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Review of the date plam white scale

(*Parlatoria Blanchardi Targ*) (Homoptera: Diaspididae)

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October 2020

□الآية

قال تعالى:

﴿لاَ يُكَلِّفُ اللّهُ نَفْسًا إِلاَّ وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ رَبَّنَا لاَ تُؤَاخِذْنَا إِن نَّسِينَا أَوْ أَخْطَأْنَا رَبَّنَا وَلاَ تَحْمِلْ عَلَيْنَا إِصْرًا كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِن قَبْلِنَا رَبَّنَا وَلاَ تُحَمِّلْنَا مَا لاَ طَاقَةَ لَنَا بِهِ وَاعْفُ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَآ أَنتَ مَوْلاَنَا فَانصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ﴾

صدق الله العظيم

سورة البقرة الآية (**286**)

DEDICATION

To my dear father and my mother, To all my family, To students of science

Acknowledgements

My gratitude to almighty Alla who gave me strength to compelte this study

I would like to express my sincere gratitude and deep appreciation to my supervisor

Dr. Saif Eldin Mohammed Khair, he dedicated a lot of his precious time to give me valuable assistance and guidance throughout the whole work.

My thanks go to everyone, who helped me in this work to see the light.

My family, for their endless continuous encouragement, support and sympathy.

Abstract

Date palm white scale insect is one of the most dangerous pests that threaten the date palm production in Sudan. It attacks all parts of the try but mostly the leaves. Our study aims to evaluate the physiological and anatomical effects of the in insect on the leaves of date palm. We found that there was a reduction in leaves' moisture; the reduction was more serious when the infestation rate is high. There was also a reduction in the total concentration of the absolute and optical chlorophyll, as well as pigments (chlorophyll a and b). We didn't observe any effect on the stomatal density of the leaves even when the infestation is heavy, the histological sections of the leaves also didn't show any difference or abnormal structure in tissues.

الخلاصة

تعتبر حشرة نخيل التمر من أخطر الآفات التي تهدد إنتاج النخيل في السودان. يهاجم جميع أجزاء المحاولة ولكن في الغالب الأوراق. تهدف دراستنا إلى تقييم التأثيرات الفسيولوجية والتشريحية للحشرة على أوراق نخيل التمر. وجدنا أنه كان هناك انخفاض في رطوبة الأوراق ؛ كان الانخفاض أكثر خطورة عندما يكون معدل الإصابة مرتفعًا. كان هناك أيضًا انخفاض في التركيز الكلي للكلوروفيل المطلق والضوئي ، وكذلك الأصباغ (الكلوروفيل). لم نلاحظ أي تأثير على كثافة الثغور للأوراق حتى عندما تكون الإصابة شديدة ، كما أن الأقسام النسيجية للأوراق لم تظهر أي اختلاف أو بنية غير طبيعية في الأنسجة.

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Chapter One

Introduction

Date palm, *Phoenix dactyifera* L., was cultivated in north Africa, the Arabian Peninsula and Indian subcontinent since ancient times. It is known for its ability to adapt to desertic conditions because of its resistance to high temperatures, drought and salinity. It is characterized by its high production and its fruit's high nutritional value that could go as far as to be one of the main commodities in the national food security (Anonymous, 2002)

Algeria ranks as the fifth most producing country of date palm with 156 thousand tons, and is the first world producer of *Deglet Nour*. Despite this, date palms agriculture today still faces some obstacles, the most dangerous of which are those related to pests such as: Bayoud (*Fusarium oxysporum*) , Khamedj (*Mauginiella scaettae*) , Boufaroua (*Oligonychus afrasiaticus*), Bouguassas (*Apatemonachus*), date moth (*Ectomyelois ceratoniae*), and the white scale insect (Achoura & Belhamra, 2016).

Parlatoria blanchardi Targ. is considered one of the most dangerous pests that infest the Arecaceae family, including date palm in all its cultivation regions. It is one of the most feared pests after Bayoud and has lately become a serious defect, especially in the newly planted regions (Saharaoui et al., 2011 in Gassou, 2015). Young palm trees are more vulnerable to white cochineals than their older counterparts. The insect spreads when appropriate conditions avail on the roofs of all vegetative parts and fruit. The heavy infestation may cause death of offshoots and weak old trees. It can reduce the palm's production to 50-60 % (Munier, 1973).

This study aims to evaluate the effect of high and low infestation of *Parlatoria blanchardi* on the physiology (moist content, chlorophyll pigments) and anatomy (stomatal density, conducting vessels) of date palms of *Deglet*

Nour in Biskra region. Our study is contended on leaves because they are the first and the most part infested by the insect**.**

1.1 Objective:

Study of scale insects and ways to combat them.

