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First Record of the Cochineal Scale Insect, *Dactylopius opuntiae* (Cockerell) (Hemiptera: Dactylopiidae), in Jordan

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Abstract

The cochineal scale, *Dactylopius opuntiae* (Cockerell, 1896) (Hemiptera: Dactylopiidae), is reported from Jordan for the first time from several localities in the north of the country. This scale insect attacks the Indian-fig prickly pear, *Opuntia ficus-indica* (L.) Miller (Cactaceae), and plants are killed by heavy infestations. The distribution and the relative degree of infestations in Jordan are shown in a map. Voucher specimens of the collected samples were preserved in the University of Jordan Insect Museum. Slides of adult females were prepared, and digital images were taken to illustrate important diagnostic characters. World distribution, morphology, control methods, natural enemies and the probable means of the introduction of this serious pest are discussed.

Keywords: Cochineal scale insect, Prickly-pear cactus.

1. Introduction

The cochineal insects are sources of red dye. They are potential agents for the control of certain pest species of *Opuntia* or prickly pears (De Lotto, 1974). They have been used for commercial purposes since the 16th century in Central and South America, in Mexico and Spain (De Lotto 1974 and Chávez-Moreno *et al.,* 2009). *D. opuntiae*, was described by Cockerell in 1896 from Mexico (De Lotto, 1974). It was introduced into Australia, India, South Africa, and Saudi Arabia to control the prickly pear cacti which were considered noxious weeds (Hosking *et al.,* 1994; Foxcroft and Hoffmann 2000; Aldawood and Tuwariqi, 2014). The current distribution of this insect includes twenty countries: Australia (New South Wales), Brazil Cape Verde, France, Hawaii, India, Jamaica, Kenya, Lebanon, Madagascar, Mauritius, Mexico, Morocco, Pakistan, Palestine, Reunion, South Africa, Sri Lanka, United States (Arizona California Texas), and Zimbabwe (García *et al.,* 2016). Additionally, it is found in Lebanon (Moussa *et al.,* 2017), Saudi Arabia (Aldawood and Tuwariqi, 2014), Morocco (Bouharroud *et al.,* 2016) and Cyprus (EPPO Reporting Service, 2017).

D. opuntiae females have three developmental stages – egg, nymph (two instars) and adult- whereas males have egg, nymph, pre-pupa, pupa and adult stages (De Lotto, 1974). This cochineal scale produces carminic acid to protect itself from predators (Eisner *et al.,* 1994). The longevity of the female is 38.4 days, while male longevity is only 4.2 days. The complete biological cycle is 77 and 43 days for the female and male insects respectively. Sexual reproduction is most common, but parthenogenetic females were found (Flores-Hernandez *et al.,* 2006).

Cactus was introduced into Palestine centuries (400 years) ago from Central America (Protasov *et al.,* 2017). In Jordan, *Opuntia ficus-indica* is planted at the edges of farms and gardens as a fence, and also for its fruits, which have a good market value. It can also be used as animal feed. The cultivated area of this plant in Jordan is estimated at 3000,000 m^2 mainly in the Jordan Valley and Madaba area. Recently, farmers from the northern parts of Jordan complained from the scale insect that attacked cactus severely. The objective of the current work is to document the first record of *D. opuntiae* (Cockerell) in Jordan, its recent distribution in the country, and to propose effective control pest methods.

2. Materials and Methods

Six field trips were conducted on the 9th, 14th, 17th, 24th of February and the 3rd of March in 2018 to several localities in northern Jordan (Map 1). The elevations of sites were recorded by GPS. All cactus plants were observed, and examined for the presence of the Cochineal scale insect in all of the visited sites. The severity of infestation was estimated as follows: 0, no infestation; 1, low infestation if less than 25 % of the pad surface was infested; 2, medium infestation if 25-50 % of the pad surface was infested; 3, high infestation if more than 50 % of the pad surface was infested (Moussa *et al.,* 2017).

The heavily infested cladodes of cactus were collected from several sites in the northern parts of Jordan. The specimens were removed from the cladodes with a fine brush, and were boiled gently in 75 % alcohol for few minutes. They were then washed with distilled water, and placed in 10 % KOH for 24 hours until the specimens became translucent. Afterwards, all body contents were

