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Research Article

Date Palm Scales and Their Management

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Abstract

This review is a thorough summary of date palm scales, including the green scale, red scale, and especially the withe scale caused by *Parlatoria blanchardi*. It intends to offer their biological characteristics, geographical distribution, damage they cause to the main host, *Phoenix dactylifera* L., and effective management practices, including chemical, cultural, and biological control.

Parlatoria blanchardi is one of the major date palm pests and is distributed worldwide, attacking all date palm-growing areas. Its lifecycle is highly suited to the *Phoenix dactylifera* L. environment, which promotes swift development and infestation. These pests are so serious that they cause significant damage through feeding on plant sap. This behaviour leads to diminishing the vigor of palm trees, the quality of fruits, and generally the overall production. Because of its severity, effective management strategies must be used, including a combination of chemical, cultural, and biological tactics, in order to decrease the infestation level. In addition, integrated pest management (IPM) can be a successful decision against date palm scales; it is an ecological approach that has shown significant results in controlling scale population levels under economic thresholds. With the aim of sustaining date palm vigor and productivity, a vital management strategy must be required to effectively control pest infestation, diminish damage, and assure production quality and crop health.

Introduction

Date palm (*Phoenix dactylifera* L.) is one of the oldest fruit crops grown in the arid regions of the Arabian Peninsula, North Africa, and the Middle East [1]. The first domestication of the date palm is believed to have taken place at least 6,000 years ago in Mesopotamia, the lands between the Tigris and Euphrates rivers, in what is today Iraq [2]. With a major proportion of the world's total date palm production in the Middle East and North Africa, date palms have also been introduced in Australia, India, Mexico, Southern Africa, South America, Pakistan, and the USA [3]. Dates are not only a staple food for local populations in many countries, but their production also contributes significantly to the economy, society, and environment of those countries [1,4]. The date is one of the most valuable domesticated fruit trees because of its ritual significance in human societies, health benefits, productive capacity in harsh semiarid and arid environments, and the range of subsistence products from its fruits and other parts of the large palm [2].

Date palm (*Phoenix dactylifera* L.) is a perennial plant, the pillar of Oasis's ecosystem, and a target for pest attack [5]. Among these insects, there is the white scale. *Parlatoria blanchardi* is one of the

main pests of the date palm [5,6], with the highest infestations worldwide observed on the young date palms [7]. *Parlatoria blanchardi*, is also called the armored scale insect or the white scale. It is widely distributed throughout tropical and subtropical regions where palms grow [8] The date trade over the centuries is among the main causes of the spread of this parasite in India, Central Asia, the Middle East, North Africa and Turkey, and later in Australia and America [9]. It is present in all date palm-growing areas and regions worldwide except in the USA, where heavy infestations have been eradicated completely since 1934 [7]. When *Parlatoria blanchardi* infests the date fruits, it causes many deformities, which greatly reduce their market value, particularly because this insect species infests the dates in all their ripening stages [7,10]. *Parlatoria blanchardi* commonly infests the leaf bases, where the insects are hidden by fibers. As populations increase, they infest first the older and then the younger foliage and finally the fruits [11]. It mainly infests the leaves, sucking the sap; if a full leaf is covered with white scales, the leaves dry out. In heavy outbreaks, fruits also attack and fall off before maturity. Nymphs and adults suck the sap from the leaflet, midribs, and fruits [10].

The severity of damage on the *Parlatoria* scale seems to be variable depending on the locality, date palm cultivar, environmental conditions, and management practices. The state of whether the scale is indigenous or recently introduced into an area plays a role as an important factor in the population control program of this pest [4]. In addition, The invasive date palm scale especially the withe scale caused by *Parlatoria blanchardi* which is one of the most destructive pests of palms in the world is widely distributed in all continents, a better understanding of the biology and the ecology of this insect and their natural enemies and early detection of infested palms is critical in order to avoid death of palms and is the fundamental to the success of any IPM strategy implemented to reduce this pest [4].

This review summarizes the current knowledge on the distribution, natural history, economic importance and management of the main date palm scales including green scale, red scale, and especially the withe scale.

Main Scales on Date Palm

The main types of scales that affect date palms are green scale, red scale, and *parlatoria* date scale (white scale). These date palm pests are highly specific to the Arecaceae family (oligophagous) and primarily spotted on the foliage, bunch stalk, and, to a lesser extent, on green fruit, ripening fruits, and shoots of date palm trees [5]. Based on their preferred date palm organ, these arthropod pests are classified into four groups, although some species can infest multiple parts simultaneously. Green and white scales prefer foliage but depending on the severity of the infestation and prevailing weather conditions, they may also attack green or ripening fruits [12]. These infestations lead to weakened date palm trees, predisposing them to attacks by termites and other pests [12].

Palmaspis phoenicis asterolecaniidae known as the green scale insect, it is considered a serious pest of date palms [13], has been recognized as a pest exclusively for date palm (*Phoenix dactylifera*) [14]. It is found in the Middle East, including Iran, Iraq, Saudi Arabia, Qatar, and Sudan [11,15]. It occurs throughout all date palm growing areas in Israel [16]. It may cause severe damage because it feeds on all parts of the leaves and on the fruits. Infested parts of the pinnae turn yellow and die. Heavily infested fruits are scarred and reduced in value [11].

Howard, et al. [11] reported that, in southern Iran, 70 % of the palms are infested and, the severity of green scale's infestations is important where the relative humidity is high occur annually, with a protracted autumn- winter generation and short generations in early summer and autumn. Nymphs are present continuously, but are most abundant in autumn and early summer, at which times control measures may be applied. Green scale may be controlled by spraying with malathion, azinphosmethyl, iazinon, or other materials [17] combined with oil for control of nymphs in spring and late autumn. In cases of severe infestations, a summer spray may be applied to kill first-instar scales before the crawlers settle on the fruit [11].

Phoenicococcus marlatti, or red date scale, is widely distributed wherever date palms are cultivated. While previously considered a significant pest in the United States [19], it is now generally regarded as a minor issue [18]. This scale insect prefers dark, protected areas and is commonly found massed on the white tissue at the bases of leaves and fruit stalks [19]. Under heavy infestations, *Phoenicococcus marlatti* can contribute to the death of fruit and the premature senescence of some older leaves. The most effective control measures include subjecting infested offshoots to a temperature of 50°C in an insulated room for 65 hours [11].

