Veterinary Medicine and Public Health Journal (VMPH)

Volume.5, Issue.2, pp: 41-52 Article 3
May (2024)

Severity of Termites (*Microcerotermes diversus* Silvestri) Infestation on Date Palms

Aqeel A. Qraidi, Aqeel Alyousuf, Muslim Ashor Al-etby

Received: 15/12/2023 **Revised:** 15/1/2024 **Accepted:** 17/2/2024

DOI: https://doi.org/10.31559/VMPH2024.5.2.3

Veterinary Medicine and Public Health Journal (VMPH)

Journal Homepage: https://www.refaad.com/Journal/Index/7

E-ISSN 2707-7195 | P-ISSN 2707-7187

www.refaad.com

Severity of Termites (*Microcerotermes diversus* Silvestri) Infestation on Date Palms

Aqeel A. Qraidi[1*], Aqeel Alyousuf[1], Muslim Ashor Al-etby[1]

[1] Department of Plant Protection, College of Agriculture, University of Basra, Iraq.

*** Corresponding author:** Aqeel A. Qraidi (pgs.aqeel.abdulrazaq@uobasrah.edu.iq)

How to cite this article: Qraidi, A., et al. (2024). Severity of Termites (Microcerotermes diversus Silvestri) Infestation on Date Palms. Veterinary Medicine and Public Health Journal, 5(2), 41-52.

Abstract:

Objective: This study was aimed to evaluate intensity of infestation and annual distribution of termite community in palm orchards in southern governorates of Iraq (Basra and Maysan) to develop appropriate integrated management programs to control termite (Microcerotermis diversus Selvestry) in palm groves.

Methods: A field survey was conducted for a whole year(October 2022- September 2023) to evaluate termite community, also relationship between intensity of termite infestation with some palm varieties was studied, and a correlation was made with some important contents for termite vitality in tissues of the frond bases such as Proteins, carbohydrates, phenols, and lignin were estimated to determine which varieties are more tolerant to termite infestation and the most sensitive.

Results: Survey showed that palm varieties Khadrawi and Shakkar most susceptible to invasion, with rates of 52.19 and 48.4 termites/frond base, respectively. As for the Barhi and Al-Maktoum cultivars, they had lowest percentage of termite infestation, with 0 and 10.0 termites/frond base, respectively.

Conclusions: Termite (Microcerotermis diversus Selvestry) prefers to invade some palm varieties that have a suitable content of carbohydrates and proteins (Khadrawi and Shakkar), especially in the moderate and cold months of the year. Termite community decrease in hot months of the year; therefore we recommend carrying out integrated termite management operations at the beginning of October and November in palm groves in arid and semi-arid areas similar to the areas of southern Iraq.

Keywords: *Microcerotermes diversus; southern Iraq; lignin; polyphenols; palm cultivars.*

1 Introduction

Date palm *Phoenix dactylifera*, is member of the family Palmaceae. This family includes more than 4,000 species and 200 genera. However, it is noteworthy that only the genera Phoenix (date palms) and Cocos (coconut palms) hold the distinction of being exclusively utilized for human food consumption (ALallaf, 2020). In Iraq, palms cultivation extends from the city of Mandali at latitude 35^{o} in north until city of Al-Faw at latitude 30^{o} in south. This extensive cultivation encompasses thirteen provinces which are Basrah, Maysan, Dhi Qar, Wasit, Muthanna, Qadisiyah, Karbala, Najaf, Babel, Baghdad, Anbar, Salah al-Din and Diyala (Ibrahim & Zaied, 2019). In the year 2019, the total number of palm trees in Iraq reached 17 million, and subsequently, in 2023, this number increased to 22 million. This notable increase of palm trees numbers indicates a positive trend within the agricultural sector. These reflect promising advancements in the agricultural landscape, signifying a favorable trajectory towards the enhancement of date palm cultivation in Iraq (Central Standardization and Control Authority, 2023).

Date palms are infested by several insect pests such as borers (*Jebusaea hammerschmidti*, *Oryctes elegans*), termite (*Microcerotermes diversus*) dust mites (*Oligonychus afrasiaticus*), and invasive pest ,the red palm weevil (*Rhynchophorus ferrugineus*) (Alderawii et al., 2020; Aldosary et al., 2013; Ali & Fhaid, 2019; Alsaedi, 2022; A. Alyousuf et al., 2020, 2021; A. A. Alyousuf, 2022; Husain & Esmaiel, 2007).

Termite, (Order: Isoptera), as a key pest, primarily feed on cellulose; Termites exhibit remarkable colony growth and propagation, with population ranging from several thousand to millions depending on age of colony. They live in regions characterized by dry tropics and semi-dry conditions (Alsibai, 2007; Eggleton et al., 2002; Eggleton & Tayasu, 2001).

Microcerotermes diversus Silvestri invaded palm orchards in the central and southern provinces of Iraq, the percentage of invasion rate was 33.8, 27.5, 26.1, 25.7, 24.6% in the date palms of Wasit, Karbala, Babylon, Basra, and Diwaniyah respectively. The invasion had varying effects on different palm cultivars, with Ashrasi experiencing the highest impact at 33.55%, followed by Zuhdi at 29.5%, Al-Sayer at 28%, Maktoum at 24.2%, and Shukr at 18.5%, respectively. Furthermore, there is a noticeable correlation between the presence of these termites and an increase in the production of robust and healthy palm trees (Shefik, 2010). In Basra province, the infestation levels in certain date palm cultivars were notably elevated. Specifically, the Al-Hartha region recorded an infection rate as high as 74%. Among all the cultivars, the Dairy cultivars suffered the most severe infestation, with a rate of infestation of 87.5%. The intensity of invasion in this case reached as high as 12 insects per frond base (Al-Dosary & Al-Najim, 2006).

