



First Record of Infestation Of *Dactylopius Ceylonicus* (Green) (Hemiptera: Dactylopiidae) On *Opuntia Elatior* Mill. (Cactaceae) From Central India.

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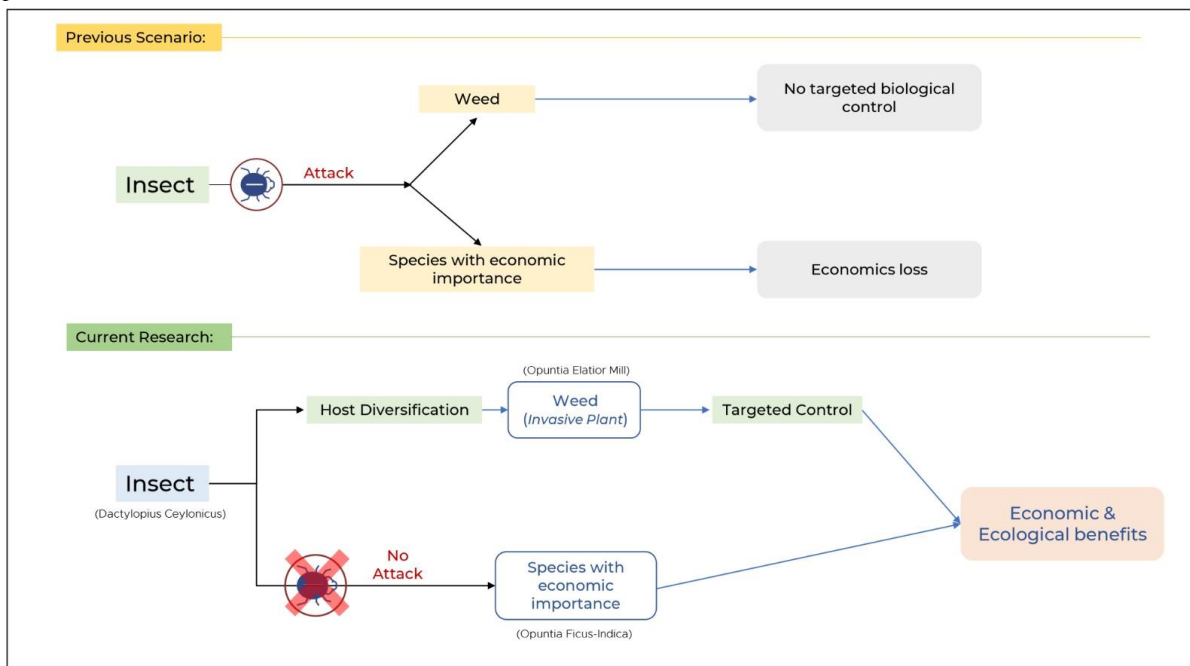
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Abstract

The attack of wild cochineal insect, *Dactylopius ceylonicus* (Green, 1869) (Hemiptera: Coccoidea: Dactylopiidae) has been reported for the first time on Red flower Prickly pear, *Opuntia elatior* Mill. (Cactaceae) from Central India. *Opuntia elatior* was introduced in India as a part of the cochineal trade during the 1800s and is considered an invasive weed in many countries. *Dactylopius ceylonicus* is a wild cochineal insect that secretes red-coloured Crimson dye. The insect was introduced mistakenly in place of a true cochineal insect (*D. cacti*) in an attempt to establish the Cochineal dye industry during the colonial period in India. Many insects of the *Dactylopius* genera act as biological control agents for invasive *Opuntia* species. Many attempts were made in the past to