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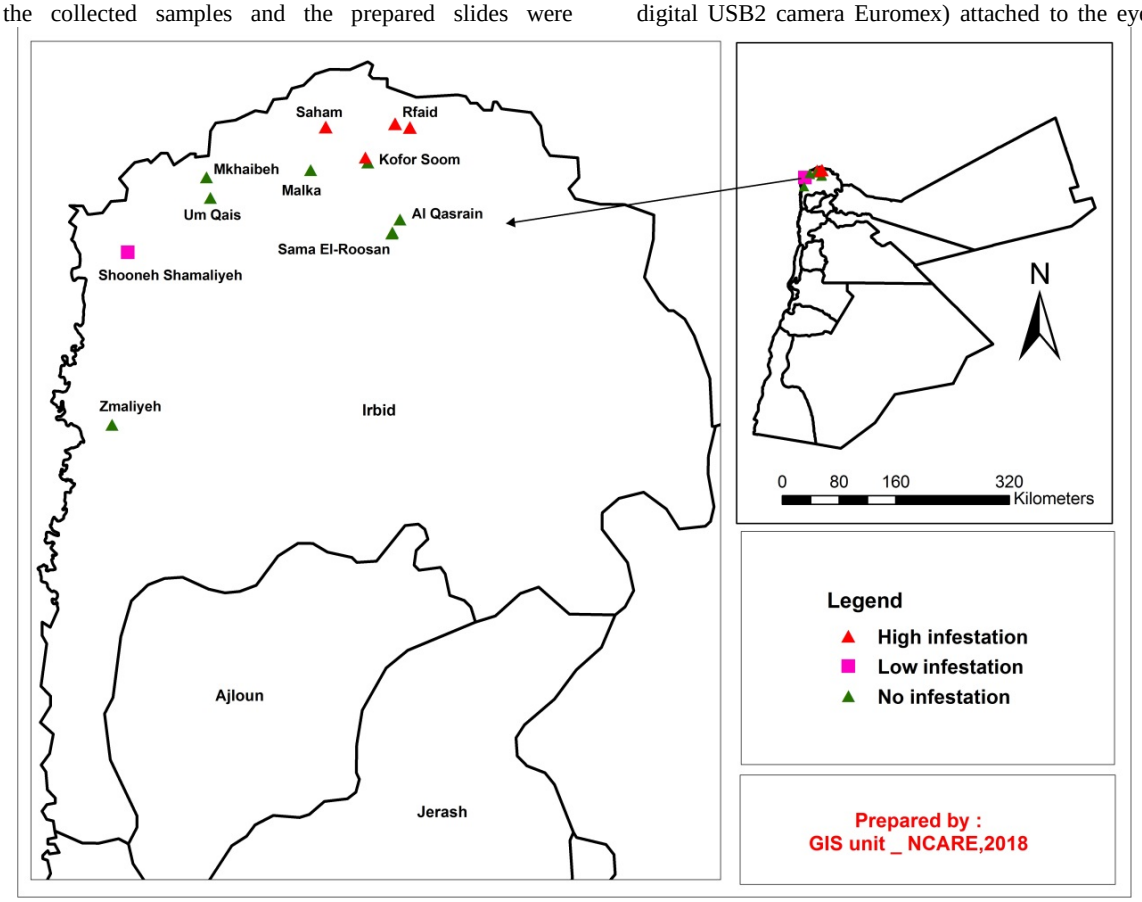
removed by pressing the insect with a small spatula. The specimens were then rinsed in distilled water for about ten minutes placed in few drops of glacial acetic acid and acid fuchsine, and were then washed in absolute alcohol. Slide mounts were prepared in clove oil. Voucher specimens of the collected samples and the prepared slides were preserved at the University of Jordan Insect Museum. The adult female was photographed using a dissecting microscope (Leica M165 C) provided with a dome illumination unit. Enlargements were carried out under light microscope by a digital camera (CMEX 5.0 M pixel digital USB2 camera Euromex) attached to the eye tube.



Map 1. Current distribution of *Dactylopius opuntiae* in Jordan.

3. Results

The mounted specimens of the examined scale insect were found by the first author to belong to *D. opuntiae* (Cockerell) according to the key of (De Lotto, 1974). Mounted adult female is elongate oval (Plate 1, A), dorsal and ventral lateral modified body setae short, cylindrical, moderately to strongly stout; rather numerous (Plate 1, B). Antennae with seven segments (Plate 1, C). Anterior and posterior spiracles large with the sclerotized operculum well developed and having the lateral edges rough or provided with a few minute indentations (Plate 1, D). Legs short and stout (Plate 1, E). *D. opuntiae* was recorded from few sites in the north of the country (Map 1). The infestation was high (cladodes totally covered with the scale) in Saham and Rafaid where *D. opuntiae* was first observed (Plate 1, F) and low (few colonies on the cladode) in Alshouna Shamaliyah (Table 1). Heavy infestation led to the death of cactus plants (Plate 1, G).

Table 1. Cactus localities sampled, their elevations and the severity of *Dactylopius opuntiae* in Jordan.