1.2 Scale insect in Sudan:

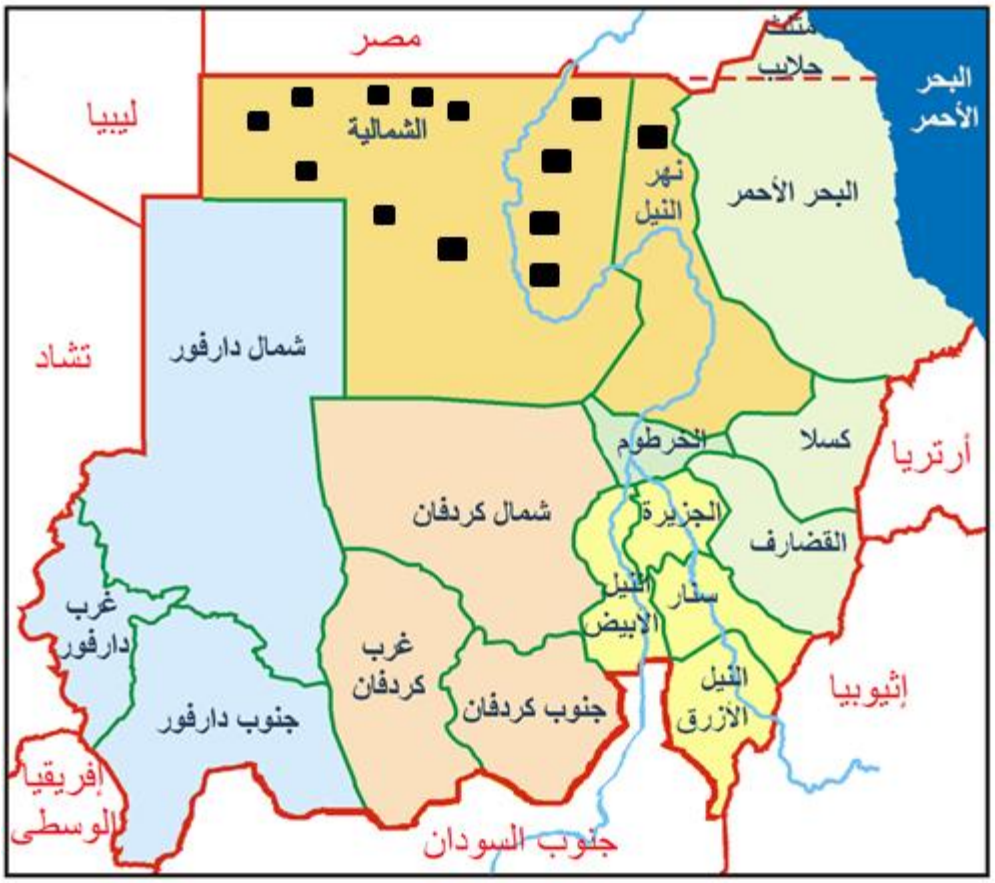

Figure (1) Scale insect in Sudan

Chapter Two

Literature Review

2.1 Biological description of date palm

Date palm is considered a crucial component of the world's permanent vegetation cover over large spaces of the earth including tropical, sub-tropical, arid and warm regions.

According to De Candolle (1883) in (Ibrahim & Khalif, 2004), date palm is a native plant of the hot arid regions extending from West Africa to Iran, where it spreads to other parts of the world.

It was named *phoenix dactylifera* by Linne in 1734. The word phoenix originates from the Greek *phoinix*, which means date in Phoenician; *dactylifera* the second part of the name comes from the Greek *dactylos* which means finger, denoting the finger shape of the fruit. (Munier, 1973)

2.2 Systematic description

Date palm is a diploid, dioecious, and monocot plant that belongs to the botanical family Arecaceae which is the only family that belongs to the Arecal order with two hundred and fifty two genus (Ibrahim & Khalif, 2004). Phoenix genus includes twelve species (Munier, 1973).

According to the angiosperm Phylogeny Group III, date palm is classified as follows:

Kingdom	Planta
Branch	Angiosperm
Class	Monocotos
Order	Arecal
Family	Arecaceae
Sub-Family	Coryphyoideae
Genus	Phoenix
Species	*Phoenix dactylifera* L.

2.3. Morphological description

2.3.1. Trunk

The trunk, also called stipe of date palm, is a vertical cylinder that grows on the ground and which is about ten to thirty meters high (Ibrahim & Khalif, 2004).

Munier (1979) and Zaid & de Wet (2002) indicate that the trunk do not branch, but the growth of the basal offshoot gives it a look of a pseudo-branching. Its vertical elongation is insured by a terminal bud called phyllophor. The lateral growth of a trunk is ensured by an extra-fascicular cambium which disappears after giving the trunk its final width.

