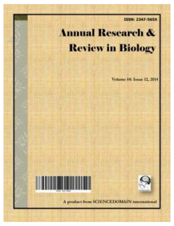

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Feeding Preferences and Control of a Pakistani Termite *Odontotermes obesus* (Rambur) (Isoptera, Rhinotermitidae)

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Authors' contributions

This work was carried out in collaboration between all authors. Author KZR designed and conceived the idea of the study and wrote the first draft of the manuscript. Author WH carried out statistical work and graphs. Author AA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Feeding preferences of *Odontotermes obesus* on five different commercial wood species were studied under choice and no choice trials both in laboratory and field conditions. Feeding preferences as a quantitative parameter of wood consumption by *O. Obesus* were recognized as follows: *Cupressus sempervirens linn >Ficus microphylapers > Ficus banghalensis linn > Ficus relgiosa linn > phylanthus embicallium*. Toxicity and LC_{50} value of fipronil, Imidacloprid indicate that Imidacloprid is more toxic than fipronil based on LC_{50} values.

Results: The wooden species used under lab no choice bioassays were follows as, *Cupressus sempervirens linn, Ficus microphylapers, Ficus banghalensis, Ficus relgiosa linn and Phylanthus emblicallium.* Survival rate, Weight loss and mean consumption were calculated. Mean wood mass loss (mg) in five different wood pairs when exposed in combination to *Odontotermes obesus* for CS/FM (*Cupressus sempervirens linn* and *Ficus microphylapers*), FM/FR (*Ficus microphylapers* and Ficus relgiosa lin), FR/FB (*Ficus relgiosa linn* and *Ficus banghalensis linn*), FB/PE (*Ficus*

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banghalensis linn and *Phylanthus emblicallium*), PE/CS (*Phylanthus emblicallium* and *Cupressus sempervirens linn*) in 2 week choice under field conditions. Maximinm consumption (mg) was recorded pair of PE/CS (*Phylanthus emblicallium* Vs. *Cupressus sempervirens linn*). *Cupressus sempervirens linn* was found to be the most palatable wood species whereas *Phylanthus emblicallium* proved the most resistant one. Minimum feeding was recorded in *Ficus banghalensis linn* (2.9 mg) and maximum in *Cupressus sempervirens linn* (9.3 mg). Whereas under no choice field conditions. Minimum feeding was recorded in *Phylanthus emblicallium* (4.8 mg) and maximum on *Cupressus sempervirens linn* (11.8 mg). Feeding preferences as a quantitative parameter of wood consumption by *O. Obesus* were recognized as follows: *Cupressus sempervirens linn* >*Ficus microphylapers* > *Ficus banghalensis linn* > *Ficus relgiosa linn* > *phylanthus embicallium*. Toxicity and LC_{50} value of fipronil, Imidacloprid indicate that Imidacloprid is more toxic than fipronil based on LC_{50} values.

Conclusions: When resistant tree species are planted in combination with those of susceptible in natural environment then the termite infestation rate could be minimised to a greater extent. Natural durability is an area of increasing attention that can help in reducing the application of industrial chemicals in the surroundings. A broader diversity of trees is needed in our urban landscapes to guard against the possibility of large-scale devastation by both native and introduced insect including pest termites. Tree diversity in forests is an important driver of ecological processes including herbivory.

Keywords: Odontotermes obesus; wooden species; LC_{50}; fipronil; imidacloprid; feeding preferences.

