Systematic Review
ISSN: 2583-7419
Journal homepage: biologyforum.actabotanica.org

Opuntia Cochineal Scale Pest, *Dactylopius opuntiae*: Current Situation, Description, Importance, and Control Methods in Countries of the Mediterranean Basin and North Africa

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Citation: Mohammed Alhady Abusharya and Hosam Ali Ashokri (2025). Opuntia Cochineal Scale Pest, *Dactylopius opuntiae*: Current Situation, Description, Importance, and Control Methods in Countries of the Mediterranean Basin and North Africa. *Acta Biology Forum*. **DOI: https://doi.org/10.51470/ABF.2025.4.2.15**

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Received 28 April 2025 | Revised 19 May 2025 | Accepted 20 June 2025 | Available Online 25 July 2025

ABSTRACT

This study aims to describe and understand the importance and methods of controlling the cochineal scale insect Dactylopius opuntiae (Cockerell, 1896), which has recently spread to most countries in the Mediterranean Basin and North Africa, as well as its original habitats in Mexico and North America. The insect attacks approximately 16 species of cacti, particularly the prickly pearOpuntia ficus-indica. Females and nymphs feed on the sap of the plant's stems and branches, causing the stems to dry out and die in severe cases, while males cause little damage. D. opuntiae protects itself with a waxy, cotton-like membrane and the secretion of carminic acid (carmine dye). Despite the damage caused by the insect, it is possible to benefit from the carminic acid it secretes, which has antioxidant properties and is used in various medical, food, and commercial applications. Cochineal pest is typically controlled through several methods, including mechanical, biological, and chemical approaches.

Keywords: *Cochineal Pest; Dactylopius opuntiae; Prickly Pear; Mediterranean Basin; Control Methods.*

1. Introduction

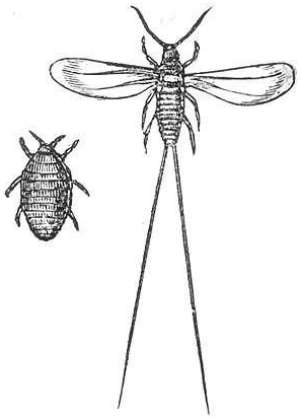
The cochineal scale insect *Dactylopius opuntiae* (Cockerell, 1896) is one of the most significant invasive pests, causing substantial economic damage to the Cactaceae family, particularly the prickly pear genus, in various regions of the world [33]. The Cactaceae family is adapted to dry and harsh environments, characterized by high temperatures and low-fertility soils. Prickly pear has a high nutritional value in its fruits, and it is also used as livestock feed and as a fence between farms [36]. The insect is characterized by its thick, waxy covering, which protects it from natural enemies. The carminic acid it secretes helps reduce parasites and predators [25], which has contributed to its widespread distribution in more than 20 countries [16].

The genus *Dactylopius*comprises 11 species, and Dactylopius opuntiae, commonly known as the cochineal, is considered one of the most damaging species to cacti [37]. Carminic acid is extracted from the species *Dactylopius coccus*[9], which has numerous medical, food, and commercial applications due to its antioxidant properties [3]. This research article aims to provide a description and definition of this pest, the damage it causes, and how to transform it from a harmful insect to an insect of economic importance.

1.2. General Description & Scientific Classification:

Cochineal (Figure 1) is a small insect belonging to the scale insect family, soft and oval, living in colonies. The colony consists of individuals in different stages. Its males are winged and able to fly.

unlike the females, which are attached to the prickly pear stems and covered with a white, waxy layer resembling cotton, which acts as a mechanical barrier against external factors such as climate and predators. Females produce a dark purple liquid containing the pigment carmine, which is rich in carminic acid. Females and nymphs feed on the sap in the stems, trunks, and fruits of prickly pear, which, in advanced and severe cases of infection, leads to drying, death, and complete fall of the trunk. As for males, they do not cause any harm to the plant [1]. Based on [2], the female ranges in length from 4 to 6 mm, width from 3 to 4.5 mm, height from 3.8 to 4 mm, and weight from 40 to 47 mg. The ventral and dorsal appearance of the female is cylindrical, the antennae are composed of seven segments, the breathing holes are large, and the legs are short and strong [4].



Cochineal pest was first described by Cockerell in 1896. It belongs to the order Hemiptera within the family Dactylopiidae and is known by the scientific name *Dactylopius opuntiae* [10].
Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hemiptera
Suborder: Sternorrhyncha
Family: Dactylopiidae
Genus: *Dactylopius*
Species: *opuntiae*

Figure 1: Female (Left) & Male (Right) Cochineal Drawing.

