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FEEDING PREFERENCE OF TERMITE FOR DIFFERENT WOODEN BLOCKS UNDER ARTIFICIAL AND NATURAL FORESTS CONDITIONS

Shaheen Abbas Mustafa[1]*, Zeynel Arslangundogdu[2] and Erdem Hizal[2]
[1]Deptartment of Forestry, College of Agriculture, Kirkuk University, Kirkuk, Iraq
[2]Deptartment of Forest Entomology and Protection, Faculty of Forestry, Istanbul University, Istanbul, Turkey
*Corresponding author: E-Mail:shahinkifre@yahoo.com

Abstract

The study was carried out to evaluate the feeding preference of termite for different wooden blocks during March to the September 2019.The results showed that all sapwood and heartwood of *Sequoia sampervirens* z. (Red wood : Cupressaceae), *Quercus castaneifolia* C. (Oak : Fagaceae), *Thuja plicata* (Western redcedar: Cupressaceae), *Melia azedarach* (Melia: Meliaceae) *Picea orientalis* (Spruce : Pinaceae), *Cedrus atlantica* (Ceder : Pinaceae), *Salix caprea* (Willow : Salixacaeceae) *Populus tremula*(Poplar: Salıxaceae), *Pterocarya fraxinifolia* (Caucasian wingnut: Juglandaceae)*, Acer ginnala* M., (Acer wood : Sapindaceae) were non preferable for subterranean termite, *Reticulitermes lucifugus* (Rossi) and dry wood termite, *Kalotermes flavicollis* (Fabr.), under natural forest condition. On the other hand, the results of the artificial forest conditions showed a significant differences between wood species after 7 months of exposure to subterranean termite, *Microcerotermes diversus* Silv., It has been found that Caucasian wingnut*, Pterocarya fraxinifolia* and *poplar, Populus tremula* was more susceptible with average wood loss reached 2.94 and 2.84 gr., respectively, followed acer, *Acer ginnala* were 2.45 gr., while Spruce trees*, Picea orientalis*, *ceder, Cedrus atlantica* and Western redcedar,*Thuja plicata* were very resistance for infestation with the rate of 0.03, 0.18 and 0.51 gr, respectively. Oak trees, *Quercus castaneifolia* and willow, *Salix caprea* was moderately resistant to termite feeding, whereas, redwood trees, *Sequoia sampervirens and* melia trees, *Melia azedarach* were slightly resistant to termite attack. Results of this study indicated that the relationship of physical properties; moisture content, specific gravity and hardness with wood consumption by termite preference was unclear according to the kind of tree, wood species and amount of wood loss by termite.
Keywords: Feeding preference, termite, wood species, susceptibility.

Introduction

Termites are the most destructive and economically important pests of wood and other cellulose products. There are currently approximately 2,800 named termite species in 282 genera worldwide (Atsbha and Hintsa, 2018), but fewer than 185 are considered pests. Termite cause tremendous losses to agricultural crops, forest trees and wood works in buildings as well as agricultural pests found primarily in the tropical regions of the world , where they play an important ecological role in the recycling of wood and other cellulose – based materials (Khan and Ahmed, 2018). Most termite species are xylophagous, feeding on the lignocellulosic xylem of woody plants. Many regions of Turkey are subjected to expansions and/or invasions of subterranean termites, *Reticulitermes* spp (Isoptera : Rhinotermitidae) and dry wood termite, *Kalotermes flavicollis* Fabr (Isoptera: Rhinotermitidae) (Hasan and Torul, 1998).

The potential for damage by termites, especially by the subterranean termites *Microcerotermes diversus* Silv. (Isoptera: Termitidae) is an important consideration in the development of forestry in Iraq (Al-Allway *et al.,* 1989; Mustafa, 2004). Susceptibility or resistance tests of wood species against subterranean termite infestation were conducted by Mustafa (2011); Ayesha and Sumbal (2012).Wood feeding preferences and resistance will vary with the hardness, lignin content or chemical constitution of the wood (Al-Mallah *et al.,* 2007). It has also been suggested that extractives from naturally durable woods could be applied to susceptible timbers or used as models for new wood preservatives (Carter and Camargo, 1983; Laks *et al*., 1988). Many approaches are available for the development of an Integrated Pest Management system for controlling termites (Lewis, 2003). Al-Mallah *et al*. (2011) reported that wood density is one of the physical properties which influence the termites ability to fragment the wood mechanically with its mandibles.

