Pakistan J. Zool., pp 1-8, 2024. DOI: https://dx.doi.org/10.17582/journal.pjz/20240104124453

Effect of Drying Temperature on Resistance of Commercial and Non-Commercial Woods Against *Microtermes obesi* (Holmgren) under Laboratory and Field Conditions

Syed Shamsheer Abbas Ali Shah[1], Ayesha Aihetasham[1]* and Khalid Zamir Rasib[2]

[1]*Institute of Zoology, University of the Punjab, Lahore 54590, Pakistan.*
[2]*Institute of Molecular Biology and Biotechnology, The University of Lahore, Lahore, 54000, Pakistan*

Article Information
Received 04 January 2024
Revised 19 January 2024
Accepted 31 January 2024
Available online 22 March 2024 (early access)

Authors' Contribution
The experimental work was conducted by SSAAS under the supervision of AA and KZR. All authors have contributed equally to the manuscript write-up and data analysis.

Key words
Resistance, Commercial and non-commercial, Impact of drying temperature

ABSTRACT

Eight species of wood were tested for their natural resistance and to reveal feeding behavior of *Microtermes obesi*. In "No choice" laboratory experiments, *Melia azedarach* Linn was found highly resistant and *Populus alba* highly palatable. The impact of drying temperature (60°C, 70°C, 80°C, 90°C and 100°C) was studied. The amount of wood consumed in general, increased with increase in drying temperature indicating that heat contributed to the loss of natural resistance components of the woods. When *M. obesi* was given a choice and the woods were offered in combination of two, this termite species repeated its instinct, easily identified the more preferred wood and consumed more of it. Consequently, *M. obesi* showed maximum feeding on *P. alba* and the minimum on *M. azedarach* Linn.

INTRODUCTION

As being susceptible basic structural material, wood is attacked by wood destroying insects such as termites (Indrayani *et al*., 2014). Significant structural damages might be result of attack, leading to early replacement and reduction of service life wooden structure (Acda, 2004). Yet the other recognized severe damage by termites is damage to buildings (Ugbomeh and Diboyesuku, 2019).

The mutual interaction of termites, bacteria and fungi to digest food causes organic waste to decompose (Su *et al*., 2016; Zhou *et al*., 2019). Termites have different feeding preferences based on quality and composition of phytochemicals (Fraga *et al*., 2020). Carbohydrate rich timber thus provides the required nutrients to termites (Poissonnier *et al*., 2018). As time goes on, baiting issuccessful in diverse ecosystems and useful for tracking termite activity (Davies et al., 2021).

Subterranean termites have a deep relationship with soil habitat, where they dig tunnels to find food and water including timber, broken lumber and other items having cellulose (Suiter *et al*., 2009) and also having a habit of moving by forming networks in the ground (Im and Han, 2020). Termites are also seen in human settlements, besides being found in nature where they attack various valuable properties. They consume a wide range of wood worldwide however some wood species are resilient to termites or containing compounds that prevent them from feeding. Strong accepted parameter like palatability is used to determine consumption rate for natural selection of wood species by termites but certain wood species are resistant and least preferred by termites (Rasib *et al*., 2014).

More than 3,000 termite species have been identified in tropics, subtropics and temperate regions (Su and Scheffrahn, 2000; Ali *et al*., 2021). Conversely, only 183 species of the studied varieties (Hassan and Morrell, 2021) from the world's tropical and subtropical climates significantly harm structures, furniture and other timber products (Hassan *et al*., 2017). Termites, one of the most destructive pests in the tropics, cause significant damages to forestry, agriculture and homes (Ahmed *et al*., 2016; Rasib *et al*., 2022). The termite community represents high species diversity (Akpan *et al*., 2020).

Fifty-three species of termites make up Pakistan's termite fauna, 13 of which are considered enemies of forests, buildings and agriculture (Hassan, 2017). *Microtermes*

* Corresponding author: ayesha.zool@pu.edu.pk
0030-9923/2024/0001-0001 $ 9.00/0

and *Odontotermes* species are prominent agricultural crop pests in Pakistan among fungus growing termites (Akhtar and Sarwar, 2003). Due to their diverse eating patterns, subterranean termites consume nearly every sort of fibrous material (Rasib *et al*., 2014; Afzal *et al*., 2017).

Coptotermes (Rhinotermitidae), being a destructive pest, is greatly dispersed beyond its original Southeast Asian region and has deteriorated live trees like poplar, mulberry and *Dalbergia sissoo* (Gentz *et al*., 2008). It is widely distributed in Bangladesh, Pakistan, and India (Ramdev and Sharma, 2013). In various regions of Punjab, *C. heimi* along with *Odontotermes* and *Microtermes* is found abundantly (Ahmed *et al*., 2006, 2007). Since Pakistan enjoys a variety of climates, from tropical to moderate, it has a vast variety of morphological and meteorological factors that are ideal for supporting a wide range of termite fauna. The goal of this study was to evaluate *M. obesi*'s preference for eight different woods dried at varying temperatures under both choice and no-choice feeding.

