

FEEDING PREFERENCES OF *MICROCEROTERMES CHAMPIONI* (SNYDER) ON DIFFERENT TIMBERS DRIED AT DIFFERENT TEMPERATURES UNDER CHOICE AND NO CHOICE TRIALS.

*KHALID ZAMIR RASIB

Department of Zoology, University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan. – 54590

Abstract: Ten species of wood were tested for their natural resistance and to reveal feeding preferences of *M. championi*. In “No choice” laboratory experiments, *Abies pindrow* was found highly resistant and *Populus euramericana* 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. championi* 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. championi* showed maximum feeding on *P. euramericana* and the minimum on *A. pindrow* and the mean feeding propensity was significantly different ($P < 0.0028$). Based on the feeding propensity, the woods are arranged in descending order of preference: *Populus euramericana* > *Azadirachta indica* > *Cedrus deodara* > *Pinus roxburghii* > *Morus alba* > *Tectona grandis* > *Mangifera indica* > *Acacia arabica* > *Thuja occidentalis* > *Abies pindrow*. Although *M. championi* fed aggressively on *P. roxburghii*, the wooden blocks had undesirable effect on the survival of the species, manifesting toxic nature of the wood.

Key Words: Wood, Feeding Preferences, Temperature Impact, Choice and No choice, *M. championi*.

INTRODUCTION

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.

Termites are of great economic importance because of the damage they cause to woodwork in the buildings, agricultural crops and forest plantations.

With the rising cost of repairs and replacements for the damage to timber structures, a sound knowledge of the natural resistance of the native timbers and feeding preferences of the native species of termites is essential.

In spite of the notable contribution by various investigators on different aspects of the termites of Pakistan (Ahmad, 1955; Akhtar, 1972, 1974a, 1976, 1978; Ahmad *et al.*, 1979; Akhtar and Ali, 1979; Afzal, 1981; Akhtar and Raja, 1985; Shahid and Akhtar, 1989; Akhtar and Kausar, 1991), our knowledge about feeding preferences of the termites is poor. On the other hand, a lot of work in different parts of the world has been done to determine the natural termite resistance quality of timbers (Wolcott, 1940; Becker, 1961b; Sen-Sarma, 1963a,

*Assistant Professor FCC University. Biological Sciences Department, Lahore, Pakistan -54600.

Currently Post Doctoral Fellow at Imperial College. Silwood Park Campus. Division of Biology, Ascot. London UK.

Email address: Khalidrasib786@hotmail .com

1963b, 1963c; Sen-Sarma and Chatterjee, 1965; McMahan, 1966; Smythe and Carter, 1970; Behr *et al.*, 1972; Howick, 1975; Williams, 1973; Haverty and Nutting, 1975b; Sen-Sarma *et al.*, 1975a, 1975b; Amburgy and Beal, 1977; Carter *et al.*, 1978; Bultman *et al.*, 1979; Lenz and Williams, 1980; Carter, 1981; Collins, 1981; Lenz, 1986; Lenz *et al.*, 1987; Waller, 1988; Delaplane and Lafage, 1989; Rokova *et al.*, 1990; Lin *et al.*, 1992; Grace *et al.*, 1994; Doi *et al.*, 1998).

The termite species are different in different ecological zones of Pakistan (Akhtar, 1974) and may have different feeding preferences. For example, *Anacanthotermes vagans* does maximum damage to woodwork in buildings in Chaman, district Quetta, but is absent from the Punjab, where *Coptotermes*

heimi, *Microtermes unicolor* and *Odontotermes obesus* play havoc.

During earlier field experiments on the natural resistance of various timbers (Akhtar and Ali, 1979), *Dalbergia sissoo* was found to be highly resistant to attack by the termite *Odontotermes obesus*. However, wooden blocks of *Cedrus deodara* previously dried at 60°C for 48 hours were severely damaged by the same termite. Akhtar and Ali (1979) have also reported that the acetone-hexane-water extract of *Cedrus deodara* was toxic and suggested that the toxic principle is volatile.

Microcerotermes championi selected for the present study nests in the roots of *Saccharum munja* and makes carton type nest. Its feeding responses are reported for the first time.

MATERIALS AND METHODS

Termite Collection

Worker termites of *M. championi* were taken from nests located in the vicinity of Punjab University, New Campus, Lahore and Wagha Border.

Wood Species

Commercially important timber species were selected for experiments. Most of the wood species were cut from standing trees except *Abies pindrow*, *Cedrus deodara*, *Tectona grandis* and *Acacia arabica*, which were obtained from commercial lumber yard. Timber species, selected for different experiments were: *Abies pindrow*, *Pinus roxburghii*, *Tectona grandis*, *Acacia*

arabica, *Cedrus deodara*, *Mangifera indica*, *Thuja occidentalis*, *Morus alba*, *Azadirachta indica* and *Populus euramericana*. Blocks 4.2x2.5x1 cm were cut from a single piece of each wood. Fine grade sand paper was used to make all sides of the block smooth. The blocks were dried at different temperatures for 48 hours before exposure to termite.

No choice laboratory trials

Wooden blocks (4.2x2.5x1 cm) of *A. pindrow*, *T. occidentalis*, *A. arabica*, *M. indica*, *T. grandis*, *M. alba*, *P. roxburghii*, *C. deodara*, *A. indica* and *P. euramericana* were prepared. Wooden blocks were dried at different

temperatures i.e., 60, 70, 80, 90 and 100°C for 48 hours. Only one type of test or wooden block was placed in a glass Petri dish (9.8 cm diameter and 2 cm high) and 300 worker termites were added. The wooden block was kept suitably moist. Three replicates of wooden blocks were used for each wood. Petri dishes were maintained at 26±1°C for 14 days. At the end of the test period the blocks were dried at the same temperature at which they were dried before exposure to termites and the amount of wood eaten were calculated. Survival of termites, confined to a type of wood for 14 days was also noted. At the conclusion of the test, data for wood consumption, percent wood consumption and percent survival were subject to analysis of variance (ANOVA) and means significantly different at the 5 percent level were separated by LSD according to Minitab (Release 9.2) and Steel and Torrie (1980).

Choice laboratory trials

A series of paired choice tests were also conducted to compare termite preference between *A. arabica* (AA) vs. *M. alba* (MA), *A. indica* vs. *M. indica* (AI/MI), *C. deodara* vs. *T. grandis* (CD/TG), *A. pindrow* vs. *P. euramericana* (AP/PE) and *P. euramericana* vs. *P. roxburghii*. This feeding comparison was considered to be more indicative of a feeding choice that termite encounter in their natural environment. Methodology was the same for this study as described for no-choice test, except that each wooden block was placed side by side with an alternate block in the same food chamber. Duration of exposure of each

choice pair was 14 days. At the conclusion of the test, data were statistically analyzed.

No choice trials based on field experiments

Test blocks measuring 4.2x2.5x1 cm of 10 different types of woods were prepared and treated at different temperatures as described above. Blocks of only one type of woods were tied together separately into a bundle. Ten nests of *M. championi* near the Punjab University, New Campus area were selected for this experiment. For each nest five bundles were allocated. Each bundle was placed at different sites of the nest buried 30 cm deep into the soil. The bundles were removed from the field after 14 days and were reweighed.

Choice trials based on field experiments

A series of paired choice tests were conducted to compare termite preference between *A. arabica* vs. *M. alba* (AA/MA), *T. grandis* vs. *C. deodara* (TG/CD), *P. euramericana* vs. *A. pindrow* (PE/AP), *A. indica* vs. *M. indica* (AI/MI) and *P. euramericana* vs. *P. roxburghii* (PE/PR). Five nests of *M. championi* near Punjab University, New Campus area were selected for this experiment. Rest of the methodology was same as described for the no choice test.

RESULTS

No Choice Laboratory Experiments

Feeding and Survival

Tables 1, 2,3 and 4 show wood consumption in milligrams, percent wood consumption and percent survival of termites confined to wooden blocks of different species dried at different temperatures, under no choice laboratory experiments.

Abies pindrow

Termites fed significantly less (at least 75% less) on wooden blocks of *A. pindrow* dried at 60°C as compared to those dried at 100°C. Wood consumption was influenced by the temperature condition at which the blocks were dried before exposure to termites (Table 1) and the wood consumption increased with increase in temperature ($P < 0.05$) (Table 2). Percent survival of termites, fed on wooden blocks dried

at different temperatures, also slightly increased but survival in blocks dried at 70°C and 80°C was not significantly different ($P > 0.05$). Survival on the wooden blocks of *A. pindrow* was very poor. The correlation between wood consumption and percent survival of termites confined to cages containing wood blocks of *A. pindrow* dried at different temperatures was positive and significant ($r = 0.999$).

Thuja occidentalis

Microcerotermes championi showed more wood consumption (43.3 mg) from wooden blocks of *T. occidentalis* dried at 60°C than that of *A. pindrow* (23.3 mg). Mean wood consumption and percent wood consumption was influenced by temperature at which the blocks were dried, and increased with increase in temperature ($P < 0.05$).

Survival, however, did not increase in cages containing wooden blocks dried at different temperatures. Consequently, survival in blocks dried at 60°C to 70°C, 70°C to 80°C and 80°C to 100°C was not significantly different ($P > 0.05$) (Table 1). The correlation between consumption and percent survival of termites confined to cages containing wooden blocks of *T. occidentalis* dried at different temperatures was positive and significant ($r = 0.92$).