The studies reported here were performed to evaluate the termite resistance of sapwood and heartwood and investigate for injury insects causing economic loss for forest trees in both region, Istanbul governorate, Turkey and Kirkuk governorate, Iraq according to the planning for their biological control and integrated pest management technique application in the future.

Materials and Methods

Studies on feeding preferences of termites, 10 timber species for each sapwood and heartwood into two different regions, First region: Faculty of forestry-Belgirad natural forests- Istanbul – Turkey, and second region was -Taq-Taq-artificial forests–Kirkuk-Iraq were surveyed during March to the September 2019 for both regions and at different environmental conditions .The experiment was Forest trees at both different regions a was not treated with any insecticides before and the experiment area was carefully cleaned up of any cellulose debris materials.

Sample Preparation

Wood Preferences of Termite under Natural Forests Condition

The timber samples of ten wood species were tested for each region. Fallen and mature trees were cut to wood pieces and were separated in to two zones (sapwood and heartwood).Each of sapwood and heartwood zones were cut to blocks and were left to dry under laboratory conditions, all tested wood blocks were prepared at 2 cm x 2 cm x 2 cm.Woods obtained were (scientific name, common name, family): *Sequoia sampervirens* z. (Red wood : Cupressaceae), *Quercus castaneifolia* C. (Oak : Fagaceae), *Thuja plicata* (Western redcedar: Cupressaceae), *Melia azedarach* (Melia: Meliaceae) *Picea orientalis* (Spruce : Pinaceae), *Cedrus atlantica* (Ceder: Pinaceae), *Salix caprea* (Willow : Salixacaeceae) *Populus tremula* (Poplar:Salıxaceae), *Pterocarya fraxinifolia* (Caucasian wingnut: Juglandaceae), *Acer ginnala* M., (Acer wood: Sapindaceae) and the average of temperature and relative humidity were 29 ± 5ºC and 71.± 0%, respectively, during period of wooden bury, wooden specimens were green and weighted by sensitive digital balance and then the pieces of woods were oven dried 105 C^0 overnight and weighted. The wood pieces were subjected to a seven months in-ground bioassay at a Belgrade natural forests ,the processes was applied in three different locations at test region. The chosen field is in a natural forests, well-drained, shaded, and high moist at this region, the design of the field test protocol is as follows: a ditch of consistently 25-30 cm depth is due to partly layered with residues ,distance between a pieces of woods is 15 cm and the ground covered with top soil 6 replications per sapwood and heartwood of ten trees species , were kept together according to species to aid identification unearthed, the woods carefully retrieved, weighed immediately to determine the final wet weight losses of the test samples after 7 months were subjected to analysis of variance (R.C.B.D.) and means significantly different at the 0.05 level were separated by Duncan's multiple rang test (SAS, 1987). Preference has most often been evaluated by measuring the reduction in wood weight (weight loss), (Smythe and Carter, 1970; Beal *et al.*, 1974; Usher and Ocloo, 1979; Rizk and Beal, 1982; Supriana, 1988 and Grace, 1996), according to the determine the amount of loss in weight of dry wood were before and after infestation by termite per sapwood and heartwood for each one of tree species.

Feeding Preference of Termite under Artificial Forests Conditions

Wooden pieces 2 cm x 2 cm x 2 cm were cut from the sap wood and heartwwod for the selected tree species, they are : *Sequoia sampervirens* Z. (Red wood: Cupressaceae), *Quercus castaneifolia* C. (Oak : Fagaceae), *Thuja plicata* (Western redcedar: Cupressaceae), *Melia azedarach* (Melia:, Meliaceae) *Picea orientalis* (Spruce : Pinaceae), *Cedrus atlantica* (Ceder : Pinaceae), *Salix caprea* (Willow : Salixacaeceae) *Populus tremula* (Poplar : Salıxaceae), *Pterocarya fraxinifolia* (Caucasian wingnut : Juglandaceae), *Acer ginnala* M. (Acer wood : Sapindaceae), respectively, during period of wooden bury, wooden specimens were green and weighted by sensitive digital balance and then the pieces of woods were oven dried 105^0 for 24 hours and weighted. The wood pieces were subjected to a seven months at Taq-Taq- artificial forests, the processes was applied in three different locations at test region. termites were collected from an active field, the design of the field test protocol is as follows: a ditch of consistently 25-30 cm depth is due to partly layered with resides. and the woods buried random in termite colony. Distance between a pieces of woods is 15 cm and the ground covered with top soil, 6 replications per sapwood and heartwood of ten studied trees, were kept together according to species to aid identification unearthed, the woods carefully retrieved, weighted immediately to determine the final dry weight losses of the test samples after 7 months field exposure, the woods were recovered and dried and the oven dry mass change recorded, and determine the weight loss of wood according to the equal and were subjected to analysis of variance (R.C.B.D.) and means significantly different at the 0.05 level were separated by Duncan's multiple rang test (SAS, 1987). In this field test, the average of temperature was 33 ± 2 C^0 and relative humidity 38.0 ± 1 %. Preference has most often been evaluated by measuring the reduction in dry wood weight (weight loss), (Smythe and Carter, 1970; Beal *et al.*, 1974; Usher and Ocloo, 1979; Rizk and Beal, 1982; Supriana, 1988; Grace, 1996), according to the determine the amount of loss in weight of dry wood were before and after infestation by termite per sapwood and heartwood for each one of tree species.