MATERIALS AND METHODS

Termite collection

Termite workers were collected from different areas of Gujranwala District, including Nowshera virkan (31.9630° N, 73.9742° E), Kamoki (31.9900°N, 74.3822°E), Gujranwala sadder (32.1667°N, 73.8333°E) and Gujranwala city (32.166351° N, 74.195900° E), and from agricultural crops and fallen logs infested with termites under natural conditions in hot rainy weather from mid June 2022 to August 2022 by using camel brush.

Termites were also collected by baiting them with sugarcane stalks to obtain maximum number of termites. The collection of termites was also carried out using artificial baiting methods, such as bucket traps and plastic bottles with small holes at the base as well as on the sides to permit the entry of termites into the baits. The baits were buried in the soil to a quarter of their length and regularly inspected twice a month (Rasib *et al*., 2017; Rasib and Ashraf, 2014). By using the identification keys the specimen was recognized as *M. obesi* (Ahmad, 1955; Akhtar, 1983). Only healthy and active termites were used for bioassays. The soil was taken from the garden area of Govt. High School Babbar Nowshera virkan, Gujranwala, sieved and then oven dried for 24 h at 70 °C (Aihetasham and Iqbal, 2012).

Selection of wooden species

Some significant commercial and non-commercial wooden species of economic importance were selected from different areas of District Gujranwala. Most of the wooden species were cut from standing trees except *Alstonia scholaris* (Alstonia), *Populus alba* (Papalar) and *Ficus benjamina* (Ficus). They were taken from commercial timber yard. Many diverse varieties of trees were present, but 8 different types of trees of economic importance were selected for choice and no-choice bioassay under both laboratory and field conditions. These species were *Psidium guajava* (Guava), *Alstonia scholaris* (Alstonia), *Populus alba* (Papalar), *Ficus benjamina* (Ficus), *Ficus benghalensis* (Bargad), *Azadirachta indica* (Neem), *Melia azedarach* Linn (Dharaik) and *Melia pinnata* (Sukhchain). Each wood was cut in blocks of size of 10×5×1 cm. Fine grade sandpaper was used to smooth the sides of the block to encourage active foraging, as termites are uncomfortable with rough surfaces. The blocks were dried at 60°C, 70°C, 80°C, 90°C and 100°C for 48 h before exposure to termites. The moisture content of woods was altered after drying, so distilled water was used to maintain the moisture levels.

No-choice assays under laboratory conditions

Dried wooden blocks were placed in glass beakers and 300 worker termites were released in each beaker. The wooden block was kept suitably moist. Three replicates of wooden blocks were used for each wood. Glass beakers were maintained at 27°C for 8 weeks in Govt. High School Babbar Nowshera virkan, Gujranwala. At the end of the test period the blocks were dried at the same temperature at which they were dried before exposing to termites. The wood consumption was calculated by applying the formula: WL= (W1-W2)/ W1 x100. Moreover, termite survivorship was recorded and the formula shown below was used to compute per individual's wood consumption = (W1-W2)/N. W1 is pre weight and W2 is post weight of the timber blocks and N is the number of workers (*M. obesi*). WL stands for the wood loss.

Choice assays under laboratory conditions

Paired choice tests were conducted to compare the preference of *M. obesi* for *P. guajava* vs *A. scholaris* (PG/AS), *F. benghalensis* vs *F. benjamina* (FB/FB), *P. alba* vs *A. indica* (PA/AI) and *M. azedarach* Linn vs *M. pinnata* (MA/MP). Timber blocks were arranged in combinations to assess the mass loss by comparing one wood pair with another pair. This feeding preference comparison was considered to be more indicative of a feeding choice that termites encounter in their natural environment. Therefore, termites had the choice of consuming whichever wood block they chose and avoiding those that they did not prefer or find palatable. Each pair of test or wood blocks was placed in a glass beaker and 300 worker termites were introduced into it. The glass beakers were maintained under the same conditions as in the no-choice trials, i.e., at 27°C for 8 weeks. The wood consumption rate was calculated using the following formula: WC= W1-W2; Where WC is the weight of wood consumed, W1 is the pre-weight and W2 is the post-weight of particular timber blocks.

No choice assays under field conditions

Three replicas of each type of dried wood were knotted into distinct bundle and placed 30 cm below the surface near termite-destructive timbers in botanical garden of Gulshan E Iqbal Park Gujranwala, and Govt. High School Babbar Nowshera virkan, Gujranwala. Sugarcane molasses were applied to every replica as a termite attractant and moisture preserver. All bundles were taken out of the field at the conclusion of the field experiment after 8 weeks, weighted again and dehydrated at the same temperature as before even being exposed to termite. The proportion of mass loss caused by *M. obesi* in the wood blocks was calculated as before.

Choice assays under field conditions

Three replicates of each dried timber blocks were tied and arranged together using wire and buried 30 cm deep into the soil, vertically as well as horizontally, into different locations of botanical garden of Gulshan E Iqbal Park and Govt. High School Babbar Nowshera virkan, Gujranwala. The paired timber blocks were removed to estimate the wood consumption rate by applying the following formula: WC= W1-W2. W1 and W2 are pre and post weight of particular wooden blocks.