Acacia Arabica

Acacia Arabica was almost as acceptable to *M. championi* as *T. occidentalis*. Survival, however, significantly increased with increase in temperature. But survival in blocks dried at 80°C and 90°C was not significantly different ($P > 0.05$). The correlation between wood consumption and percent survival of termites confined to cages containing

wooden blocks of *A. Arabica* dried at different temperatures was positive and significant ($r=0.958$).

Mangifera indica

Termites consumed slightly more amount of wood from the wooden blocks of *M. indica* and the wood consumption was affected by temperature at which the blocks were dried. Amount of wood consumed from blocks dried at 60°C was 63.3 mg compared to 233.3 mg from wooden blocks dried at 100°C. There were, however, non-significant differences in wood consumption between blocks dried at 70°C and 80°C ($P>0.05$) and between blocks dried at 80 and 90°C ($P>0.05$).

Survival of termites showed a slight increase with increase in temperature but mostly increase in survival was not significant. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *M. indica* dried at different temperatures was positive and significant ($r=1.000$).

Tectona grandis

Wood consumption from wooden blocks of *T. grandis* dried at 60°C was 63.3 mg, whereas from wooden blocks dried at 100°C, it was 233.3 mg and was significantly different ($P<0.05$). Wood consumption on wooden blocks dried

at 60 and 70°C was not significantly different ($P>0.05$). Similarly, there was non-significant difference in the amount of wood consumption from wooden blocks dried at 80 and 90°C (Table 1). Survival of termites ranged from 40.3 to 47.3% in wooden blocks dried at different degrees of temperature and % survival was mostly non-significant. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *T. grandis* dried at different temperatures was positive and significant ($r=0.990$).

Morus alba

Morus alba which is palatable to other termites was not much acceptable to this termite species. Consequently, wood consumption and % survival was almost similar to that of observed in case of *T. grandis*. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *M. alba* dried at different temperatures was positive and significant ($r=0.973$).

Pinus roxburghii

So far as wood consumption from wooden blocks of *P. roxburghii* was concerned, it was an exception.

Pinus roxburghii is known for its natural resistance. Feeding significantly increased with increase in temperature. Wood consumption from wooden blocks dried at 60°C was 133.3 mg compared to 1533.3 mg from wooden blocks dried at 100°C.

Survival of termites also showed an increase with increase in temperature at which the blocks were dried but survival of termites was not significantly different in cages with wooden blocks dried at 90°C and 100°C temperatures ($P>0.05$). The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *P. roxburghii* dried at different temperatures was positive and significant ($r=0.980$).

Cedrus deodara

Cedrus deodara is also known for its natural resistance to other species of termites and is very popular amongst the public for wood work in the buildings. Wood consumed by *M. championi* from wooden blocks dried at 60°C and 100°C was 143.3 mg and 276.7 mg respectively and was comparatively very poor if compared with wood consumption for wooden blocks of *Pinus roxburghii* dried at the same temperature.

Percent survival, however, was significantly different ($P<0.05$) in cages

containing wooden blocks dried at different temperatures. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *C. deodara* dried at different temperatures was positive and significant ($r=0.981$).

Azadirachta indica

Wood consumption from wooden blocks of *A. indica* dried at 60°C was 183.3 mg, whereas, from wooden blocks dried at 100°C it was 323.3 mg. There were significant differences in the amount of wood consumed from wooden blocks dried at different temperatures (Tables 1-2).

Percent survival of termites ranged from 68.7 to 78.3% in wooden blocks dried at different temperatures and was mostly non-significant. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *A. indica* dried at different temperatures was positive and significant ($r=0.974$).

Populus euramericana

Termites consumed relatively the maximum amount of wood from wooden blocks of *P. euramericana*. Wood consumption was affected by temperatures at which the blocks were dried. Amount of wood consumed from blocks dried at 60°C was 233.3 mg compared to 1833.3 mg from wooden blocks dried at 100°C. Survival of termites showed a slight increase in cages containing block dried at higher temperature but the increase in survival was not significant. The correlation between wood consumption and percent survival of termites confined to cages containing wooden blocks of *P. euramericana* dried at different temperatures was positive and significant ($r=0.964$).

Table 1: Amount of wood consumption (mg) from different wooden blocks dried at different temperatures after 2 week exposure to workers of *M. championi*. Means followed by the same letters show non- significant differences ($P>0.05$).

Abies pindrow

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	23.3	0.71	13.3
70	73.3	2.24	17.7A
80	93.3	2.86	18.7A
90	123.3	3.78	21.3
100	163.3	5.0	24.7
LSD	10.49	0.32	1.32

Thuja occidentalis

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	43.3	0.65	51.3A
70	93.3	1.40	55.3AB
80	113.3	1.70	59.3BC
90	143.3	2.15	60.0C
100	183.3	2.75	60.3C
LSD	10.49	0.15	4.01

Acacia arabica

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	43.3	0.68	44.7
70	93.3	1.48	49.7
80	113.3	1.80	54.7A
90	143.3	2.28	55.7A
100	183.3	2.91	57.7
LSD	10.49	0.16	1.04

Mangifera indica

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	63.3	0.84	50.7A
70	113.3A	1.52	53.3AB
80	133.3AB	1.78	54.3B
90	163.3B	2.19	55.7B
100	233.3	3.13	59.0
LSD	47.8	0.64	3.08

Tectona grandis

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	63.3	0.64	40.3A
70	113.3A	1.15	42.7AB
80	143.3AB	1.46	43.3BC
90	183.3B	1.86	46.0CD
100	233.3	2.37	47.3D
LSD	47.8	0.48	2.85

Morus alba

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	83.3	1.52	56.3A
70	133.3A	2.43	59.0AB
80	146.6AB	2.68	61.3BC
90	183.3B	3.35	62.3BC
100	233.3	4.26	64.3C
LSD	47.8	0.87	3.28

Pinus roxburghii

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	133.3	1.91	35.3
70	810.0	11.6	48.3
80	1233.3	17.7	53.3
90	1333.3	19.1	61.3A
100	1533.3	22.0	61.7A
LSD	95.3	1.39	4.71

Cedrus deodara

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	143.3	2.46	47.3
70	186.7	3.20	54.3
80	206.7A	3.55	61.7
90	208.3A	3.58	65.7
100	276.7	4.75	77.7
LSD	11.25	0.19	1.32

Azadirachta indica

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	183.3	5.65	68.7A
70	226.6	6.99	71.3AB
80	246.6	7.61	74.7BC
90	276.6	8.54	76.3BC
100	323.3	9.97	78.3C
LSD	10.49	0.32	3.75

Populus euramericana

Temperature (°C)	Wood consumption (mg)	Wood consumption (%)	Survival (%)
60	233.3	12.5	76.3A
70	733.3	39.4	78.0A
80	1133.3	60.9	78.3A
90	1633.3	87.8	79.0A
100	1833.3	98.5	79.3A
LSD	105.02	5.65	3.45

Table 2: Amount consumed (milligrams) of each wooden block in 2 weeks by *M. championi* in no choice laboratory trials. Figures in parenthesis indicate % consumption.

Temp. (°C)	Wooden Blocks Used ^a									
	<i>Abies pindrow</i>	<i>Thuja occidentalis</i>	<i>Acacia arabica</i>	<i>Mangifera indica</i>	<i>Tectona grandis</i>	<i>Morus alba</i>	<i>Pinus roxburghii</i>	<i>Cedrus deodara</i>	<i>Azadirachta indica</i>	<i>Populus euramericana</i>
60	23.3±5.77 a (0.71%)	43.3±5.77 ab (0.65%)	43.3±5.77 ab (0.68%)	63.3±5.77 ab (0.84%)	63.3±5.77 ab (0.64%)	83.3±5.77 b (1.52%)	133.3±57.7 c (1.91%)	143.3±5.77 cd (2.46%)	183.3±5.77 d (5.65%)	233.3±57.7 (12.5%)
70	73.3±5.77 a (2.24%)	93.3±5.77 ab (1.40%)	93.3±5.77 ab (1.48%)	113.3±5.77 Abc (1.52)	113.3±5.77 Abc (1.15%)	133.3±5.77 Ac (2.43%)	810.0±20.0 (11.6%)	186.7±5.77 (3.20%)	226.6±5.77 (6.99%)	733.3±57.7 (39.4%)
80	93.3±5.77 a (2.86%)	113.3±5.77 ab (1.70%)	113.3±5.77 ab (1.80%)	133.3±5.77 ABab (1.78%)	143.3±5.77 ABb (1.46%)	146.6±5.77 ABb (2.68%)	1233.3±57.7 (17.7%)	206.7±5.77 Ac (3.55%)	246.6±5.77 c (7.61%)	1133.3±57.7 (60.9%)
90	123.3±5.77 a (3.78%)	143.3±5.77 ab (2.15%)	143.3±5.77 ab (2.28%)	163.3±5.77 Babc (2.19%)	183.3±5.77 Bbc (1.86%)	183.3±5.77 Bbc (3.35%)	1333.3±57.7 (19.1%)	208.3±7.64 Ac (3.58%)	276.6±5.77 (8.54%)	1633.3±57.7 (87.8%)
100	163.3±5.77 a (5.0%)	183.3±5.77 a (2.75%)	183.3±5.77 a (2.91%)	233.3±57.7 ab (3.13%)	233.3±57.7 ab (2.37%)	233.3±57.7 ab (4.26%)	1533.3±57.7 (22.0%)	276.7±5.77 bc (4.75%)	323.3±5.77 c (9.97%)	1833.3±57.7 (98.5%)

a: Three replicates, mean ± standard deviation. Means within a column followed by same capital letter and means within rows followed by same small letter are not significantly different at 5 percent level (Duncan's New Multiple Range Test).