Determinate visual rating

The rate of infestation for wood species were determined according to Wong *et al.*, (1998); Mohd and Azlan, (1994) as follow: 0= sound, I = surface nibbles, 2= light attack, 3=Moderate attack, 4= heavy attack, 5= completely destroyed.

Weight Loss of Wood Species

The percent weight loss for the wood specimens was determined according to D1413 American standards (2003) (Grace and Lawrence, 2013) as follow:

Percent weight loss = 100(W1-W2) / W1

Where

W1 = Weight of test specimen before exposure to termite.

W2 = Weight of test specimens after exposure.

Degree of Infestation

This study extended from March to September during (2019), according to the Abdel – Malak (1995) the rate of infestation was calculated as:

$$\text{Degree of inf estation} = \frac{\text{Number of inf ested trees}}{\text{Number of exa min ed trees}}$$

and it was categorized as follow :

Zero	No. infestation	"O"
5 <	Rare	"R"
5 – 10	Low	"L"
10 – 25	Moderate	"M"
25>	High	"H"

Physical Properties of Wood

Moisture Content

Wooden pieces were determined of sound trees for all samples per sapwood and heartwood according to the Panshen (1980) per Sapwood and heartwood for trees, three replicates per sapwood and heartwood for ten species of forest trees, as follow :

$$\text{Moisture content} = \frac{\text{Green wt. of wood } - \text{oven dry wt. wood}}{\text{\% Oven dry weight of weed}} \times 100$$

Specific Gravity

Wooden piece were dried in oven 105 ºC for 48 hours then weight, also the volume calculated depended on removed water volume when wood sample put in the water. The density can get by divided oven dry weight / volume, according to the Haygreen and Bowyer (1982) per Sapwood and heartwood for trees, three replicates per sapwood and heartwood for ten species of forest trees.

$$\text{Specific gravity} = \frac{\text{Weight of sample}}{\text{Volume}}$$

Hardiness

Wooden pieces were measured for all samples per sapwood and heartwood according to the ASTM 52-143 (Panshin *et al*., 1980).

Results and Discussion

Ten species of wood were used for each region under artificial and natural forests conditions to determine the termite preference of these trees depending on the weight loss due to the attack by termite.

Feeding habitats and wood preferences of termite under natural forests conditions