The trunk is covered with leaf bases that are enclosed in fiber to protect it from herbivorous insects and animals, as well as an insulation to reduce water loss. Through time the appearance of the trunk changes and it becomes smoother with visible remaining cicatrices of the leaves' bases.

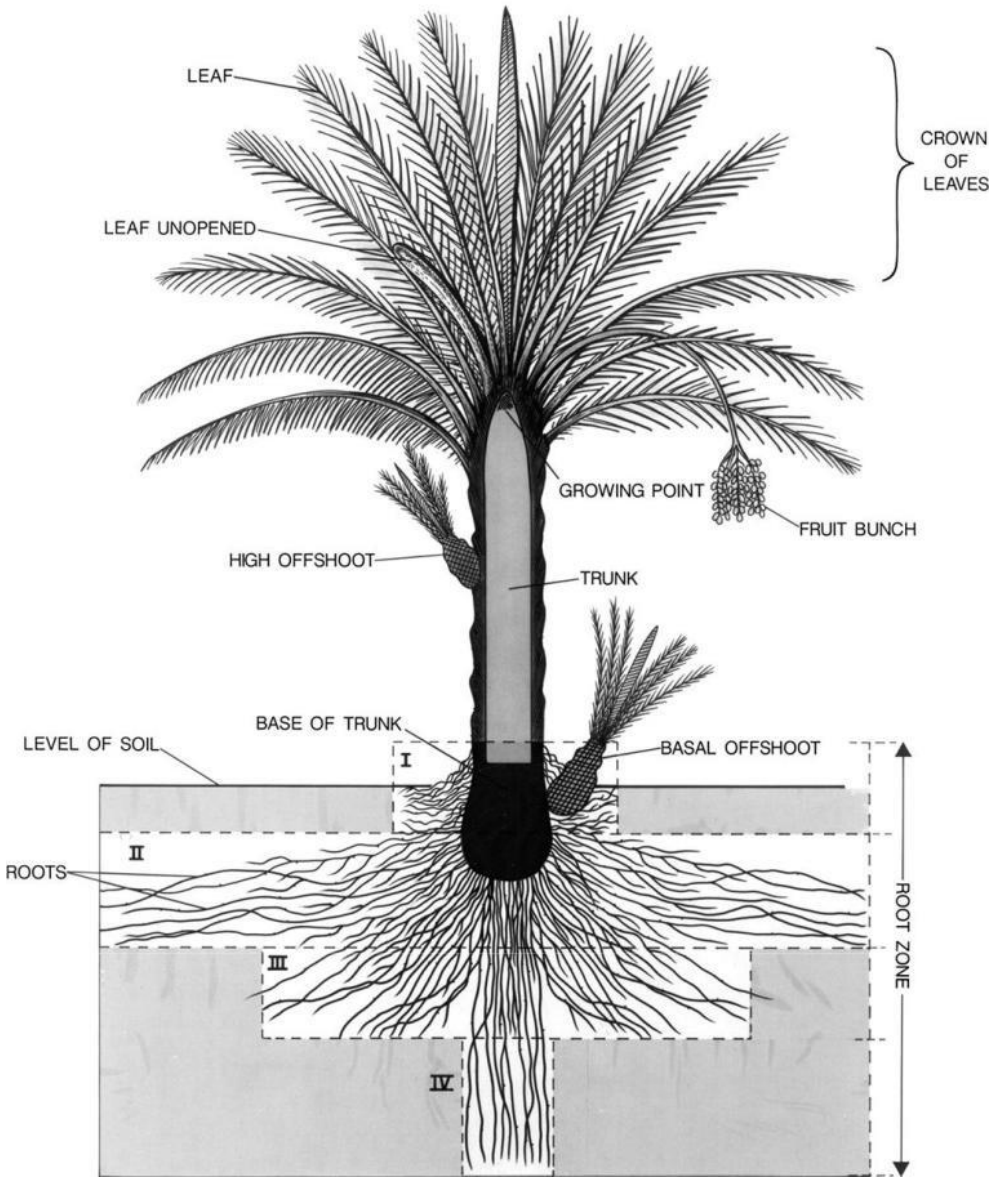

Figure 2 : Diagrammatic representation of date palm structure (ChihCheng & Robert, 2007)

2.3.2. Roots

Date palm has dense fasciculate fibrous roots which sprout of an enormous bulb attached to the base of the trunk; furthermore, a part of it emerges from the soil (Munier, 1973). The roots of date palm are distinct according to Zaid and de Wet (2002), the primary roots that develop directly from the seed at the beginning have an average of four to ten meters. They produce similar but shorter secondary roots which also grow thinner tertiary roots from it.