1. INTRODUCTION

Termites belong to order Isoptera, completely social insects with an astonishing range of morphological forms. The factors affecting wood consumption by termites are numerous and highly interrelated. It has been widely accepted that wood species palatability is one of the influential parameters of termite wood consumption [1-2]. Wood feeding preferences and resistance will vary with the hardness, lignin content or chemical constitution of the wood. The presence of organic chemicals, e.g. Phenol, quinones, terpenoids, and high concentration of lignins may also affect the areas where feeding takes place. The pH of wood content might also be important. Sapwood, which has more starch and sugar, is generally preferred to heartwood. Many of the indigenous trees are therefore more resistant to termite attack and have developed chemical defenses to protect themselves. These chemical defenses may be present to a greater level in immature trees and crops, making these even less susceptible. The chemical concentrations in trees can vary from the outside to the inside. Older trees may develop cracks in the bark, and the resistant chemicals may not reside near the outer layers of the tree potentially allowing termite attack to occur [3]. The preference of termites to a particular wood species could be altered by the wood combination offered to them [4-6]. The choice feeding test was a more appropriate method to be used in determining termite wood preference than no choice test (forced-feeding) because in the later test method, termites were forced to feed on whatever resource was available for survivorship [7]. 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. A study by sheikh et al. [8] 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 [9]. Heartwood and sapwood contains maximum concentration of components and top of stem contains minimum [10]. Sometimes the presence of essential oils also protects plants from termite attack. [11] 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 [12]. 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 [13]. It was also studied by [14]. 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.

Different investigators have contributed in termite feeding preferences studies [15-32].

Investigators of termites and termite damage have noted that certain woods appear to have greater immunity to termite attack than others. [33] Suggested that the factors determining woods selected by termites in nature include moisture content, amounts and chemical nature of the wood extracts, physical hardness, differences between heartwood and sapwood, and the nature and extent of pre-existing fungus attack. They suggested, for example, that the high death rate of termites in redwood may be due to the lethal effect of redwood extract on protozoa of the termite gut. Wolcott [34-35] found that some highly resinous woods are termite resistant, as are woods with high lignin content. Marchan [36] reported relationship between lignin, ash, and protein content of various kinds of wood and their termite resistance. Keeping in view the damages caused by termites to the environment and the wood importance, the present study was aimed to compare feeding preferences in *Odontotermes obesus* and its control using Imidacloprid and Fipronil respectively.

2. MATERIALS AND METHODS

2.1 Collection of Termite

Termites were collected from the botanical garden at Forman Christian College Lahore, Pakistan in the heavy rainy season from July 15, 17 to mid August 12, 2017. Most of the termites were collected from infested dead logs that were present in the Botanical garden. Termites shifted in the Petri plates with some log pieces and brought to the laboratory to acclimatize them under lab conditions. All termites were handled with camel brush, only healthy and active termites were used for bioassays.

2.2 Selection of Woods

Some significant wood species of economic importance were selected from the Botanical garden of Forman Christian College Lahore, Pakistan. Many diverse varieties of trees were present, but five different types of trees of economically important species were selected for choice and no choice bioassay under both laboratory and field conditions. These species were *Cupressus sempervirens linn* with different dimensions (length x Diameter: 1.9x3.2 cm), *Ficus microphylapers* (1.8x3.5 cm), *Ficus relgiosa linn* (1.9x3.0 cm), *Ficus banghalensis linn* (1.8x3.2 cm) and *Phylanthus emblicallium* (2.3x2 cm). For choice lab conditions, *Cupressus sempervirens linn* and *Ficus microphylapers* (LxD: 1.8x3.2 cm and LxD: 1.3x2.8 cm), *Ficus microphylapers* and *Ficus relgiosa linn* (1.5x3.0 and 1.3x2.1 cm), *Ficus relgiosa linn* and *Ficus banghalensis linn* (1.3x3.1 and 2.0x2.6 cm), *Ficus banghalensis linn* and *Phylanthus emblicallium* (1.8x3.4 and 2.1x2.1 cm), *Phylanthus emblicallium* and *Cupressus sempervirens linn* (2.3x2.0 and 1.6x2.9 cm). For no choice field conditions were *Cupressus sempervirens linn* (2.3x3.0 cm), *Ficus microphylapers* (2.3x2.3cm), *Ficus relgiosa* (2.2x2.0 cm), *Ficus banghalensis linn* (2.3x2.1 cm), *Phylanthus emblicallium* (2.3x2 cm) and choice field conditions were *Cupressus sempervirens linn*/*Ficus microphylapers* CS/FM (2.3x3 and 2.2x2.3 cm), *Ficus microphylapers*/*Ficus relgiosa linn* FM/FR (2.2x2.1 and 2.2x2.3 cm), *Ficus relgiosa linn*/*Ficus banghalensis linn* FR/FB (2.2x2.1 and 2.2x2.0 cm), *Ficus banghalensis linn*/*Phylanthus emblicallium* FB/PE (2.2x2.0 and 2.2x2.1cm), *Phylanthus emblicallium*/*Cupressus sempervirens linn* PE/CS (2.0x2.3 and 2.3x2.6 cm). All wooden samples were taken from the heart wood because termites mostly favour heart wood, sap wood and bark of the plants. All samples were cut into appropriate dimensions and rubbed into smooth surfaces using sand paper. All wooden species were tested under no choice and choice bioassays separately and desiccated at 60°C for feeding preferences.