Field studies on wood consumption rate of sapwood and heartwood for ten tree forest species. Table 1 shows feeding preferences of wood species have not been attacked by the workers termite (visual rating of wood 0 and infestation percentage 0%). These results obtained was uncompleted concordance with those found by Hasan and Torul (1998) who stated that the Subterranean termites, *Reticulitermes* spp., and dry wood termites, *Kalotermes flavicollis* Fabr., were founded in Istanbul region, whereas, Ali *et al.* (1982) in Egypt who found that wood species, *Eucalyptus rostorata*, *Casuarina equisetifola*, *Cupressus semperverns* and *Acacia arabica* were non preferences to subterranean termite, *Amitermes desertorum* during eight weeks force feeding test. Termites form asocial societies and live in colonies, creating nest systems that may be underground, epigeous, or arboreal. AS essential components of the soil ecosystem, termites improve soil pH, organic carbon content, water content and soil porosity by cycling dead organics, plant decomposition, nitrogen and carbon cycling, and microbial activity (Holt and Lepage, 2000). However, termites also cause damage to food crops and trees, termite faunal structure is determined by climatic and vegetation characteristics, termite species rich nesses, abundances, diversity, and trophic structures, however, differ between the two kinds of ecosystems. Based on habitat, in their natural habitats termites are considered beneficial insects because they break down dead or dying plant materials and thus are an important part of the nutrient cycle. When termites feed on wooden structures, however, they become pests, in the case of a termite living in a single piece of wood there may be little choice, since there is only one food source available, the termite will have to eat or die, this may also be seen in the field, the presence of a food source is also important; whether it be indigenous shrubs or crops, some termite (e.g. Macrotermitinae) have reserve food supplies for times when food is short or the climate is too harsh for forging, plant damage from pests other than termites, wind, weeding or animal feeding or trampling can encourage termite attack, some of the factors affecting termite presence, as well as examples of different predators of termites (Pearce, 1997). The structure of the termite fauna can vary considerably between areas in the same ecosystem, after exposure to different degrees of anthropogenic alterations (Vasconcellos *et al.,* 2010). The modification of natural areas to form agroecosystems, for example, can result in significant loss of species richness, abundance, and diversity (Bandeira *et al.,* 2003). Considerable naturally occurring variability in durability was observed in wood samples taken from different locations axially within trees and from different trees (Namujehea and Orikirizab, 2013). Such high variability in the termite resistance of heartwood within and between trees of the same species is agrees with previous observations of these and other wood species (Bush *et al*., 2011). This could possibly be due to the fact that the distribution of the repellent substances (extractives) in the living trees is uneven (Arongo *et al.,* 2006; Verma *et al.,* 2009). At the natural forests, Biotic and abiotic factors play a role in the successful establishment of invasive species. Evans and Gleeson (2001) documented similar observations from the study of another subterranean termite species, *Coptotermes lacteus* (Froggatt), in Australia. Haverty *et al.* (1974) noted that foraging intensity of *Heterotermes aureus* (Snyder) increased in spring and fall but decreased during the winter months in desert grassland.*Reticulitermes* sp. preferred significantly lower temperatures than *Coptotermes* sp. (Cao and Su, 2016).

Results of field study under natural forests condition obtained reveal the ten timber species within the period of exposure 7 months, this may be interpreted as an indication of variability in pattern of termite feeding behaviour within certain period of time or the existence of some chemical constituents that are distasteful or repellent rather than high cellulose content (Abdel-Karim *et al*., 2006), the same behaviour was found by Wolcott (1959). The results of field study showed no infestation of wooden blocks by termite *Microcerotermes diversus*, as a result natural residues of trees at the Belgrade natural forests, like, fallen leaves, branches, tree barks and humus cumulative materials were founded on ground soil, these residues on soil surface are preferred by termites. Among the abiotic factors, moisture and temperature play a vital role in determining which areas are the most suitable for establishment, whereas, temperature is another important factor that determines the geographic distributions, feeding and survival of species. It was believed that soil temperature has more effect on activity of subterranean termites than air temperature (Ettershank *et al*., 1980). Sen-Sarma and Mishra (1968) studied the seasonal activity variation of *Microcerotermes beesoni* Snyder in North India and indicated that soil temperatures determined termite activity levels in different seasons.

Table 1 : Tree species of wooden blocks (non infestation) to termite infestation feeding during 7 seven force-feeding test under Belgrade natural forest conditions.

Tree species	visual rating**	No.attacked / Total observation	Infestation percentage %
Quercus castaneifolia C.	0	0 / 12 *	0
Sequaia sampervirens z.*	0	0 / 12	0
Thuja plicata	0	0 / 12	0
Populus tremula	0	0 / 12	0
Picea orientalis	0	0 /12	0
Cedrus atlantica	0	0 / 12	0
Salix caprea	0	0 / 12	0
Melia azidarich	0	0 / 12	0
Pterocarya fraxifolia	0	0 / 12	0
Acer ginnala M.	0	0 / 12	0

* Per mean represented (12) replicates (6/sapwood and 6/heartwood).
** Woods were visually rated as 0= sound, 1 = surface nibbles, 2 = light attack, 3 = moderate attack, 4 = heavy attack, or 5 = completed destroyed.

Susceptibility species of wood under Artificial Forests Conditions

The accelerated subterranean termite preference assessments for both sapwood and heartwood of ten tree species as followed; weights of green wood and dry wood before and after infestation, amount wood loss and wood loss %, (table 2), moisture content, specific gravity, hardiness, visual rating, degree of infestation and infestation percentage are presented in (tables 2,3) based upon both visual rating of termite damage and wood mass loss according to Grace *et al.* (1996), wood species are devisable in to four categories of relative termite resistance; (resistant, moderately resistant, slightly resistant and susceptible).