Table 3: Percentage survival ($\bar{x} \pm SD$) of workers of *M. championi* on different wooden blocks dried at different temperatures after 2 week exposure at laboratory conditions under “NO CHOICE TRIALS”.

Temp. (°C)	Wooden Blocks Used ^a									
	<i>Abies pindrow</i>	<i>Pinus roxburghii</i>	<i>Tectona grandis</i>	<i>Acacia arabica</i>	<i>Cedrus deodara</i>	<i>Mangifera indica</i>	<i>Thuja occidentalis</i>	<i>Morus alba</i>	<i>Azadirachta indica</i>	<i>Populus euramericana</i>
60	13.3±0.57	35.3±4.16	40.3±1.52 A	44.7±0.57 a	47.3±1.15 a	50.7±1.15 Ab	51.3±2.51 Ab	56.3±1.52 A	68.7±1.52 A	76.3±2.51 A
70	17.7±0.57 A	48.3±1.52 a	42.7±1.15 AB	49.7±0.57 a	54.3±0.57 b	53.3±1.52 ABb	55.3±1.15 ABb	59.0±2.0 AB	71.3±3.60 AB	78.0±1.73 A
80	18.7±0.57	53.3±1.52 a	43.3±1.52 BC	54.7±0.57 Ab	61.7±0.57 c	54.3±1.52 Bab	59.3±1.52 BCd	61.3±1.52 BCcd	74.7±1.52 BC	78.3±1.52 A
90	21.3±1.15	61.3±2.30 Aa	46.0±2.0 CD	55.7±0.57 Ab	65.7±0.57	55.7±2.08 Bb	60.0±2.0 Cd	62.3±2.30 BCd	76.3±1.52 BCe	79.0±2.0 Ae
100	24.7±0.57	61.7±2.51 Aab	47.3±1.52 D	57.7±0.57 c	77.7±0.57 de	59.0±2.0 acd	60.3±3.21 acC	64.3±1.52 Cb	78.3±1.55 Ce	79.3±1.52 Ae

a: Three replicates, mean ± standard deviation. Means within a column followed by same capital letter and means within rows followed by same small letter are not significantly different at 5 percent level (Duncan's New Multiple Range Test).

Table 4: Average survival %age ($\bar{x} \pm SD$) of workers of *M. championi* under CHOICE trials on different combinations of wooden blocks dried at different temperatures after 2 week exposure at laboratory conditions.

Temperature (°C)	Wood Combinations Used ^a				
	<i>A. arabica</i> + <i>M. alba</i>	<i>A. indica</i> + <i>M. indica</i>	<i>C. deodara</i> + <i>T. grandis</i>	<i>A. pindrow</i> + <i>P. euramericana</i>	<i>P. euramericana</i> + <i>P. roxburghii</i>
60	52.3±2.51A	60.7±2.51	45.3±2.51A	46.3±2.51A	56.3±4.16
70	56.3±1.52AB	64.3±2.08A	50.3±5.13AB	49.3±4.16AB	65.3±2.51A
80	60.7±1.52BC	66.3±1.52AB	54.3±3.51BC	51.3±2.05ABC	67.3±4.16AB
90	62.3±4.50CD	68.7±0.57BC	57.3±4.16CD	54.3±2.62BC	71.3±3.21AB
100	64.3±2.51D	70.7±2.51C	63.3±2.51D	56.3±3.39C	73.3±4.16B
	LSD=2.24	LSD=1.61	LSD=3.02	LSD=2.81	LSD=3.02

a: Three replicates: Mean $\pm$ Standard deviation. Means within a column followed by same capital letter are not significantly different at 5% level (Duncan's New Multiple Range Test).

Table 5: Amount consumed (milligrams) of each wooden block in 2 weeks by *M. championi* in No Choice field trials.

Temp. (°C)	Wooden Blocks Used ^a									
	<i>Abies pindrow</i>	<i>Thuja occidentalis</i>	<i>Acacia arabica</i>	<i>Mangifera indica</i>	<i>Cedrus deodara</i>	<i>Morus alba</i>	<i>Tectona grandis</i>	<i>Azadirachta indica</i>	<i>Pinus roxburghii</i>	<i>Populus euramericana</i>
60	44.6±2.08	52.6±2.52 a	54.6±2.52 a	78.3±3.06 b	75.3±2.52 b	96.0±2.00	159.3±2.52	190.0±2.00	147.0±2.00	728.0±3.00
70	81.3±3.51	104.6±2.52	98.3±1.53	125.3±2.52 a	123.3±2.52 a	148.3±3.51	214.0±4.00	236.6±3.06	824.3±5.51	916.6±5.13
80	97.3±2.08	122.0±2.00 a	126.3±1.53 a	145.3±2.52	158.6±2.52 b	159.3±2.52 b	230.0±4.00	256.6±2.08	1243.3±4.73	1214.3±4.04
90	133.6±3.51	153.3±3.06	159.0±3.00	175.0±2.00	195.3±2.52 a	193.3±1.53 a	244.3±3.51	289.0±3.00	1345.3±2.52	1642.0±5.29
100	174.3±4.51	192.3±2.52 a	196.6±1.53 a	244.3±4.04 bc	244.6±2.52 bc	246.6±1.53 c	287.6±2.52	338.0±4.00	1548.3±3.06	1844.6±2.52

a: Three replicates mean ± standard deviation. Means within rows followed by same small letter are not significantly different at 5 percent level (Duncan's New Multiple Range Test).

Choice Laboratory Experiment

Feeding

Different species of woods dried at different temperatures were offered in combination of two in a cage to workers of *M. championi* (Table 6). *M. championi* easily identified the palatable wood in a choice of two woods and fed more on the palatable wood. Table 6 indicates that amongst the wooden

blocks dried at 60°C and offered in combinations of two wood species, *M. championi* showed the maximum (260 mg) feeding on *P. euramericana* and the minimum on *A. pindrow*, and the amount of wood consumed was significantly different ($P=0.0028$).

Table 6: Mean wood consumption ($\bar{X} \pm SD$) workers of *M. championi* in “mg” on AA/MA (*A. arabica*, *M. alba*), AI/MI (*A. indica*, *M. indica*), CD/TG (*C. deodara*, *T. grandis*), AP/PE (*A. pindrow*, *P. euramericana*), PE/PR (*P. euramericana*, *P. roxburghii*) dried at different temperatures in 2-week “CHOICE” trial Under laboratory condition.

Temperature (°C)	Comparison ^a	Wood Mass Loss (mg)		Probability ^b
		Wood 1	Wood 2	
60	AA/MA	83.3±5.77	100.0±10.0	0.088
	AI/MI	186.6±5.77	220.0±20.01	0.11
	CD/TG	126.7±11.5	146.7±11.5	0.10

	AP/PE	33.3±5.77	260.0±20.0	0.0028**
	PE/PR	243.3±15.3	163.3±45.1	0.10
70	AA/MA	103.3±5.77	126.6±5.77	0.0078*
	AI/MI	210.0±10.0	243.3±15.3	0.051*
	CD/TG	150.0±17.3	170.0±10.0	0.18
	AP/PE	53.3±5.77	290.0±20.0	0.0026**
	PE/PR	273.3±15.3	173.3±45.1	0.068
80	AA/MA	116.7±11.5	143.3±5.77	0.070
	AI/MI	233.3±15.3	274.0±15.1	0.046*
	CD/TG	173.3±15.3	196.7±11.5	0.13
	AP/PE	66.6±5.77	313.3±25.2	0.0036**
	PE/PR	293.3±15.3	183.3±40.4	0.048*

90	AA/MA	140.0±10.0	166.6±5.77	0.028*
	AI/MI	250.0±20.0	313.3±25.2	0.042*
	CD/TG	200.0±17.3	226.7±11.5	0.11
	AP/PE	90.0±10.0	336.7±30.6	0.0056**
	PE/PR	336.7±11.5	203.3±30.6	0.019*
100	AA/MA	160.0±10.0	200.0±10.0	0.0080**
	AI/MI	273.3±25.2	336.7±20.8	0.044*
	CD/TG	216.7±20.8	253.3±15.3	0.091
	AP/PE	103.3±5.77	360.0±30.0	0.0047**
	PE/PR	363.3±15.3	226.7±32.1	0.022*

- 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 block indicated by * = 0.05 and ** = 0.01, are significantly different (paired comparison t-test).

Amongst the wooden blocks dried at 70°C and offered in combination of two, the maximum feeding again was recorded on *P. euramericana*, but the minimum in this set of experiment on *C. deodara*, which was offered in combination with *T. grandis*. Amongst wooden blocks dried at 80°C, the maximum

feeding again was noted on *P. euramericana*, and the minimum on *A. pindrow* (Table 6). *Microcerotermes championi* like most of the other termite species is capable of locating the palatable wood and avoiding the wood that has some natural resistance properties.