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 analyzed using a paired comparison t-test. Similarly, the percentage of mass loss in wood species in the no-choice field trails was analyzed using Tukey's test.

RESULTS

No-choice under laboratory conditions

Table I shows wood consumption (mg) and percent wood consumption both in laboratory and field conditions, whereas Table II shows percent survival of termites

Table I. Amount of wood consumed (mg and %) by *M. obesi* in 8 weeks under no-choice laboratory and field conditions. Figure in parenthesis indicate consumption.

Wooden blocks*	Laboratory conditions					Field conditions				
	60°C	70°C	80°C	90°C	100°C	60°C	70°C	80°C	90°C	100°C
P. alba	10000.64± 58.02e (28.5%)	12000.79± 60.79d (34.2%)	16000.21± 62.64c (45.7%)	19000.23± 65.09b (54.2%)	22000.91± 67.95a (62.8%)	18000.3± 58.02e (51.4%)	19000.77± 60.79d (54.28%)	20000.11± 62.64c (57.14%)	22000.12± 65b (62.85%)	24000.9± 67.95a (68.57%)
F. benghalensis	3000.9± 6.06e (8.5%)	5000.6± 8.83d (14.2%)	8000.33± 10.68c (22.8%)	13000.34± 13.04b (37.1%)	18000.12± 15.99a (51.4%)	5000.66± 40.76e (14.28%)	7000.33± 43.53d (20%)	13000.22± 45.37c (37.14%)	17000.11± 47.74b (48.57%)	21000.12± 50.69a (60%)
P. guajava	3500.88± 40.76e (10.0%)	4500.66± 43.53d (12.8%)	6000.09± 45.37c (17.1%)	12000.11± 47.74b 1 (34.2%)	17000.01± 50.69a (48.5%)	3500.72± 11.77e (10%)	7500.45± 14.54d (21.43%)	10000.9± 16.39c (28.57%)	15000.92± 18.76b (42.86%)	19000.48± 21.7a (54.28%)
F. benjamina	1200.45± 63.79e (3.4%)	2000.56± 66.56d (5.7%)	3000.42± 68.41c (8.5%)	9000.9± 70.78b (25.7%)	15000.56± 73.72a (42.8%)	3000± 63.79e (8.57%)	5000.67± 66.56d (14.28%)	7000.93± 68.41c (20%)	15000.04± 70.78b (42.85%)	19000.01± 73.72a (54.28%)
A. scholaris	3000.22± 11.77e (8.5%)	5000.23± 14.54d (14.2%)	6000.25± 16.39c (17.1%)	10000.24± 18.76b (28.5%)	15000.29± 21.71a (42.8%)	5000.7± 63.97e (14.28%)	7000.78± 66.74d (20%)	1000.48± 68.58c (2.85%)	15000.75± 70.95b (42.85%)	17000.17± 73.9a (48.57%)
M. pinnata	1000.62± 5.83e (2.8%)	1500.66± 8.60d (4.2%)	2000.41± 10.45c (5.7%)	5000.93± 12.81b (14.2%)	7000.23± 15.76a (20.0%)	1500.74± 35.04e (4.28%)	3500.79± 95.55d (10%)	5000.7± 97.39c (14.28%)	6000.76± 99.76b (17.14%)	9000.77± 102.71a (25.71%)
A. indica	50.25± 2.19e (0.14%)	150.15± 4.96d (0.42%)	200.99± 6.81c (0.57%)	900.34± 9.17b (2.5%)	1200.66± 12.12a (3.4%)	300± 46.53e (0.85%)	600.79± 49.3d (1.71%)	1000.9± 51.15c (2.86%)	1500.64± 53.52b (4.28%)	1700.54± 56.46a (4.85%)
M. azedarach Linn	10.7± 0.98d (0.03%)	25.65± 3.17d (0.07%)	50.25± 5.02c (0.14%)	100.1± 7.39b (0.28%)	200.35± 10.33a (0.57%)	80.6± 0.98e (0.23%)	150.15± 3.17d (0.42%)	300.96± 5.02c (0.86%)	700.99± 7.39b (2%)	1000.03± 10.33a (2.85%)

*Three replicates (Mean±SD). Values in rows having no common superscript are significantly different (P<0.05) (Duncan's test).

(*M. obesi*) on different wooden blocks dried at different temperatures. The no-choice feeding trials under laboratory conditions indicate that maximum wood consumption was observed on the wooden blocks of *P. alba* dried at 100°C among the 8 different wood species when tested against *M. obesi.* However, minimum consumption was recorded on wooden blocks of *M. azedarach* Linn when dried at 100°C. Survival of termites also showed an increase with increase in temperature at which the blocks were dried.

Table II. Survival (%) of *M. obesi* under no-choice laboratory trials on wooden blocks dried at different temperatures after 8 weeks exposure.