Numerous scientific inquiries have been conducted to study the complexities of termite behavior and their selective preference for plant tissues rich in cellulose, which is essential for its permanence in the environment. In the searching for environmentally safe and sustainable methods for termite control, researchers have focused on devising techniques that attract these insects to traps containing materials that correspond with their dietary preferences; this approach has emerged as a promising avenue for effective termite management. This innovative strategy offers considerable potential for mitigating the adverse impact of termite infestations on various agricultural crops, trees, and wooden structures while minimizing environmental harm and fostering long-term pest management solutions (Culliney & Grace, 2000; Dhang, 2011; Habibpour, 2006a). Further research and development in this area are expected to yield invaluable insights and advancements in the field of termite control strategies.

According to the studies conducted by Wolcott (1954) and Behr et al. (1972) on termite *Reticulitermes flavipes*, certain types of tree wood are observed to be unattractive to termite due to their possession of specialized chemical compounds. These compounds specialized against the organisms directly or indirectly by affecting on coexisting protozoa (flagellates) in the digestive system. Consequently, such wood exhibits natural resistance to infestation. Wolcott (1954) indicated that wood hardness and lignin content have no relationship to the infestation of termite *Reticulitermes flavipes* (Isoptera: Rhinotermitadae), especially dry wood termites, as they infest all wood species. However Behr et al., (1972) showed there is a significant correlation between the hardness of wood and its resistance to dry-wood termite.

Termites infesting orchards are managed through various methods, with the most prominent approach being the application of toxic baits at different locations within the fields or orchards (Ekhtelat et al., 2018; Habibpour, 2006b). The nature of termite infestation in palm trees remains concealed beneath the bases of their fronds. Consequently, it becomes essential to conduct on-site field investigations to determine the presence and activity of these pests within the orchard. This investigation serves as a guide for those involved in termite control, enabling them to strategically place baits in suitable locations and quantities; It's worth noting that the rates and severity of insect infestation can vary significantly from one palm tree cultivar to another. This variation is influenced by certain characteristics inherent to each plant cultivar, including biochemical and morphological traits, as well as the nutritional value offered by each plant cultivar (Bennett & Wallsgrove, 1994; Russell, 2013; Smith, 1999).

Research have demonstrated that a heightened presence of phenolic compounds within plant tissues exerts a suppressive effect on the metabolic activity of numerous insect pests. The elevated concentration of phenolic compounds in plant tissues has been associated with a reduction in their ability for feeding, subsequently weaken these pests (Dixit et al., 2017; Hisham et al., 2022; Othmen et al., 2022; Silva et al., 2005; Usha Rani & Pratyusha, 2014). Lignin, a complex phenolic polymer, plays a multifaceted role in augmenting the rigidity and hydrophobic properties of plant cell walls, facilitating the translocation of minerals via vascular bundles in plants. Notably, lignin serves as a pivotal deterrent against plant-based pests (Ithal et al., 2007; Schuetz et al., 2014). In contrast, the protein content and the amount of carbohydrates provide an appropriate nutritional value for insect pests, and thus increase feeding on it and increase the rate of insect infestation.(Cabrera et al., 1995; Jood & Kapoor, 1992; Stathers et al., 2020). Hence, this investigation aimed to evaluate the biochemical and morphological attributes within palm stems and elucidating their correlation with the severity of termite infestation across diverse palm cultivars at Basra and Maysan provinces.

2 Materials and Methods

2.1 Study sites

Two provinces in southern Iraq, Basra and Maysan (Fig. 1), were chosen as study areas to evaluate the severity of termite Microcerotermes diversus Silvestri, infestation in date palm orchards. Six locations were selected from each province one orchard in every region (Table 1).

Table 1: Date palm orchards locations at Basra and Maysan were selected to study the severity infestation of termite *Microcerotermes diversus* Silvestri.

Province	Region	Coordinates	
		N	E
Basra	Qurna	N30.987228	E47.401291
	Dier	N30.776181	E47.605675
	Zeraji	N30.746176	E47.698911
	Chibbasi	N30.590871	E47.800498
	Tanuma	N30.514968	E47.872646
	Zubair	N30.391694	E47.660827
Maysan	Mashtal	N31.794896	E47.195648
	Gsebah	N31.804068	E47.150542
	Maimouna	N31.725455	E47,003573
	Kahlatsaleh	N31.538037	E47.299224
	Al-Majar Al-Kabeer	N31.744047	E47.150648
	Qalaat Saleh	N31.711996	E47252821

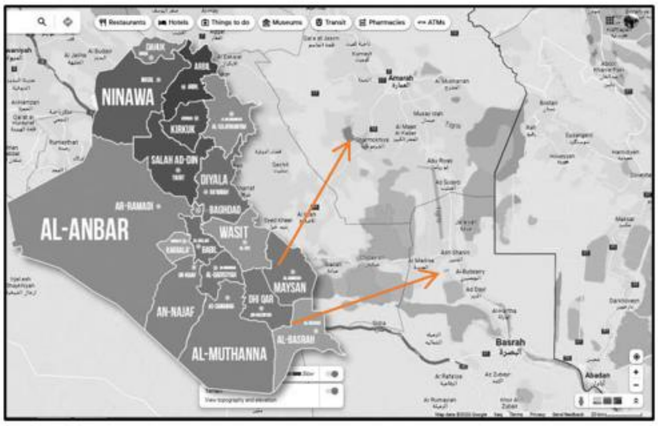

Figure 1: A map of locations of the study at the southern provinces of Iraq.

2.2 Termite infestation rate

The termite infestation rate in the study areas sample was calculated after fifty palm trees were randomly selected in each orchard for the purpose of estimating the percentage of infestation rate.

$$\textbf{Termite infestation rate} = \frac{Number\ of\ infected\ palm\ trees}{total\ number\ in\ sample\ (50)} * 100$$

2.3 Severity of termite infestation

The number of insects was counted by breaking five frond bases on the palm stem using an ax or a wooden saw (Figure 2).

To evaluate the Severity of termite infestation, total number of insects calculated was then divided by five to determine the final number for each frond base in palm, as shown in the equation below:

$$\textbf{Severity of termite} = \frac{Total\ counting\ termites\ in\ five\ bases\ fronds\ in\ each\ cultivar}{5}$$

The insect count was conducted according to the scale provided in the Table 2 (Al-Dosary & Al-Najim, 2006) .