The red date scale (RDS) frequently infests date palms in its native North Africa and the Middle East, and from there it has spread to Sicily and Spain. In the Western Hemisphere, it was introduced into Argentina on date offshoots and into the southwestern USA on infested date saplings [11,15,20]. In Israel, damages were recorded mainly in the Jordan and Bet She'an Valleys, but RDS is not usually considered a serious pest of date palms [5].

The *parlatoria* date scale (PDS) is dispersed across most of the date palm growing regions of the world [9,11,15,20].

Date palms are the preferred host of PDS, but its infestations have also been recorded on additional hosts belonging to four plant families: Arecaceae (Palmae), Apocynaceae, Oleaceae, and Rhamnaceae [14]. Infestation levels vary by region, with serious cases reported in Iran, Libya, and Morocco, while lighter infestations have been observed in Afghanistan [18].

The Green Scale may seriously damage the date palms, it infests the pinnae, the rachis, the basal parts of the leaves, and even the fruits. The infested plant parts (mainly the pinnae) turn yellow, and consequently the entire leaf may degenerate. Also, heavy infestation by the scale may kill the palm tree [16]. To control the green scale, the applications of organophosphate insecticides combined with mineral oils were very effective in minimizing the level of GS infestation and damage [21]. In addition, biological

control, emergence holes observed in many GS individuals indicate that parasitoids probably exercised efficient control of these pests. This may explain why no further outbreaks of GS since the early 1970s have been recorded in plantations that were not treated with insecticides [5].

Palmapsis phoenicis is an important pest of date palms in Israel. The tests on its control were carried out in the Beit Shean Valley between December 1959 and December 1960. The most effective combinations were 2% of a special formulation of malathion in oil (88 parts malathion and 712 parts white medium oil in 1,500 parts concentrate by weight) and 0.2% wettable diazinon or 0.5 % azinphos-methyl (Gusathion) in 2 % oil emulsion; 0.5-1 % malathion in 2 % oil emulsion was inferior but still satisfactory. The sprays should be applied since the nymphs are more easily controlled than the adult females, during autumn and winter, and they can be supplemented, if necessary, by summer treatment in June or July, during the mass appearance of crawlers, to protect the fruits [21].

With the extensive planting of date palms in Israel, especially in the northern valleys, and with the introduction of high-quality cultivars, the danger posed by the red scale has increased. This pest is likely to retard the development of young palms, and heavy infestations may impair the survival prospects of newly planted young date shoots and may cause dryness and mortality in the infested palms [15]. Table 1 summarizes the main species of scale insects that affect date palms.

Table 1: Main date palm scales.

No	Scientific Name, Order and Family	Common Name	Reference
1	*Palmapsis phoenicis Rao*, Homoptera, Asterolecaniidae	Green pit scale	Reported by El-Shafie [12]
2	*Parlatoria blanchardi*i Targ. Homoptera, Diaspididae.	White scale	Mashal, M. and Albeidat, B. 2006
3	*Parlatoria oleae (Colvee)*, Homoptera, Diaspididae	Olive scale	Mashal, M. and Albeidat, B. 2006
4	*Aonidiella aurantii* (Mask.), Do.	Red scale	Mashal, M. and Albeidat, B. 2006
5	*Aonidiella orientalis*, Do.	Oriental yellow Scale	Mashal, M. and Albeidat, B. 2006
6	*Chrysomphalus aonidum L.*Do.	Date palm scale	Reported by El-Shafie [12]
7	*Phoenicoccus marlatti Cockerell*. Homoptera, Dactylopidae	Red date scale	Stickney and Simmons [19]
8	*Chrysomophalus aonidum L.*, Homoptera, Diaspididae	Black scale	Mashal, M. and Albeidat, B. 2006
9	*Aspidiotus destructor* Signoret, Homoptera, Diaspididae	Coconut scale	Butani, R.K. 1974
10	*Fiorinia phoenicis*, Do	Brown flat scale	Reported by El-Shafie [12]
11	*Fiorinia lindereae*, Do.	Date palm scale insect	Reported by El-Shafie [12]

White Scale of Date Palm

Parlatoria blanchardi Targ

Parlatoria blanchardi (Targioni-Tozzetti) is found wherever date palm is grown. It is one of the oldest date palm pests, and it belongs to the family of Diaspididae, characterized by posterior abdominal segment coalescing into a wax-forming structure called pygidium; generally, with lobes and plates or gland spines on the pygidium; legs absent or represented by a small, sclerotized area; and antennae represented by an unsegmented knob [22].

The female is protected by an elliptical, convex armor, white gray in color. Its body length is 1–1.5 mm and its width are 0.6–0.8 mm; its body (underneath the armor) is elongate, reddish, and ~0.8 mm in length. The female is neotenic and lays its eggs underneath the armor. The crawler is reddish, 0.23 mm in length. The male bears flattened and elongate armor, white in color, and its body is ~0.8 mm in length [5].

From a biological viewpoint, like all Diapsid date palm scale insects, females and males pass through two distinct development types from the second stage onward [23]. The larva in the first stage, after a period of mobile life, settles and begins secreting a white shield. After the first molt, it secretes a second, flattened shield that includes the first-stage shield. A second molt gives rise to the adult female, whose shield retains those of the earlier stages as before [23]. The adults average about 0.7 mm in length; the female is broadly oval, and a bit flattened in all stages [15]. Females stay stationary for life and, after mating, produce numerous eggs. After hatching, the nymphs crawl out from under the female and move about, feeding at various locations until their third molting. These nymphs exhibit pink to red coloring, while adult females are gray [15]. They are about 1.8 mm in length and 0.7 mm in width [24]. Regarding females, a characteristic difference in coloration distinguishes immature females from mature ones; the former are pale pink, while the latter are reddish wine-colored [75]. The duration of the egg stage depends on temperature, ranging from 2 to 11 days, there is nearly continuous overlapping of egg, nymph, and adult stages throughout the year, resulting in generation boundaries that are not clearly defined [15].