2.3 Laboratory Feeding Bioassays

2.3.1 No choice bioassay under laboratory conditions

All wooden blocks were oven dried at 60°C for 24 hours to avoid contaminants. Only one type of block was placed in a glass Petri dish. A total of 40 worker termites were released in each petri dish (Three replicates were maintained). Feeding activity and termite survival was facilitated by maintaining moisture content by using distilled water. The Petri dishes were maintained at 25°C and set up was maintained up to 14 days. At the completion of bioassay, the blocks were again dried at the same temperature used before exposing to termites. The wood consumption was calculated by applying the formula.

$$W_L = (W_1 - W_2)/ W_1 \times 100$$

The survival of termites was also recorded. Wood consumption/individual were also calculated using the following formula:

$$(W_1-W_2)/N$$

Where W_L stands for the wood loss, W_1 is the pre-weight of wood, W_2 is the post-weight of wood and N shows the number of initial workers.

2.3.2 Choice bioassay under laboratory conditions

Paired choice tests were conducted for comparing termite preferences for different woods preferences. Wooden blocks arranged in combinations were used to assess the mass loss by the comparison of one wood pair with another and was considered to be indicative of a feeding choice between palatable and non preferred wood that is encountered by termites in their natural environment. Each pair of wooden blocks was placed in a glass Petri dish and 40 workers termites were released into it. The Petri dishes were maintained under similar temperature i.e. 25ºC as for non choice laboratory bioassay for 14 days. The rate of wood consumption was calculated as:

$$W_C = W_1-W_2$$

Where W_C is the weight of wood consumed, W_1 is the pre-weight and W_2 is the post-weight of wood.

2.4 Field Feeding Bioassays

2.4.1 No choice bioassay

All blocks were dried at 60°C up to 24 hours. Three replicates of each wooden species were tied together into bundles separately and buried 30 cm deep into the soil near termites infested log in a botanical garden at Forman Christian College Lahore, Pakistan. After 14 days, bundles were removed from the field, reweighed and dried at 60°C for 48 hours. The percentage of mass loss in the wooden blocks due to termites was calculated as:

$$W_L = (W_1-W_2)/W_1 \times 100$$

2.4.2 Choice bioassay under field conditions

All wooden blocks were dried at 60°C for 24 hours. Three replicates of each wooden block were used. Wooden 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 at Forman Christian College Lahore, Pakistan. The paired wooden blocks were removed to estimate the wood consumption rate by applying the following formula:

$$W_C = W_1-W_2$$

As the absorption properties varies for different wooden species which could have an impact on termite preferences for feeding. W_1 and W_2 are pre and post weight respectively. Rhinotermitidae termites mostly prefer wood with higher moisture content for feeding.

2.5 Toxicity

Different concentrations of Imidacloprid and Biflex were prepared in distilled water by serial dilution method. Desired ppm (Part per million) was calculated by considering distilled water. Only one ml of each insecticide concentration was placed on the Whatman No 1 filter paper already placed at the bottom of Petri dishes whereas the Wet filter paper with appropriate amount of distilled water was used as control. Filter papers were dried then released 10 worker termites of *Odontotermes obesus*. Three replicates were used for each concentration for a week. The percentage average mortality was observed after 7 days. The mortality was recorded daily after the exposure to each concentration.