Wood species	Survival (%) at different temperature				
	60°C	70°C	80°C	90°C	100°C
P. alba	34.3	45.3	57.3	65.3	75.3
F. benghalensis	15.3	19	27.3	41.6	56
P. guajava	15.6	17	22.3	39.6	53
F. benjamina	8.6	12.3	14.6	28	47.3
A. scholaris	13	19.3	22.6	33	47
M. pinnata	10.3	13.6	15	19.3	25.6
A. indica	5.3	6	7.3	9.6	13.3
M. azedarach Linn	3.3	4.6	5.3	6.6	7.3

M. obesi consumed wood blocks dried at 60°C in the following order *P. alba* > *P. guajava* > *A. scholaris* > *F. benghalensis* > *F. benjamina* > *M. pinnata* > *A. indica* > *M. azedarach* Linn. Wooden blocks dried at 100°C were consumed with following preference *P. alba* > *F. benghalensis* > *P. guajava* > *F. benjamina* > *A. scholaris* > *M. pinnata* > *A. indica* > *M. azedarach* Linn (Table I).

Generally, survival of workers of *M. obesi* increased with the increase of temperature. The survival on wooden blocks dried at 60°C was as in the descending order: *P. alba* > *P. guajava* > *F. benghalensis* > *A. scholaris* > *M. pinnata* > *F. benjamina* > *A. indica* > *M. azedarach* Linn. When wooden blocks were dried at 100°C the above trend was as *P. alba* > *F. benghalensis* > *P. guajava* > *F. benjamina* > *A. scholaris* > *M. pinnata* > *A. indica* > *M. azedarach* Linn. The percent survival at 100°C was much higher compared to 60°C. The percentage increase of survival at 100°C compared to that of 60°C was 75.33% for *P. alba,* 56% for *F. benghalensis*, 53% for *P. guajava*, 47.33% for *F. benjamina,* 47% for *A. scholaris,* 25.66% for *M. pinnata*, 13.33% for *A. indica* and 7.33% for *M. azedarach* Linn (Table II).

From above results, it can be concluded that wood consumption preference by *M. obesi* was variable according to the kind of wooden species and this change in feeding preferences with increased temperature can be credited to two reasons, either this termite species feeding behavior was different from other termite species or exposing woods to termites, were distinctly different and fed variably and therefore might give different results.

Choice under laboratory conditions

The termite workers easily identified the palatable wood from paired wood. At 60°C, maximum wood consumption was observed on *P. alba* and minimum consumption was observed on *M. azedarach* Linn (Table IV). Wood consumption was increased with the increased temperature treatment and survival rate also vary (Tables III and IV).

Table III. Survival (%) of *M. obesi* under choice laboratory trials on wooden blocks dried at different temperatures after 8 weeks exposure.

Wood combination*	Survival (%) at different temperature				
	60°C	70°C	80°C	90°C	100°C
P. alba/ A. indica	40/3	48/4	60/6	68/11	78/11
F. benghalensis/ F. benjamina	13/13	14/17	15/22	30/33	53/47
P. guajava/A. scholaris	13/12	19/13	26/16	39/24	50/37
M. azedarach Linn/ *M. pinnata*	1/8	3/9	3/13	5/20	7/27

*Each wooden block was paired with a wooden block of other species (Wood-1/Wood-2) in a glass beaker containing 300 workers of *M. obesi.*

At 100°C, the maximum preferred wood was *P. alba* by *M. obesi*. It shows that increased in temperature had profound impact on the wood resistance against *M. obesi*.

Table III shows percent survival of termite workers in choice feeding laboratory trials on different combination of wooden blocks at different temperatures. At 60°C, the percent survival in descending order was as follows: *P. alba* vs *A. indica* (PA/AI) > *F. benghalensis* vs *F. benjamina* (FB/FB) = *P. guajava* vs *A. scholaris* (PG/AS) > *M. azedarach* Linn vs *M. pinnata* (MA/MP). At 100°C, this order was as follows: *P. alba* vs *A. indica* > *F. benghalensis* vs *F. benjamina* > *P. guajava* vs *A. scholaris* > *M. azedarach* Linn vs *M. pinnata.*

No- choice under field conditions

Among 8 species of woods, maximum percentage of mass loss (18 g) at 60°C under no-choice field conditions was recorded on wooden blocks of *P. alba* and minimum mass loss (80.6 mg) was observed on wooden blocks of *M. azedarach* Linn. Maximum consumption was observed at

Table IV. Consumption of wood in mg (Mean±SD) by *M. obesi* in choice feeding experiments under laboratory and field conditions dried at different temperatures. The wood combinations offered were *P. alba*/*A. indica* (PA/AI), *F. benghalensis*/*F. benjamina* (FB/FB), *P. guajava*/*A. scholaris* (PG/AS) and *M. azedarach* Linn/*M. pinnata* (MAL/MP).