Males undergo a different development; under their shield, they form a protonymph (pre-nymph) and a deutonymph (nymph)

before maturing and emerging, leaving their empty shield on the leaflet at hatching, male shields have a characteristically elongated shape compared to those of females [23], they are about 1 mm in length and 0.4 mm in width [24]. The male undergoes five nymphal stages and emerges as an adult with well-developed wings [15].

Date palm trees are subjected to attack by several insect pests, especially the white date palm scale, *Parlatoria blanchardi* (Targioni-Tozzetti) [25]. It infests all parts of the date palm [5] and causes significant damage [23]. At high population densities, infestation covers the fruit bunches and the fruit stalks. Dense populations may impair the development of the palm and cause the fruits to shrink, rendering them unmarketable. In extreme cases, it may cause deterioration of the palm [5]. Laudeho & Benassy [23] reported that in Erfoud (Morocco) a 70 to 80% waste in the date harvest and at El Haroun yield reductions of up to 50 to 60% over three years.

Salman, et al. [26] noted that, most parts of the tree, such as leaflets, leaves, tender shoots, offshoots, twigs, and fruits, are attacked by both immatures and adult females of this diaspidid insect. Adults and nymphs of this insect feed on leaf sap, sucking a great amount of sap that contains macro-elements and micro-elements. At high levels of infestation with this scale insect, remarkable damage occurs, resulting in early leaf drop and yield reduction. Great damage can be done by this scale insect by sucking the plant sap that gives low rates of photosynthesis and respiration, which leads to curling, yellowing, and dropping of leaves. A characteristic symptom of infestation by *P. blanchardi* is the appearance and accumulation of its scales on attacked palm parts [5,27].

This insect sucks the sap with its mouth parts and secretes toxic saliva during feeding, causing malformation of leaves and shoots, low photosynthesis, and low respiration rate. All of this leads to curling, yellowing, and dropping of leaves, dwarfing of the plant, and subsequently causes considerable qualitative and quantitative yield losses and eventually affects the marketing value of the fruits. Therefore, the presence of this insect weakens the infested plant itself [28].

In a heavily intestate area by *P. blanchardi*, it accumulates its scales on the infested part of the tree, secreting toxic saliva [5,28,29] that affects the respiration, transpiration, and photosynthesis processes and thus obstructs the growth process, and several biotic and abiotic factors affect populations of scale insects [30].

Under favorable conditions, *Parlatoria* date scale can spread over the surfaces of the foliage and fruit of the date palm, covering them with both live and dead insects. The scale feeds on the white succulent tissues at the base of the leafstalk, one of the most protected and inaccessible places on the palm. As the population increases, the insects move from these areas onto the pinnae. Heavy infestations on the pinnae cause them to wither and die. In commercial plantings, date palms are seldom killed by *Parlatoria* date scale, but feeding by these insects definitely affects the vigor of the palms and decreases yields. Infestations on fruit reduce its commercial value and may render it unfit for human consumption [15].

White scale's damage is very serious on young palms between two to eight years of age, but even under severe attacks, the palm and its offshoots do not die, Nymphs and adults suck the sap from the leaflet, midribs and dates. Under each scale insect, a discolored area appears on the leaflet. Heavy infestation causes leaflets to turn yellow and contributes to the premature death of the fronds [24,31].

Parlatoria blanchardi infests the date palm leaflets, fronds, midribs, spines, bunches, and fruits where the nymphs and adults feed by sucking the sap from the green parts and the dates most of the year. Then, the color of the infested parts changes from dark green to pale or light green, or to yellow color with the appearance of several spots. These spots start as light green in color and then turn tawny (tan or brownish) in color. Where scales settle and feed, a discolored area of injured tissue develops. The affected areas gradually withered. Severe infestation leads to the death of the leaflets, dry fronds, and premature death by inhibiting transpiration and photosynthesis. All these together cause general weakness in the date palm tree and deterioration in crop production both qualitatively and quantitatively. Particularly because this insect species infests the dates in all their ripening stages, Khalal (Color stage), Rutab (soft ripe stage) and Tamer (full ripe stage) [7] (Table 2).

Table 2: Progression of *P. blanchardi* in the main date palm plantations in Morocco [35].

Dates of Appearance	Affected Palmeraies	Geographic Location in Morocco
1937	Figuig	East
1938	Ain chair	East
1941	Erfoud	East
1941	Tata	West
1951	Goulmima	Center-East
1958	Taghbalt	South-West
1959	Tagounit	South-West
1960	Zagoura	South-West

1964	Agdz	Center-West
1974	Marrakech	West

Distribution and host range

Parlatoria blanchardi (Targioni-Tozzetti) is an insect belonging to the family Diaspididae. This insect is reported in all data producing countries [23]. It's worldwide and found wherever date palm is grown [4]. It also opts for the areas with high humidity and shaded spots away from the direct sunrays [7]. *Parlatoria blanchardi* was discovered in 1868 by Blanchard M.E., in an oasis of the Oued-Right, in the Algerian Sahara [31]. It is one of the oldest pests of date palm and is thought to have originated from the oases of Mesopotamia or Iraq [15]. *Parlatoria* scale was accidentally introduced in the USA, particularly in Arizona, California, and Texas, and it was eradicated in 1914 from Arizona, 1919 from Texas, and in the 1930s from California. Wakil, et al. [4] reported that, due to the international movement and trade in date palm offshoots, the pest is now found in Europe, Central Asia, the Middle East, Africa, the Western Hemisphere, and Oceania.

Date palm (*Phoenix dactylifera*), is the main host of *Parlatoria blanchaardi* [23,32]. it is uniquely susceptible to *Parlatoria blanchardi* due to its extensive cultivation and favorable environmental conditions characterized these grows areas, this relationship underscores the importance of targeted pest management strategies to mitigate the impact of date palm scale on these essential crops [11]. as well as some other Arecaceae. It is also found on Canary Island palm, *Phoenix canariensis* Chabaud, *Washingtonia* palm, *Washingtonia filifera* (Lindl.) H. Wendl., and doum palm, *Hyphaene thebaica* (L.) Mart [33]. In addition, Wakil et al. [4] reported that the scale has been found on plants belonging to the families Apocynaceae, Oleaceae, and Rhamnaceae. Other hosts of *Parlatoria* scale included species of the genera *Jasminum, Latania, Pritchardia*, and *Vinca* [34]. Additionally, *P. blanchardi* was found attached to fig leaves, a tree frequently associated with date palms in orchards in southern Morocco [23]. A list of hosts for *Parlatoria blanchardi* given in Table 3.

