World's first record of infestation of Dactylopius ceylionicus (Green) (Hemiptera:Dactylopiidae) on Opuntia elatior Mill. (Cactaceae) from Central India

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Research Article

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Abstract

The attack of wild cochineal insect, *Dactylopius ceylionicus* (Green, 1869) (Hemiptera: Coccoideae : Dactylopiidae) has been reported for the first time on Red flower Prickly pear, *Opuntia elatior* Mill. (Cactaceae) from Central India. Voucher specimen of Insect sample was submitted to the National Bureau of Agricultural Insect Resources, Bangalore. Spatial distribution is localised to small region and has been shown on the map. Probable reasons for host diversification, evolution and possible economic benefits are discussed here and the need for further research has been emphasized.

Introduction

Genus Opuntia belongs to 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 as 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 as “Weeds of national significance” (Chinnock 2015).

O. elatior is known widely by its common name red flower prickly pear (Pasiecznik 2022). *O. elatior* was introduced as a part of cochineal trade in India during 1800s (Kumar 2015). It is the only species of Opuntia present in 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 ceylionicus is commonly known as ‘wild cochineal insect’. *D. ceylionicus* is one among 11 species of monogeneric family Dactylopiidae. All 11 species secrete carminic acid which Yield red coloured crimson dye (Bader and Abu-Alloush 2019).

In an attempt to establish cochineal dye industry, it was introduced mistakenly in India in place of 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 Andhra Pradesh, Bihar, Himachal Pradesh, Odhisa, Tamilnadu and West Bengal (García Morales M, Denno BD, Miller DR, Miller GL, Ben-Dov Y 2016)

D. ceylionicus is a family specific insect i.e it feeds on only one family 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. ceylionicus is characterised by unusual life cycle with female resembling hemimetabolous insect having three stages: egg, nymph, adult and male with holometabolous insect having four stages: egg, nymph, pupa, adult (Sullivan 1990)(Fig. 1) .We unexpectedly noticed the attack of *D. ceylionicus on O. elatior* Mill. while surveying cacti and succulents plant species.

To best of our knowledge, this research work is aimed at documenting w orld's first attack of *D. ceylionicus* (Green) on *O. elatior* Mill. and presenting its spatial distribution in Central India. Furthermore, to contemplate and put forward possible reasons behind host diversification and its possible economic benefits in countries where *Opuntia* is cultivated.

Materials And Methods

Study Area and Duration: -

Nagpur and Wardha districts are North Eastern and Eastern parts of Nagpur Division respectively, as demarcated by Revenue Department of Maharashtra state for administrative convenience. They together occupy prominent part of central India. Nagpur District is situated between latitudes $20^{o}35'$ and $21^{o}44'$ N and longitudes $78^{o}15'$ and $79^{o}40'$ E and Wardha district between $20^{o}18'$ and $21^{o}21'$N latitude and longitude $78^{o}4'$E to $79^{o}15'$ E. They together occupy surface area of 16,202 km^2. (Table 1)

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 during 10^{th} September 2021 to 1^{st} of 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. But we found only one species of Opuntia was infested by cochineal scale insect.

Out of total 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 elevation were recorded with the help of Global Positioning System(MAP 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 brush, then 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. ceylionicus* 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 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 National Bureau of Agricultural Insect Resources Bangalore, with the help of various keys and confirmed to be *Dactylopius ceylionicus.* The infestation was recorded only from one site i.e. Narsingpur from Ashti tehsil. Now it has been observed that, most of the plants died due to heavy infestation. (Fig. No.5)

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

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

Discussion

To the best of our knowledge this is world’s first record of *D. ceylionicus* infestation on *Opuntia elatior* Mill. Most of the plants died as infestation progressed. During late 19th century and early 20th century efforts were done in North and South India to control invasion of *O. elatior* Mill., by using *D. ceylionicus* but 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. ceylionicus* has not only established itself and damaged some cladodes but caused extensive damage to entire structure of *O. elatior* Mill.