<p>CC License CC-BY-NC-SA 4.0</p>	<p>control <i>O. elatior</i> by using <i>D. ceylonicus</i> but didn't establish itself on <i>Opuntia elatior</i>. It is the first instance when <i>D. ceylonicus</i> attacking <i>O. elatior</i> is recorded. Through these research findings, we can achieve targeted biological control of <i>O. elatior</i> without affecting species of economic importance i.e. <i>O. ficus-indica</i>. A voucher specimen of Insect sample was submitted to the National Bureau of Agricultural Insect Resources, Bangalore. The spatial distribution of insects is localized to small regions and has been shown on the map. Probable reasons for host diversification, evolution, and possible economic benefits are discussed in this research article and the need for further research has been emphasized.</p> <p>Keywords: Opuntia, Dactylopius, cochineal scale Insect, Wild cochineal Insect, Host diversification, Biological Control, First record, <i>O. elatior</i>, <i>D. ceylonicus</i>.</p>
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Introduction

Genus *Opuntia* belongs to the family Cactaceae and has about 1500 species of cacti (Kovačević et al. 2020). Genus *Opuntia* contains about 181 species out of which 27 are invasive. Invasion of *Opuntia* species has been recorded in about 35 countries, India being one of them. Countries where invasion has been recorded are Angola, Algeria, Australia, Austria, Canary Islands, China, Croatia, Czech Republic, Eritrea, Ethiopia, France, Germany, Ghana, India, Kenya, Madagascar, Mauritius, Morocco, Namibia, New Zealand, Pacific Islands, Portugal, Reunion, Saudi Arabia, Somalia, Spain, Sri Lanka, South Africa, Swaziland, Switzerland, United Republic of Tanzania, Tunisia, Uganda, Yemen and Zimbabwe (ICARDA 2017).

Opuntia elatior Mill. is considered an invasive weed in Australia, India, Kenya, and Indonesia. Madagascar, Ethiopia, Yemen, Somalia, Angola, Namibia, and Kenya have recorded serious invasions recently (ICARDA 2017). IUCN describes *O. elatior* Mill. under the category of least concern (LC) as it is present in abundant quantity and is not at any risk (Majure et al. 2017). All *Opuntia* species found in Australia except spineless *Opuntia ficus indica* are considered "Weeds of national significance" (Chinnock 2015).

O. elatior is known widely by its common name red flower prickly pear (Pasicznik 2022). *O. elatior* was introduced as a part of the cochineal trade in India during the 1800s (Kumar 2015). It is the only species of *Opuntia* present in the wild in Maharashtra (Singh et al. 2001). It is reported separately to have been present in Wardha and Nagpur District (Acharya 1985; Ugemuge 1986). *Dactylopius ceylonicus* is commonly known as a 'wild cochineal insect'. *D. ceylonicus* is one among 11 species of monogeneric family Dactylopiidae. All 11 species secrete carminic acid which Yields red-coloured crimson dye (Bader and Abu-Alloush 2019).

In an attempt to establish a cochineal dye industry, it was introduced mistakenly in India in place of the true cochineal insect *D. cacti* from Brazil. When it was introduced, it controlled *O. vulgaris* but could not establish itself on *O. elatior* (Kumar 2015). It was recently found to be distributed geographically in over 16 countries like Argentina, Australia, Bangladesh, Bolivia, Brazil, Ethiopia, India, Madagascar, Mauritania, Mauritius, Mexico, Nepal, Paraguay, South Africa, Sri Lanka, United States. In India insect *D. cacti* was found to be distributed in the states of Andhra Pradesh, Bihar, Himachal Pradesh, Odhisa, Tamilnadu, and West Bengal (García Morales M, Denno BD, Miller DR, Miller GL, Ben-Dov Y 2016)

D. ceylonicus is a family-specific insect i.e. it feeds on only one family of Cactaceae and it infects only five genera of Cactaceae which are Austrocylindroopuntia, Cylindroopuntia, Nopalea, *Opuntia* and Tunilla (García Morales M, Denno BD, Miller DR, Miller GL, Ben-Dov Y 2016). *D. ceylonicus* is characterized by an unusual life cycle with a female resembling hemimetabolous insect having three stages: egg, nymph, adult, and male with a holometabolous insect having four stages: egg, nymph, pupa, adult (Sullivan 1990)(Fig 1). We unexpectedly noticed the attack of *D. ceylonicus* on *O. elatior* Mill. while surveying cacti and succulents plant species.