Group a: More Resistant Species:

Regarding to the statistical analysis of the data obtained after seven months of exposure (table 2,3).The results revealed that the sapwood of Ceder , *Cedrus atlantica* was the more resistant to the termite *M. diversus* (visual rating: 1, wood loss: 0.03 gr.), followed sapwood and heartwood of spruce, *Picea orientalis* (visual rating: 1 and 0, wood loss : 0.06 and 0.00 gr.) respectively, and Western redcedar, *Thuja plicata* (visual rating:1 and 1, 0.22, 0.80 gr., respectively. The results of Statistical analysis showed significant differences according to the tree species, wood species and amount of wood loss, the wood species of this study was highly resistances to the subterranean termite *Microcerotermes diversus* and this is in agreement with the findings of Su and Tamashiro (1986), Scheffrahn (1994), Al-Mallah *et al.* (2007) and Mustafa, (2012) they reported that the pine and cypress trees has less preferable timber to termite attacked, these results of this phenomenon may be due to occurrence of lignin, phenol compounds and extractives like oils, wax and resinous materials in timber samples may have a role in the resistance of wood as repellent to termite also contain the chemical determinants which given the degree of resistance of a wood sample to damage infested by termites and addition that extractives also contain the chemical determinants which given the degree of resistance of a wood sample to damage infested by Formosan subterranean termites.(Grace and Yamamoto, 1994).

Table 2 : Means of weights green wood , dry wood before and after infestation, amount of wood loss and wood loss % per sapwood and heartwood for 10 tree species exposed to subtereanean termite, *Microcerotermes diversus*.

Tree species	Wood species										Total Average of wood loss
	Sap wood					Heart wood					
	Green wt. of wood (gr.)	dry weight of wood gm.		4 Amount of wood loss (gr.)	5 Wood loss %	Green wt. of wood (gr.)	dry weight of wood.gm.		Amount of wood loss (gr.)	Wood loss %	
		Before infestation	After infestation				Before infestation	After infestation			
Quercus castaneifolia C.	6.54*	4.99	2.80	2.19 c	43.88	6.98	5.14	4.00	1.84 c	35.79	2.01 c
Sequaia sampervirens z.*	10.58	9.10	6.41	2.69 d	29.56	10.76	9.13	8.75	0.38 a	4.16	1.53 b
Thuja plicata	9.54	7.72	7.50	0.22 a	2.84	10.39	8.50	8.10	0.80 b	9.41	0.51 a
Populus tremul	8.71	7.00	3.16	3.84 e	54.85	7.36	6.10	4.23	1.84 c	30.16	2.84de
Picea orientalis	4.82	3.16	3.10	0.06 a	1.89	4.63	3.00	3.00	0.00 a	0.00	0.03 a
Cedrus atlantica	5.23	4.01	3.98	0.03 a	0.74	5.25	4.03	3.70	0.33 a	9.00	0.18 a
Salix caprea	9.15	7.49	4.90	2.59 d	34.57	10.20	8.50	6.90	1.60 d	18.82	2.09 c
Melia azidarich	4.96	3.96	2.88	1.08 b	27.27	5.57	4.36	2.10	2.26 e	51.83	1.67 b
fraxifolia fraxifolia	10.24	8.93	5.80	3.13 e	35.05	9.71	8.37	5.61	2.76 ef	32.97	2.94 de
Acer ginnala M.	7.60	5.94	3.50	2.44 d	41.07	6.27	4.97	2.60	2.47 f	49.69	2.45 d

* Per value represent 6 replications.
1) *Means within a column followed by the same letter are not significantly different at 5% level according to Duncan multiple range test.
2) Amount of wood loss (gr.) = Wt. dry wood before infestation - Wt. dry wood after infestation

Table 3 : Mean wood loss, visual rating, degree of infestation and infestation percentage of sapwood and heartwood exposed to subterranean termites for 7 months under artificial forests conditions.