The attack was localized in very small part of Central India as *Opuntia* species are not cultivated for farming in Central India. Unfortunately, all *Opuntia* species are considered as weed and common people

and farmers are not aware about economic benefits of *Opuntia* species. Hence, they grow only on barren land or in forest. Therefore, we found only localised attack of *D. ceylionicus* species as female insects of this species can't fly and only disperse passively by means of wind. Vegetation was sparsely distributed and other plants of same species were not available in radius of 5–6 kms and thus they couldn't establish themselves on other plants of same species hence, infestation was found to be localised.

The attack by D. opuntiae on O. elatior was known since when 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 as plant of economic importance and cultivated for agricultural production, fodder production and rural development for additional income(Novoa et al. 2019).

Number of 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).

As, *D. opuntiae* feeds on both *O.elatior* and *O. ficus-indica in* many counties. Ethiopia have stopped cultivation of *O.elatior* and *O. ficus-indica*, while others like Kenya are contemplating on 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. ceylionicus* association with *O. elatior* might help in targeting biological control of only O. *elatior* leaving *O. ficus-indica* unaffected. The possible reasons for host diversification by *D. ceylionicus* might be due to inadequate availability of food. 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 insect.

Conclusions

As we have said earlier, to the best of our knowledge, this is the first record of infestation by cochineal scale insect *D. ceylionicus* on *O. elatior* Mill. from Central India. Attack was localised in a small place, so we can conclude that it is the case of host diversification and evolution by insect. This insect can be studied at genome level and can be used in countries where *O. ficus indica* is used for commercial cultivation.

Declarations

Author Contributions:- Both Authors have contributed equally .

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Ethical Approval None required

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Map

Map 1 is available in the Supplementary Files section.