Temperature (°C)	Wood combination[a]	Laboratory conditions			Field conditions		
		Wood 1 (n=3)	Wood 2 (n=3)	P-value[b]	Wood 1 (n=3)	Wood 2 (n=3)	P-value[b]
60°C	(PA/AI)	12000.44±92.66	30.95±5.83	0.00***	19000.01±92.66	100.98±5.83	0.001***
	(FB/FB)	1500.33±58.02	2500.92±63.79	0.04*	3000.72±57.96	3000.56±52.19	0.05*
	(PG/AS)	3500.9±40.58	1000.66±52.19	0.03*	6000.55±40.58	4500.23±58.02	0.02*
	(MAL/MP)	5.39±1.44	900.98±17.66	0.001***	50.65±1.44	2000.07±46.53	0.006**
70°C	(PA/AI)	14000.56±95.43	70.29±8.6	0.00***	20000.84±95.43	200.25±8.6	0.00***
	(FB/FB)	2200.44±60.79	4500.83±66.56	0.01**	5500.01±60.73	5000.78±54.96	0.03*
	(PG/AS)	5500.89±43.35	2000.21±54.96	0.01**	9000.88±43.35	7000.45±60.79	0.02*
	(MAL/MP)	10.85±4.21	1500.8±20.43	0.001***	200.35±4.21	3500.03±49.3	0.007**
80°C	(PA/AI)	17000.33±97.28	100.35±10.45	0.00***	21000.66±97.28	500.99±10.45	0.003**
	(FB/FB)	3000.12±62.64	6000.19±68.41	0.01**	11000.62±62.58	9000.14±56.81	0.01**
	(PG/AS)	7000.92±45.20	3000.52±56.81	0.009**	12000.52±45.2	10000.54±62.64	0.02*
	(MAL/MP)	20.66±6.06	2000.24±22.28	0.001***	500.89±6.06	5000.12±51.15	0.001***
90°C	(PA/AI)	19000.01±99.65	1000.39±12.81	0.002**	23000.02±99.65	1000.57±12.81	0.04*
	(FB/FB)	10000.28±65	10000.33±70.78	0.05*	17000.44±64.95	12000.21±59.17	0.01**
	(PG/AS)	12000.61±47.57	7000.26±59.17	0.008**	15000.65±47.57	13000.11±65	0.03*
	(MAL/MP)	100.89±8.42	5000.3±24.65	0.003**	700±8.42	8000.59±53.52	0.001***
100°C	(PA/AI)	21000.9±102.59	1200.41±15.76	0.001***	24000.06±102.59	1200.55±15.76	0.005**
	(FB/FB)	18000.5±67.95	15000.45±73.72	0.01**	19000.34±67.89	17000.34±62.12	0.02*
	(PG/AS)	16000.11±50.51	12000.52±62.12	0.005**	18000.15±50.51	16000.86±67.95	0.01**
	(MAL/MP)	150.5±11.37	7000.4±27.59	0.001***	900.89±11.37	9800.53±56.46	0.006**

[a]Each wooden block was paired with a wooden block of other species (Wood-1/Wood-2) in a glass beaker containing 300 workers of *M. obesi.* [b]Difference in mass loss for each pair of wooden block indicated by *=0.05, **=0.01 and ***=0.001 are significantly different (Paired comparison t-test).

100°C on wooden blocks of *P. alba* was 24g and minimum consumption observed on wooden blocks of *M. azedarach* Linn was 1g (Table I). From these results, it can be concluded that *M. azedarach* Linn was least preferred by *M. obesi* and therefore can be classified as highly resistant. On the other hand, *P. alba* was highly susceptible and palatable.

Choice under field conditions

In choice field trials two different wooden blocks were given to the termites (*M. obesi*). At 60°C, the maximum wood consumption was observed in following order *P. alba* vs *A. indica* > *P. guajava* vs *A. scholars* > *F. benghalensis* vs *F. benjamina* > *M. azedarach* Linn vs *M. pinnata.* At 100°C, the maximum consumption was observed on *P. alba* and minimum consumption was on *M. azedarach* Linn. (Table IV). At 100°C, the impact of temperature on wood consumption of *P. alba* was significantly maximum from all woods combinations. It means increase temperature had significantly decreased the resistance of wood to termite attack (Table IV).

DISCUSSION

For the life span of tree species feeding hindrance is a serious indicator. Main objectives of this study were to illuminate effect of drying temperatures on wood species and which species of wood shows natural hindrance and palatability against *M. obesi*. In our study, the results of wood consumption showed that *M. azedarach* Linn, *A. indica* and *M. pinnata* were natural resistant wood species against *M. obesi's* attack. Physical and antifeedant bioactive chemical contents like hardness of bark, heartwood and sapwood may hinder the feeding activity of termite. The terpenoids, phenol and quinines like organic constituents causing vary in the degree of resistance of wood species against termites (Yohannes, 2006). In the current findings, choice feeding conditions were more successful than no-choice assays for determining wood resistance against termites because in no-choice sources termites were forced to feed whatever source was available for food. It is found that *M. obesi* in the laboratory choice bioassays could easily differentiate most palatable and resistant wood.