Munier (1973) divided the roots' zone into four sections based on their function (Figure01):

- Zone I: is called the respiratory zone; it starts from the debut of the stipe base and reaches twenty five centimeters into the soil with a lateral distribution of a maximum of half a meter away from the stipe, and it has many aerial adventitious roots growing over the ground. The roots of this zone have a negative geotropism and play a respiratory role.
- Zone II: is called nutritional zone; it extends from the first zone and contains a high proportion of the roots.
- Zone III: is the absorption zone; its importance depends on the mode of culture and the phreatic surface.
- Zone VI: is the largest portion of this zone and is dependent on underground water. At a shallower depth, it becomes difficult to distinguish between this zone and the third zone. The roots in this zone are assembled in beams with positive geotropism.

The depth and the length of the roots depend on several conditions such as the quality of the soil (heavy or light soil), culture mode, water level in the soil, and cultivars among other conditions (Munier, 1973; Hocine, 1978 in Ibrahim & Khalifa, 2004).

2.3.3 Leaves

Date palm leaves, called frond, are compound, pinnate leaves growing on top of trunk and forming a crown (canopy) (Munier, 1973; Ibrahim & Khalifa, 2004).

The crown of a healthy adult date palm holds from a hundred to a hundred and twenty five green leaves with annual formation of ten to thirty new leaves. Each leaf remains active for a period between four and seven years, then it starts to wither and become yellowish and finally droop from the crown only to be removed later (Munier, 1973).

The leaves develop from a terminal bud that generates close spirals of leaves along the trunk (Toutain, 1967).

As stated by Zaid and de Wet (2002), the crown is divided into three main parts or layers of leaves:

a- The outside is photosynthetically-active, green leaves form 50% of the whole crown. According to Tourneur and Vilardebo (1975), the tissue of this part of the crown is aged, in time, it hardens and becomes more coriaceous due to external factor such as the intense infestation by insects and fungi and the corrosion caused by the sand.

b- At the centre, there are fast growing green leaves. The leaves here form an angle of 30° with the principal axe; they are highly active physiologically speaking. (Tourneur & Vilardebo, 1975)

c- Inside, the palm's heart constitutes of white-colored juvenile leaves that are not yet photosynthetic. It is constituted of 8 to 12 leaf attached to each other (Tourneur & Vilardebo, 1975).

The leaf of date palm is a long flexible frond; its length depends on the varieties and the age of the palm. It is between 0.9-1.2 meters in young palms and sometimes reaches 4.8 meters in adult palm. It is composed of a principal axe, rachis or leaf midrib that is narrow on the top and starts to widen as it moves towards the insertion point of the petiole (Ibrahim & Khalif, 2004).

The leaflets are arranged obliquely on the rachis, which can either be isolated or gathered, all folded longitudinally. The underneath leaflets are longer than the ones on top (Munier, 1973); they are usually covered with a thick cuticle and are always coriaceous (Toutain, 1967).

The leaflets are transformed into spines just before the base of the petiole; this latter is attached to a fibrous leaf-sheath which covers the trunk and also helps protect (Munier, 1973; Ibrahim & Khalifa, 2004).