2.6 Calculation of LC_{50}

More precise method by Finney and Busvine (1971) of toxicity was used. The method is based on dose response bioassay where mortality over a range of insecticide concentrations were plotted and analysed through probit analysis. Ppm (Part per million) were calculated when 50%

termites were killed in a specified time. The regression plot was plotted and regression equation was calculated along with the root square. The value however, calculated for LC_{50} for fipronil (0.668 ppm) and for Imidacloprid was (2.60 ppm) respectively. This reflects that imidacloprid being slow acting toxicant proved more effective in managing termite than the other.

2.7 Statistical Analysis

After the conclusion of trails, the data of the wood consumption, percentage of wood consumption and percentage survival were subjected to one way ANOVA using Minitab (Version-3.8). Paired comparison t-test was used choice for laboratory and field bioassays. Correspondingly, the percentage of mass loss in wooden species and their means in the no choice field bioassays were analyzed by Tukey's test.

3. RESULTS

3.1 No Choice Bioassay under Laboratory Condition

Based on results of five different wooden species when fed to *O. obesus*, Maximum survival rate 87.5% was recorded on *C. sempervirens*. Contrary to this 50% survival was recorded on *P. emblicallium* with mean wood consumption of 5.6 mg although this consumption was correlated with 50% mortality which shows the antifeedant activity of the wood. In other wooden species, *F. microphylapers*, *F. banghalensis* and *F. religiosa*, wood consumption was 8.8, 6.9 and 6.7 mg recorded with average survival was 83, 75 and 67.5% respectively, with consumption rate 9.97, 17.10 and 5.46%. The results are significant (P<0.05) in a way that *P. emblicallium* wood drastically shown antifeedant behaviour to this termite and can be exploited for further use in baiting technology of termites (Fig. 3).

3.2 Choice Bioassay under Laboratory Conditions

When different species of wood were exposed in the combinations of two wood species in Petri plates to *Odontotermes obesus* workers, maximum feeding was recorded in *Cupressus sempervirens linn* (9.3 mg) and *Ficus microphylapers* (3.4 mg) and minimum feeding in *Ficus relgiosa linn* (4.84 mg) and *Ficus banghalensis linn* (2.9 mg). The consumption rate recorded for other wood blocks combination in descending order was as follows: FB/PE, FM/FR, and PE/CS. The amount of wood consumed was significantly different (P=0.006) Table 2. The mean percentage of survival of *Odontotermes obesus* on wood blocks exposed in combination in laboratory conditions is summarized in Table 3. Maximum survival (76.25%) was recorded for CS/FM; whereas minimum survival (45%) was recorded for FR/FB. The difference in mass loss for each pair of wood blocks was statistically significant, (P>0.05) (Fig. 4).

3.3 No Choice Bioassay under Field Conditions

Among the five species of wood, minimum percentage of mass loss in no choice field conditions was recorded in *Cupressus sempervirens linn* was 3.81%. On the other hands *Odontotermes obesus* consumed more amounts of *Ficus relgiosa linn* was 46.28% after fourteen days. From these results, it can be concluded that *Cupressus sempervirens linn* is least preferred by *Odontotermes obesus* and therefore can be classified as highly resistant. But *Ficus relgiosa linn* was highly vulnerable. In the no choice bioassay mean consumption of wooden species, *Cupressus sempervirens linn* (CS) was 11.8 mg, *Ficus relgiosa linn* (FM)was 4.7 mg, PE was 4.8 mg, FB was 4.1 mg and FR was 3.2 mg (Fig. 5).