Table 3: Hosts for *Parlatoria blanchardi* TARG.

Apocynaceae	***Vinca major***	**Draper [93]**
Arecaceae	*Chamaerops humilis*	Moghaddam [102]
	Hyphaene	Miller & Davidson [101]
	Howea belmoreana	Biche, et al., [88]
	Hyphaene thebaica	Ben-Dov [87]
	Latania	Hall [97] / Miller & Davidson [101]
	Nannorrhops	Moghaddam [102]
	Phoenix	Miller & Davidson [101]
	Phoenix canariensis	Miller & Davidson [101]
	Phoenix dactylifera	Miller & Davidson [101] / Hall [97]/Targioni Tozzetti [104]
	Pritchardia	Miller & Davidson [101]
	Washingtonia	Miller & Davidson [101] / Borchsenius [34]
Moraceae	*Ficus elastica*	Biche et al., [88]
	Ficus retusa	Biche et al., [88]
Oleaceae	*Chrysojasminum humile/ Jasminum revolutum*	Draper [93]
	Jasminum	Borchsenius [34]

A new distribution map is provided for *Parlatoria blanchardi* (Targioni Tozzetti), information is given on the geographical distribution in Europe, France, Italy, Spain, ASIA, Afghanistan, India, Andhra Pradesh, Delhi, Gujarat, Punjab, Rajasthan, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, Syria, Turkey, Turkmenistan, United Arab Emirates, Yemen, AFRICA, Algeria, Chad, Egypt, Eritrea, Kenya, Libya, Mali, Mauritania, Mauritius, Morocco, Niger, Somalia, Sudan, Tunisia, CENTRAL AMERICA & CARIBBEAN, Jamaica, Montserrat, SOUTH AMERICA, Argentina, Bolivia, Brazil, Pemambuco, Rio de Janeiro, Sao Paulo, OCEANIA, Australia, Queensland [32]. It is an important pest in Algeria, Kuwait, Libya, Mauritania, Morocco, and Tunisia. Iraq, Oman, Saudi Arabia, and Sudan consider this pest a moderate one, while Egypt, Jordan, the UAE, and Yemen consider it a minor pest [24].

In Morocco, the *Parlatoria blanchardi* first appeared in 1937 in the palm groves of Figuig (in the eastern part of the country), originating from the surrounding Algerian oases. Subsequently, *P. blanchardi* encountered no barriers to its spread. This dissemination

is often facilitated by wind but primarily by human activities. Indeed, the exchange of young plants (palm offshoots) frequently occurs in date cultivation and inevitably serves as an excellent source of contamination between different palm groves. Moreover, the decision to introduce an Algerian variety (Deglet-Nour) into the oases of the Tata region in 1941 also led to the establishment of *P. blanchardi* in these palm groves, located in the western part of the country, which until then were considered unaffected by the pest [35].

Nomenclature and taxonomy

Parlatoria blanchardi Targ. belongs to the order Homoptera, within the superfamily Coccoidea, the family Diaspididae, the subfamily Diaspidinae, and the tribe Parlatorini, and is classified under the subtribe Parlatorina. It was first discovered by Blanchard in 1890 in an Algerian palm orchard. Targioni-Tozzetti was first described in 1892 under the name *Aonidielia blanchardi* Targ. A detailed morphological description was carried out by Stickney in 1934 and then by Balachowsky in 1953 [36].

Parlatoria blanchardi has received many local designations, like Djreb, Sem, Elmen in Algeria, Gmel in Tunisia, Rheifiss et K'lefiss in Mauritania, Nakoub, Guemla, Tilichte, Tabkhocht et Tasslacht in Maroc [9].

The taxonomy of the Coccoidea is mainly based on the microscopic cuticular features of the adult female, which is paedomorphic, maturing to a wingless juvenile form with functional mouthparts, whereas the adult male (when present) goes through "prepupal" and "pupal" stages and turns into an alate form with non-functional mouthparts [72]. Adult females are small insects (1.0–2.0 mm) covered by an infuse scale, legs absent, antennae reduced to stumps, and abdominal segments five to six fused into a pygidium, which is important in the diagnosis of species. The pygidium bears a complex of specialized structures: tubular ducts, marginal lobes, plates, and gland spines, and the anus lies on the dorsal surface [4] (Figure 1).

Figure 1: *P.blanchardi* A-1-nymphal stage male 2-fixed larval stage B-Adult winged male, C- larval stage 2, D-female adult E-Aptate male F-Crawler (Source: Authors of this article).

Biology, Ecology, and Behaviour

Laudeho & Benassy [23] noted that *Parlatoria blanchardi* is oviparous year-round and reproduces sexually. Under their protective scale covers, females lay their eggs in clusters throughout the reproductive process. Every female lays a distinct quantity of eggs., females lay an average of 8.6 eggs per cluster, ranging from 4 to 16. In addition, a female might have between 13 and 24 eggs. The females die after laying their eggs, providing protection for the eggs beneath the scale.

El-Shafie [37] reported that, the eggs hatch into tiny, pink nymphs of 0.3 mm in length, these nymphs, often referred to as "crawlers," initially remain under the maternal scale, the duration they stay under the scale depends on the prevailing weather conditions, following their emergence, the nymphs quickly look for ideal feeding locations, favoring humid, shady regions of the palm like the base of the leaf stalks and the undersides of the leaves.

Once they have located an appropriate spot, the crawlers use their stylets to penetrate the plant tissue in order to feed on the sap and start secreting a sticky substance that eventually forms their protective scale outer covering, to achieve the mature adult stage, female nymphs must go through two in situ molts, while male nymphs must undergo four molts [14,23]. Female adults have a broad oval shape and are slightly flattened. They live their entire lives under scale coverings. To create a composite scale cover composed of the scales from preceding nymphal stages, they secrete many layers of wax. On the other hand, males follow a different developmental process. Before emerging as adults, they pass through two stages under their scale: protonymph (pronymph) and deutonymph (nymph). Males that are sufficiently mature and possess well-developed wings, are able to peel off their scales and find females for reproduction [14,23]. The lifespan of an adult male is relatively short, varying between two and six days. In *P. blanchardi* populations, the proportion of males to females is usually less than 25%, indicating a preference for females [23].