Survival

Table 4 indicates percent survival of *M. championi* on wooden blocks offered in combination of two wood species dried at different temperatures. The maximum survival (73%) was noted in cages containing combination of *P. euramericana* and *P. roxburghii* (dried at 100°C) whereas the minimum survival was noted in cages containing combination of *C. deodara* and *T. grandis* (dried at 60°C). Both the wood species i.e., *C. deodara* and *T. grandis* are known to deter termite attack of different species of termites and, therefore, seriously affected the survival of *M. championi* also. Termite survival was also seriously affected when they were confined to cages containing combination of woods of *A. pindrow* and *P. euramericana*. In fact, survival of *M. championi* was the minimum (56.3%) in cages containing wooden blocks of *A. pindrow* and *P. euramericana* dried at 100°C. *Abies pindrow*, therefore, is more resistant to the attack of *M. championi* than other timber species tested presently (Table 4).

No Choice Field Experiment

Feeding

Of the ten species of wooden blocks dried at 60°C, minimum feeding in no choice tests was

recorded on wood of *A. pindrow*. *Microcerotermes championi* showed maximum feeding on the wooden blocks of *P. euramericana*. The amount of wood consumed from *T. occidentalis*, *A. arabica*, *M. alba*, *M. indica* and *C. deodara* was not significantly different ($P>0.05$). However, significantly less feeding ($P<0.05$) was recorded on wooden blocks of *T. grandis* as compared to *P. roxburghii* and *C. deodara*. The feeding behaviour of *M. championi* is important in the sense that it fed comfortably on woods of *P. roxburghii* and *C. deodara*, which are known to deter the attack of other termite species. Feeding propensity of *M. championi* in descending order of preference was *P. euramericana* > *P. roxburghii* > *A. indica* > *T. grandis* > *M. alba* > *C. deodara* > *M. indica* > *A. arabica* > *T. occidentalis* > *A. pindrow*.

As regards the impact of temperature at which different species of wooden blocks were dried, the amount of wood consumption (no choice test), in general, increased with the increase of temperature (Table 5). Consequently amount of wood consumed from wooden blocks of *A. pindrow* dried at 60, 70, 80, 90 and 100°C was 44.6, 81.3, 97.3, 133.6 and 174.3 mg, respectively, and was significantly different ($P<0.05$) from one another. Amount of wood consumed from wooden blocks of *M. indica* dried at 70 and 80°C was 125.3 and 145.3 mg,

respectively, similarly, there was significant ($P<0.05$) difference in the amount of wood consumed from block of this species dried at 80 and 90°C.

Amount of wood consumed from wooden blocks of *P. roxburghii* and *C. deodara*, known for natural resistance, increased significantly ($P<0.05$) with increase in temperature, indicating that the timbers lose their natural resistance with increase in temperature. But comparison of *Cedrus deodara* and *P. roxburghii* when offered in combination revealed that in such a choice situation, *P. roxburghii* is much more acceptable to *M. championi* than *C. deodara*. Amount of wood consumed from wood blocks of *P. roxburghii* at 70, 80, 90 and 100°C was 147.0, 824.3, 1243.3, 1345.3 and 1548.3 mg, respectively, and was significantly more ($P<0.05$) than that of *C. deodara* i.e., 123.3, 158.6, 195.3 and 244.6 mg, respectively.

Choice Field Experiment

Feeding

Different species of wood dried at different temperatures were offered in combination of two, in nests of *M. championi* located in the

Field (Table 7). *Microcerotermes championi* easily identified the

palatable wood in a choice of two woods and fed more on the palatable wood. Table 28 indicates that amongst the wooden blocks dried at 60°C and offered in combinations of two wood species, *M. championi* showed the maximum (734.3 mg) feeding on *P. euramericana* and the minimum on *A. pindrow*, and the amount of wood consumed was significantly different ($P=0.000$).

Amongst the wooden blocks dried at 70°C and offered in combination of two, the maximum feeding again was recorded on *P. euramericana*, but the minimum in this set of experiment on *A. arabica*, which was offered in combination with *M. alba*. Amongst wooden blocks dried at 80°C, maximum feeding again was noted on *P. euramericana*, and the minimum on *A. pindrow* (Table 7). *Microcerotermes championi* like most of the other termite species is capable of locating the palatable wood and avoiding the wood that has some natural resistance properties.

Table 7: Average amount of wood consumption ($\bar{x} \pm SD$) in “mg” by workers of *M. championi* on *A. arabica* (AA), *M. alba* (MA), *T. grandis* (TG), *C. deodara* (CD), *P. euramericana* (PE), *A. pindrow* (AP), *A. indica* (AI), *M. indica* (MI) and *P. euramericana* (PE), *P. roxburghii* (PR) dried at different temperatures in 2-week “CHOICE TRIAL” under field condition.

Temperature (°C)	Comparison ^a	Wood Mass Loss (mg)		Probability ^b
		Wood 1	Wood 2	
60	AA/MA	103.3±5.77	113.3±5.77	0.10
	TG/CD	156.7±11.5	136.7±11.5	0.10
	PE/AP	734.3±4.04	43.3±5.77	0.000**
	AI/MI	196.6±5.77	230.0±20.0	0.11
	PE/PR	734.6±4.04	150.0±2.00	0.000**
70	AA/MA	113.3±5.77	158.3±3.51	0.0014*
	TG/CD	180.0±10.0	153.3±5.77	0.028*
	PE/AP	925.0±10.0	85.0±2.00	0.0000**
	AI/MI	246.6±3.06	253.3±15.3	0.54
	PE/PR	927.0±10.0	826.0±8.54	0.0009**
80	AA/MA	136.6±2.08	169.3±2.52	0.0004**
	TG/CD	206.7±11.5	183.3±15.3	0.13
	PE/AP	1229.6±4.51	108.3±7.64	0.0000**
	AI/MI	266.6±2.08	284.0±15.1	0.19
	PE/PR	1330.6±7.02	1248.6±9.02	0.0011*

Cont'd.....

90	AA/MA	168.6±3.06	206.6±4.73	0.0013*
	TG/CD	236.7±11.5	210.0±17.3	0.11
	PE/AP	1655.3±5.51	138.3±4.04	0.0000**
	AI/MI	302.6±8.14	323.3±25.2	0.31
	PE/PR	1648.0±3.00	1355.0±4.58	0.0000**
100	AA/MA	206.3±11.8	256.6±1.53	0.018*
	TG/CD	263.3±15.3	226.7±20.8	0.091
	PE/AP	1848.3±1.53	179.6±5.03	0.0000**
	AI/MI	348.0±4.00	360.0±5.00	0.048*
	PE/PR	1853.6±5.13	1563.0±7.55	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 block indicated by * = 0.05, ** = 0.01, are significantly different (paired comparison t-test).

DISCUSSION

Termite investigators have long noted that certain woods are resistant to termites. Wolcott (1951) and Wood (1978) have reported that resistance of timber to attack of termite is due to specific chemicals in the wood, which repel certain termites. Toxic chemicals of woods may act on the termites directly or indirectly by affecting their symbiotic protozoa. For instance, Mauldin *et al* (1981) have reported that protozoan populations varied for termites exposed to heart wood samples of 21 American wood species. Neither

hardness nor high lignin content of wood prevent it from being eaten by dry wood termites (Wolcott, 1951). Behr *et al.* (1972), however, report that there is a strong correlation between hardness of the wood and its resistance to attack by termites other than dry wood termites.

Different types of studies and experiments have been performed on feeding preferences of termites and about natural resistance of timber. Sen-Sarma and Chatterjee (1965) reported that the resistance of *C. deodara*

progressively deteriorates with time due to various causes, including evaporation that repletes the repellent chemicals. Currently conducted studies also indicate more wood consumption by *M. championi* from wooden blocks of *C. deodara* dried at 100°C than those of dried at 60°C.

Different species of termites also have different food preferences and results obtained from tests with only one species do not necessarily apply to other species and may in fact, be misleading (Gay *et al.*, 1954). In Australia *Pinus* is attacked by a wide range of termites but not by *Nasutitermes eximiosus* and the resistance of this species appear to be due to fact that essential oil in the timber contain α and β pinenes which are dominant constituents of the termite alarm-pheromone (Moore, 1965).

Similarly, Chaudhry *et al.* (1978) studied natural resistance of various timbers to the attack of *Coptotermes heimi* (Wasman). They also investigated the survival of this species on the sawdust of 12 common Pakistani timber species in the laboratory conditions. Based on the longevity of the workers and soldiers, *C. deodara* and *T. grandis* were declared resistant to termite attack, while *Salmalia malabarica*, *A. pindrow* and *Picea smithiana* were the most susceptible. The present studies indicate that *P. roxburghii* was consumed by *M. championi*. The findings were slightly different from the results reported earlier by Akhtar and Ali (1979), who arranged feeding propensity of *O. obesus* in descending order of preference as follows: *P. euramericana* (S.W.), *A. pindrow* (H.W.), *A. arabica* (H.W.), *C.*

deodara (H.W.), *M. indica*, *M. alba* (H.W.), *P. roxburghii* (H.W.), *D. sissoo* (S.W.), *P. wallichiana* (H.W.), *P. gerardiana* (H.W.) and *D. sissoo* (H.W.). Some woods such as *C. deodara*, *D. sissoo* (H.W.), *P. gerardiana*, *P. roxburghii* and *P. wallichiana* have the reputation of natural resistance. But surprisingly *M. championi* consumed enough amount of wood from *P. roxburghii*, *A. indica*, *T. grandis* and *C. deodara*, whereas *A. pindrow* was found highly resistant. Akhtar (1980) reported that *A. pindrow* is resistant to *C. heimi*.