3.4 Choice Bioassay under Field Conditions

Among the blocks exposed in combinations of two different wood species in the choice bioassay under field conditions, maximum feeding was recorded in CS/FM (9.5 and 3.3 mg) and minimum feeding was recorded in FB/PE (2.9 and 4.6 mg) (Table 5). Wood consumption recorded in other wood species was also high feeding preference of termites for the combinations in descending order were as follows: PE/CS> FR/FB> FM/FR. The difference in mass loss for each pair of wood blocks was significant different (P>0.05, paired comparison t test) (Fig. 6)

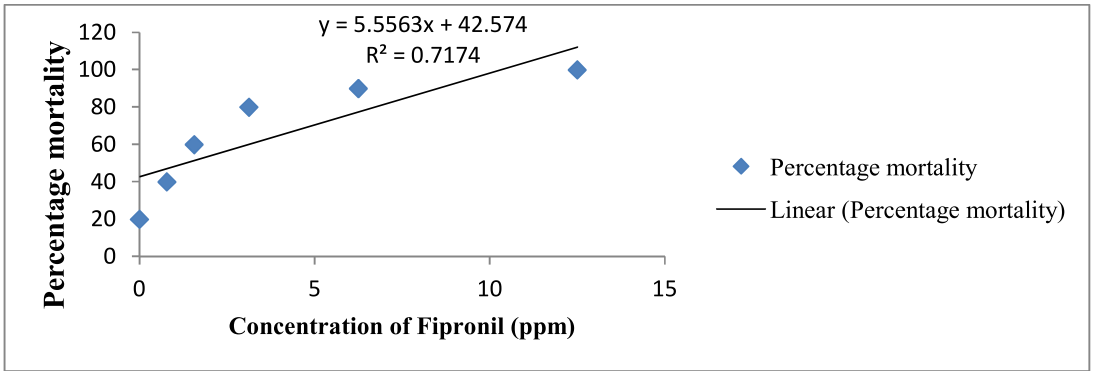

Fig. 1. Calculation of LC_{50} value treated at different concentrations with Fipronil for 7 day under laboratory condition

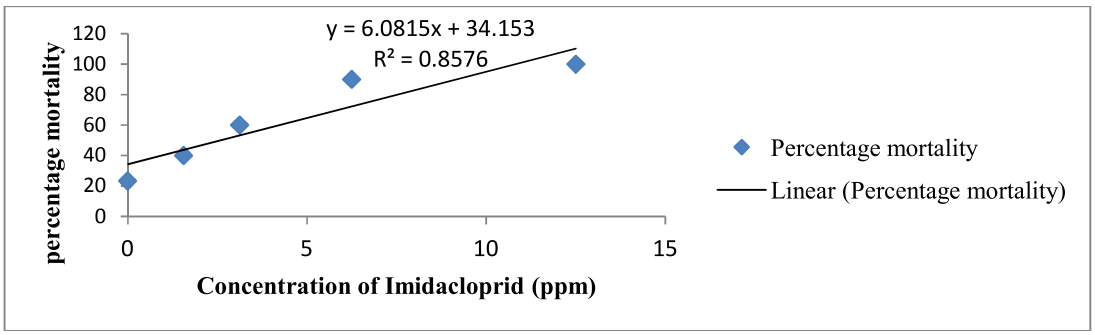

Fig. 2. Calculation of LC_{50} value treated at different concentrations with imidacloprid for 7 day under laboratory condition