Tree species	Wood species	Visual rating[1] (wood) [1]	Amount of Wood loss (gr.) gm.	wood loss (%)	Degree of infestation[2]	Infestation percentage %
Quercus castaneifolia	Sapwood*	3	2.19	43.88	3 /6	50.0
	heartwood	2	1.84	35.79	2/ 6	33.3
Sequaia sampervirenns	Sapwood	2	2.69	29.5	2/ 6	33.3
	heartwood	1	0.38	4.16	1/ 6	16.6
Thuja plicata	Sapwood	1 1	0.22	2.84	2/ 6	33.3
	heartwood	0	0.80	9.41	1 / 6	16.6
Populus tremula	Sapwood	5	3.84	54.8	6 / 6	100.0
	Heartwood	3	1.84	30.16	4/ 6	66.6
Picea orientalis	Sapwood	1	0.06	1.89	1 / 6	16.6
	heartwood	0	0.00	0.00	0 / 6	0.00
Cedrus atlantica	Sapwood	1	0.03	0.74	1 / 6	16.6
	heartwood	1	0.33	9.00	1 / 6	16.6
Salix caprea	Sapwood	3	2.59	34.57	4 / 6	66.6
	heartwood	2	1.60	18.82	3/ 6	50.0
Melia azidarich	Sapwood	1	1.08	27.27	2 / 6	33.3
	heartwood	2	2.26	52.00	2 / 6	33.3
Pterocarya fraxifolia	Sapwood	5	3.13	35.05	6 / 6	100.0
	heartwood	3	2.76	32.97	5/ 6	83.3
Acer ginnala M.	Sapwood	4	2.44	41.07	4 / 6	66.6
	heartwood	4	2.47	49.69	4/ 6	66.6

* Per value represent 6 replications.

1) Woods were visually rated as 0= sound = , 1 = surface nibbles , 2 = light attack , 3= moderate attack , 4 = heavy attack , 5 = completed destroyed .

2) Degree of infestation = No. attack (wood) / Total observation.

Generally, the most resistant wood species in this study was represented by *Picea orientalis*, *Cedrus atlantica* and *Thuja plicata* and by total average of wood consumption of 0.03, 0.18 and 0,51gr., respectively (Table 2). In this study, under artificial forest conditions, greatest termite attack occurred on sapwood of *Populus tremula* (wood loss 54.85%) followed by heartwood of *Melia azidarich,* (wood loss : 51.83 %) and the least feeding occurred on *the heartwood of Picea orientalis* (wood loss: 0.00 %) Only, *Picea orientalis* and *Cedrus atlantica* were considered "resistant" to termite attack followed by *Thuja plicata*, the relatively high mortality of termites fed Spruce, ceder and cypress in this test, however, indicates the presence of toxic extractives and suggests that this wood may less preferred than other available susceptible wood species by termites (Mustafa 2004). Although the principle chemical constituent of resistance species are toxic to many insect species, however, Spruce, ceder and Western redcedar wood are less preferred by termites than Caucasian wingnut, suggesting that these trees could be useful for important wood industries like paper manufacturing, planting and ornamental arboriculture in Iraq even if not suitable for wood harvesting, Similar results were obtained by Ali *et al.* (1982) who showed that *C.sempervirens* is less preferable timber for the subterranean termite, *Amitermes desertornum, a*lso Rizk and Beal (1982) stated that *C. sempervirens* is unfavorable host for *P.hybostoma*, the same results were obtained by Abdel-karim *et al.* (2006) who found that Cypress tree, *C.sempervirens* seemed to be more resistant to the dry wood termite *Cryptoterms brevis*.

Group b: More Susceptible Species

Data in Tables (2 and 3) show that this group contains tree species .These species is susceptible to attack by termite *Microcerotermes diversus*,this susceptible group was represented of sapwood of *Populus tremula* and *Pterocarya fraxinifolia*, (visual rating: 5 and 5, wood loss : 3.84 and 3.13 gr., infestation percentage 100.0 and 100.0%), respectively, followed by sapwood and heartwood of acer, *Acer ginnala* M. (visual rating : 4 and 4, wood loss : 2.44 and 2.47 gr., infestation percentage 66.6 and 66.6 %), (Table 3). Sultan *et al*. (2015) who fonud that *Populus alba* was the preferred host for termite, *Anacanthotermes iranicus* in Egypt.Results obtained from choice feeding and wood consumption tests proved that *Pterocarya fraxinifolia*, *Populus tremula* and *Acer ginnala* are the most susceptible wood for termite, *Microcerotermes diversus* infestation with the total average infestation were 2.94, 2.84 and 2.45 gr., respectively. No significant differences was found between mean infestation levels of tested timber species. Whereas, the mean infestation level ranged between 2.45-2.94. These results in agreement with Farouk *et al.*(2011) mentioned that the sapwood of *Acer cinerascens* and sapwood blocks of *Populus alba* percentages were high susceptible of termite, *Psammotermes hybostoma* Dens., with wood consumption reached 80.21 and 87.89 % respectively., while, Rizk and Beal (1982) reported that *Populus nigra* is more resistance host for termite*, P. hybostoma.* Results of this study were in agreement with the finding of Mustafa (2012) who found that *Juglanus regia*, family Juglandacea is susceptible to the affected by termite*, Microcerotermes gabrielis* with wood loss percentage were