Table 2: Categories of severity of termite infestation.

infestation severity	Number of termite /frond base
No infestation	0
Weak	1-15
Medium	16-30
Severe	36-50
Harmful (Hot spot)	< 75

A **B**

Figur 2: Termites infeste the base of frond of palms (A). Base of fronds (B).

2.4 Termite infestation

While conducting the sampling, the termite infestation was assessed based on:

A. Age of palm trees: The insect's preference for palm trees of different ages was investigated in a study. The trees were divided into two categories: the first category included trees younger than 20 years old, and the second category included trees older than 20 years old. From the study areas mentioned in item 2 of the materials and methods above, 25 trees were selected from each category.

B. Direction (north, south, east, and west) effect on the infestation rate: This data collection was carried out from October 2022 to September 2023. 50 palm trees were randomly selected in each orchard of the study areas above.

C. Determine infestation according to location of palm tree in the orchard: 25 palm trees from the orchard's borders and 25 palm trees from its center were examined in order to determine whether termites prefer to infest palm trees on the outer edges of the orchard or in its center and to compare the severity of the infestation.

2.5 Detection of biochemical traits date palm cultivars

The biochemical traits were determined on the most common date palm cultivars (Sayer, Bream, Bari, Khadrawi, Shukkur, and Maktoum). The correlation relationships between these traits and the level of infestation were studied.

A. Total content of phenols analysis.

Total phenolic compounds were estimated in dry frond bases using the Folin-Calcalteu reagent method as mentioned in (Nadeem *et al.*, 2019; Singleton *et al.*, 1999).

10 grams of powdered frond base for each of the six cultivars of palm trees were weighed, and added 50 ml of a 50% ethanol solution to it after heating it at 50 °C for 10 minutes. 0.5 ml of Folin–Ciocâlteu 50% (by add 10 ml distilled water to 10 ml Folin–Ciocâlteu reagent) was added to 5ml of solution. 1 ml of sodium carbonate 5% (by add 5gm of sodium carbonate to 100 ml of distilled water) was added to the mixture to equalize the mixture. The absorbance was measured by a spectrophotometer (UV-9200) at a wavelength 600 nm. The concentrations were estimated based on the graphic relationship between the concentration of gallic acid and the amount of absorbance for each of the standard concentrations of gallic acid (0,10,30,50,70,90,100) mg\ml.

B. Total content of carbohydrate.

To estimate the total content of carbohydrates in the frond bases, the method of phenol and Concentrated sulfuric acid was used as stated in (Abed et al., 2007; DuBois et al., 1956) .

ml of alcoholic extract of samples was placed in a test tube. 1 ml of phenol was added to it and mixed well with Vortex device. 5 ml of concentrated sulfuric acid was added to it. After one hour, absorbance was measured by a spectrophotometer (UV-9200) with a wavelength 490 nm. Amounts of carbohydrate content were calculated graphically after making standard concentrations of glucose and comparing them with absorption of standard concentrations (0,20,50,80,100 mg\ml).

C. Total content of protein.

To estimate protein content of palm frond bases, a method was used as in (Assirey, 2015; Association of Official Analytical & Chemists, 1925) it's known micro-kjeldahl method.

By boiling the vegetable sample (1g of frond base) in concentrated sulfuric acid (digestion stage) for an hour, the nitrogenous components in the sample are transformed into ammonium sulfate (NH4)2 SO4. utilizing intense caustic soda NaOH (40%) to dissolve or crack previously-formed ammonium, then steam distilling it in micro-kjeldahl it's a closed system when release ammonia and receiving it in a 2% solution of boric acid H3BO3, 2 drops of red methyl and green bromocresol reagent . Additionally, by titrating ammonium borate (NH) 3 BO3 with HCL acid of known concentration (0.005) and knowing the acid's volume, the calibration step allows to determine the sample's nitrogen content. The sample's nitrogen content can be determined using following formula,

$$\boldsymbol{N}\% = \frac{\text{consumer HCL volume} * \text{ HCL titer}(0.005) * 14.1 * \text{ dilution volume}}{\text{Sample volume at distillation} * \text{Weight o sample}(1\text{g}) * 1000} * 100$$

$$\text{protien}\% = 6.25 * \%\text{N} \quad \text{when 6.25 is a fixed value}$$

D. Lignin content:

To estimate Lignin content of palm frond bases, a method was used as in (Abdulqader et al., 2009; Anis et al., 2011) which approved in (Browning, 1967)

1 gram of palm leaf powder was placed in a beaker and 15 cc diluted sulfuric acid (72%) was added to it. The beaker was placed in a water bath for four hours. The mixture was stirred with a glass rod for successive periods, and the mixture was filtered using glass filter paper (sintered disk 40 mm PoR4) The powder was washed with distilled water three times to get rid of the acid, and after drying the sample in an electric oven at 70 degrees Celsius for a full day, the lignin was estimated by the following equation.

$$\%\text{Lignin} = \frac{\text{w1} - \text{w2}}{\text{w1}} * 100$$

w1:Weigh sample before separating lignin
w2: Weigh sample after separating lignin

website www.meteoblue.com specialized in climate and weather forecasting, was used to express temperatures in the southern regions of Iraq.

2.6 Statistical analysis

The data were tested using analysis of variance (ANOVA) and means were compared using a Least Significant Difference (LSD) test at P ≤ 0.05. Pearson correlation coefficient was determined to examine the relationship between infestation indicators and the Biochemical content of frond bases.

3 Results and Discussion

3.1 Rates of termite infestation

The results of Table 3 showed the highest intensity of the termite *Microserotermus diversus* selvestri infestation rate was in Basra province: Al-Deer at 90%, Al-Zeraji at 88%, and Qurna at 86%. Interestingly, the orchards in the Al-Zubair region were completely free from infestation, registering a 0% rate. In areas within Maysan Province, specifically Al-Maymouna and Qalaat Saleh, high infection rates of 82% were recorded for both regions. The elevated pest infestation levels in the study areas can be attributed to the absence of essential control measures, mainly due to the cryptic nature of termites and insufficient support and efforts from governmental institutions involved in the palm cultivation sector (Basrah Agriculture Directorate, 2022; Shefik, 2010).