Feeding preferences of *Odontotermes obesus*

Cupressus sempervirens linn

Ficus microphylapers

Ficus relgiosa linn

Ficus banghalensis linn

Phylanthus emblicallium

Fig. 3. No choice bioassay under laboratory conditions

Cupressus sempervirens linn / Ficus microphylapers

Ficus microphylapers/ Ficus relgiosa linn

Ficus relgiosa linn/ Ficus banghalensis linn

Ficus banghalensis linn/ Phylanthus emblicallium

Phylanthus emblicallium/ Cupressus sempervirens linn

Fig. 4. Choice bioassay under laboratory conditions

Cupressus sempervirens linn

Ficus microphylapers

Ficus relgiosa linn

Ficus banhalensis linn

Phylanthus emblicallium linn

Fig. 5. No choice bioassay under field condition

Cupressus sempervirens linn/ Ficus microphylapers

Ficus microphylapers/ Ficus relgiosa linn

Ficus relgiosa linn/ Ficus banghalensis linn

Ficus banghalensis linn/ Phylanthus emblicallium

Phylanthus emblicallium/ Cupressus sempervirens linn

Fig. 6. Choice Bioassay under field conditions

Table 1. Amount of mean wood consumption (mg) and wood consumption (%) in blocks of 5 different wood species exposed to the workers of *Odontotermes obesus* for 14 days under no choice laboratory conditions

Wood species	*Wood consumption (mg)	Wood consumption (%)	Survival rate (%)
Cupressus sempervirens linn	10.6±0.10[a]	3	87.5
Ficus microphylapers	8.8±0.73[b]	9.79	83
Ficus banghalensis	6.9±0.27[c]	17.10	75
Ficus relgiosa linn	6.7±0.29[dc]	5.46	67.5
Phylanthus emblicallium	5.6±0.06[e]	9.20	50

**Mean Followed by the same letter within a column are not significantly different(P <0.05, Tukey's test) Values are mean from three replications.*

3.5 Toxicity

In Petri dishes different concentration was used to prepare each of three replicas against Fipronil. However consumption (mg) at different concentration 12.5 ppm, 6.25 ppm, 3.125 ppm, 1.562 ppm and 0.78 ppm was 0.02, 0.016, 0.013, 0.003 and 0.006 mg respectively. For control consumption was used to prepare each of three replicas against Fipronil and Imidacloprid. Minimum percentage mortality was recorded in concentration 1.562 ppm was 40% and consumption was 0.006 mg as shown in Table 7. Maximum percentage mortality recorded in concentration 12.5 ppm. For control consumption was 0.006 mg, percentage mortality was 23.3%. However consumption (mg) at different concentration 6.25 ppm, 3.125 ppm was 0.006, 0.003 mg respectively.

Table 2. Mean wood consumption/ mass loss (mg) in five different wood pairs when exposed in combination to the worker of *Odontotermes obesus* for CS/FM (*Cupressus sempervirens linn* and *Ficus microphylapers*), FM/FR (*Ficus microphylapers* and *Ficus relgiosa linn*), FR/FB (*Ficus relgiosa linn* and *Ficus banghalensis linn*), FB/PE (*Ficus banghalensis linn* and *Phylanthus emblicallium*), PE/CS (*Phylanthus emblicallium* and *Cupressus sempervirens linn*) in 14 days choice test under laboratory conditions

Comparison*	Wood mass loss (mg)	
	Wood 1	Wood 2
CS/FM	9.3±0.33	3.4± 0.28
FB/PE	7.6±0.63	5.1±0.25
FM/FR	5.8±0.49	2.2±1.02
PE/CS	4.89±0.09	7.2±0.10
FR/FB	4.84±0.37	2.9±0.10

**Each wood block was paired with a block of another species (wood 1 / wood 2) in a Petri plate containing 40 termites (N=3). [2]Difference in mass loss for each pair of wood blocks indicated by *=0.05 is significantly different (paired comparison t test).*

Table 3. Mean survival percentage of the workers of *Odontotermes obesus* on five different combinations of wood blocks in choice feeding laboratory trials after two weeks of exposure

*Different wood combinations	Mean survival (%)
CS/FM	76.25
FB/PE	71.25
FM/FR	65
PE/CS	52.5
FR/FB	45

**CS/FM, Cupressus sempervirens linn and Ficus microphylapers, FB/PE, Ficus banghalensis linn and Phylanthus emblicallium, FM/FR, Ficus microphylapers and Ficus relgiosa linn, PE/CS, Phylanthus emblicallium and Cupressus sempervirens linn, FR/FB, Ficus relgiosa linn and Ficus banghalensis linn.*

3.6 LC_{50} Calculation

Finney and Busvine method [37] of toxicity was used. The value however calculated for LC_{50} for fipronil (0.668 ppm) and for Imidacloprid was (2.60 ppm) respectively. LC_{50} value from the equation. Put value of LC_{50} in equation, calculated the value of Y by simple mathematical steps as given in the graphs.