Sen-Sarm *et al.* (1978) carried out laboratory studies on the survival and feeding of *M. beesonii* workers on the heart wood of deodara (*C. deodara*), redwood (*Dalbergia latifolia*), garuga (*Garuga pinnata*), machilus (*Machilus macrantha*), sal (*Shorea robusta*) and toon (*Toona ciliata*). Each test lasted 60 days or until the death of the colony, whichever was the earlier. The results showed that *C. deodara* and rosewood heartwood were very resistant to termite attack. The outer heartwood of sal and toon was also resistant, although the inner heartwood of sal was only moderately resistant. Garuga heartwood was moderately resistant, but machilus heartwood was susceptible.

Bultman *et al.* (1979) investigated the natural resistance of 42 African woods to *C. formosanus*. The termites did not feed on 19 of the 42 woods with which they were confined, and 13 of the remaining 23 woods were only lightly damaged. The termites were unable to survive the full eight weeks of exposure while confined with 26 species

of the woods, and in some cases complete mortality occurred within one to five weeks. It is thought that this was due to systematic poisons volatilizing from the wood in the test chambers. An inverse relationship was found between the wood density and the amount of wood damage.

Sen-Sarma *et al.* (1979) studied the consumption, by laboratory colonies of *M. beelsoni* of the outer heartwood of three timber species (*Terminalia alata*, *Toona ciliata* and *Grewia tilifolia*) in association with either a highly susceptible timber species (*M. alba*) or a highly resistant species (*D. latifolia*). Test blocks of the timber were buried in soil with a small carton nest of *M. beelsoni* and blocks of either *M. alba* or *D. latifolia*. After 60 days it was found that all three species showed an inconsequential (approximately 0.2%) weight loss when confined with *M. alba*, but a high weight loss (10-30%) in conjunction with *D. latifolia*. The importance of this food preference behaviour in the designs of field experiments, where a moderately susceptible timber may escape severe termite attack if tested with a more susceptible timber, was emphasized.

Akhtar and Jabeen (1981) carried out laboratory tests using *C. heimi* on the variation of the amount of wood (*P. euramericana*) consumed with variation in specimen size. Blocks were dried, weighed and exposed to 300 workers, for one month after which the amount of wood consumed was determined by re-weighing. Field tests were also carried out using weighed specimens of *P. euramericana* and *D. sissoo* placed near

O. obesus mounds for two, five or ten day periods. In both sets of experiments, the amount of wood consumed increased with increasing specimen length, but the difference was only significant when the difference in specimen length was three fold or greater.

Don-Pedro (1983) studied the natural resistance of four Nigerian timber species to *Amitermes evuncifer* attack in the laboratory under choice and forced feeding regimes. Under both conditions, iron wood (*Nosogardonia papaverifera*) was the least resistant to *A. evuncifer* attack followed by afzelia (*Afzelia* sp.), teak (*Tectona grandis*) and copal (*Gossweillerodondron balsamiferum*) respectively. The rate of survival of *A. evuncifer* over a period of eight weeks under choice feeding conditions using a sawdust matrix was uniform and significantly higher than the survival rates under forced feeding conditions in all treatments. Similar situation was witnessed with *M. championi* and survival was higher under choice feeding conditions.

Scheffrahn *et al.* (1983) studied the feeding deterrent activity of sapwood extracts of sugar pine (*Pinus lambertiana*) and related compounds using *Incisitermes minor*. A bioassay was designed to quantify reductions in termite feeding caused by deterrent chemicals. Crude extracts and isolated fractions of sugar pine were deterrent and not preferred by *I. minor* at 0.5 mg/cm². Fatty acids occurring in sugar pine extracts had a broad range of deterrent activity. Long chain saturated fatty acids were deterrent at 0.25 and 0.05 mg/cm².

Badawi *et al.* (1984) studied five wood species at Al-Kharj, Saudi Arabia for their resistance to termites (*Microcerotermes*, *Microtermes* and *Anacanthotermes*). Stakes of each wood species were half buried in the soil and the extent of damage were 0% for mahogany (*Keya* sp.), 3% for apitong (*Dipterocarpus* sp.) and 13% for pine (*Pinus* sp.), 30% for spruce (*Picea* sp.) and 97% for beech (*Fagus* sp.). Severity of damage was correspondingly highest for beech. Termite species showed some host preference: damage to beech was caused mainly by *Microcerotermes* and damage to the spruce by *Microtermes*.

Carter *et al.* (1984) investigated protozoan populations of *C. formosanus* Shiraki exposed to heartwood samples of 21 American species in no choice experiments and from nine wood species in choice experiments. In the no choice tests, all protozoan were eliminated from the termites fed on northern white cedar (*T. occidentalis*) and catalpa (*Catalpa binoniodes*) and were greatly reduced in termites exposed to white mulberry (*M. alba*) and yellow poplar (*Liriodendron tulipifera*). *Pseudotriconympha grassii* was the protozoan most affected by the test woods; after three weeks no *P. grassii* was found in termites exposed to white cedar, catalpa, white Mulberry, yellow poplar, baldcypress (*Taxodium distichum*) or holly (*Ilex opaca*). Other woods reduced the protozoan population and with additional time would probably have eliminated it. In the choice experiments, the protozoan populations were little reduced, as the termites preferred to eat the control (*Pinus elliotti* var. *elliotti*) blocks.

Imamura *et al.* (1984) studied termites resistance of commercial particle boards in which different types of commercial particle-boards were exposed to attack by *C. formosanus* in choice tests (where the termites could move freely in moist soil) and in feeding tests in a small vessel. Differences were observed in the degree of damage and in the form of galleries made by the termites. Low density boards were severely infested than boards with dense surface of finer particles and a higher content of adhesive. It is suggested that the hardness of boards is more important in restricting termite activity than other factors such as the species of wood and the type of adhesive.

Supriana (1987) conducted tests on 28 timber species with *Coptotermes curvignathus* and *Cryptotermes cynocephalus*. The results showed that replacement preference test have no consistent pattern of preference although some of the most preferred species, such as *D. latifolia*, had been shown to be resistant to termites in earlier studies, and some of the less preferred, such as *Mangifera foetida* and *M. caesia* to be susceptible; ranking varied between the termite species. The preference test gives similar results, again suggesting a random termite orientation, and gave different rankings for each termite species.

Domingos *et al.* (1988) studied termite resistance in three cerrado timber species (*Qualea grandiflora*, *Salvertia convallariodora* and *Terminalia argentea*) and one exotic species (*Euclyptus citriodora*) in Minas Gerais, Brazil. Fragments of wood, including

bark were partially buried in cerrado areas for upto 34 months. *S. convallariodora* and *Q. grandiflora* showed the greatest resistance. *E. citriodora* was the most susceptible. The majority of the damage was caused by *Heterotermes* and *Parvitermes*.

Salman *et al.* (1988) studied resistance of some Egyptian timbers to the attack of sand termite *Psammotermes hybostoma* and results showed that *Nile acacia*, *Nile tamarisk*, spider, olive and athel tamarisk were highly resistant, and Dom palm, Guava, Gambosia, apricot and date-palm leaf were resistant. Red guam, ficus, sissoo tree and river oak were susceptible, and royal Poinciana, sesban, orchid tree, silk cotton, Senegal mahogany and date palm were highly susceptible. Tipu was extremely susceptible.

Delaplane and LaFage (1989) studied preference for moist wood by the Formosan subterranean termite (Isoptera: Rhinotermitidae) under no choice feeding tests, groups of *C. formosanus* were offered wood blocks which differ in initial moisture content. Wood feeding rate, number of workers, and number of soldiers were highest in the high moisture treatment. In higher moisture blocks, damage by termites was associated with gain of moisture. Even though block moisture contents changed, termites determined their preferred wood blocks early, when contents were more discrete; they then continued to prefer those blocks. Changes in moisture contents were probably the result of blocks equilibrating to ambient relative humidity of the containers, but the termites enhanced this process, perhaps

by actively relocating water. This suggests that damp wood in buildings is especially vulnerable to *C. formosanus* and that bait blocks for remedial control of this pest should have high moisture content.

Delaplane and LaFage (1989) also investigated preference of *formosanus* subterranean termites in a laboratory choice-feeding test, in which groups of termites from five colonies of *C. formosanus* were presented with wood blocks, which had no damage, or which had been damaged previously either by nestmates or by conspecifics from another colony, or by another termite species, *Reticulitermes virginicus*. *Coptotermes formosanus* preferred wood which had previously been damaged by conspecifics, regardless of colony origin, to wood damaged by *R. virginicus* to undamaged wood. Also, they preferred wood damaged by *R. virginicus* to undamaged wood. The results were almost entirely explained by thigmotaxic cues on the surface of damaged wood blocks rather than pheromonal cues deposited on the wood.