Getachew *et al*. (2003) suggesting some termites species showed a propensity for definite wood preferences, like fast growing tissues of wood, e.g. spring wood growth, that produce large cells with thin cell walls and fibers mostly preferred by dry wood termites. In this study, it was also concluded that natural preservatives and antifeedant properties of wood species may cause resistance against termite's attack. *M. azedarach* Linn has high antifeedant property, which helped for its avoidance against *M. obesi* than *P. alba*; similarly, *A. indica* and *M. pinnata* may have natural preservatives that showed high resistance. It has been tested that various environmental factors such as moisture contents, lignifications attack by fungus may increase wood susceptibility and age of wood which determine its compactness (Pearce, 1997; Qureshi *et al*., 2012a). In this study, wood blocks of *P. alba* and *F. benghalensis* have high consumption rate against *M. obesi* compared to all other wood species. On other hand, *M. azedarach* Linn, *A. indica* and *M. pinnata* were antifeedant against termite workers.

Similarly, effect of drying temperature (40, 50, 60, 70 and 80°C) on feeding behavior of *M. championi* was studied by Aihetasham and Iqbal (2012). It was found that increase in drying temperature caused decrease in the resistance of eight different commercial wooden species. The most palatable wooden species for *M. championi* was *A. arabica,* whereas the less palatable wooden species was *T. grandis*. The feeding propensity of *M. championi* (Snyder) was in following order: *Acacia arabica* > *Ficus religiosa* > *Azadirachta indica* > *Morus alba* > *Melia azederach* > *Mangifera indica* > *Cedrus deodara* > *Tectona grandis.*

In ongoing investigation, a strong association between temperature, wood consumption (mg) and the percent survival of termite was found. The increase in drying temperatures was discovered to be directly correlated with *M. obesi*'s preferred feeding regime. Also, it was shown that *M. azedarach* Linn and *A. indica* were very resistant to *M. obesi*, which is consistent with findings from earlier studies (Manzoor *et al*., 2009; Shanbhag and Sunararaj, 2013).

In a laboratory experiment with no option, termite mass loss of wood at 100°C ranged from 200.35 mg to 22g (Table I). The physical and chemical characteristics of the timber may be the reason of the variance in the loss of mass. The percentage of workers of *M. obesi* that successfully survived on *P. alba* was 75.33%, whereas, the percentage of termites that successfully survived on *M. azedarach* Linn's blocks was 7.33% dried at 100°C (Table II). According to Rasib *et al*. (2014) *O. obesus* workers were unable to endure after no-choice feeding in fourteen days laboratory tests. Yet, our results largely agree with those that have been published. Several experts have examined the termite's feeding preferences and determined that some types of woods are highly resistant to termite assault and eating. Qureshi *et al*. (2012b) had investigated that due to presence of bioactive chemicals in wood species, may cause the resistance and repellent against certain wood feeding insects, termite attack and even termite death either entirely or partially upsetting the chemical makeup of mutually beneficial microorganisms like flagellates and bacteria.

It is intimated that if we can isolate resistance active ingredients from extractives of resistant wood species then be able to produce them economically on large scale. The findings of feeding assays both in field and laboratory conditions are also assuring to indicate a wide range of resistance of wood species against *M. obesi*, which might be a turning point for baiting technology and feeding behavior of termites. It is revealed from the findings of present study that wood resistance and susceptibility may prove important measures for wood prevention against termite attack. It is also intimated from the present investigations that resistance among wood species may be reduced due to effect of drying temperatures (60°C, 70°C, 80°C, 90°C and 100°C).

The present experiments revealed that among the 8 woods species experimented; the most attractive was *P. alba* that can be used as bait attractant to enhance baiting performance for the control of *M. obesi* in commercial stores and household furnishers. The present study also recommends that the natural durability is an important feature to identify and explore the wood species that can reduce the use of chemical termiticides which are expensive and harmful to environment. Furthermore, the findings of present study also revealed the impact of drying temperature (60°C, 70°C, 80°C, 90°C and 100°C) on wood species resistance.

CONCLUSION

This study concludes that *M. azedarach Linn*, *A. indica* and *M. pinnata* have efficient resistance against *M. obesi*. It recommends the durability that increases the use of these species as wooden structures and suppresses the exploitation of chemical pesticides against termites. The present study also revealed that the *P. alba* and *F. benghalensis* were most palatable woods to *M. obesi* which can be used in baiting technology to control termite infestation. Furthermore, the impact of drying temperature showed that the wood consumption generally increased with increasing drying temperature (60°C, 70°C, 80°C, 90°C and 100°C) indicating that heat contributed to the loss of natural resistant components of woods.

IRB approval

The experimental work was approved by Advanced Studies and Research Board (ASRB) of the University of the Punjab, Lahore, Pakistan.

Funding

The study received no external funding.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Acda, M.N., 2004. Economically important termites (Isoptera) of the Philippines and their control. *Sociobiology,* **43:** 159-168.

Afzal, M., Qureshi, N.A., Rasib, K.Z. and Hussain, I., 2017. Resistance of commercial and non-commercial woods against *Heterotermes indicola* Wasmann (Blattodea: Rhinotermitidae) in laboratory and field conditions. *Pakistan J. Zool.,* **49:** 785-792. https://doi.org/10.17582/journal.pjz/2017.49.3.785.792

Ahmad, M., 1955. Termites of West Pakistan. *Biologia,* **1:** 202–264.