95.7%.These results obtained was uncompleted concordance with those found by Smythe and Carter (1970) who stated that (*Caucasian wingnut*) walnut trees was not susceptible to subterranean termite, *Reticulitermes flavipes*.

Group c: Moderate Resistance Species

It was represented by two species per sapwood and heartwood according to their descending resistance of oak trees, *Quercus castaneifolia*. (visual rating : 3 and 2; wood loss : 2.19 and 1.84 gr., infestation 50.0, 33.3%) and willow trees, *Salix caprea* (visual rating : 3 and 2; wood loss : 2.59, and 1.60 gr., infestation percentage 66.6 and 50.0%, infestation percentage 66.6, 33.3%), respectively (Table 4). Abdel-Malak (1995) who reported that *Salix babylonica* was not susceptible to feeding by dry wood termite *Kalotermes flavicollis* in Egypt, similar results were obtained by Farouk *et al.* (1991) who found that the highest mean weight loss were heartwood of *Salix safsaf* (6.98 gr.) with wood consumption percentage 97.62% after 6.60 mounths followed by sapwood blocks of *Quercus infectoria* (5.39gr.) with wood consumption percentage 92.14% after 9.0 mounths of field exposure.Generally,the most moderate resistance species in this group was represented by *Quercus castaneifolia* and *Salix caprea* by total average of wood loss of 2.01 and 2.09 respectively, this result obtained was uncompleted concordance with those found by Abdel-Nur (1980) who stated that *E. microthica* was highly resistant to *P.hybostoma* and Grace *et al*. (1996) who found that *Eucalyptus microcorys* is light attack by termites in Hawaii region, while Abdel-Malak (1995) in Egypt who found that *Quercus robur* was susceptibility to termite, *K. flavicollis* while *Q. canariensis* and *Q. ilex* were not attacked by *K. flavicolli.*

Group d : Slight Infestation Species

This group was represented by two tree species per sapwood and heartwood of red wood, : *Sequoia sampervirens* and melia, *Melia azedarach* (visual rating : 2 and 1; wood loss : 2.69 and 0.38 gr., infestation percentage 33.33 and 16,6%) and *Melia azedarach* (visual rating : 1 and 2; wood loss : 1.08 and 2.26 gm. Infestation percentage 33.3 and 33.3%), respectively. The light resistant species was represented *Sequoia sampervirens* and with a total average infestation reached 1.53 and 1.67 gr., respectively (Table 5). Hadi *et al.* (2010) in Malaysia showed that mindi wood (*Melia azedarach*) was more resistant to subterranean termite attacks *Coptotermes curvignathus*.Neem tree, *Azadirachta indica* A.Juss (Meliaceae) is deterrent or toxic to many insect species (Grace *et al.,* 1996), whereas, these results agreement with Grace and Yates (1992) that the neem tree is slightly deterrent to Formosan subterranean termites, *Coptotermes formosanus* (Isoptera: Rhinotermitidae) and less preferred by termites, *C. formosanus* than Douglas-fir tree, *Psudotsuga menziesii* (Delate and Grace, 1995). Generally, in this field the sapwood of tree species were more preferable to attack by termite comparison with the heartwood. These results in agreement with Harris (1961) mentioned that there are, in sapwood, starches and sugars, which render it more palatable than the heartwood of the same tree.