1.3. Life Cycle:

As illustrated in Figure 2, the female goes through three stages of development: the egg, the nymphal stage which consists of two stages (the first nymphal instar and the second nymphal instar), and the adult insect stage, while the male goes through the following stages: the egg, the nymphal stage, the pre-pupa, the pupa, and the adult insect which carries a pair of wings [2]. The eggs are bright red, oval in shape, and have a smooth surface. The average length of the egg is 0.7 mm, and its width is 0.3 mm [24].

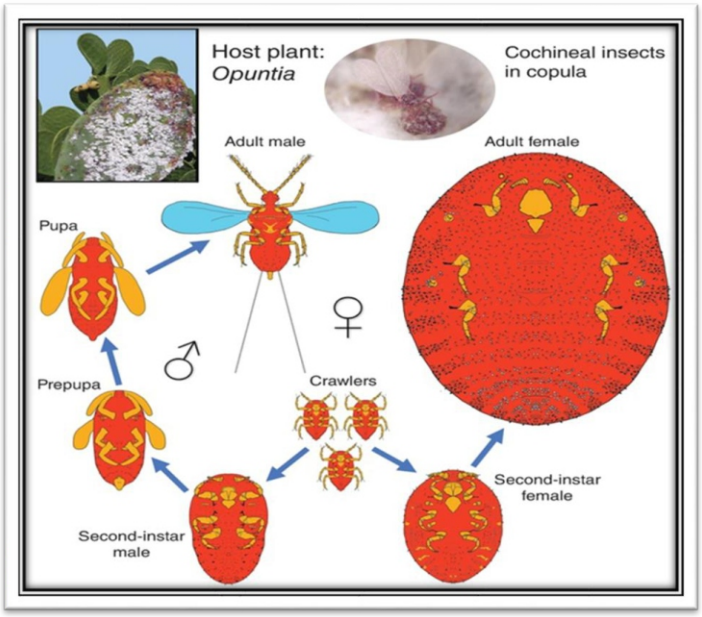


Figure 2: Lifecycle of Dactylopius opuntiae [19]

The female lays eggs individually or in groups, linked in a chain [30]. The eggs hatch approximately 18-27 minutes after laying. The female lays approximately 226 eggs during her lifetime. The average duration of one generation ranges from 56 to 58 days from egg laying until the adult insect emerges. The life cycle of females ranges from 40-180 days, while that of males does not exceed 35-52 days, depending on climatic conditions [27]; [28]. *D. opuntiae* usually reproduces sexually, but may tend to reproduce parthenogenetically to produce fewer offspring under harsh conditions, especially during high temperatures [14]; [32]. The insect produces between 4 and 5 generations per year, especially in warm regions [27].

1.4. Means of insect spread:

According to [17], the high fertility and the waxy cover that protects the insect are factors that have helped it spread in several environments. This insect is also easily spread by wind, rain, and water, in addition to its spread by birds, humans, and livestock.

1.5. Damage and symptoms:

The cochineal *D. opuntiae* is a harmful insect that infects about 16 species of cactus worldwide, causing significant losses, especially to the prickly pear genus and its various species [25]; [33]. As shown in Figure 3, the plant first appears as yellow-green areas and necrosis on the branches, which gradually expand, then dry up within about a year [25]; [11], while the woody stems can remain alive for another 6 months after the branches die and dry up [18]. Then, the large colonies of *D. opuntiae* increase the growth of endophytic fungi within the host and host plant as a result of stem and trunk rot [15].

Figure 3: Prickly Pear Infected with Cochineal

1.6. World Geographical Distribution:

The native habitat of *Dactylopius opuntiae* isMexico, and the current distribution of this insect includes many countries around the world. Based on [16], the most important countries in which the insect has been recorded are: Australia, Brazil, Hawaii, India, Jamaica, Madagascar, Mexico, South Africa, Sri Lanka, the United States, Zimbabwe, Pakistan, France, Spain, India, and Cyprus. The presence of *D. Opuntiae* has also been recorded in Arab countries, including Morocco, Lebanon, Palestine, Saudi Arabia, Jordan, Syria, as well as Yemen. Aleading study conducted by [20] reported the presence of the cochineal insect in the state of Algeria in the city of Misserghin (Oran) in 2024.In Libya, the insect first appeared in the western coastal areas such as Zawiya and Abu Surra in May 2024, then spread to other areas such as JudDaim, Al-Maya, Al-Tuwaibiya, Al-Maamura, Qarquza, and Al-Zahra.It is believed that it spread from neighboring countries via wind, agricultural machinery, sheep, or fodder.The insect feeds exclusively on the sap of the prickly pear plant, causing the pads to yellow and fall off, turn brown, and eventually die if left uncontrolled.