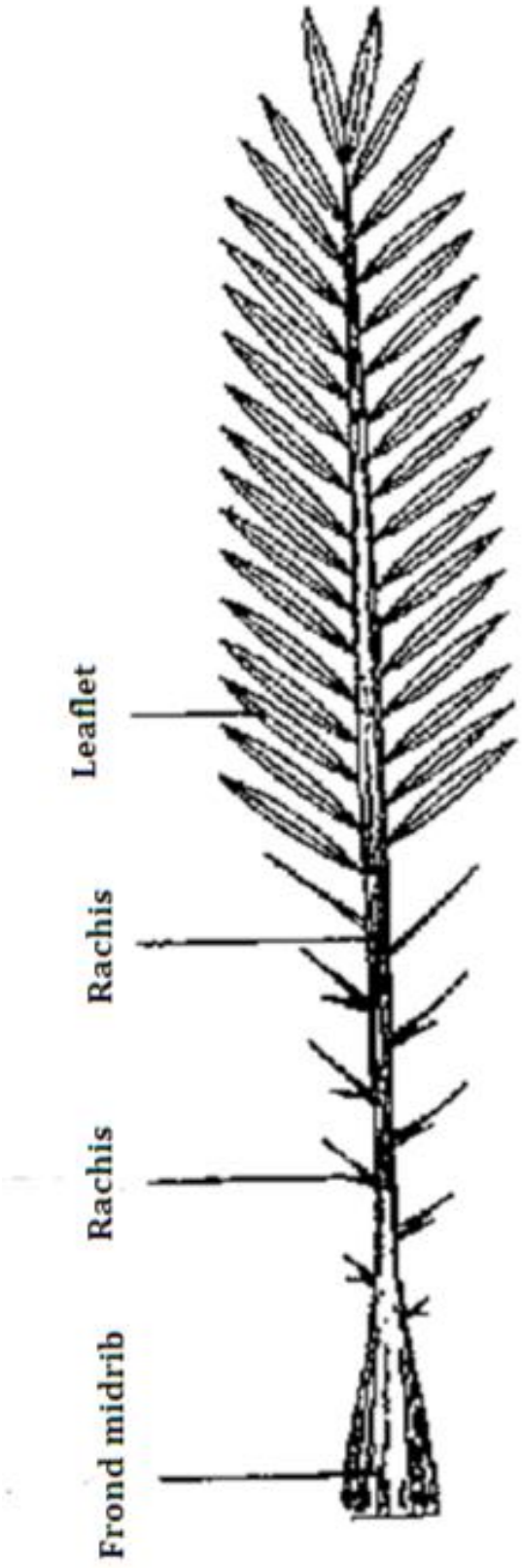

Figure 3 : Diagram of date palm leaf (Zaid & de Wet, 2002)

2.4 Reproductive organs

Date palm is a dioecious species with both male and female flowers being produced in clusters (inflorescence) on separate palms and is called spadixes or spikes. The clusters emerge from an auxiliary bud at the base of each leaf of the previous year's growth.

The unisexual flowers (pistillateand staminate) are sessile; they are attached to a fleshy central stem with several spikelets (usually 50 - 150 lateral branches), all of which are enfolded by a membranous sheath that remains entirely closed as long as the flowers are not mature : the spathe. The spathe protects the delicate flowers from shriveling caused by the intense heat until they mature and begin to function. Following maturation, the spathe splits longitudinally exposing the entire inflorescence for pollination purposes.

The male flower with a slightly elongated form is sweet-scented and generally has six stamens. It is surrounded by waxy scale-like petals and sepals; each stamen is composed of two little yellowish pollen sacs.

The female flower, on the other hand, is of a diameter of about 3 to 4 millimeters and has rudimentary stamens and three carpels closely pressed together with the ovary placed above (hypogynous). The three sepals and three petals are connected together so that only the tips diverge.

The color of male and female calyx and corolla are ivory-white, with the female calyx having green color around the edges (Munier, 1973; Zaid & De Wet, 2002).

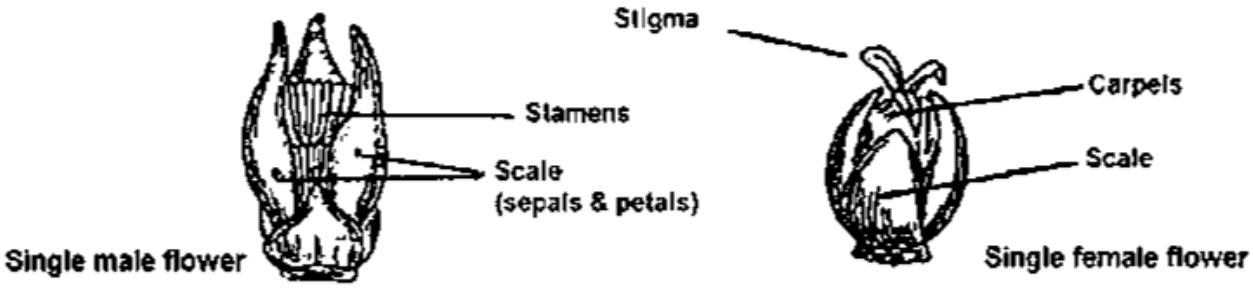

Figure 4: Diagram of male and female flower of date palm (Munier, 1973)

2.5 Fruit

The fruit is a one seeded, oblong berry composed from the outside inwards from: an exocarp which consists of an epidermis covered with a cuticle, they both cover a fleshy fibrous mesocarp, which constitutes most of the fruit. This latter is divided into an outer-mesocarp and an inner-mesocarp, with 3-10 layers of tanninferous cells filling the space between them. The final layer is the membranous endocarp which consists of one layer of small cells that separate the mescarp from the seed (Al-Awdat & El-Deajy, 1992 in Sakr et al., 2010).

The shape, the size and the color of the fruit depend on the variety, and it measures from 2-11 centimeters in length and from 1-3 centimeters in width. The color of the fruit varies from pale yellow, amber translucent yellow, brown, dark or red (Ibrahim & Khalif, 2004).

Normally, date palm pollination is anemogamous, but to increase the probability of female flowers getting pollinated this needs to be done artificially. Only one ovule per flower is fertilized, leading to the development of a single carpel which in turn produces a fruit, the date, while the other ovules are aborted. The aborted carpels persist as two brown spots in the calyx of ripe fruits. In case of non-pollinated flowers, an immature seedless fruit develops via parthenogenesis (Munier, 1973).

