on the world market has to be appreciated, their properties such as natural durability should be specified.[10] Naturally durable timbers usually have longer service life and require replacement less frequently, which consequently reduces the frequency of associated harvesting including commercial tropical timbers. Additionally, naturally durable timbers provide an opportunity for developing environmentally benign wood preservatives from their natural toxic compounds.[11,12] Among these woods, *D. sisso* and *A. arabica* and *E. globulus* found to be most resistant to termites. Only 7.2 % wood *A. arabica* was consumed in no choice (Table 2) and 2 g in choice bioassay (Table 3) and *D. sisso* was consumed 1.3g in choice bioassay (Table 3) and 3.6 g in no choice bioassay (Table 2). *M. indica* are the favorite woods to termites under different environmental conditions and can be used in termite trapping and bait station. The efficiency of bait station to destroy and eliminate the colonies of termites in the fields can be improved and enhanced by selecting appropriate wood, size of bait station and placement of bait. Wood possesses different characteristics. Wood density, nutritional values and presence of chemicals in them make the wood different from others. Therefore, more suitable and palatable wood is much important in trapping larger number of termite workers in the monitoring station. Measuring. foraging activity in sites of toxicant-bait application[13] or use of toxicant-bait consumption[14] is misleading because it may only represent bait avoidance by termites. Wood softness and palatability attract the larger number of termite workers in the baiting station. Recent study has shown the preference of *O. obesus* to 6 local wood species. Amongst the 6 wood species examined in the choice and no choice bioassay, the *M. indica* trees were found to be most palatable wood species since the *O. obesus* workers removed the more mass from these two woods. It has long trunk; it is used in timber structure and for making other wood structures. But its wood is not too hard and very susceptible to termite. Due to its light weight and softness, *O. obesus* preferred mango tree. Previous studies showed that soft woods are easy to eat and chew as compared to hard woods; therefore, termites prefer soft wood to feed. Our results match with the[14] who observed that wood hardness is a key factor in wood feeding by subterranean termites with maximum mass consumption rates for softwood compared to hard wood species.

Conclusion

Results of studies of this type are important to determine the levels of preservative treatments required to protect timbers in regions with high termite pressure, and to identify naturally durable woods that may not require preservative treatment. Natural durability is an area of increasing interest due to the interest of policy makers in reducing migration of industrial chemicals into the environment.

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Conflicts of interest

Author declares there is no conflict of interest in publishing the article.

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