Table 3: Rates of termite infestation in the study areas

Province	Area	Rate of infestation
Basra	Qurna	86%
	Dier	90%
	Zeraji	88%
	Chibbasi	82%
	Tanuma	74%
	Zubair	0%
Missan	Mashtal	74%
	Gsebah	76%
	Maimouna	82%
	Kahla	78%
	Al-Majar Al-Kabeer	70%
	Qalaat Saleh	82%

3.2 Severity of termite infestation in date palm cultivars

The results of Table 4 indicated that most date palm cultivars are highly susceptible to termite infestation. The highest infestation rates were observed in Shukkur and Khadrawi cultivars, with 48.45 and 52.19 termites per frond base, respectively. While Al-Dosary & Al-Najim (2006) showed that Deri cultivar is the most sensitive variety to termite infestation, and this difference may be due to the difference in choosing study areas and field surveys.

In Barhi and Maktom cultivars had the lowest infestation rates, with 0.00 ,10.00 termite per frond base respectively, This may be due to the fact that Barhi and Al-Maktum varieties are among the varieties that receive the attention of orchard owners through pest control and fertilization, as they are expensive cultivars and their fruits are exported abroad, thus being a financial source for the farmer (Ibrahim, 2013).

Table 4: severity of infestation cultivars of palm trees.

Variety	Mean ± SD	Severity of infestation
Sayer	26.09±48.68 b	Medium
Bream	21.09±31.49 b	Medium
Barhi	0.00±0.00 c	No infest.
Kadrawi	52.19±64.45 a	**Harmful**
Maktom	10.00±5.58 bc	Weak
Shukker	48.45±73.47 a	**Severe**
Zahdi	28.48±48.13 b	Medium
Dery	29.93±57.99 b	Medium
Gntaar	36.68±60.02 ab	**Severe**
Male	16.72±23.06 b	Medium

*Means within a column followed by the same letter are not significantly different.

The results of Table 4 indicated that termite in Basra and Missan province increased in severity during months of the year of low to moderate temperatures, The highest infestation intensity was observed in January, with the highest termite infestation rate reaching 115.59 termites per frond base when the average maximum temperature is 27°C and average minimum temperature is 7°C (Metiablue for weather and climate forecasting, 2023). In contrast, the lowest infestation rates were observed during the hottest months of the year, specifically during the months of June, July, when infestation rates reached 0,83 termite per frond base, 0.14 termite per frond base respectively.

Table 4: Severity of termite infestation according to months of the year (October 2022 to September 2023)

Months	Mean ± Std. D.
January	115.59±83.47 a
February	66.56±63.65 b
March	34.02±34.48 c
April	13.93±11.04 de
May	5.93±5.87 e
June	0.83±2.53 e
Juli	0.14±.65 e
August	1.75±1.55 e
September	5.41±5.15 e
October	30.19±28.41 cd
November	64.33±68.14 b
December	69.62±72.48 b

*Means within a column followed by the same letter are not significantly different.

The results of Table 5 showed that there were significant differences in the directions of termite infestation; the southern direction exhibited the most pronounced severity, with the average number of insects reaching 123.5492 termite per frond base. In contrast, the other three directions did not display significant variation in termite infestation levels. The reason for this is that the southern side of the palm stem faces the sun's rays during the months in which termites are active, especially in December, January and February, so they obtain warmth and suitable conditions for living.

Table 5: The direction effect on the termite infestation in the palm trunks

Direction	Means
North	29.4268 b
West	30.8962 b
East	31.1905 b
South	123.5492 a

*Means within a column followed by the same letter are not significantly different.

The results of Figure 3 showed termite infestation was higher in older palm trees with aged and dry trunks compared to younger trees that are less than 20 years old. The termite infestation was 32.22 termite per frond base in significant difference from palm trees less than 20 years old, whose termite infestation rate was about 0.35 termite per frond base. The reason for this is that termite prefer to feed on relatively dry wood instead of juicy and soft wood (RASIB, 1991; Sheikh et al., 2010).

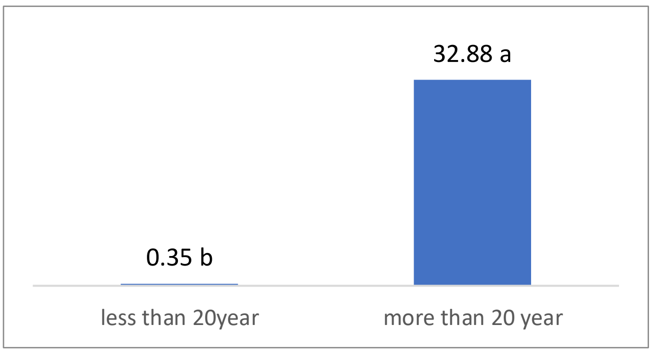

Figure 3: The severity of the termite infestation according to the age of the palm trees.

The results of Figure 4 indicated that the palm trees in the border of the orchard were more susceptible to termite infestation it reach to74.36 termite per frond base compared to the trees in the center of the orchard which was 47.4 termite per frond base. The reason for this is that most orchard owners plant some fruit and vegetable trees under the shade of palm trees, especially in the central area of the orchard, orchards owners spray pesticides to combat some pests and weeds, this will affect the density of agricultural pests, including termites. It has been shown that termites avoid agricultural pesticides even if they are in non-lethal concentrations (Rashied & Iqbal, 2019).

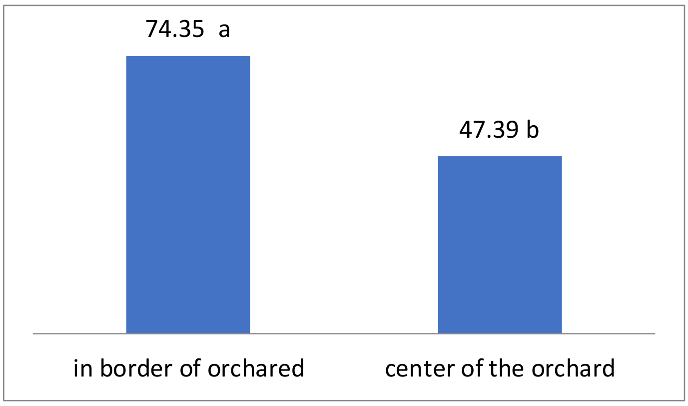

Figure 4: Infestation severity in palm location in orchard according to the location of palm tree in orchard.