To the best of our knowledge, this research work is aimed at documenting the world's first attack of *D. ceylonicus* (Green) on *O. elatior* Mill. and we are presenting its spatial distribution in Central India. Furthermore, to contemplate and put forward possible reasons behind host diversification by insect and its possible economic benefits in countries where *Opuntia* is cultivated. The present study has national & global significance as it brought forward novel research findings of host diversification by *D. ceylonicus* and infestation on *O. elatior*, through this it can achieve targeted biological control of *O. elatior* without affecting *O. ficus-indica* (the most commercially important cactus) which was not the case previously.

Materials and Methods






Study Area and Duration: -

Nagpur and Wardha districts are North Eastern and Eastern parts of Nagpur Division respectively, as demarcated by the Revenue Department of Maharashtra state for administrative convenience. They together occupy a prominent part of central India. Nagpur District is situated between latitudes 20°35' and 21°44' N and longitudes 78°15' and 79°40' E and Wardha District is between 20°18' and 21°21'N latitude and longitude 78°4'E to 79°15' E. They together occupy a surface area of 16,202 km².



Map 1 Current distribution of infestation of *D. ceylonicus* on *O. elatior*.

Symbols:

	High Infestation
	Medium Infestation
	Low infestation
	No Infestation.
	Farms

Opuntia species are not cultivated in central India. They are used in parks for ornamental purposes, in farms as hedges or they widely grow in forests and on barren lands. About 23 field visits were done from 10th September 2021 to 1st March 2022 in several localities in Nagpur and Wardha District. We surveyed all 14 territories (tehsils) of Nagpur and 8 territories (tehsils) of Wardha district. However, we found only one species of Opuntia was infested by a cochineal scale insect.

Out of a total of 22 territories (tehsils) surveyed from two districts; infestation was found to be localized in a small village named Narsinghpur from Ashti tehsil of Wardha District. All the infested plants were geotagged and elevations were recorded with the help of the Global Positioning System (MAP 1, Table-1). Identification and authentication of plant samples were done by comparing characteristics from standard floras such as Flora of Nagpur District (Ugemuge 1986), Flora of Wardha District (Acharya 1985), Flora of Maharashtra state Vol. I (Singh et al. 2001), Indian Medicinal Plants Vol. II (B.D.Basu 2006); various literary sources, research papers, online databases (Field Identification Guide) (Sheehan, Matt 2017), etc. Further, confirmation was done by Dr. S. R. Yadav, INSA Sr. Scientist Department of Botany Shivaji University Kolhapur Maharashtra.

Collection of Insect:-

Scale Insects were collected from cladodes with heavy infestation, with the help of a brush. They were preserved in 70 % alcohol and were sent for Identification and species confirmation to NBAIR, Bangalore. The preserved specimens were slide-mounted in Canada balsam according to the procedure described in Watson & Chandler (2000)(Watson). Slide-mounted adult females were observed through a Nikon Eclipse 80i microscope and microphotographs were captured with a Nikon DS-Vi1 camera mounted on this microscope (Fig.No.2). The scale insect was identified based on the description of the cochineal insects (de Lotto 1974). A voucher specimen of *D. ceylonicus* is deposited in the ICAR-NBAIR (Accession No. NBAIR/HEM/DACTY/DACTYLO/30112021).

Results: -

The plant species was identified and authenticated as *Opuntia elatior* Mill. with the help of various floras, online databases, and literary sources and further confirmed by expert taxonomist Dr. S. R. Yadav. The insect species was identified by expert entomologist, Dr. Sunil Joshi from the National Bureau of Agricultural Insect Resources Bangalore, with the help of various keys, and confirmed to be *Dactylopius ceylonicus*. The infestation was recorded only from one site i.e. Narsinghpur from Ashti tehsil (Fig. No.3) Now it has been observed that most of the plants died due to heavy infestation. (Fig. No.5)