Al Jboory [7] reported that, the number of *P. blanchardi* generations per year varies with geographic location. In Iraq, there are four overlapping generations annually. Morocco records three to four generations per year [38], while Pakistan and Saudi Arabia observe six to seven generations. Oman is expected to have four generations each year. In Iran, the species produces six to seven generations annually. Four generations of white scale insect, *Parlatoria blanchardi*, per year have been detected on date palms in southwestern Tunisia and Algeria [55,39]. The most injurious is the spring generation, all green parts of the trees are damaged, with infestation higher on the palms at the base of the crown than in the center [40]. The number of generations developed for one year varies from three to four depending on temperature [24]. Generally, *P. blanchardi* is reported to have three to five overlapping generations per year [31,41].

Stickney [33] presented a detailed description of the *Parlatoria* scale's external anatomy. This pest is characterized by sexual reproduction and oviparous behavior throughout the year. In addition, Wakil et al. [4] noted that, the lifespan of each female is between 5 and 25 days, and it lays between 4 and 13 eggs in a cluster underneath her scale cover. The period of development differs depending on the climatic conditions of the date palm growth area. In Iran, female development ranged from 85 to 100 days in spring and 120 to 150 days for the winter generation [42]. While Wakil et al. [4], reported that the life cycle duration of *Parlatoria blanchardi* is about 75 days in summer and 150 to 180 days in winter, pairing is followed by a pre-oviposition period of 10 to 15 days in spring and 5 to 7 days in summer. Furthermore, after the egg laying, the female dies leaving them protected under her cover. The crawlers leave the scale after 10 to 15 days in spring and 3 to 5 days in summer, settling on the lower surfaces of the leaflets in shady places. Although, *Parlatoria* scale is a xerophilous (adapted to very dry climate/ habitat) and thermophilous (warmth loving) insect [37], it avoids the scorching sun by settling inside folds at the base of the pinnae [43]. Before selecting the feeding site, the dispersal stage can crawl for a short distance [37]). The combined effects of high temperature, low relative humidity, and wind, causes a significant mortality of crawlers [39].

Establishment, Dispersal, and Phenology

Despite other serious pests of date palm *Parlatoria blanchardi* is a fearsome pest of young date plantation [44]. It is one of the most dangerous pests of date palm trees, *Phoenix dactylifera* L, which is a crop that plays a major role in the economy and social life in the Middle East and North Africa region [45]. The white scale insect attacks the leaves and fruits of the date palm trees by sucking the plant sap across its mouth parts, which causes deformities, defoliation and death of the fronds due to the insect's toxic saliva, resulting in reduced yields and also reduced photosynthesis and respiration resulting in leaf curling, yellowing and shedding [46,47]. Because of the morphological characteristics that protect them from insecticides, these insects are the most common arthropod pests that are hard to control. Adults and nymphs are covered with a waxy layer that protects them from pesticides to avoid contacting their bodies [48]. It is important to find new and innovative ways to control the white scale insects by repelling the insects creeping which may prevent it from settling on the host plant [12].

Watson [57] noted that, the pest damages date palms by covering infested parts so thickly that transpiration, respiration and photosynthesis are impaired, causing withering of foliage, hinderance of growth and reduction of yield of mature trees and death of young palms. Infestation of the fruit causes shriveling, distortion, small size and may make them unmarketable; under favorable conditions, severe infestations in Morocco have damaged 70-80% of the crop [9].

Parlatoria blanchardi is a species of scale insect belonging to the family *Diaspididae* (Tehranchi, Year). The PDS infests all parts of the date palm. At high population densities, infestation overs the fruit bunches and the fruit stalks [5].

DPS is prevalent throughout the year but tends to increase markedly during spring and autumn. Oviposition over an extended

period, overlapping of generations, and the presence of young nymphs throughout the year, are some of the obstacles to effective control [49].

Climatic factors, particularly winter cold and summer heat and drought, appear to be more important than other factors on the number of generations and species survival than other abiotic factors of habitat [50]. The scale population showed a significant negative correlation with maximum and minimum temperatures, while non-significant negative correlation with maximum relative humidity and rainfall. However, minimum relative humidity had a significant negative correlation [51].

Effects of the studied climatic conditions (minimum, maximum and mean temperatures, precipitation, humidity, wind, rain days, and climatic indices) on the DPS densities at different phenological stages showed great variability from one stage to another [39].

The high density of date palms and the lack of proper pruning, the use of leaves to fence the orchards and the fact that a large number of shoots are left on the palms are the main factors contributing to the increase in DPS attacks [38,52,53].

Dissemination to new hosts is the result of several factors including movement by wind, birds, insects and the transportation of infested plants from one area to another one [8]. Movement of *P. blanchardi* into new areas has commonly been due to the importation of infested date offshoots [54].

1.1. Injury and Economic Loss

The entire date palm tree attacked by white scale, which principally appears on the abaxial leaf surfaces, it is found also on fruit stalks and fruit bunches during severe infestations [5,55]. Because of direct feeding of the white scale, the Fruit losses reached 70–80 % [9]. Wakil et al. [4] stated that, a discolored area of injured tissue develops due to the feeding and injection of toxic saliva, scale feeding implicit a significant increase of date palm productivity by affecting transpiration, depletion of nutrients, destruction of chlorophyll, and hindering the photosynthesis. Infestation often results in chlorosis or discoloration of leaves, yellowing and pre-mature withering and dropping of leaves. Additionally, infested fruits become small, stunted, shriveled, distorted with low marketed value and sometimes unfit for human consumption. Also, this pest has destroyed palms in Algeria during 1920s killing around 100,000 date trees and it causes economic damage in India, Pakistan, Israel, Saudi Arabia, Sudan, Mauritania, Egypt, Libya, Tunisia, Algeria and Morocco.