3.3 Biochemical traits of the date palm cultivars

According to the results of Table 6, notable variations were observed in the percentages of protein, carbohydrate, lignin, and phenolic contents. The Kadrawi cultivar exhibited the highest protein and carbohydrate percentages at 0.75% and 4.27 mg/ml, respectively, while recording the lowest lignin and phenol contents at 0.58 g and 3.46 mg/ml, respectively. Conversely, the Barhi variety displayed the highest lignin and phenols content at 0.68 g and 3.98 mg/ml, respectively, and the lowest protein and carbohydrate percentages at 0.435 and 1.42 mg/ml, respectively. Given the significant disparities in infestation rates and severity across the study areas and palm varieties, these chemical analyses were conducted to assess the infestation severity in terms of biochemical compounds.

Table 6: Concentrations of biochemical substances in the bases of palm cultivars fronds

Cultivars	Protein ± Std.D.	Lignin ± Std.D.	Carbohydrate ± Std.D.	Total phenols ± Std.D
Bari	0.43%±0.003 d	0.68g ±0.0003 a	1.42 mg\ml±0.03 d	3.98 mg\ml ±0.008a
Maktoom	0.47%± 0.037 d	0.44g ±0.0003 f	0.64 mg\ml ±0.02 f	3.93 mg\ml ±0.011 b
Sayer	0.52%± 0.008 c	0.56g ±0.0002 e	1.01 mg\ml ± 0.01 e	3.95 mg\ml ±0.022 b
Brem	0.54%±0.020 c	0.63g ±0.0006 b	2.03 mg\ml ±0.07 c	3.97 mg\ml ±0.005 a
Shekker	0.60%±0.020 b	0.61g ±0.0002 c	2.88 mg\ml ±0.06 b	3.65 mg\ml ±0.007 c
Kadrawi	0.75%±0.046 a	0.58g± 0.0002 d	4.27 mg\ml ±0.14 a	3.46 mg\ml ±0.013 d

The correlation analysis results between the phenolic content at the base of fronds and the severity of termite infestation indicate a negative association, with a correlation value of -0.704, as depicted in Figure 4. Phenolic compounds are known for their toxicity to insects. Previous studies have demonstrated that these compounds can hinder insect feeding, diminish egg production and reproductive capabilities (Hisham et al., 2022; Pavela, 2011a; Usha Rani & Pratyusha, 2014; Wiwat et al., 2022), and exhibit a toxic effect comparable to that of chemical pesticides (Pavela, 2011b). termite infestation, with a correlation value of -0.558. Lignin serves as an essential component in constructing plant cell walls, contributing to the rigidity of these walls (Liu et al., 2018). The firmness provided by lignin in wood is instrumental in preventing termite feeding on the material (BEHR et al., 1972).

Figure 5 illustrated a positive correlation between the carbohydrate content in the frond bases and the severity of termite infestation, with a correlation value of 0.472. Carbohydrate compounds are fundamental for the sustenance of a species' life. Higher concentrations of carbohydrate compounds in the insect diet contribute significantly to an increased likelihood of termite invasion and infestation (Saran & Rust, 2005).

In Figure 6, there was a positive relationship between the percentages of protein in the bases of the fronds of each cultivar with the severity of termite infestation, which amounted to 0.713. Sogbesan & Ugwumba (2008) showed that increasing protein in termite food greatly improved growth characteristics and thus the reproduction processes occurred and the colony increased.

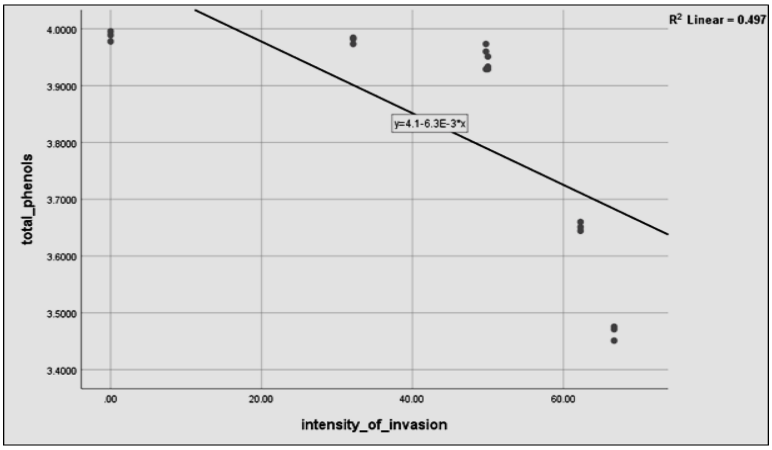

Figure 5: Correlation between the total phenolic content and severity of the invasion with termites in palm trees.

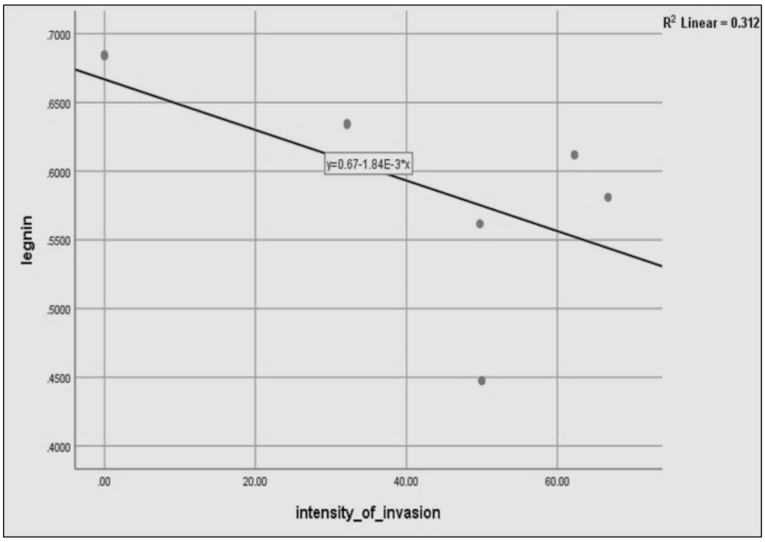

Figure 6: Correlation between the lignin content and the intensity of the invasion with termites in palm trees.