Coordinates	Altitude in (m)	Level of Infestation
21 ⁰ 11'11"N 78 ⁰ 11'14"E	344	High
21 ⁰ 11'10"N 78 ⁰ 11'18"E	342	High
21 ⁰ 11'12"N 78 ⁰ 11'13"E	352	Medium
21 ⁰ 11'13"N 78 ⁰ 11'13"E	354	High
21 ⁰ 11'23"N 78 ⁰ 11'14"E	333	Medium
21 ⁰ 11'14"N 78 ⁰ 11'13"E	355	Medium
21 ⁰ 11'14"N 78 ⁰ 11'13"E	356	High
21 ⁰ 11'23"N 78 ⁰ 11'07"E	336	Low
21 ⁰ 11'15"N 78 ⁰ 11'13"E	356	Medium
21 ⁰ 11'16"N 78 ⁰ 11'13"E	355	High
21 ⁰ 11'13"N 78 ⁰ 11'15"E	353	High
21 ⁰ 11'13"N 78 ⁰ 11'14"E	352	High
21 ⁰ 11'14"N 78 ⁰ 11'15"E	355	High
21 ⁰ 11'15"N 78 ⁰ 11'14"E	356	Medium
21 ⁰ 11'13"N 78 ⁰ 11'11"E	335	Low
21 ⁰ 11'11"N 78 ⁰ 11'04"E	332	No

Table 1 List of locations with the level of infestation where the attack of *D. ceylonicus* on *O. elatior* was detected.

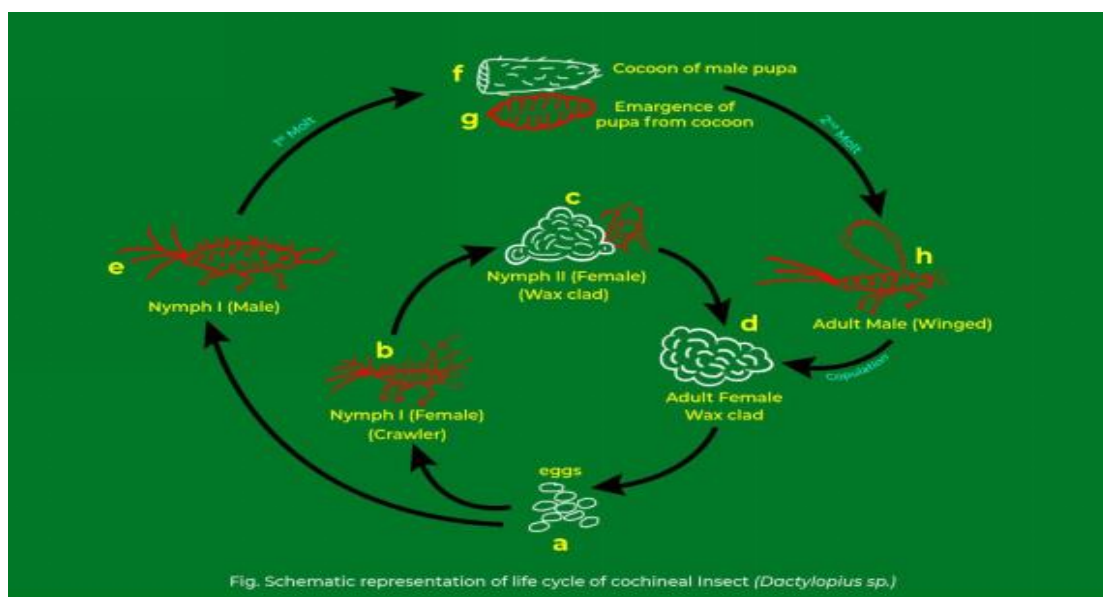


Figure 1 Schematic representation of the Life cycle of a cochineal Insect (*Dactylopius sp.*)