Mwanza (1989) investigated natural resistance to fungal decay in heartwood from 20-year old *Eucalyptus* trees (five species) and compared with that in cedar (*Juniperus procera*) in field and laboratory tests in Kenya. After five years in the field, samples of *E. grandis* showed severe termite attack; attack on *E. camaldulensis*, *E. microcorys* and *J. procera* was slight.

Rokova *et al.* (1990) studied eight major commercial timber species,

which were exposed in ground contact to termites; Kwila (*Intsia palembanica*), taun (*Pometia pinnata*), malas (*Homalium foetidum*), walnut (*Dracontomelon dao*), calophyllum (*Calophyllum* species), kamarene (*Eucalyptus deglupta*), beech (*Nothofagus* spp.) and white cheese wood (*Alstonia scholaris*). Results after 24 months of exposure showed that Kwila was still sound, while taun, walnut, malas and white cheese wood had traces of termite attack on some stakes. All stakes of calophyllum and beech had been totally destroyed; three kamarene stakes had also been destroyed. The termites found attacking the stakes were *Nasutitermes graveolus*, *Cryptotermes obiratus*, *C. acinaciformis* and *Microcerotermes repugnans*.

Lin *et al.* (1992) studied termite resistance of the 10 native hardwoods, *Cyclobalanopsis pachyloma*, *Sapium discolor*, *Mallotus paniculatus*, *Elaeocarpus sylvestris*, *Trema orientalis*, *Ormosia formosana*, *Syzygium boxifolium*, *Prunus phaeosticta*, *Engelhardtia roxburghiana* and *Neolitsea konishii*. Taiwan red pine was used as control. Termites mortality was not significantly correlated with oven dry specific gravity, but showed a significant correlation with alcohol-benzene extracts of the wood. Weight loss of wood blocks following termite feeding was significantly correlated with both oven dry specific gravity and alcohol-benzene extracts. *Cyclobalanopsis pachyloma* was the most resistant species, and *Sapium discolor* and *Mallotus paniculatus* were the least resistant.

Moein and Rust (1992) studied effect of wood degradation by fungi on the feeding and survival of the West Indian dry wood termite, *Cryptotermes brevis* (Isoptera : Kalotermitidae). In this pseudergates of *Cryptotermes brevis* were fed on blocks of *Pinus sylvestris*, *Picea oblea*, *Eucalyptus camaldulensis* and *Casuarina glauca* which had been exposed to five different species of mould, sapstain and rot fungi. The amount of fungal decay was dependent on the species of fungi and wood. Only 17-62% termite survival was observed on air dried blocks decayed by *Aspergillus flavus*, *A. niger* and *Trichoderma viride* after 24 hours; by week four, survival had dropped to 0-28%. Feeding and survival were significantly higher on oven dried blocks of *Picea obiea* and *Pinus sylvestris* decayed by *A. flavus*, *A. niger* and *T. viride*, and on *Casuarina glauca* by *T. viride*. *E. camaldulensis* resisted fungal infection and deferred feeding and survival of *C. brevis*.

Grace *et al.* (1994) studied natural resistance of Alaska-Cedar red wood and teak to Formosan subterranean termites, *C. formosanus* in 4 week two choice laboratory tests and reported that in choice tests, termites avoided feeding on either Alaska-Cedar or red wood, if Douglas Fir was also present. When presented with a choice of either Alaska-Cedar or red wood termites fed significantly less on Alaska-Cedar. Fungus has been shown to be of importance to subterranean termites both as a pathogen and as an attractant. Rust *et al.* (1996) showed that *Reticulitermes hesperus* is attracted to extracts of the fungus, *Gloeophyllum trabeum*. Various

isolates of the fungi *Metarhizium anisopliae* and *Beauveria bassiana* have potential for future use in control programs (Delate *et al.*, 1995; Wells *et al.*, 1995; Jones *et al.*, 1996). Grace (1997) reported that many of the chemicals causing attracting and avoidance in several tree species are polar molecules. Doi *et al.* (1998) found that steaming of the heartwood of the Japanese larch degraded or removed the chemicals responsible for the inhibition of termite attack.

The process of termite control involves a vigorous, ongoing inspection programme and use of one or more control tactics. Building construction practices, building materials, the termite species present, soil and climatic conditions are all factors that influence the potential risk associated with termite infestation of structures (Barbara *et al.*, 2000).

Most problems in large buildings involve subterranean termite colonies that persist for years on buried scrap wood and constantly explore upwards for new source of food. Economic loss caused by termites to woodwork in buildings, agricultural crops, makes them object of public interest (Akhtar, 1996). Roonwal (1976) reports the occurrence of some 525 species in the oriental. Many more have been described since 1970, but not all species are of economic importance, only a few species damage human property. For example Akhtar (1972, 1983), reports that out of 50 species of termites described from Pakistan, only 11 are of great economic importance. Of these, *Odontotermes guptai*, *M. mycophagus*

and *M. obesi* are more common foragers in agricultural fields (Akhtar and Shahid, 1993). Akhtar (1983) described feeding patterns of eleven species of termites damaging woodwork in the buildings. Of these, *Heterotermes indicola*, *C. heimi*, *M. obesi*, *M. unicolor* are common in Punjab and NWFP but *Anacanthotermes vagans* is the main wood-destroying termite in Baluchistan.

Several termite species have been reported from forests in different ecological zones of Pakistan. Depending upon the plant species, the termite species vary. In NWFP, for instance, forest trees mostly fall victim to *O. obesi*, *H. indicola* and *C. heimi*. In the plains of Punjab, *C. heimi*, *O. guptai*, *O. obesus*, *M. obesi* mostly attack forest trees. In Azad Kashmir, *H. indicola* is more abundant in Muzaffarabad Azad Kashmir and its preferred host is *Alianthus altissima*. Same is true for district Bagh and Poonch. In district Mirpur, however, *O. guptai* and *C. heimi* are more common and their preferred hosts are *Acacia arabica* and *Dalbergia sissoo* (Shakoor *et al.*, 1991). In Baluchistan *A. vagans* and *Amitermes* spp., attack forest trees.

Comparing *M. championi* with other sympatric species, it is found that *M. championi* is widely distributed in Punjab and Sindh provinces of Pakistan, besides India and Bangladesh (Akhtar, 1974, 1975; Sen-Sarma, 1975a, b). It attacks decaying stumps of *Shorea robusta*, *Swietenia macrophylla* and standing trees of *Acacia catechu* and *Cissia fistula*. It makes dirt carton type nests at the base of Bamboo and *Saccharum munja*.

In India (Dehra Dun) *Microcerotermes beelsoni* attacks *Morus alba* which is more palatable and *Delbergia latifolia* highly resistant to this termite. Likewise, in other parts of India (Haryana) *M. beelsoni* found as a pest of forestry and agriculture, and found attacking *Euclyptus* trunk (Sen-Serma and Gupta, 1979; Verma, 1989). *Microcerotermes biroi* (Papua New Guinea) has been found as pests of forests (Robert, 1987). *Microcerotermes repugnans* (from Papua New Guinea) found attacking stakes of Kwila (*Intsia palembanica*), Taun (*Pometia pinnata*), Malas (*Homalium foetidum*), Walnut (*Drancontemelon dao*), Callophylum (*Callophylum* spp.), Kamarere (*Eucalyptus deglupta*), Beech (*Nothofagus* spp.), and White CheeseWood (*Alstonia scholaris*). (Rokova and Konabe, 1990). *Microcerotermes diversus* Silv. (Iraq) found to attack Date (*Phoenix dactylifera*), Grapes (*Vitis vinifera*), rough bark Eucalyptus (*Euclyptus microtheca*) and were heavily infested, while least infested were smooth bark (*Euclyptus camaldulensis*), Citrus (*Citrus sinensis*, *C. Aurantium*) and olive (*Olea eurpaea*), respectively. Kunar wood (*Platanus orientalis*) is susceptible to *M. diversus* Silv., while Orange (*Citrus sinensis*) least susceptible, so in Iraq *M. diversus* Silv. had a wide range of host trees and therefore is widely distributed (Al-Alawy *etal*; 1989). *Microcerotermes fletcheri* and *M. heimi* (in Dehra Dun, India) have been found as pests of bamboos (Thakur, 1988). *Microcerotermes solidus* (in Ghana) found as pests of coconut palm (Kumar, 1989). *Microcerotermes* sp., in Bangladesh cause damage to Tea

plantation (Mir and Mainuddin), while in Southern China *Microcerotermes* sp., attacks houses built close to forest on hillsides (Gao *etal*; 1992). *Microcerotermes diversus*, *M. gabrielis* and *M. buettikeri* (from India) attacks agricultural and forest trees (Esmaeilli and Ghayurfar, 1992). *Microcerotermes diversus* from Iran was also found attacking twigs and trunks of grapevine (*Vitis vinifera*) in Khuzestan province. *Microcerotermes serratus* (from Pilbara region, North Western Australia) found attacking Rail sleepers of Karri (*Eucalyptus diversicolor* F. Muell.) and considered as the major wood destroyer in Australia (Barnacle *etal*; 1992). *Microcerotermes arboreus* (from city of Belem, Para; Brazil) found attacking building timbers (Bandeira *etal*; 1989). Similarly, *M. exiguss* and *M. strunkii* (Amazonia, Brazil.) are considered as structural pesta as they have been found attacking domestic buildings (Mill, 1991).