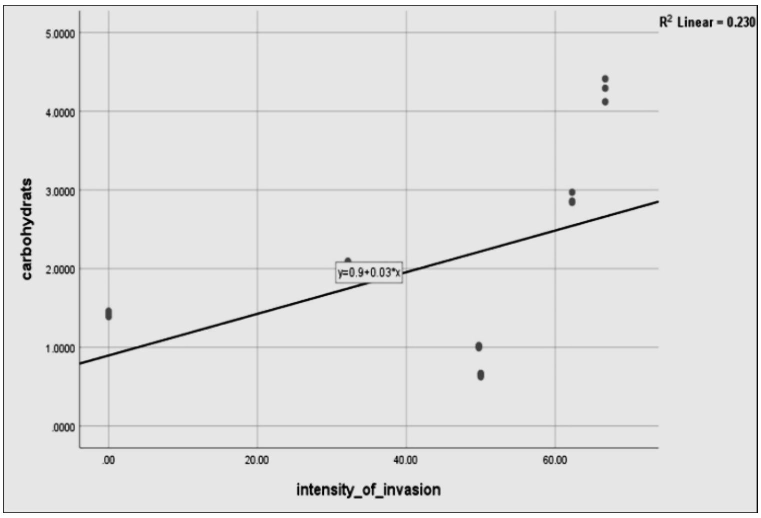

Figure 7: Correlation between carbohydrate content and the intensity of the invasion with termites in palm trees.

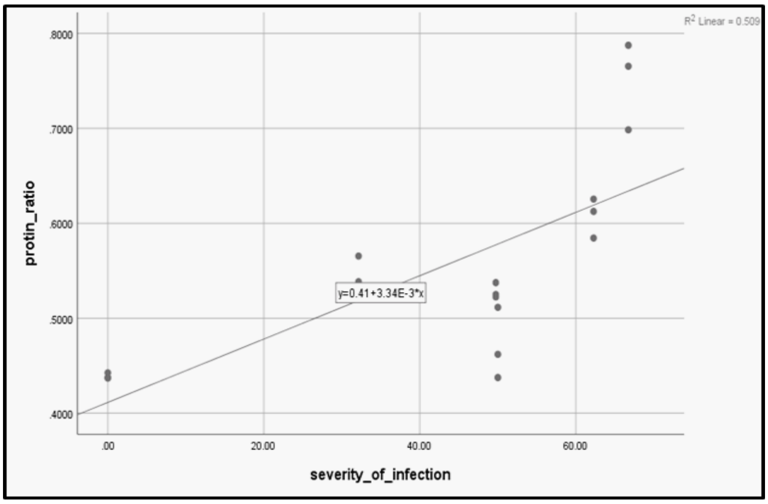

Figure 8: Correlation between the protein ratio and the intensity of invasion with termites in palm trees.

4 Conclusions

The investigation revealed that the termite species, *Microserotermis diversus* silvestri, displayed a preference for Shokker and Khadrawi cultivars. The intensity of infestation heightened during the colder months (November, December, January, and February) and markedly diminished during the hotter summer months of June and July. Infestation was predominantly concentrated on the southern side of the palm stem, with a higher likelihood of occurrence in trees surpassing 20 years in age. Furthermore, it was noted that infestation tended to be more prevalent at the outer edges of orchards rather than in the central regions. The study proposes that understanding the seasonal activity patterns and preferred locations of the insects can aid in planning control measures and integrated pest management at the appropriate time and in the right areas.

Acknowledgments:

The authors extend their appreciation to the laboratory technicians at the College of Agriculture, University of Basrah, for their assistance in carrying out the biochemical analysis. Additionally, they express their gratitude to the orchard owners who cooperated with the researchers during the field survey, providing support and facilitating various tasks.

References:

Abdulqader, A. A., Kasir, W. A. J., & Taha, K. H. (2009). EFFECT OF Nattrassiae mangiferae ON THE WOOD SOLUBLE AND NON-SOLUBLE CHEMICAL COMPONENT. *Journal of Alrafidain Agricalture*, *37*(3), arabic.

Abed, A. al kareem mohamed, Altemimi, E. H., & Jameel, N. S. (2007). DETERMINE OF CARBOHYDRATES, PROTEIN AND PHENOLIC COMPOUNDS OF FIVE DATE PALM CULTIVARS Phoenix dactylifera L. *Basrah J.Agric.Sci (Arabic)*, *19*, 16–20. https://doi.org/10.33762/bagrs.2006.57309

Al-Dosary, N. H., & Al-Najim, A. E. A. (2006). Survey On The Infestation Of Date Palm Phoenix dactylifera With Termites Microcerotermes diversus (Silvestri) (Isoptera :Termitidae) In Different Locations In Basrah Governorate. *Basrah J.Agric.Sci (Arabic)*, *3*(32), 65–72.

ALallaf, E. H. (2020). *Date palm fruit*. Cientific Bulletin - Ministry of Higher Education and Scientific Research - College of Agriculture, Department of Horticulture and Landscape Engineering - University of Mosul(Arabic).

Alderawii, M. M., Alyousuf, A. A., Hasan, S. A., Mohammed, J. K., Jappar, H. A., & Paudyal, S. (2020). AN EVALUATION OF INVASIVE PEST, RED PALM WEEVIL RHYNCHOPHORUS FERRUGINEUS (OLIVIER, 1790)(COLEOPTERA, CURCULIONIDAE) POPULATION IN IRAQ. *Bulletin of the Iraq Natural History Museum (P-ISSN: 1017-8678, E-ISSN: 2311-9799)*, *16*(2), 203–218.