Location	Sampling date	Elevation (m)	Severity*
Saham	14.2.18	330	3
Kufr Soom	14.2.18	380	3
Rafaid	9.2.18	440	3
Rafaid	9.2.18	380	3
Sama Rousan	14.2.18	470	0
Al-Qasrin	14.2.18	470	0
Malka	17.2.18	390	0
Um-Qias	17.2.18	310	0
Alshouna Shamaliyah	24.2.18	-210 (below sea level)	1
Zmalyeh	3.3.18	-190 (below sea level)	0
Mukhaibah	3.3.18	20	0

* Severity scale: 0 (no infestation); 1 (low infestation, less than 25 % of the pad surface was infested); 2 (medium infestation, 25-50 % of the pad surface was infested; 3 (high infestation, more than 50 % of the pad surface was infested).

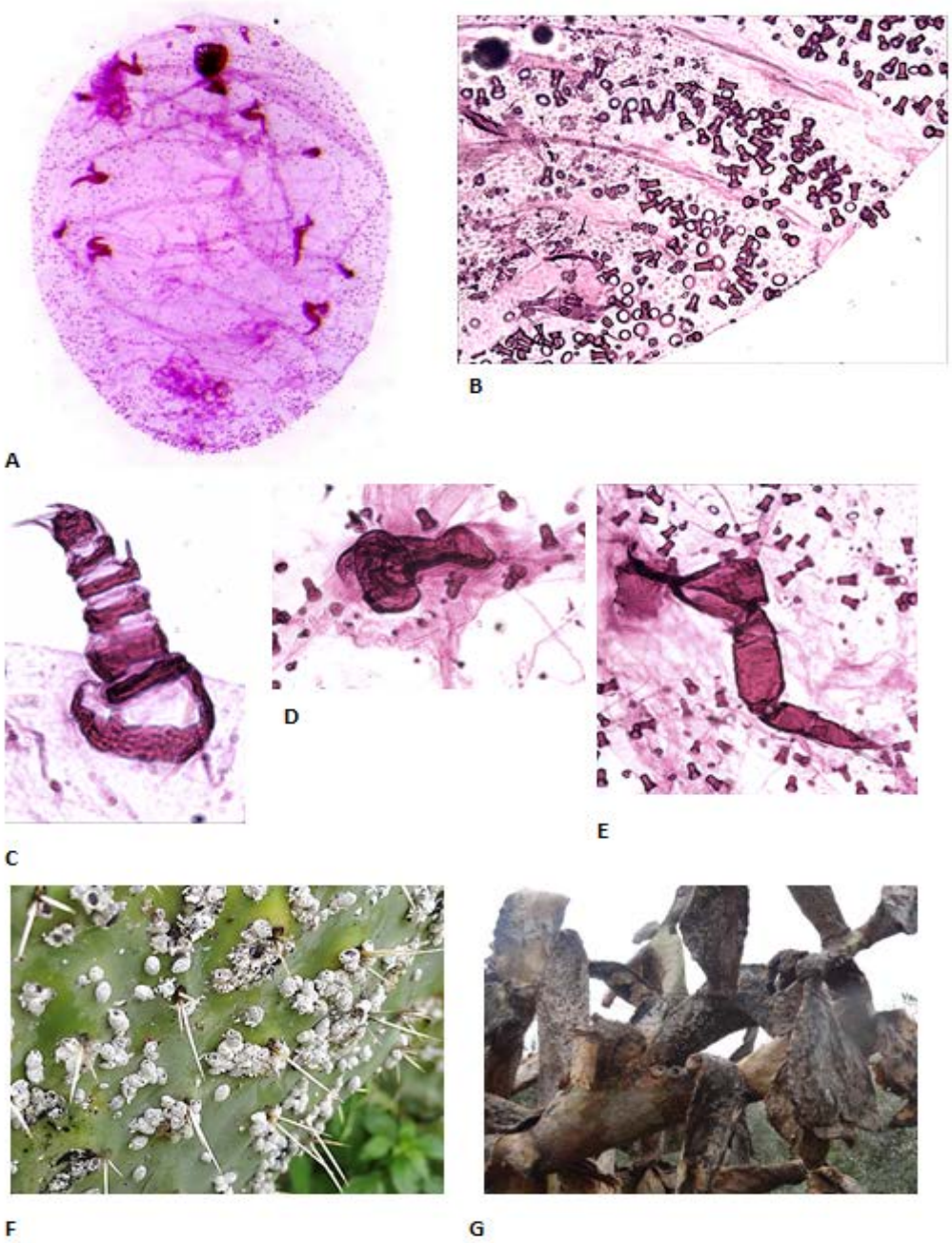


Plate 1. *D. opuntiae*: A. Adult female (3 mm length); B. Dorsal cylindrical setae (40x); C. Antenna (40x); D. Spiracle (40x); E. leg (40x); F. Cochineal scale infested cladode; G. Dead cactus due to heavy infestation.