Present studies on feeding preferences of *M. championi* have shown that *A. pindrow* was found highly resistant and *P. euramericana* highly palatable. Future studies on extract of *A. pindrow* may reveal the nature of resistance to this termite. Woods like *C. deodara*, *P. roxburghii* and *T. grandis* have local reputation for resistance to termite in Pakistan. *Cedrus deodara* has been found to be highly susceptible to *O. obesus*, indicates that local reputation is not always true. Deodar is grown at higher elevations where *Archotermopsis wroughtoni* is the most common termite and *O. obesus* is absent (Chaudhry, 1954; Ahmad, 1955; Akhtar, 1974b). At lower elevations, termite species are

different and, therefore, deodar used at lower elevations for woodwork in houses, can be attacked by them also. Laboratory tests are underway on *C. deodara* to know its resistance against other species of termite.

CONCLUSIONS

Feeding preferences of *M. championi* in "No choice" laboratory experiments, indicated that the *Abies pindrow* was found highly resistant and *Populus euramericana* highly palatable. The impact of drying temperature showed that 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. championi* 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. championi* showed maximum feeding on *P. euramericana* and the minimum on *A. pindrow*. So it's suggested that buildings construction and design is preferred with the use of less susceptible wood keeping in view of the climatic conditions of the specific region around the globe to increase the durability and life of the buildings. As the next step, it is necessary to investigate environmental condition preferences such as optimum temperature and relative humidity to achieve complete understanding of the feeding activity of the invasive species of the genus *Microcerotermes*.

REFERENCES

- Ahmad, M., 1955. Termites of Pakistan. *Biologia (Pakistan)*, 1: 202-264.
- Ahmad, M., Sheikh, K.H. and Jafri, R.H., 1979. Biology, pathology and distribution (in relation to soil conditions) of termites of Pakistan. USDA Research project No. 17-FS-21, pp.1-424.
- Akhtar, M.S., 1972. *Studies on the taxonomy and zoogeography of the termites of Pakistan*. Ph.D. Thesis, University of the Punjab, Lahore.
- Akhtar, M.S., 1974a. New termites from Pakistan. *Biologia (Pakistan)*, 20: 23-61.
- Akhtar, M.S., 1974b. Zoogeography of the termites of Pakistan. *Pakistan J. Zool.*, 6: 85-104.
- Akhtar, M.S., 1975. Taxonomy and zoogeography of termites of Bangladesh. *Bull. Dept. Zool. Univ. Punjab (N.S.)*, pp.1-200.
- Akhtar, M.S., 1976. Descriptions of hitherto unknown imagoes of termites (Isoptera : Termitidae). *Pakistan J. Zool.*, 8: 159-165.
- Akhtar, M.S., 1978. Some observations on swarming and development of incipient colonies of termites of Pakistan. *Pakistan J. Zool.*, 10: 283-290.

- Akhtar, M.S. and Ali, S.S., 1979. Wood preferences and survival of *Coptotermes heimi* (Wasmann) and *Odontotermes obesus* (Rambur) (Isoptera). *Pakistan J. Zool.*, 11: 303-314.
- Akhtar, M.S. and Jabeen, M., 1981. Influence of specimen size on the amount of wood consumed by termites. *Pakistan J. Zool.*, 13: 79-84.
- Akhtar, M.S. and Raja, Z.A., 1985. Survival and feeding responses of *Bifiditermes beelsoni* (Gardner) to wood and wood extracts of *Albizia procera* and *Bauhinia variegata*. *Pakistan J. Zool.*, 17: 363-367.
- Akhtar, M.S. and Kausar, R., 1991. Effect of container volume, moisture content, temperature and matrix on survival and wood consumption of *Coptotermes heimi* (Wasmann) (Isoptera: Rhinotermitidae). *Proc. Pakistan J. Zool.*, 11: 101-106.
- Akhtar, M.S., 1996. Strategies in termite control. *Proc. Pakistan Congr. Zool.*, 16: 1-26.
- Amburgey, T.L. and Beal, R.H., 1977. White rot inhibits termite attack. *Sociobiology*, 3: 35-38.
- Badawi, A., Faragala, A.A. and Dabbour, A., 1984. The natural resistance of some imported wood species to subterranean termites in Saudi Arabia. *Zeitschrift für angewandte Entomologie*, 98:500-504.
- Bandeira, A.G., Gomes, J.I; Lisboa, P.L.B and Silv-e-Souza, P.C; 1989. Insectos Pragas de madeiras de edificacoes em Belem-Para (Insect pests of wood in buildings in Belem,Para). *Boletim de Pesquisa-Centro de Pesquisa Agropecuaria do Tropico Umido*, 101:25.
- Barbara, L.J. and Forschler, B.T., 2000. Criteria for assessing efficacy of stand-alone termite bait treatments structure. *Sociobiology*, 36(1): 245-255.

- Barnacle, J.E.; Creffield, J.W. and Miller, L.R.; 1992. Attack of oil/creosote treated rail sleepers of Karri (*Eucalyptus diversicolos* F.Muell.) by *Microcerotermes* spp; in North Western Australia.. *Mater. Org*; 27:32-45
- Becker, G., 1961a. Beobachtungen und Versuche über den Beginn der Kolonie-Entwicklung von *Nasutitermes ephratae* Holmgren (Isoptera). *Z. Angew. Entomol.*, 19: 78-93.
- Becker, G., 1961b. On the examination and estimation of the natural resistance of wood to termites. *Holz Roh-u. Werkstoff.*, 19: 278-290.
- Behr, E.A., Behr, C.T. and Wilson, L.F., 1972. Influence of wood hardness on feeding by the subterranean termite *Reticulitermes flavipes* (Isoptera : Rhinotermitidae). *Ann. ent. Soc. Am.*, 65(2): 457-460.
- Bultman, J.D., Beal, R.H. and Ampong, F.F.K., 1979. Natural resistance of some tropical African wood to *Coptotermes formosanus* Shiraki. *For. Proc. J.*, 29: 46-51.
- Carter, F.L., Garlo, A.M. and Stanley, J.B., 1978. Termicidal components of wood extracts: 7. Methyl Juglone from *Diospyros virginiana*. *J. Agric. Fd. Chem.*, 26: 869-873.
- Carter, F.L., 1981. Responses of *Reticulitermes flavipes* to selected North American hardwood and their extracts. *Int. J. Wood Preserv.*, 1: 153-160
- Carter, F.L., Mauldin, J.K. and Rich, N.M., 1984. Protozoan population of *Coptotermes formosanus* Shiraki exposed to heart wood samples of 21 American species. *Material und Organismen*, 16: 29-38.
- Chaudhry, G.U., 1954. A useful termite. *Pakistan J. For.*, 4: 31-32.
- Chaudhry, M.I., Malik, N.K. and Arshad, M., 1978. Natural resistance of various timbers to the attack of *Coptotermes heimi*

- (Wasmann). *Pakistan J. Forest.*, 28: 123-126.
- Collins, N.M., 1981. Consumption of wood by artificially isolated colonies of the fungus growing termite *Macrotermes bellicosus*. *Entomol. Exper. et. Appel.*, 29: 313-320.
- Dalaplaine, K.S. and LaFage, J.P., 1989. Preference for moist wood by the Formosan subterranean termite (Isoptera: Rhinotermitidae). *J. Econ. Entomol.*, 82: 85-100.
- Delate, K.M., Grace, J.K. and Armstrong, J.W., 1995. Carbon dioxide as a potential fumigant for termite control. *Pesticide Science*, 44: 357-361.
- Delate, K.M., Grace, J.K. and Tome, C.H.M., 1995. Susceptibility of neem to attack by the Formosan subterranean termite *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae). *J. Appl. Entomol.*, 119: 93-95
- Doi, S., Takahashi, M., Yoshimura, T., Kubota, M. and Adachi, A., 1998. Attraction of stemmed Japanese Larch [*Larix leptolepis* (Sieb. Et Zucc.) Gord.]. Heartwood to the subterranean termite *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae). *Holzaforschung*, 52: 7-12.
- Domingo, D.J., Gontijo, T.A. and Cavenaghi, T.M.C.M., 1988. Uso diferencial de madeiras por termites em cerrado (Differential use of timbers by termites in the Cerrado). *Brasil Florestal*, 15: 26-31.
- Don-Pedro, K.N., 1983. Natural resistance of some Nigerian timber species to *Amitermes evuncifer* Silvestri (Isoptera). *Appl. Entomol. Res. Lab., Univ. Lagos, Nigeria*, 97: 647-650.
- Esmaeilli, M. and Ghayurfar, R; 1992. An investigation on the termite fauna of Iran. In: *Living with insects*. Proceeding of the 19th international congress of Entomology, Beijing, China, pp. 243.