Throughout the year, a date palm generally produces five to ten bunches of fruit; a mature tree produces up to 150 pounds annually (El-Hadrami and Al-Khayri, 2012 in Radwan, 2017).

2.6 Date palm white scale *Parlatoria blanchardi* Targ.

2.6.1 History

Date palm white scale, *Parlatoria blanchardii* (Targioni-Tozzetti), is one of the most damaging pests known in most parts of the world, including Algeria. It was discovered for the first time in the Algerian desert in 1868, in the palm groves of Oued Rhig by Blanchard. It was Stickney (1934) and Balachowsky (1953) who gave the final total description of the insect (Smirnoff, 1957).

Date palm white scale have various common names; sometimes it has many names in the same country: cochenille blanche in French, parlatoria date scala in U.S.A., Djreb, sem, Elmen in Algeria, Nakoub, Guelma, Tilichte, Tabkhocht, Tasslacht in Morocco, and Klefiss, Rheifiss in Mauritania (Munier, 1973).

2.7 Classification

Date palm white scale *Parlatoria blanchardi* (Targioni-Tozzetti) is a typical species of the family of diaspididae (Munier, 1973).

Depending on the classification of cochineal that Balachowsky (1954) has proposed, *Parlatoria blanchardi* is classified as follows: (Achour, 2013)

Enbranchement	Arthropoda
Class	Insecta
Division	Exopterygota
Super-order	Hemipteroidea
Order	Homoptera
Sub-order	Sternorrhyncha
Super-family	Coccidae
Family	Diaspididae
Sub-family	Diaspididae
Tribu	Parlatorini

Sub-tribu	Parlatorina
Genus	Parlatoria
Species	*Parlatoria blanchardi* Targioni-Tozzetti

2.8 Geographical distribution

Parlatoria blanchardi is thought to be native to Mesopotamia (Munier, 1973) and Southern Mesopotamia (Toutain, 1967). It can be found in Middle East countries such as Turkey, Iraq, Palestine, Syria, Jordan, Saudi Arabia Iran, in addition to India as well as Turkestan in south Asia where it was detected out for the first time in 1935.

The insect gradually spread over North Africa through the East boarders when date palm offshoots were transported there, in Egypt, Libya, Sudan, Somalia, Sahara, Mauritania, Niger and Chad, and also Algeria (Munier, 1973; Malumphy, 2013). Idder (1991) reported that all phoenicicol regions in Algeria are infested with date palm cochineal.

According to Munier (1973), *Parlatoria blanchardi* spread through the eastern oasis of Algeria startinginTimimoun, 1912; Colomb Bechar, 1920 ; Boussaada, 1925 ;El-Golea, 1926
; Tidikelt, 1928; Saoura, 1930 All the oasis from Biskra to Ouargla (Balachowsky ,1932); In Marocco, it was observed in Figuig, 1937 ;Tafilalt, 1938 ; Bani et Tata, 1940 ; Goulmina, 1951.

Generally, it exists in areas where date palm is cultivated (Alhadj & Aldaghiri, sd.) except for U.S.A where its extinction was declared in 1936 as a result of an eradication campaign following its transportation there in 1890 via an Algerian plant material (Munier, 1973) where it affected regions of the U.S.A such as California and Arizona (Laudho & Benssy, 1969; Munier, 1973). It has also been transported to Australia in 1894, to Brazil in 1929, and to Argentina through the new plantations of Turkestan in 1935 (Smirnoff, 1954 in Achour, 2013).

Smirnoff (1957) noticed that the initial centers of contamination are located in date palms planted near villages, markets, tracks and rivers infected due to transmission of the pest from regions contaminated by white scale insect.

2.9 Dispersion

The dispersion happens only during the first instar crawler stage which lasts a few hours (36-48 h); thus, it can travel very short distances from twenty to fifty centimeter (Laudeho & Benassy, 1969)**.**

The infestation is either natural or artificial:

a- Natural infestation

Wind is one of the main natural factors that control the infestation to other oases near the infected one. This type of dispersion only transports larva for short distances. (Hoceini, 1977 in Achour, 2013). Other factors that are considered to be as serious as the wind are water irrigation, density of plantation, in addition to birds that build their nests in the oases such as sparrows (Djoudi, 19992 in Mehaoua, 2006).

b- Artificial infestation

According to Smirnoff (1957), human activity is by and far the most vital reason for the dispersion of date palm cochineal. These insects are carried and transmitted in clothes and animal fur, but they are also transmitted through commercial activities such as selling date palm parts including the trunk, fruit, leaves, offshoots, and also male inflorescence.