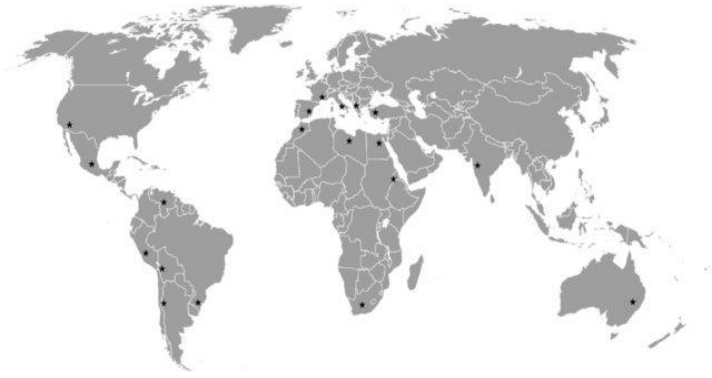


Figure 4: World Distribution of Dactylopius opuntiae[38]

1.7. Industrial and Economic Importance:

The cochineal insect *D. opuntiae* has long been used in biological control to control the spread of several cactus species, such as *Opuntia stricta* and *O. ficus-indica*[27]. Carminic acid extracted from the insect
has antioxidant properties and has been used in beef storage and preservation [3]. Carminic acid also helps inhibit tumors and reduce the progression of fatty liver disease [21].

The red dye carmine is widely used in cosmetics, pharmaceuticals, food, and the clothing industry [11]. Due to the insect's reproductive capacity and the damage it causes to cactus stems, this pest is considered one of the pests that cause significant economic and agricultural losses in several countries around the world [35].

1.8. Cochineal Control Techniques:
Given the widespread damage caused by the insect, methods are required to limit its spread. These methods consist of several techniques based on mechanical, physical, biological, chemical, and other methods, which can be combined in various ways to achieve the best results in controlling the pest.

1.8.1 Mechanical and Physical Methods: Mechanical methods are highly effective, especially in areas where the first outbreak of *D. opuntiae* is detected. This is achieved through regular and continuous field visits. This method mainly consists of harvesting or mechanically cleaning infected plant parts and destroying them by burning or burying them as quickly as possible. It is also possible to preserve and store them for use as livestock feed [34].

1.8.2 Biological Control Methods: Many natural enemies of *D. opuntiae* have been recorded, some of which are capable of controlling the insect. These predators include insects and spiders. The most important predators of *D. opuntiae* are the beetles belonging to the order Coleoptera: *Hyperaspis trifurcata*, *Chilocorus cacti*, *Coccidophilus citricola*, *Zagreus bimaculosus*, *Exochomus flavipes*, *Exochomus flaviventris*, *Cryptolaemus montrouzieri*, and *Cybocephalus sp*[22]; [31]. The beetle *Hyperaspis trifurcate* is considered the most efficient and effective due to its abundance [8]. This beetle is used as a biological control agent in many ecosystems and agricultural systems due to its strong predatory activity, as the female consumes more than 5,400 nymphs during her lifetime, making it one of the most important predators of the cochineal insect *D. opuntiae*[35]. Several insects also feed on the nymphal stage of *D. opuntiae*, including the aphid *Leucopis bellula* and the brown barber worm *Sympherobius barberi*[29], while the snout moth *Laetilia coccidivora* feeds on the adult stage of *D. opuntiae*[26]; [13].

1.8.3 Chemical Control Methods: In the early stages of chemical control, *D. opuntiae* colonies are sprayed and treated with insecticides and some detergents [12]; [23]. When the prevalence of *D. opuntiae* increases significantly and it is difficult to eliminate it using biological and mechanical methods, chemical compounds are used. These compounds are mainly used in Mexico, which relies on malathion, methyl parathion, and chlorpyrifos [8], and triclofen[5]. Cypermethrin, carbaryl, and chlorpyrifos have been used in South Africa [25]. The use of mineral oil has been successful in eliminating *D. opuntiae* by 93–97% [7] and 100% [6].

2. Conclusion:
The insect of *D. opuntiae* causes severe damage to cactus species worldwide. It feeds on plant sap, causing the plant to desiccate and die. It is widespread in several countries. The female produces carminic acid, which has antioxidant properties, making it an important ingredient in many industries and economically important.The insect has also been used as a pest control for cactus plants in some countries. Mechanical, biological, and chemical control methods are among the most important.

3. Recommendations:
The Authors of this work would highly recommend an immediate action plan that includes:

- Launching control campaigns in affected areas. These campaigns aim to contain the spread of the pest and prevent its transmission to new areas.
- Continuous monitoring and evaluation of the results of the control campaigns.
- Launching national awareness campaigns for farmers about the risks of this pest and the importance of early detection and immediate reporting.

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