- Gay, F.T., Greaves, T., Holdaway, F.G. and Wetherly, A.H., 1954. Standard laboratory colonies of termites for evaluating the resistance of timber, timber preservatives and other materials to termite attack. *C.S.I.R.O. Aust.*, 277: 1-64.
- Grace, J.K. and Yamamota, J.R., 1994. Natural resistance of Alaska-Cedar red wood, and teak to Formosan subterranean termites. Forest Product Society. *Forest. Prod. J.*, 44(3): 41-45.
- Grace, J.K., 1997. Influence of tree extractives on foraging preferences of *Reticulitermes flavipes* (Isoptera: Rhinotermitidae). *Sociobiology*, 30: 35-42.
- Haverty, M.I. and Nutting, W.L., 1975b. Natural wood preferences of desert termites. *Ann. ent. Soc. Am.*, 68: 533-536.
- Howick, C.D., 1975. Influence of specimen size, test period and matrix on the amounts of wood eaten by similar groups of laboratory termites. *Rec. Brit. Wood Pres. Assoc.*, pp.13.
- Imamura, Y. and Nishimoto, K., 1984. Termite resistance of commercial particle boards. *Mokuzai Kogyo (Wood Industry)*, 38: 70.
- Jones, W.E., Grace, J.K. and Tamashiro, M., 1996. Virulence of seven isolates of *Beauveria basiana* and *Metarhizium anisopliae* to *Coptotermes formosanus* (Isoptera: Rhinotermitidae). *Environ. ent.*, 25: 481-487.
- Kumar, S. 1989. A review of Palm pests and their management in Africa. Discovery and innovation. *Deptt. of Biological Sciences, River state university of science and Technology, Port Harcourt, Nigeria*, 1(2): 41-48.
- Lenz, M. and Williams, E.R., 1980. Influence of container, matrix volume and group size on survival and feeding activity in species of *Coptotermes* and *Nasutitermes* (Isoptera: Rhinotermitidae: Termitidae).

- Material U. Organismen*, 15: 25-46.
- Lenz, M., 1986. Principles behind the laboratory assessment of material with subterranean termites. Recent perspective and shift in emphasis. *Material U. Organismen*, 21: 123-137.
- Lenz, M., Amburgey, T.L., Dai, Zi Rong, Kuhne, H., Mauldin, J.K., Preston, A.F. and Westcott, M., 1987. Inter laboratory studies on termite wood decay fungi association: I. Determination of maintenance conditions for several species of termites (Isoptera: Mastotermitidae: Termopsidae: Rhinotermitidae: Termitidae). *Sociobiology*, 13: 1-56.
- Lin, T.S. and Yin, H.W., 1992. Termite resistance of ten hard wood species of Taiwan. *J. Bull. Taiwan Forest. Res. Inst. New Series*, 7: 101-108.
- Mauldin, J.K., Carter, F.L. and Rich, M.N., 1981. Protozoan populations by *Reticulitermes flavipes* (Kollar exposed to heartwood samples of 21 American species. *Material U. Organismen*, 16: 16-28.
- McMahan, E.A., 1966. Food transmission within the *Cryptotermes brevis* colony (Isoptera: Kalotermitidae). *Ann. ent. Soc. Am.*, 59: 1131-1137.
- Mill, A.E; 1991. Termites as structural pests in Amazonia., Brazil. *Sociobiology*, 19: 339-348.
- Moein, S.I. and Rust, M.K., 1992. The effect of wood degradation by fungi on the feeding and survival of the West Indian dry wood termite, *Cryptotermes brevis* (Isoptera: Kalotermitidae). *Sociobiology*, 20: 20-39.
- Moore, B.P., 1965. Pheromones and insect control. *Aust. J. Sci.*, 28: 243-245.
- Mwanza, E.J.M., 1989. Some factors influencing natural decay resistance in Eucalyptus and Cedar. Research Note. Kenya Forestry Research Institute No. 1, pp.24.

- Rokova, M. and Konabe, C., 1990. Assessment of untreated Papua New Guinean timbers against subterranean termites. Progress report 1. Stockholm, Sweden, The International Research Group on wood preservation. Document No. IRG/WP/1436, pp.8.
- Roonwal, M.L., 1976. Termites of Oriental region. In: *Biology of Termites* (eds. K. Krishan and F.M. Weesner), pp.315-391. New York.
- Rust, M.K., Haagsma, K. and Nyugen, J., 1996. Enhancing foraging of western subterranean termites (Isoptera: Rhinotermitidae).
- Salman, A.G.A., Morsy, M.A. and Sayed, A.A., 1988. Resistance of some Egyptian timbers to the attack of the sane termite *Psammotermes hybostoma*. *Material und Organismen*, 23: 31-36.
- Scheffrahn, R.H. and Rust, M.K., 1983. Dry wood termite feeding deterrents in sugar pine and antitermitic activity of related compounds. *J. Chem. Ecol.*, 9: 39-55.
- Sen-Sarma, P.K., 1963a. Studies on the natural resistance of timbers to termites. 1. Observations on the longevity of test termite – *Heterotermes indicola* (Wasmann) in the saw dust from forty common Indian timbers. *Indian For. Bull. (N.S.) (Ent.)*, 220: 1-3.
- Sen-Sarma, P.K., 1963b. Studies on natural resistance of timbers to termites. II. Preliminary results of accelerated laboratory tests of 37 Indian timbers against *Heterotermes indicola* (Wasmann). *Ibid*, 220: 4-10.
- Sen-Sarma, P.K., 1963c. Studies on natural resistance of timbers to termite attack. III. Results of accelerated tests of a species of Indian woods against the Mediterranean dry wood termite (yellow necked dry wood termite), *Kalotermes flavicollis* Fabr. (Insecta: Isoptera: Kalotermitidae). *Holsforsch. Holzverwend.*, 15: 300-314.
- Sen-Sarma, P.K. and Chatterjee, P.N., 1965. Studies on the natural

- resistance of timbers to termite attack. IV. Qualitative and quantitative estimations of resistance to sixteen species of Indian woods against *Neotermes bosei* Snyder based on laboratory tests. *Indian Forester*, 91: 805-813.
- Sen-Sarma, P.K. and Thakur, M.L., Misra, S.C. and Gupta, B.K., 1975.a. Studies on wood destroying termites in relation to natural termite resistance of timber. Final Technical Report, PL-480 Project No. A7-FS-58, Grant No. Fe-1N-477, pp.1-187.
- Sen-Sarma, P.K., Thakur, M.L., Misra, S.C. and Gupta, B.K., 1975. b. Wood destroying termites of India (Dehra Dun; Forest Research Institute & Colleges).
- Sen-Sarma, P.K. and Gupta, B.K., 1978. Natural resistance of six Indian timbers to termite under laboratory conditions. *Holzforschung und Holzverwertung*, 30: 88-91.
- Sen-Sarma, P.K. and Gupta, B.K., 1979. Food preference in laboratory colonies of *Microcerotermes beelsoni* Snyder. *Indian J. ent.*, 41: 283-285.
- Shahid, A. S. and Akhtar, M.S. 1983. Wood preferences and survival of *Coptotermes heimi* (Wasmann) and *Odontotermes obesus* (Rambur) (Isoptera). *Pakistan J. Zool.*, 11: 303-314.
- Shahid, A.S. and Akhtar, M.S., 1989. Effect of volume and position of stakes on feeding by subterranean termites (Isoptera). *Sociobiology*, 16: 99-108.
- Shakoor, A., Akhtar, M.S. and Awan, S., 1991. Feeding preferences of termites of Azad Kashmir. *Pakistan J. Zool.*, 23: 355-359.
- Smythe, R.V. and Carter, F.L., 1970. Feeding responses to sound wood by *Coptotermes formosanus*, *Reticulitermes flavipes* and *R. virginicus* (Isoptera: Rhinotermitidae). *Ann. ent. Soc. Am.*, 63: 841-847.

- Supriana, N., 1987. Replacement preference test and pairing test of Indonesian timbers with two wood destroying termites. Forest Research Insitute. *Bull. Penelitian Kehutana*, 3(2): 3-8.
- Thakur, M.L; 1988. Current status of termites as pests of Bamboos and their control. *Indian forester*, 141: 720-725.
- Verma, S.C; 1989. Termite pests of forestry and agriculture in Haryana, India. *Indian J. Forest*; 12: 1-16.
- Waller, D.A., 1988. Host selection in subterranean termite: Factor affecting choice (Isoptera: Rhinotermitidae). *Sociobiology*, 14: 5-13.
- Wells, J.D., Fuxa, J.R. and Henderson, G., 1995. Virulence of four fungal pathogen to *Coptotermes formosanus* (Isoptera: Rhinotermitidae). *J. ent. Sci.*, 30: 208-215.
- Williams, R.M.C., 1973. Evaluation of field and laboratory methods for testing termites resistance of timber and building materials in Ghana, with relevant biological studies. *Trop. Pest Bull.*, 3: 1-64.
- Wolcott, G.N., 1940. A list of wood arranged according to their resistance to "Polilla" the dry wood termite of West Indies, *Cryptotermes brevis* Walker. *Caribb. Forester*, 1: 1-10.
- Wolcott, G.N., 1951. Termite repellent wood extractives. *J. Agric. Univ. Puerto Rico*, 27: 224-227.
- Wood, T.G., 1978. Food and feeding habits of termites. In: *Production Ecology of Ants and Termites* (ed. Brain), pp.55-80, London.