Ahmed, N., Huma, Z., Haq, M.U., Rehman, S., Ullah, M. and Ahmed, S., 2016. Effect of different plant extracts on Termite species (*Heterotermes indicola*). *J. Biores. Manage.,* **3:** 9-16. https://doi.org/10.35691/JBM.6102.0049

Ahmed, S., Khan, R.R. and Riaz, M.A., 2007. Some studies on field performance of plant extracts against termites (*Odontotermes guptai* and *Microtermes unicolor*) in sugarcane at Faisalabad. *Int. J. Agric. Biol.,* **9:** 398–400.

Ahmed, S., Mustafa, T., Riaz, M.A. and Hussain, A., 2006. Efficacy of insecticides on subterranean termites in sugarcane at Bhakkar. *Int. J. Agric. Biol.,* **8:** 508–551.

Aihetasham, A. and Iqbal, S., 2012. Feeding preferences of *Microcerotermes championi* (Snyder) for different wooden blocks dried at different temperatures under forced and choice feeding conditions in laboratory and field. *Pakistan J. Zool.,* **44:** 1137-1144.

Akhtar, M.S. and Sarwar, G., 2003. Termite population, diversity and damage in cotton fields of Bahawalpur division. *Pakistan J. Zool.,* **35:** 9-13.

Akhtar, M.S., 1983. Wood destroying termites (Isoptera) of Pakistan: Key to the most important species, their distribution and pattern of attack. *Mater. Organ.,* pp. 277–291.

Akpan, A.U., Ojianwuna, C.C., Ubulom, P.M.E., Yaro, C.A. and Oboho, D.E., 2020. Effects of Physico-chemical parameters on the abundance and diversity of termites and other arthropods in termite mounds in Uyo, AkwaIbom State, Nigeria. *Fudmen. J. Sci.,* **4:** 92-100. https://doi.org/10.33003/fjs-2020-0402-206

Ali, G., Rasib, K.Z., Arshad, M., Munir, A. and Amanat, T., 2021. Feeding preferences of subterranean termites, *Odontotermes obesus* (Ramber) (Blattoidea: Termitidae) in field and their control and developing bait strategies. *Egypt. Acad J. biol. Sci.,* **14:** 83-92. https://doi.org/10.21608/eajbsa.2021.151774

Davies, A.B., Parr, C. and Eggleton, P., 2021. A global review of termite sampling methods. *Insect Soc.,* **68:** 3-14. https://doi.org/10.1007/s00040-020-00797-y

Fraga-Corral, M., García-Oliveira, P., Pereira, A.G., Lourenço-Lopes, C., Jimenez-Lopez, C., Prieto, M.A. and Simal-Gandara, J., 2020. Technological application of tannin-based extracts. *Molecules,* **25:** Article No. 614. https://doi.org/10.3390/molecules25030614

Gentz, M.C., Rubinoff, D. and Grace, J.K., 2008. Phylogenetic analysis of subterranean termites (*Coptotermes spp*., Isoptera: *Rhinotermitidae*) indicates the origins of Hawaiian and North American invasions: potential implications for invasion biology. *Hawai. Ent. Soc.,* **40:** 1–9.

Getachew, D., Taddesse, W., Fekadu, W., Kaba, G., Teketay, D. and Taye, G., 2003. Effectiveness of protection measures of 32 timber species against subterranean termites and fungi at Ziway Research Station, Central Ethiopia. *Ethiop. J. biol. Sci.,* **2:** 189-216.

Hassan, B. and Morrell, J.J., 2021. Termite testing methods: A global review. *J. Test. Eval.,* **49:** 20200455. https://doi.org/10.1520/JTE20200455

Hassan, B., 2017. *Studies on the effect of wood extractives in combination with plant oil on subterranean termites.* PhD thesis, University of Agriculture, Faisalabad, Pakistan.

Hassan, B., Mankowski, M., Grant, K. and Sohail, A., 2017. Effects of heart wood extractives on symbiotic protozoan communities and mortality into termite species. *Int. Biodeterio. Biodegrad.,* **123:** 27-36. https://doi.org/10.1016/j.ibiod.2017.05.023

Im, I.G. and Han, G.S., 2020. Laboratory evaluation of the marking effect of sudan red 7b on subterranean termites (*Reticulitermes speratus*) in Republic of Korea. *J. Kore. Wood. Sci. Tech.,* **48:** 745-754. https://doi.org/10.5658/WOOD.2020.48.5.745

Indrayani, Y., Hikmayanti, A. and Takematsu, Y., 2014. *Survey on the infestation of school buildings by termites in Pontianak*. Proceeding of the 10th Pacific-Rim Termite Research Group Conference (TRG 10). Kuala Lumpur, Malaysia, 26-28.