Aldosary, N. H., Al-Najim, I. A., & Mahdi, H. A. (2013). The efficiency of Bahia and Fendkm Pesticides Against Lesser moth Batrachedra amydraula (M.)(Lepedoptera: Cosmopterygidae) and Dust Mite Oligonychus afrasiaticus (M.)(Acari: Tetranychidae) during Different Periods and Different Parts of Date Palm Trees. *Basrah Journal of Agricultural Sciences*, *26*(2). https://doi.org/10.33762/bagrs.2013.111634

Ali, H. M., & Fhaid, K. A. (2019). Field Efficacy of Pesticides Against Dust Mites Oligonychus afrasiaticus (McGregor)(Acari: Tetranchidae) on Date Palm, Hillawi Cultivar. *Basrah Journal of Agricultural Sciences*, *32*(2), 160–168. https://doi.org/10.37077/25200860.2019.206

Alsaedi, G. F. (2022). The infestation percentage and the population density of the lesser date moth

Batrachedra amydraula Meyrick (Cosmopterygidae: Lepidoptera) on cultivars Date Palm trees in Basrah governorate. *Texas Journal of Agriculture and Biological Sciences*, *7*, 25–31.

Alsibai, Y. (2007). *white ants* (1st ed.). Agriculture, Egyptian Ministry of Agriculture - Printing Unit of the Ministry of.

Alyousuf, A. A. (2022). Integrated management of key insect pests of date palms Phoenix dactylifera L. in Basrah southern Iraq. *Basrah Journal For Date Palm Research*, *21*(1).

Alyousuf, A., Abood, R. A., & Alderawii, M. M. (2021). *Dispersion and Bi-nomial Sequential Sampling Plan for Lesser Date Moth Batrachedra amy-draula (Lepidoptera: Batrachedri-dae) Infesting Date Palm Planta-tions*. Proceedings of the 1st Inter-National Electronic Conference on Entomology, 1–15.

Alyousuf, A., Shaaban, A. D., Alderawii, M. M., & Alsaadie, H. M. (2020). Monitoring and management of date palm borers by using light traps. *Basrah Journal of Agricultural Sciences*, *33*(2), 147–157. https://doi.org/10.37077/25200860.2020.33.2.13

Anis, M., Siti Nadrah, A. H., Kamarudin, H., Astimar, A. A., & Mohd Basri, W. (2011). Isolation and functional properties of hemicelluloses from oil palm trunks. *Journal of Oil Palm Research*, *23*(DECEMBER), 1178–1184. https://doi.org/10.21894/jopr.2020.0062

Assirey, E. A. R. (2015). Nutritional composition of fruit of 10 date palm (Phoenix dactylifera L.) cultivars grown in Saudi Arabia. *Journal of Taibah University for Science*, *9*(1), 75–79. https://doi.org/10.1016/j.jtusci.2014.07.002

Association of Official Analytical, & Chemists. (1925). *Official methods of analysis of the Association of Official Analytical Chemists* (Vol. 2). The Association.

Basrah Agriculture Directorate. (2022). *Basrah Agriculture Directorate-Department of Planning* (p. An official report to the Ministry of Agriculture).

Behr, E. A., Behr, C. T., & Wilson, L. F. (1972). Influence of wood hardness on feeding by the eastern subterranean termite, Reticulitermes flavipes (Isoptera: Rhinotermitadae). *Annals of the Entomological Society of America*, *65*(2), 457–460. https://doi.org/10.1093/aesa/65.2.457

Bennett, R. N., & Wallsgrove, R. M. (1994). Secondary metabolites in plant defence mechanisms. *New Phytologist*, *127*(4), 617–633. https://doi.org/10.1111/j.1469-8137.1994.tb02968.x

Browning, B. L. (1967). Methods of wood chemistry. Volumes I & II. *Methods of Wood Chemistry. Volumes I & II*.

Cabrera, H. M., Argandoña, V. H., Zúñiga, G. E., & Corcuera, L. J. (1995). Effect of infestation by aphids on the water status of barley and insect development. *Phytochemistry*, *40*(4), 1083–1088. https://doi.org/10.1016/0031-9422(95)00325-2

Culliney, T. W., & Grace, J. K. (2000). Prospects for the biological control of subterranean termites (Isoptera: Rhinotermitidae), with special reference to Coptotermes formosanus. *Bulletin of Entomological Research*, *90*(1), 9–21. https://doi.org/10.1017/s0007485300000663

Dhang, P. (2011). *A preliminary study on elimination of colonies of the mound building termite Macrotermes gilvus (Hagen) using a chlorfluazuron termite bait in the Philippines*. Molecular Diversity Preservation International (MDPI).

Dixit, G., Praveen, A., Tripathi, T., Yadav, V. K., & Verma, P. C. (2017). Herbivore-responsive cotton phenolics and their impact on insect performance and biochemistry. *Journal of Asia-Pacific Entomology*, *20*(2), 341–351. https://doi.org/10.1016/j.aspen.2017.02.002

DuBois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. t, & Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, *28*(3), 350–356. https://doi.org/10.1021/ac60111a017

Eggleton, P., Bignell, D. E., Hauser, S., Dibog, L., Norgrove, L., & Madong, B. (2002). Termite diversity across an anthropogenic disturbance gradient in the humid forest zone of West Africa. *Agriculture, Ecosystems & Environment*, *90*(2), 189–202. https://doi.org/10.1016/s0167-8809(01)00206-7

Eggleton, P., & Tayasu, I. (2001). Feeding groups, lifetypes and the global ecology of termites. *Ecological Research*, *16*(5), 941–960. https://doi.org/10.1046/j.1440-1703.2001.00444.x

Ekhtelat, M., Habibpour, B., Ziaee, M., & Poursartip, L. (2018). *The effects of bait shape and composition on acceptance and consumption of bait by Microcerotermes diversus (Isoptera : Termitidae) under laboratory and field conditions*. *January*.

Habibpour, B. (2006a). *Laboratory and field evaluation of bait-toxicants for suppression of subterranean termite populations in Ahvaz*. PhD Dissertation, College of Agriculture, Shahid Chamran University, Ahvaz, Iran.

Habibpour, B. (2006b). *Laboratory and field evaluation of bait-toxicants for suppression of subterranean termite populations in Ahwaz (Iran)*. PhD Thesis.