4. DISCUSSION

Feeding preferences of *O. obesus* to five different wood species were studied as termite control efforts could only be planned by having profound knowledge of feeding tendencies of termites. On the other hand the rate of consumption was very low in *Ficus banghalensis linn* and *Phylanthus emblicallium*, because both these wood species are resistant to termite. Many researchers have studied timber resistance to termite attack which have been directly or indirectly, affected by resistant toxic chemicals present in woods [38-39].

In developing countries like Pakistan, heavy termite infestations are often tolerated as control cost exceeds timber replacing cost but scenario has been changed in big cities of Pakistan due to improved living standards and better incomes which have made people more conscientious of damages by the termites. Appreciable work has been carried out by various researches in Pakistan to study the feeding preference of termites [39].

Aihetasham and Iqbal [37] studied feeding preferences of *Microcerotermes championi* (Snyder) for different wooden blocks dried at different temperatures under forced and choice feeding conditions in laboratory and field. It was found that wood consumption was propotional to the degree of drying temperature, increase in drying temperature would increase consumption percentage. The feeding propensity was *Acacia arabica >Ficus religiosa> Azadiracta indica> Morus alba >Melia azederach > Mangifera indica >Cedrus deodara>Tectona grandis*. Sheikh et al. (2010) evaluated feeding preferences of *Odontotermes obesus* on four different wooden species (*Fagus sp, Pinus wallichiana, Abies pindrow* and *Cedrus deodara*) treated at various temperatures for either 24 hours or 48 hours. They found *Fagus* sp and *P. Wallichiana* as the most preferred by *O. obesus*. Ijaz and Aslam (2002) found positive correlation between mean infestation of *O. obesus* and humidity. This study was conducted in Lahore, Pakistan, whereas, *Cupressus sempervirens linn* because of its dense shelter and commercial application is the most widely planted tree. That is why this region highly infested by *Odontotermes obesus*. However in Pakistan local knowledge related to termites revealed that wood species such as *Phylanthus emblicallium* consumed large than *Cupressus sempervirens linn* but the result of the present study differ from those of the previous work based on the inherent resistance of wood protects it from termite attack. Wood feeding preference and resistance will alter with the hardness, lignin content or chemical constitution of wood. Organic chemicals such as phenol, quinines, terpenoids and lignins at high concentrations may also have an effect on the ecology where feeding occurs. The pH of wood content might also be important. Sapwood, which has more starch and sugar, is generally preferred over heartwood. Therefore, many indigenous trees are more resistant to termites attack and have developed chemical defence mechanisms to protect themselves. These chemical defence mechanisms are more prevalent in immature trees and crops, making them less susceptible to termite *Odontotermes obesus* are capable of locating palatable wood and avoiding wood that has some natural resistant properties. Under field conditions, a slight shift was observed in the feeding preferences over lab experiments. In feeding bioassays on *Odontotermes obesus* the impact of different species exposed to this termites reveals the following descending order of feeding preferences: *Cupressus sempervirens linn* > *Ficus microphylapers* > *Ficus relgiosa linn* > *Ficus banghalensis lin* > *Phylanthus emblicallium*. But the results for laboratory feeding bioassay was different from field conditions that is *Cupressus sempervirens linn* > *Ficus microphylapers* > *Ficus banghalensis linn* > *Ficus relgiosa linn* > *Phylanthus emblicallium*. Further studies on the extract of the most resistant wood species followed by the analysis of the resistant components can reveal the resistance of wood. This could be the real task in the eco friendly management of termites. Qureshi et al. [39] 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.