Manzoor, F., Zameer, K., Saadiya, A.M., Cheema, K.J. and Rahmin, A., 2009. Comparative studies of two Pakistani subterranean termites (Isoptera: *Rhinotermitidae, Termitidae*) for natural resistance and feeding preferences in laboratory and field trials. *Sociobiology,* **53:** 259-274.

Pearce, M.J., 1997. *Termites: Biology and pest management*. CAB International, New York. https://doi.org/10.1079/9780851991306.0000

Poissonnier, L.A., Arganda, S., Simpson, S.J., Dussutour, A. and Buhl, J., 2018. Nutrition in extreme food specialists: An illustration using termites. *Funct. Ecol.,* **32:** 2531-2541. https://doi.org/10.1111/1365-2435.13200

Qureshi, N.A., Aziz Ullah., Ali, N., Akhtar, M. and Qureshi, Z.M., 2012a. Proto zoidal activities of *Eucalyptus cammeldulensis, Dalbergia sissoo* and *Acacia arabica* woods and their different parts on the entozoic flagellates of *Heterotermes indicola* and *Coptotermes heimi*. *Afr. J. Biotech.,* **11:** 12094-12102. https://doi.org/10.5897/AJB12.375

Qureshi, N.A., Qureshi, M.Z., Akhtar, M., Malik, N. and Aziz Ullah., 2012b. Fumigant toxicity of *Mentha arviensis* leaves extracts on *Coptotermes heimi*, *Heterotermes indicola* and their gut flagellates. *Sociobiology,* **59:** 1509-15019. https://doi.org/10.13102/sociobiology.v59i4.508

Ramdev, A. and Sharma, R.M.L., 2013. Bioeffacy of two traditional botanical insecticides against subterranean termites (*Coptotermes heimi*). *Ind. J. Fund. appl. Lif. Sci.,* **3:** 24–28.

Rasib, K.Z. and Ashraf, H., 2014. Feeding preferences of *Coptotermes heimi* (Isoptera: Termitidae) under laboratory and field conditions for different commercial and non-commercial woods. *Int. J. Trop. Insect Sci.,* **34:** 115–126. https://doi.org/10.1017/S1742758414000290

Rasib, K.Z., Ali, G., Munir, A. and Malik, A., 2022. Biotic and abiotic factors affecting the feeding behavior of subterranean termite *Odontotermes obesus* (Rambur) (Blattoidea: Termitidae) under field. *Pak. J. Scient. Indust. Res. Ser. B: Biol. Sci.,* **65B:** 292-296.

Rasib, K.Z., Ashraf, H. and Afzal, M., 2014. Feeding preferences of *Odontotermes obesus* (Rambur) (Isoptera: Termitidae) on different commercial and non-commercial woods from Lahore, Pakistan, under laboratory and field conditions. *Zoo. Ecol.,* pp. 1-10. https://doi.org/10.1080/21658005.2014.972044

Rasib, K.Z., Hidayat, W. and Aihetasham, A., 2017. Feeding preferences and control of a Pakistani termite *Odontotermes obesus* (Rambur) (Isoptera, Rhinotermitidae). *Annu. Res. Rev. Biol.,* **18:** 1-13. https://doi.org/10.9734/ARRB/2017/36225

Shanbhag, R.R. and Sundararaj, R., 2013. Physical and chemical properties of some imported woods and their degradation by termites. *J. Insect Sci.,* **13:** 1-8. https://doi.org/10.1673/031.013.6301

Su, L., Yang, L., Huang, S., Su, X., Li, Y., Wang, F., Wang, E., Kang, N., Xu, J. and Song, A., 2016. Comparative gut microbiomes of four species representing the higher and the lower termites. *J. Insect. Sci.,* **16**: 97; 1–9. https://doi.org/10.1093/jisesa/iew081

Su, N.Y. and Scheffrahn, R.H., 2000. Termites as pests of buildings. In: *Termites: Evolution, sociality, symbiosis, ecology* (eds. by T. Abe, D. E. Bignell and M. Higashi). Kluwer Academic Publishers, Dordrecht/Norwell. pp. 437–453. https://doi.org/10.1007/978-94-017-3223-9_20

Suiter, D.R., Jones, S.C. and Forschler, B.T., 2009. *Biology of subterranean termites in the Eastern United States*. University of Georgia, Athens, UGA, USA.

Ugbomeh, A.P. and Diboyesuku, A.T., 2019. Studies on termite infestation of buildings in Ase, a rural community in the Niger Delta of Nigeria. *J. Basic appl. Zool.,* **80:** 1-7. https://doi.org/10.1186/s41936-019-0100-8

Yohannes, G., 2006. *Evaluation of termite resistant plant attributes for their bioactivities against* Macrotermes *termites*. M.Sc. dissertation, Biology Department, Addis Ababa University.

Zhou, J., Duan, J., Gao, M., Wang, Y., Wang, X. and Zhao, K., 2019. Diversity, roles, and biotechnological applications of symbiotic microorganisms in the gut of termite. *Curr. Microbiol.,* **76:** 755–761. https://doi.org/10.1007/s00284-018-1502-4