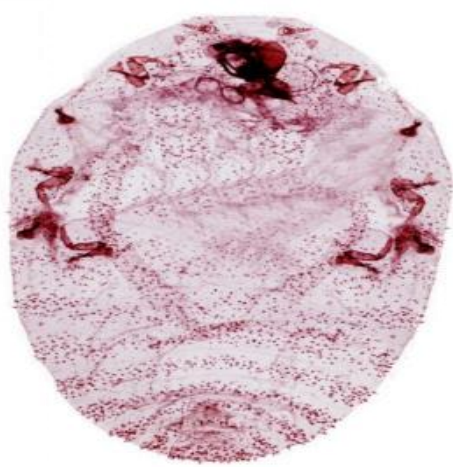


Fig. 2 Slide of mounted Female Insect



Fig. 3 Plant Infested by cochineal scale Insect



Figure 4. Fruiting Twig of *O. elatior* (Mill.).



Figure 5. Destroyed Vegetation due to Heavy Infestation

Discussion: -

To the best of our knowledge, this is the world's first record of *D. ceylonicus* infestation on *Opuntia elatior* Mill. Most of the plants died as the infestation progressed (Fig. No. 5). During the late 19th century and early 20th century, efforts were made in North and South India to control the invasion of *O. elatior* Mill., by using *D. ceylonicus*. Still, it did not establish itself on cladodes and no damage was caused to plants (Novoa et al. 2019). Surprisingly during our field survey, we noticed that *D. ceylonicus* has not only established itself and damaged some cladodes but caused extensive damage to the entire structure of *O. elatior* Mill.

The attack was localized in a very small part of Central India as *Opuntia* species are not cultivated for farming in Central India. Unfortunately, all *Opuntia* species are considered weeds, and common people and farmers are not aware of the economic benefits of *Opuntia* species. Hence, they grow only on barren land or in forests. Therefore, we found only localised attack of *D. ceylonicus* species as female insects of this species can't fly and only disperse passively using wind. Vegetation was sparsely distributed and other plants of the same species were not available in a radius of 5-6 km thus they couldn't establish themselves on other plants of the same species hence, infestation was found to be localised.

The attack by *D. opuntiae* on *O. elatior* has been known since it was first introduced in 1926 in India (Kumar 2015; ICARDA 2017). This same insect *D. opuntiae* also feeds on *O. ficus-indica* (L) Mill. In many countries, *O. ficus-indica* is considered a plant of economic importance and is cultivated for agricultural production, fodder production, and rural development for additional income (Novoa et al. 2019).

Several attempts were also made in India by BAIF Development Research Foundation Pune, CIAH Bikaner, CAFRI Jahnsi, and CSSRI Karnal to cultivate *O. ficus-indica* for food and fodder (Kumar et al. 2018). *D. opuntiae* feeds on both *O. elatior* and *O. ficus-indica* in many countries. Ethiopia has stopped cultivating *O. elatior* and *O. ficus-indica*, while others like Kenya are contemplating implementing biological control due to potential threats to cultivated plant species i.e. *Opuntia ficus-indica*. (Muniappan et al. 2009; ICARDA 2017; Novoa et al. 2019).

This novel finding of *D. ceylonicus* association with *O. elatior* might help in targeting the biological control of only *O. elatior* leaving *O. ficus-indica* unaffected. The possible reasons for host diversification by *D. ceylonicus* might be due to inadequate food availability. Climate change could also be another possible reason. Time is alarming for scientists to further investigate and focus on finding potential reasons behind the evolution of insects.

Conclusions:

As we have said earlier, to the best of our knowledge, this is the first record of infestation by cochineal scale insect *D. ceylonicus* on *O. elatior* Mill. from Central India. The attack was localized in a small place, so we can conclude that it is a case of host diversification and evolution by insect. This insect can be studied at the genome level and can be used in countries like Brazil, Tunisia, Mexico, Morocco, Malta, Spain, Italy, Cyprus, United States, Turkey, Bulgaria, France, Chile, Saudi Arabia, Israel, Portugal, Albania, Yemen, Lebanon, Egypt, Sicily, Greece, Libya etc. where *O. ficus indica* is used for commercial cultivation.

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