Effect of Some Physical Properties per Sapwood and Heartwood for Tree Species to Termite Attack

Study the effect of some physical properties like moisture contenet, spicific gravity and hardness of wood species; nam red wood, *Sequoia sampervirens* Z., oak, *Quercus castaneifolia*, Cypress, *Thuja plicata*, *melia, Melia azedarach*, spruce, *Picea orientalis*, ceder, *Cedrus atlantica*, willow, *Salix caprea*, poplar, *Populus tremula*, Caucasian wingnut, *Pterocarya fraxinifolia, acer, Acer ginnala* M., to termite feeding showed that there was no clear relation between the wood physical properties and the weight loss in wooden pieces due to termites workers feeding, the results of Duncan test showed varied significant and no significant values according to the tree species, wood species and physical properties of the woods, the relative moisture content was between 14.44- 54.33% per heartwood and sapwood for *Pterocarya fraxinifolia* and heartwood of *Picea orientalis*, respectively (wood loss: 2.76 and 00.0 gr.), respectively (Table 4), whereas the specific gravity ranged between 0.80-0.37 gr., for sapwood of *Quercus castaneifolia* and heartwood of *Salix caprea* and with wood loss reached 2.19 and 2.26 gr.), respectively followed by *Pterocarya fraxinifolia* (sp.gravity: 0.79 gr.), while the hardness of wood species were 3351.00-5520.33 Nt., for sapwood of *Populus tremula* and heartwood of *Pterocarya fraxifolia*, respectively. In this study, the determining factors was termite preference associated with nutrition contents of wood (cellulose, hemicellulose and lignin) as well as the physical properties of wood and moisture content.

The results showed that the physical properties of wood may not be the main factor of termite but rater play the components of wood and chemical compounds are role to wood prefer by termite. The results of this study agreed with Al-Mallah *et al*. (2009) mentioned that the correlation values between the physical properties of wood and the wood consumption due to termites feeding varied significant and non-significant values according to the tree species and physical properties of wood and was found that a significant positive correlation with specific gravity and negative sıgnıfıcant wıth moisture content hardness. wood feeding preferences and resistance will vary with the hardness, lignin content or chemical constitution of the wood, on the other hand, wood density is one of the physical factors which influence the termites ability to fragment the wood mechanically with its mandibles. Al-Humairi (1999) stated that regression analysis showed significant negative correlation between percentage of wood damage and wood density. Bultman and Southwell (1976). Bultman *et al.* (1979) which showed that after 158 months of exposure of 112 tropical woods in the Panamanian forest, some of woods highly damaged by termites had high densities and vice versa. Risk *et al.* (1982) mentioned that wood density might not be the major factor in wood resistance against termite attack. Scheffrahn (1994) Concluded that the basis of termite resistance in any wood in not high lignin content, or hardness, but a specific chemical constituent, often present in only minute quantity, therefore the termite resistance depends on many factors such as hardness and chemical content, whereas, Behr *et al.* (1972) who found positive correlation between wood weight loss by termite and wood hardness with density, Rudman and Gay (1967) who found three factors are known to influence susceptibility of wood to termite attack like density, nature of the wood substance and nature of the extraneous materials, extractives and nutrients.

Table 4: Mean moisture content, specific gravity, hardness and wood mass loss of wooden blocks exposed to subterranean termites under artificial infestation conditions.

Tree species	Wood species	Moisture content[1] (%)	Specific gravity[1] (gr.)	Hardness[1] (Nt.)	Wood mass loss gr.[2]
Quercus castaneifolia	Sapwood	31.06	0.80	4616.00	2.19
	heartwood	35.79	0.77	4925.45	1.84
Sequaia sampervirenns	Sapwood	16.26	0.63	4721.00	2.69
	heartwood	17.85	0.66	4473.66	0.38
Thuja plicata	Sapwood	23.57	0.47	3680.33	0.22
	heartwood	22.23	0.49	3820.11	0.80
Populus tremula	Sapwood	24.42	0.55	3351.00	3.84
	heartwood	20.65	0.58	3866.10	1.84
Picea orientalis	Sapwood	52.53	0.41	3750.41	0.06
	heartwood	54.33	0.47	4721.60	0.00
Cedrus atlantica	Sapwood	30.42	0.62	3910.33	0.03
	heartwood	30.27	0.58	4850.00	0.33
Salix babilonica.	Sapwood	22.16	0.40	4470.33	2.59
	heartwood	20.00	0.37	4681.00	1.60
Melia azedarich	Sapwood	25.25	0.50	4586.10	1.08
	heartwood	27.75	0.42	4562.30	2.26
Pterocarya fraxifolia	Sapwood	14.44	0.75	5520.33	3.13
	heartwood	22.34	0.79	5033.00	2.76
Acer ginnala M.	Sapwood	27.94	0.71	4980.10	2.44
	heartwood	26.15	0.77	5310.33	2.47

1 Per value represent 3 replications.
2 Per value represent 6 replications.

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