2.10 Morphological description

2.10.1 The Egg

Parlatoria blanchardi Targ. eggs are elongated in shape and are about 0.04 millimeters in length, they have a pale pink color, with delicate external envelop. Eggs are laid underneath the scale cover of a female which lays from 6-9 egg, and it can reach up to 59 eggs (El-Haidari, 1980 in meahaoua, 2006) and the incubation period lasts for two days (Tourneur & Lecoustre, 1975)**.**

2.10.2. Nymph

Nymphs are flesh-colored or pale lilac (Smirnoff, 1957), of a length of about0.3 mm with a round white scale (Al-Juboori, 2018).

2.10.3. Female

The young immature female has a pink color which turns into lilac as it grows. The adult female's color gets darker or turns wine red (Madkouri, 1975 in Mehaoua, 2006). According to Dhouibi (1991) in (Mehaoua, 2006), females are largely oval in shape and flattened during all stages, measuring 1.2 to 1.6 mm in length and 0.3 mm in width. Females have a white scale with brown spots on it and measure from 1.3 to 1.8 mm in length and 0.7 in width. They live 5-25 days (Watson, 2002).

2.10.4. Male

Males have a white elongated scale measuring 1mm in length and 0.4 mm in width. After hatching, males turn into a yellowish red color, they are winged, with highly developed transparent wings (Mehaoua, 2006).

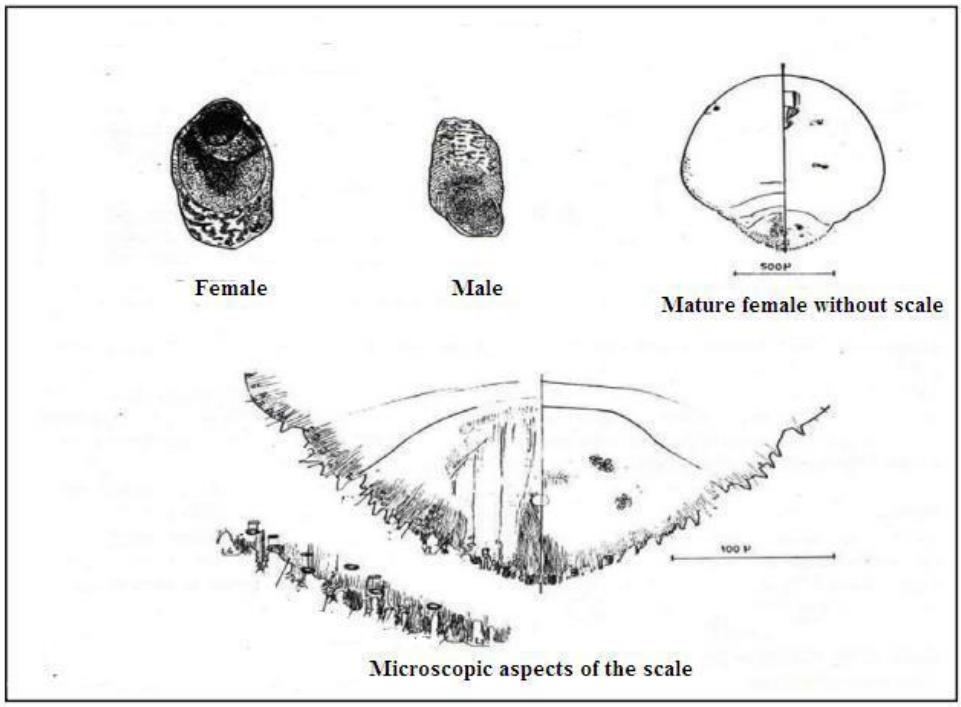

Figure 5: Microscopic characteristic of adult female *Parlatoria blanchardi* Targ. (Smirnoff, 1957)

Figure 6 palm white scale

2.11. Life cycle

Winged males fly during March, May and Juin to fertilize females in young palms, while females fixed on adult ones are often fertilized by micropterous males. The eggs laid under the scale take from 18-20 days to fully mature inside the female insect (Smirnoff, 1954 in Achour, 2013). The spawn lasts for two weeks during early spring, and from two to six days during summer. The eggs that are laid under the scale of the female hatch and the new nymphs stay under the scale for a while before leaving it (Balachowsky, 1950 in Mehaoua, 2006).

According to Laudeho (1969), males and females develop differently starting from the second stage (Annex 07) . The nymph of the first stage walks a short distance before it settles on the leaf and feed on its sap and secretes a white scale. After the first molting, it secrete another flattened scale with the old one inside it, the result is a nymph of second stage. The second molting gives an adult female in which the scale contains the two previous scales.

The male develops differently, they go through two ecdysis phases forming a protonymph (prenympic) and then a deutonymph (nymph) under the scale before it becomes an adult and leaves it on the leaves.