Wakil et al. [4] noted that, in Saudi Arabia, the varieties Sokkari and Mactomi were the most susceptible while Magvesi was the most resistant. In the region of Biskra (Algeria), the scale insects thrived well on the cultivars Ghars and Deglet Noor than the cultivar Degla Baida [56]. The severity of damage by *Parlatoria* scale seems to be variable depending on the locality, date palm cultivar, environmental conditions, and management practices. The state of whether the scale is indigenous or recently introduced into an area plays role as an important factor in the population control program of this pest [4].

Management

Scale insects cause serious infestations in date palms, but the use of organophosphates against this and several other pests was indiscriminate and did not follow any rules or principles. This situation led farmers in Israel to gradually adopt IPM based programs. Preliminary IPM trials in date palm were aimed at controlling fruit pests and scale insects [5,57].

Integrated Pest Management (IPM) demands information on pest biology, ecology, sampling, and monitoring, for developing action and identifying thresholds. Integrated pest management approaches combine elements of plant resistance, chemical, semi chemical, biological, and microbial control. In this context, an evaluation of the pest complex and associated biological control agents is essential [4].

Integrated pest management (IPM) can be shown to be the best combination of available tactics for a given pest problem by comparison with the yield, profit, and safety of alternative mixes. IPM programs try to extend the best mix to large numbers of farmers. Sandler [58] defined IPM as the intelligent selection and use of pest control actions that ensure positive economic, ecological, and sociological findings.

Thus, in the case of date palm, IPM could be a broad-based ecological approach to structural and agricultural control that integrates pesticides into a management system, incorporating a wide range of practices for economic pest control. A successful IPM program requires proper identification of the pest and knowledge of its biology, ecology, as well as sampling and monitoring of its population to develop appropriate actions and identify thresholds [59].

Integrated Pest Management is an integrated approach to managing pests, that combines the collection of information about the pest's biological characteristics and connects them with the controlling environmental factors to identify available control methods to manage the pest in a more economical and efficient way that is more environmentally friendly and less risky to human health [60].

The key elements of the pest management program are as follows: provide adequate information concerning the identification, biology, life cycle, ecology of the target pests, and their natural enemies; and develop an effective decision-making tool, including monitoring predictions and a program evaluation system, in order to trace pests's population damage and the role of their natural enemies. In addition, the development of a decision-making system using the economic threshold as a base to determine the proper time for control application and take a suitable decision on what is the best control approach to be implemented. An evaluation program should be conducted annually [60].

In integrated pest management (IPM), success depends significantly on the precision of the monitoring process because

the monitoring helps in determining the exact population levels of pests in the field, which is crucial to evaluating the damaging levels, knowing if pests are still manageable, and deciding if the control's action is needed and at what intensity. Also, based on monitoring data, we can determine the timing of intervention and take control action at the right time because it's a critical step for effective management and minimizing environmental impact. This also helps in optimizing resource use by applying control measures only, when necessary, thus reducing costs and minimizing pesticide use [60].

IPM is difficult to define, not because it is so complex or abstract, but because it is an approach to pest control. It is a strategy rather than a specific and exact methodology. Its power lies in its adaptability, in one form or another, to all pest problems. IPM is the balanced use of cultural, biological, and chemical measures appropriate· to an individual situation [61].

Sensitivity of Different Date Palm CVrs to Infestation and Host Plant Resistance

Variability in cultivar sensitivity and resistance to *Parlatoria blanchardi* is highlighted. Actually, Kentichi cv. is significantly more resistant than Deglet Noor, Aligue, or Khouat allig [65]. Wakil et al. [4] reported that the varieties of Sokkari and Mactomi were the most sensitive to *Parlatoria blanchardi* attack while, Magvesi was the most resistant. In the region of Biskra (Algeria), the scale insects thrived well on the cultivars Ghars and Deglet Noor than the cultivar Degla Baida [56].

Date palm varieties varied significantly in their susceptibility to *P. blanchardi*. The white date palm variety was the most susceptible to infestation by the pest, with an average of 23.9 insects per leaflet, and showed the highest crude protein's concentrations, total carbohydrates, and index of food quality, but exposed the lowest concentrations of both total tannins and phenols in the infested leaflets compared with other tested varieties. Conversely, the variety of Gendeila was the least infested, with an average of 8.2 insects per leaflet. While Malakaby, Seedy Balady, and Shamia varieties were moderately infested, with an average number of 17.2, 15.7, and 12.9 insects per leaflet, respectively [62].

The susceptibility levels of date palm varieties to the infestation by *P. blanchardi* depend on the combined action of essential nutrients and their inhibitors of leaflets of date palm, which determine the quality of their leaflets [62]. The study of ten palm cultivars (Shweithi, Prem, Gozzy, Shukar, Omrani, Maktoom, Khadraoui, Balga, Derri, and Zahdi) showed that the Shweithi and Prem varieties were more sensitive to *Parlatoria blanchardi* infection. It has reached an average number of 22.62 and 17.92 per cm^2 for the two varieties, respectively, on the other hand, derri and zahdi were less susceptible to insect infection by an average of 4.75 and 3.75 insects per cm^2, respectively. This study showed that there is a significant difference in the sensitivity of the studied varieties of *P. Blanchardi*, which indicates that there is a dietary preference for the insect among these varieties [63].

Youssef [64] stated that, Hayany variety was more sensitive to *P. Blanchardi* infestation, where the average number was 54,6 scale insects per 5 leaflets and 48,8 insects per 5 leaflets for Sammany variety [64]. In Egypt, *P. blanchardi* attached date palm trees of the varieties zaghloul and Sammany at Idko, and they were more susceptible to this pest than at Rashid. In Tunisia, the Kentichi cultivar was significantly more resistant to *P. blanchardi* than the Deghlet Nour variety [55].

The varieties viz., Zagloul and Zahidi were rated as less susceptible with highest yield production, Sewi, Shamran, Khasab, Khadrawy and Khuneizi as moderately susceptible, on the other hand, Halawy, Medjool and Barhee, were noticed highly susceptible to *Parlatoria* date palm [65].