Helrich, K. (1990). *Official methods of analysis of the Association of Official Analytical Chemists* (Issue BOOK). Association of official analytical chemists.

Hisham, S. M., Mohammad, A. M., & Mohammed, M. J. (2022). The effect of extracts and phenolic compounds isolation from Rosmarinus officinalis plant leaves on Tribolium castaneum mortality. *Technology*, *12*(2), 814–819.

Husain, F. A., & Esmaiel, R. M. (2007). *Studying the reality of palm cultivation, date production, processing,* *marketing and development prospects*. A Study Submitted to the International Food and Agriculture Organization within the Palm Groves Rehabilitation Project in Iraq (Arabic).

Ibrahim, A. A. (2013). Palm cultivation and the production of dates in the Arab world - current reality, obstacles and development horizons. *Juma Al Majid Center for Culture and Heritage- Dubai (Arabic)*, 514.

Ibrahim, A. A., & Zaied, A. (2019). *Palm cultivation and the quality of dates between environmental factors, service and care programs*. *In A book of the Khalifa International Prize for Dates and Agricultural Innovation (arabic).*

Ithal, N., Recknor, J., Nettleton, D., Maier, T., Baum, T. J., & Mitchum, M. G. (2007). Developmental transcript profiling of cyst nematode feeding cells in soybean roots. *Molecular Plant-Microbe Interactions*, *20* (5), 510–525. https://doi.org/10.1094/mpmi-20-5-0510

Jood, S., & Kapoor, A. C. (1992). Effect of storage and insect infestation on protein and starch digestibility of cereal grains. *Food Chemistry*, *44*(3), 209–212. https://doi.org/10.1016/0308-8146(92)90189-9

Metiablue for weather and climate forecasting. (2023). Basra, Maysan weather. *Swiss Website Metiablue for Weather and Climate Forecasting, 8\10\2023.* https://www.meteoblue.com/ar/weather/historyclimate/weatherarchive

Nadeem, M., Qureshi, T. M., Ugulu, I., Riaz, M. N., Ain, Q. U., Khan, Z. I., Ahmad, K., Ashfaq, A., Bashir, H., & Dogan, Y. (2019). Mineral, vitamin and phenolic contents and sugar profiles of some prominent date palm (Phoenix dactylifera) varieties of Pakistan. *Pakistan Journal of Botany*, *51*(1), 171–178. https://doi.org/10.30848/PJB2019-1(14)

Othmen, S. Ben, Boussaa, F., Hajji-Hedfi, L., Abbess, K., Dbara, S., & Chermiti, B. (2022). Effects of nymphal density (Bactericera trigonica) and feeding on photosynthetic pigments, proline content and phenolic compounds in carrot plants. *European Journal of Plant Pathology*, *163*(1), 51–59. https://doi.org/10.1007/s10658-021-02456-9

Rashied, A., & Iqbal, N. (2019). *Toxicity and repellency of different insecticides to Odontotermes obesus (Rambur , 1842) (Blattodea : Termitidae : Macrotermitinae) 1 Öz.* *43*(3), 241–251.

RASIB, K. Z. (1991). *FEEDING PREFERENCES OF MICROCEROTERMES CHAMPIONI (SNYDER) ON DIFFERENT TIMBERS DRIED AT DIFFERENT TEMPERATURES UNDER CHOICE AND NO CHOICE TRIALS .*

Republic of Iraq - Ministry of Planning - Central Standardization and Control Authority. (2023).

Russell, G. E. (2013). *Plant breeding for pest and disease resistance: studies in the agricultural and food sciences*.

Schuetz, M., Benske, A., Smith, R. A., Watanabe, Y., Tobimatsu, Y., Ralph, J., Demura, T., Ellis, B., & Samuels, A. L. (2014). Laccases direct lignification in the discrete secondary cell wall domains of protoxylem. *Plant Physiology*, *166*(2), 798–807. https://doi.org/10.1104/pp.114.245597

Shefik, M. A. A. (2010). THE EFFECT OF INFESTATION OF TERMITE Microceritermes diversus (SILVESTRI) (INSECTA:ISOPTERA) ON THE PRODUCTIVITY OF SOME DATE PALMS CULTIVARS IN IRAQ. *Iraqi Journal of Science*, *51*(3), 376–391.

Sheikh, N., Qureshi, A. M., Latif, M. U., & Manzoor, F. (2010). Study of temperature treated woods for the preference and first food choice by Odontotermes obesus (Isoptera: Termitidae). *Sociobiology*, *56*(2), 363–374.

Silva, R. J. N. da, Guimarães, E. R., Garcia, J. F., Botelho, P. S. M., Ferro, M. I. T., Mutton, M. A., & Mutton, M. J. R. (2005). Infestation of froghopper nymphs changes the amounts of total phenolics in sugarcane. *Scientia Agricola*, *62*, 543–546. https://doi.org/10.1590/s0103-90162005000600005

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). [14] Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In *Methods in enzymology*, 299, 152–178.

Smith, C. M. (1999). Plant resistance to insects. In *Biological and biotechnological control of insect pests* (pp. 171–208). CRC Press.

Sogbesan, A. O., & Ugwumba, A. A. A. (2008). Nutritional evaluation of termite (Macrotermes subhyalinus) meal as animal protein supplements in the diets of Heterobranchus longifilis (Valenciennes, 1840) fingerlings. *Turkish Journal of Fisheries and Aquatic Sciences*, *8*(1), 149–158.

Stathers, T. E., Arnold, S. E. J., Rumney, C. J., & Hopson, C. (2020). Measuring the nutritional cost of insect infestation of stored maize and cowpea. *Food Security*, *12*, 285–308. https://doi.org/10.1007/s12571-019-00997-w

Usha Rani, P., & Pratyusha, S. (2014). Role of castor plant phenolics on performance of its two herbivores and their impact on egg parasitoid behaviour. *BioControl*, *59*, 513–524. https://doi.org/10.1007/s10526-014-9590-y

Wolcott, G. N. (1954). Termite damage and control as factors in the utilization of timber in the Caribbean area. *J. Agric. Univ. Puerto Rico*, *38*(2).