Table 4. Mean consumption (mg) and percentage of consumption of five different wood species exposed to *Odontotermes obesus* in no choice feeding bioassay after two weeks under field conditions

Wood species	Mean consumption(mg)[+]	Mean consumption (%)
Cupressus sempervirens linn	11.8±0.407[a]	3.81
Ficus microphylapers	4.7±0.467[be]	17.82
Ficus relgiosa linn	3.2±0.223[c]	46.28
Ficus banghalensis linn	4.1±0.225[d]	6.20
Phylanthus emblicallium	4.8±0.217[e]	8.67

[+]Mean followed by the same letter within a column are not significantly different (P<0.05, Tukey's test) [+]values are means from three replications.

Table 5. Mean wood mass loss (mg) in five different wood pairs when exposed in combination to *Odontotermes obesus* for CS/FM (*Cupressus sempervirens linn* and Ficus *microphylapers*), FM/FR (*Ficus microphylapers* and *Ficus relgiosa lin*), FR/FB (*Ficus relgiosa linn* and *Ficus banghalensis linn*), FB/PE (*Ficus banghalensis linn* and *Phylanthus emblicallium*), PE/CS (*Phylanthus emblicallium* and *Cupressus sempervirens linn*) in 2 week choice trails under field conditions

Comparison[*]	Wood mass loss (mg)	
	Wood 1	Wood 2
CS/FM	9.5±0.58	3.3±0.61
PE/CS	5.6±1.1	18.6±11.1
FR/FB	4.0±0.13	3.0±0.12
FM/FR	3.4±0.03	4.7±0.21
FB/PE	2.9±0.24	4.6±0.10

*[*]Each wood block was paired with a block of another species (wood1 and wood2) in the termite mound (n=3).[2]difference in mass loss for each pair of wood blocks indicated by *=0.05 and **=0.01 are significantly (different paired comparison t - test).*

Table 6. Mortality and consumption (mg) of *Odontotermes obesus* treated with different concentration of Fipronil for a week

Concentration used in ppm	Average mortality	Consumption used (mg) ($\bar{x}$±SD)	Co-efficient of variability ($\bar{x}$/SD)	Mean percentage mortality
12.5	10	0.02±0	0	100
6.25	9	0.016±0.005	3.2	90
3.125	8	0.013±0.005	2.28	80
1.562	6	0.003±0.005	0.6	60
0.78	4	0.006±0.011	0.54	40
Control	2	0.013±0.005	2.6	20

Table 7. Mortality and consumption (mg) of *Odontotermes obesus* with different concentrations of Imidacloprid for a week

Concentration used in ppm	Average mortality	Consumption used (mg) ($\bar{x}$±SD)	Co-efficient of variability ($\bar{x}$/SD)	Percentage (%) mortality
12.5	10	0.016±0.005	3.2	100
6.25	9	0.006±0.005	1.2	90
3.125	6	0.003±0.005	0.6	60
1.562	4	0.006±0.011	0.54	40
Control	2.33	0.02±0.01	2	23.3

In this study toxicity of fipronil and imidacloprid was also determined at different concentrations and LC_{50} was calculated. The LC_{50} value of fipronil was 0.668 ppm and for Imidacloprid was 2.60 ppm respectively. Previous studies have indicated that non-repellant, slow-acting toxicants are superior to conventional toxicants; i.e., more robust because one can treat a portion of a colony and termites will forage through the treatment residue and distribute the toxin to nestmates. The main purpose of this study was to determine the wood species with the highest level of resistance and susceptibility to attack by *Odontotermes obesus* and its feeding preferences.

5. CONCLUSIONS

The most resistance and least resistant woods component can further be investigated against other termite species to fully understand feeding preferences in termite species. 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.

ETHICS APPROVAL

Experiments were conducted in accordance with the ethical permission number AZ522-27-22/02-00 (113) released by the Senator for Health-care, Bahnhofsplatz 29, 28195 Bremen on February 21st, 2013 and valid until February 21st, 2017.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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