Chemical Control

The combination of petroleum oil along with synthetic insecticides such as dimethoate, malathion, and methyl parathion effectively controlled *Parlatoria blanchardi* in Sudan. This combination not only controlled the scale insect but also significantly augmented the yield per palm tree over consecutive seasons. Specifically, the yield per palm tree increased by 46%, 52%, and 74% in the first, second, and third seasons, respectively [77]. Insect growth regulators (IGRs) like Admiral 10% showed a different efficacy pattern compared to synthetic insecticides that offered high efficacy, but their effectiveness decreased over time. In contrast, Admiral 10% initially showed lower efficacy but steadily augmented in effectiveness over the period of the experiment. In addition, Admiral 10% was noted for its safety profile compared to synthetic insecticides [66]. For successful control, insecticides must be applied before the larvae enter the dates. In the absence of pheromone monitoring, the first spray should be applied when the fruit changes color, followed by another spray 3-4 weeks later [5,67,68]. These treatments also help prevent infestations by *Parlatoria* date scale (*Parlatoria blanchardi*) and Carpophilus spp. [21,68].

The evaluation of pesticides TIAM and IMIDOR by different techniques including, irrigation, injection and spray methods to control *P. blanchardi* showed that the pesticide TIAM 25% WG was more significant than other chemical pesticides in mortality of *P. blanchardi* which reached to 69.34 % when was using in spray method. However, the results of using mixed pesticide with bioagent showed that the treatment TIAM 25% WG + B. Bassian sprayed on data palm in the field significantly different from other treatment, which reached 78.56% in average and the mortality was 82%.40 after 7 days of treatment [69].

The University of Basrah do a study to evaluates the efficacity of growth regulator hormone, Salicylic acid, and some Chemical insecticides to manage and control the White Scales Insect *Paralatoria blanchardi* L. as one of the major and serious Date palm pests. Results showed that after 7 days of treatments all Salicylic acid's concentrations of 0.5mm, 0.7mm, 0.8mm and 1mm were very effective against all phenological stages of the *Parlatoria blanchardi*

which were 38.12%, 40.24%, 42.64%, and 46.56% as mortality, respectively. This study reveal that Thiamethoxam application resulted in a right level of control to the pest which was 66.78% of mortality after 7 days of treatment, while the result of Methidathion and Dichlorvos were 61.65 and 58.33% respectively at the same time [70].

Kehat [99] tested several chemical products on the white scale insect (*Parlatoria blanchardi*) and found that dimethoate was the most effective. However, he also noted that all the tested products had side effects on the insect. Insecticide sprays are particularly effective on young date palms, whose restricted size allows easy coverage of the entire leaf surface. Sprays of sulfuric acid and iron sulfate, as well as sulfosalicylic mixtures at 7%, are commonly employed, along with yellow and white phytosanitary oils.

The chemical control method includes the application of an organophosphorus insecticide, like Foliate or Omethoate at 50%, exploiting a backpack sprayer. Only one treatment is necessary, and it is crucial that all surfaces and the entire crowns are thoroughly soaked. This treatment takes approximately 25 minutes per tree [71]. A list of chemical treatments (mineral oils, Ethopaz, malathion, phosphamidon and Rogor), applied separately and in combination with oil, was tested against *Parlatoria blanchardi*. The results show that 0.5% Rogor (20% w.p.), alone or in combination with 2% oil, was the most effective for the control of the pest [67]. In addition, a spray of white oil with a 'superacid' solution was effective against the *Parlatoria* scale of date palm [72].

Limits to Chemical Control

The use of chemical control methods against *Parlatoria blanchardi* is effective, but they pose a significant danger for naturally occurring auxiliaries [71]. Various chemical products were tested against *Parlatoria blanchardi* [21], however, their action proved to be much more harmful to beneficial entomophagy's than to the scale insect.

Various chemicals, including mineral oils, Ethopaz, malathion, phosphamidon, and Rogor, were tested against *Parlatoria blanchardi*. The toxicity of these compounds to *Pharoscymnus numidicus*, a major predator of the date palm scale, was determined by bioassays. The chimical materials affected the beetle in the following declining order of toxicity: Rogor, phosphamidon, malathion and Ethopaz. Rogor was 50 times more toxic to *Pharoscymnus* than Ethopaz [67].

The use of chemical products against *Parlatoria blanchardi* is limited by the presence, in the basal part of date palm tree, of the under-crops such as Alfalfa, vegetables, cereals, and fruits trees, that constituted the main family subsistence for farmers, and they can't support the high toxicity level of these products. Also, the financial situation of some date palm farmers does not allow to buy efficient insecticides [73].

Cultural Control

The use of appropriate cultural methods against *P. Blanchardi* is essential in order to maintain the date palm trees in agreeable conditions. Irrigation, fertilization, and periodic pruning will limit the development of this pest. Also, during the installation of new date palm orchards, we must choose vigorous and certified pest-free plants to avoid the formation of primary infestation foci [74].

Physical methods of control already mean the use of a curative process that consists of taking off all of the infested palms except the ones in the heart of the tree and completely burning the pruning's waste. In addition, salty and hot water must be poured on the palm crown. This particular procedure sometimes compromises the plant's recovery.

At the beginning of the 20th century, this technique was used in Arizona by the Americans. They used flamethrowers in order to spray flamed gasoline on palms infested by scale pests. Such a treatment can be applied to a small number of date palm trees, but it's difficult to use it on thousands of trees [74].

Preventive measures against *Parlatoria blanchardi* involve thorough pruning. A severe cutback, almost completely removing the foliage to the base of the trunk, generally yields very satisfactory results [76] without causing significant growth delays in treated plants [50]. It is also crucial to avoid transferring contaminated plant material to new date palm-growing areas. This physical control method utilizes temperature through the use of fire. Curatively, burning the palms, a practice historically used by Arabs and adapted by Americans [20], remains a viable method and is still in use in the USA for eradication treatments [74]. In addition, pruning and removal of old infested fronds, optimal fertilization, adequate and regular irrigation, and strict, effective internal quarantine measures play a major role in the management of date scales. Some farmers have resorted to burning severely infested palms; however, this practice has resulted in the killing date palm trees and caused wide fire hazards that destroyed several thousand palms [4].

Pruning, removal, and burning of old infested fronds as sanitary measures, as well as the construction of a basin around each palm to improve irrigation and pre-watering of trees 24 hours before the application of insecticides, are effective mechanical methods of control and cultural practices to manage date palm trees [76]. Pruning and disposing of infested leaves as phytosanitary measures proved to be effective in controlling *Parlatoria* scale, particularly under the conditions of minor infestations [77].