The dry and hot climate seems to be suitable for cochineal development according to Smirnoff. (Iperti, 1970). The duration of a *P. blanchardi's* life cycle varies from 50 to 60 days during the hot season to 75-85 days in spring and autumn, and can reach 130 to 150 days in winter. In winter, the nymphs of the second and the third stage diapause. The trophic and climatic conditions of the region control the proliferation activity of the insect and also the number of annual generations of Cochineal (Iperti, 1970).

The *Parlatoria blanchardi* is recorded to have three to five overlapping generations annually (Watson, 2002). Nonetheless, it was noted that there is an overlap and rapprochement between generations which make it difficult to define precisely their exact number (Abd El Ahad & Jassim, 1983).

2.12. Insect damage

The infection appears in a waxy oval form, white to gray scales measuring 1-1.5 mm on the leaves of date palm. These scales are the exuviae and waxy secretion left by the insect on the leaves. (Alhadj & Aldaghiri, sd.)

At high population densities, infestation covers the fruit bunches and the fruit stalks. Dense populations may impair development of the palm and cause the fruits to shrink, rendering them unmarketable. In extreme cases it may cause deterioration of the palm. (Blumberg, 2008). Munier (1973) denotes that cochineal feeds on the sap it sucks using its rostrum while, at the same time, it injects a certain amount of a toxin that modifies the chlorophyll resulting into impeding photosynthesis and respiration.

2.13. Insect control

Managing the date palm white scale insect is laborious (Toutain, 1967). Thus, Different methods are applied to control and eliminate it (Idder, 2011).

Iperti (1970) mentioned that certain agricultural, physical, and biological methods can be used jointly or seperately. According to Idder et al.(2007) , only three of these methods are used in Algeria.

2.13.1. Physical method

According to Pagliano (1934) in (Idder, 2011), the physical method consists of pruning all the leaves of the crown except those of the heart; pruning can either be partial by trimming and then burning the leaves of the outside of the crown covered with the cochineals, or total in cases when the infestation is more serious and the insect covers all the parts of the crown. The removed leaves are burned at the bottom of the plant trunk (Idder et al., 2007). When burning is done, salty hot water is poured over the remaining leaves of date palm crown (Iperti, 1970).

2.13.2. Agricultural method

This method is the first and less difficult one to process with; the plant is taken care of keeping the vegetative system of the plant healthy. This can be achieved by assuring the plant needs of water by regular irrigation of the grove, enhancing the plant nutrition by fertilization, and pruning and removing surplus offshoots (Iperti, 1970).

2.13.3. Chemical method

The chemical method consists of spraying organophosphoric insecticides on the tree (Idder et al., 2007). Insecticide spray is used on young date palms which facilitates its spread to the infested part of the crown. There are many chemical products used to kill date palm cochineals, and they include: 7% lime sulfur, sulfuric acid, ferrous sulfate (Delassus & Pasquier, 1931in Idder et al., 2007). Cyanhyfric fumigation is also used according to Toutain (1967) and Iperti (1970), although, it requires a specific material which make it expensive.

The chemical method is as efficient as physical method with a mortality percentage of 73.1-80% (Idder et al., 2007).

2.13.4. Biological method

This method consists of using the natural predator of *Parlatorai blanchardi* Targ. When the insect is accompanied with its predator, its extension regresses and the damage is reduced (Toutain, 1967). Introducing natural enemies was used since a long time and it is remarkable both for its frequency and its results (Idder, 2011).

Conclusion

In our study we attempted to verify the negative effect of *Palatoria blanchardi* on the physiology of date palm of *Deglet Nour* and reveal the anatomical aspects of the injury.

The samples from shadowed date palm trees were more infested by the insect although they receive the same maintenance efforts, while samples from trees exposed directly to the sun were barely infested. In the two samples, the infestation rate was higher in the lower crown than in the upper one, and there was no significant difference between the infestation rate of the adaxial and abaxial surface of the leaves.

The infestation by date palm white scale insect has serious effects on the palm physiology. The highly infested samples contained less moisture than the barely infested ones, the upper crown of the two samples was also less infested than the lower, the result was a negative correlation between the infestation rate and moisture loss in leaves. The optical chlorophyll concentration measurement *in situ* matched the absolute chlorophyll concentration *in vitro*, there was also a negative correlation between the infestation rate and chlorophyll concentration, indeed, the chlorophyll concentration was less in the highly infested samples than in the hardly infested ones.

Anatomically, there was no difference between stomatal density of the leaves, whether they are highly or barely infested. The transverse sections showed also no difference in leaves' tissues, and we didn't observe any pierced cells or traces of stylet bundle target through cell's tissues, thus, we suggest using another precise sectioning technique.

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