4. Discussion

This is the first record of *D. opuntiae* from Jordan. Subsequent observations on cactus plants in areas southwards from the sites of initial records during March and April of 2018 in Amman area, Madaba, Wadi Al Walah and Wadi al Hidan, Dayr Alla, Wadi Al Huwarat, Abu Az Zeeghan, Sawalhah showed that cactus plants were uninfested which may suggest that the introduction of this insect into Jordan is recent. It may have been introduced naturally by wind, livestock, or birds coming from Palestine and/or Lebanon. It is highly expected that it has been recently introduced into Syria because most of the study records were from areas close to the Syrian border. It is probable that this invasive insect will spread southwards in Jordan, and may infest most cactus plantations in the country unless an effective control program is implemented.

Moussa *et al.*, (2017) stated that the risk of the spread of this pest to new areas in Lebanon is very high and urgent eradication programs must be implemented. The predator *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) was found in association with the colonies of *D. opuntiae*, but its densities were too low to regulate the population of this new invasive pest.

After the first detection of *D. opuntiae* in Palestine in 2013 (Spodek *et al.*, 2014), its management with inundated releases of 100,000 adult predatory beetles of *C. montrouzieri* was apparently unsuccessful. Accordingly, two natural enemies were introduced from Mexico into Palestine; a predatory beetle, *Hyperaspis trifurcata*

(Coleoptera: Coccinellidae) and a predatory fly, *Leucopis bellula* (Diptera: Chamaemyiidae). Recently, individuals of *H. trifurcata* were released in the cochineal infested sites in the Galilee (Protasov *et al.,* 2017). The efficiency of these bioagents is not reported so far.

D. opuntiae is not attacked by parasitoids due to the presence of the carminic acid. Its predators in Mexico were studied by Vanegas-Rico *et al.* (2010). The most common species were *Leucopis bellula* (Diptera: Chamaemyiidae), *Sympherobius barberi* (Neuroptera: Hemerobiidae), and *Laetilia coccidivora* (Lepidoptera: Pyralidae). García *et al.,* (2016) listed the natural enemies of this pest which included the predatory fly larvae of Chamaemyiidae (*Leucopis bellula*), beetles of Coccinellidae (*Chilocorus cacti, Cryptolaemus montrouzieri, Exochomus* sp. *Hyperaspis trifurcata* and *Tenuisvalvae notata*), the brown lacewings of Hemerobiidae (*Sympherobius angustus* and *Sympherobius barberi*), the moth larvae of Pyralidae (*Laetilia coccidivora*), and larvae of the syrphid flies of Syrphidae (*Eosalpingogaster cochenillivora* and *Salpingogaster* sp.).

Resistant cactus cultivars may be used to control *D. opuntiae* (Borges *et al.,* 2013). One biotype of *D. opuntiae*, the 'stricta' biotype, only survives on low-growing species such as *O. stricta*, while the other, the 'ticus' biotype, is associated with tree-like cacti, including *O. ficus-indica*. The 'stricta' biotype was used, with considerable success, for the biological control of *O. stricta* in Australia for over sixty years (Githure *et al.*, 1999).

The application of pyrethroid and organophosphate insecticides, mineral oils and neem oils were used in Mexico (Vannegas-Rico *et al.,* 2010) giving partial control. Heavy rain was reported to reduce the development of cochineal insects by dropping crawlers from the cladodes (Moran *et al.,* 1987).

An urgent action plan for controlling *D. opuntiae* in Jordan is needed. First of all, the current distribution of this pest should be determined by surveying all cactus plantations in Jordan. Heavily infested plantations should be eradicated which may include the destruction of the first clusters of infested plants, collecting fallen cladodes and burning abandoned cultivations. The transport of cactus plants or fruits from infested areas to pest-free areas must be prevented through internal quarantine regulations. The search for local natural enemies (predators) is important, and the release of introduced bioagents may be implemented if native populations were found insufficient or ineffective. The use of entomopathogenes such as *Fusarium incarnatum–equiseti* in combination with plant extracts may be a good option (Santos *et al.,* 2016; Carneiro-Leao *et al.,* 2017). Insecticidal sprays including powdered soap or liquid detergents in urgent situations could be used. In addition, Jordanian farmers should be encouraged to plant the resistant variety, *Nopalea cochenillifera* after conducting the necessary assessments regarding the suitability of this variety to Jordanian soils and climate.

5. Conclusions

The cochineal scale insect, *D. opuntiae* (Cockerell), was recorded from Jordan for the first time in several localities in the northern parts of the country. This invasive insect species was most probably introduced from nearby countries only recently. Controlling procedures must be implemented urgently.

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