Biological Control

Wakil et al. [4] found that predators have been recorded to supply up to 45% of the white-scale population's mortality. The efficacy of biological control agents against *P. blanchardi* appears to be dependent upon the predator's ability to adapt to a particular region, as well as its fecundity and consumption rate. It was possible to decrease the white scale infestation in Saudi Arabia to a subeconomic level using the predator *Cybocephalus* sp.. Biological control against *P. blanchardi* can be used to reduce and diminish the pest population to acceptable levels in those areas where chemical control cannot be used [9,15].

As reported by Wakil et al. [4], the natural enemies of *P. blanchardi* in the date palm agro-ecosystems were mostly coccinellid beetles.

The release of the predators *C. bipustulatus* and *C. bipustulatus* var. iranensis into date palm grooves in Mauritania, Niger, and Tunisia, respectively, provided an acceptable level of control for *P. blanchardi* [55,78,79]. As well, the predacious mite *Hemisarcoptes coccophagus* Meyer proved to be an effective biocontrol agent against white scale in Niger [80]. In addition, biological control against white scale was tried by the introduction of an exotic predator in the Segdoud region (oases of Gafsa) in Tunisia. The exotic ladybird beetle, *Chilocorus bipustulatus* L. var. iranensis, is giving promising results [78].

The predator, *Pharoscymnus horni* (Weise), was also effective against *Parlatoria blanchardi* in India [81]. *Rhyzobius lophanthae* (Blaisdell) is an exceptional biological control agent because of its high fecundity, lack of parasitoids, absence of diapause, and resistance to low temperatures, especially in the immature stages.

There are four main groups of natural enemies; they were found during a comprehensive survey of natural enemies conducted on unsprayed date plantations in Israel from the late 1950s to the early 1970s [5].

Initially, as reported Blumberg [5], there is the Parasitic Hymenoptera. Two species of parasitic wasps were found in Israeli PDS populations: *Aphytis* sp. (Aphelinidae), which is widely distributed in groves in the north and in the southern Arava Valley and is likely to be highly effective, and *Archenomus arabicus* Ferriere (Encyrtidae). This one is later described from Saudi Arabia, and it is rare and was found only in the southern Arava Valley [74]. Seven aphelinid species (Chalcidoidea) that attack PDS [5]. *Aphytis phoenicis* (Aphelinidae) is one of a few species of parasitic Hymenoptera that is considered an important natural enemy of PDS in North Africa [11]. Watson [54] claimed that it is also found in Israel, but its presence here is questionable.

Secondly, predatory Coccinellidae (Coleoptera), a rich fauna of predatory lady beetles, was identified as associated with PDS. Among the 25 coccinellid species recorded, the criteria for determining their utility are searching ability as well as feeding behavior, distribution, population density, survival under extreme environmental conditions, and regularity of appearance on date palms [5,19]. Based on these criteria, except for *Pharocymus.* Setulosus, which was widely distributed throughout the country, *Pharoscymnus* spp. were considered to be of great importance; *Pharocymnus numidicus* was the most prevalent of them because it maintained very high populations and its seasonal predatory activity lasted longer than that of the other species. In the northern plantations (the Bet She'an and Jordan Valleys), *C. bipustulatus* seemed to be an important lethal predator in well-shaded, old plantations [5].

Thirdly, predatory *Cybocephalidae* (Coleoptera) were discovered to be associated with the *Parlatoria* date scale, including *Cybocephalus nigriceps* (J. Sahlberg), *C. micans* Reitter, *C. mediterraneus* Endrody-Younga, *C. aegyptiacus* Endrody-Younga, and *C. pullus* Endrody-Younga. Their distribution, phenology, biology, and survival under extreme climatic conditions were studied [82-86]. The most prevalent species was *C. nigriceps*. In plantations with high *parlatoria* infestation, *Cybocephalus* spp. also appeared in very large numbers, especially in the Arava Valley, but also, to a lesser degree, in the northern plantations, adults of *C. nigriceps* were present in date plantations throughout the year; their populations reached their peak in summer, whereas eggs and larvae were abundant only during spring and summer. In autumn and winter, the adults entered a diapause, the development of their ovaries was arrested, oviposition stopped, and predatory activity decreased. The predominance of *C. nigriceps* in local habitats is attributed to the fact that all stages of this predator display high survival capacity under extreme conditions of high temperatures and relative humidity [82]. At a very low prey population density and in insecticide-treated plantations where coccinellids were destroyed, *Cybocephalus* spp. survived well [16]. According to the climatic conditions and prey species prevalent in their specific habitats, the comparative biological studies of several *cybocephalid* species explained their different distributions [85,86].

Finally, Blumberg [5] stated that, green lacewings (*Chrysoperla* spp.) were found mainly during spring and autumn; their significance in the control of PDS was not investigated. The predacious mite *Hemisarcoptes coccophagus* Meyer (Hemisarcoptidae) was also identified to attack PDS [87-107].

Conclusion

The major types of scales that affect date palms are green scales. Palmaspis phoenicis, red scale Aonidiella aurantii (Mask.), Do., especially with scale caused by *Parlatoria blanchardi*. The withe scale is found wherever date palm is grown. It's worldwide and found in many countries, including Morocco. Date palm trees are subjected to attack by several insect pests, especially the white date palm scale, *Parlatoria blanchardi*. It infests all parts of the date palms and causes serious damage. Leaflets, leaves, tender shoots, offshoots, twigs, and fruits are attacked by both immature and adult females of this Diaspididae insect. This insect sucks the sap with its mouth parts and secretes toxic saliva during feeding, which affects the respiration, transpiration, and photosynthesis processes and thus obstructs the growth process and may contribute to the premature death of the fronds in the case of high infestations. In order to control these pests and diminish their damages, integrated pest management (IPM) is an ecosystem approach for the production and protection of crops that unites different strategies and practices of management. It can be shown to be the best combination of available tactics for a given pest problem by comparison with the yield, profit, and safety of alternative mixes. A successful IPM program requires proper identification of the pest and knowledge of its biology and ecology, as well as sampling and monitoring of its population to develop appropriate actions and identify thresholds. It is an ecological approach for controlling agricultural insects.

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Conflict of Interest

No conflict of interest.

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