Figures

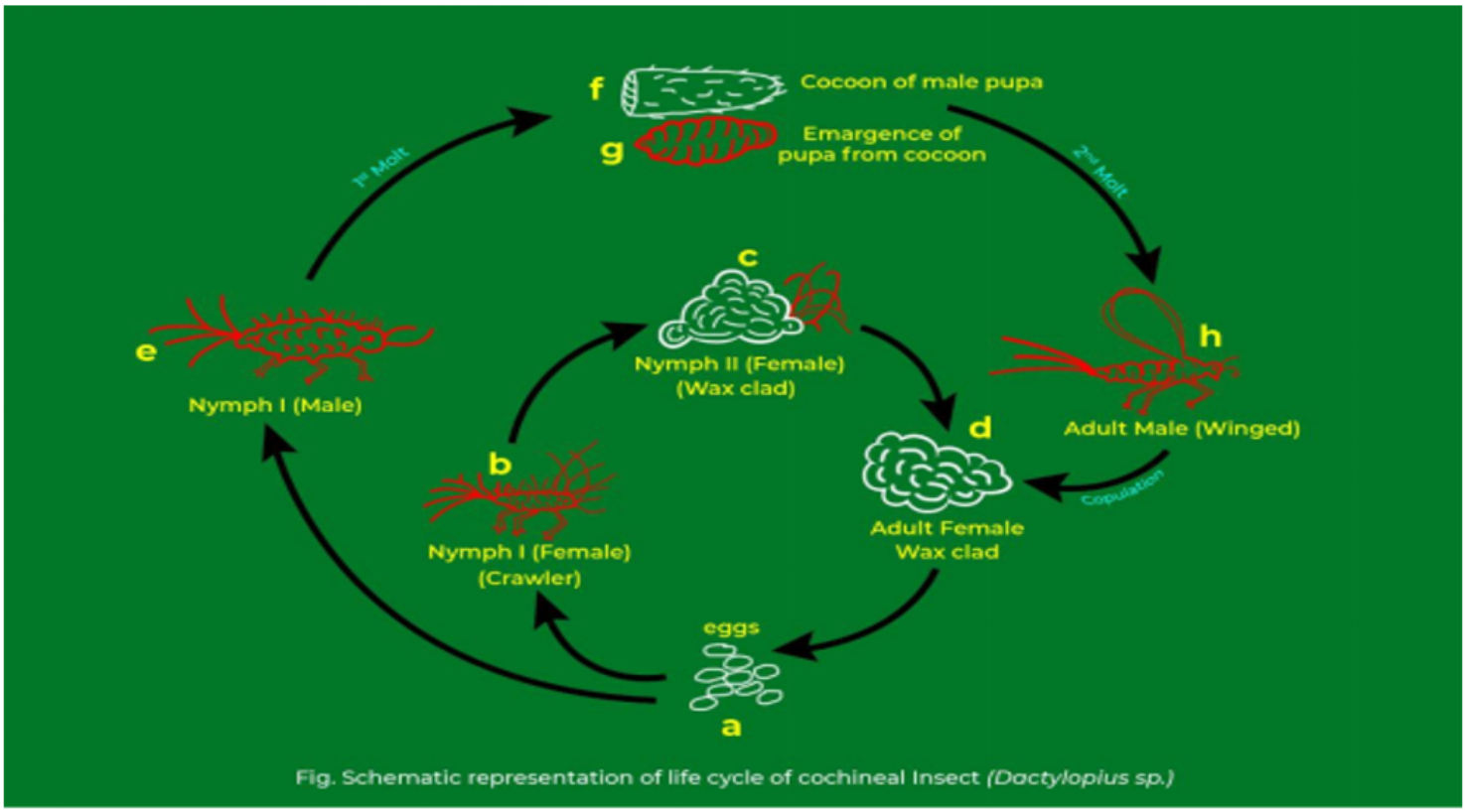

Figure 1

Schematic representation of Life cycle of cochineal Insect *(Dactylopius sp.*)

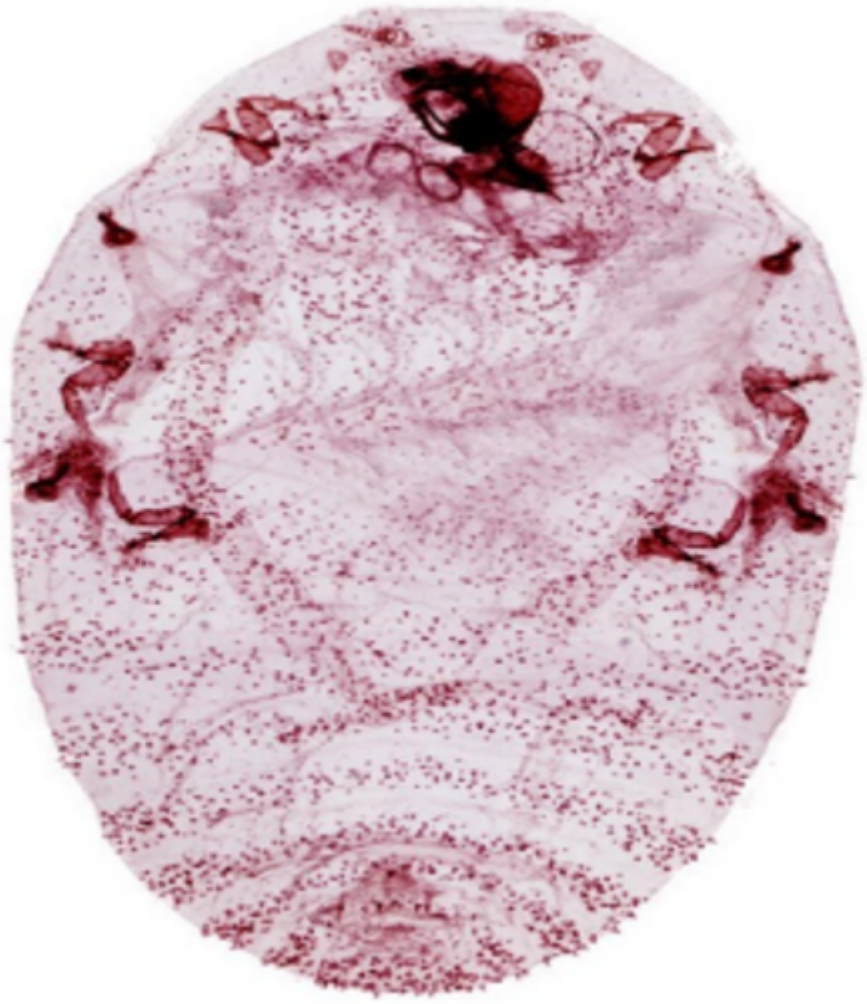

Figure 2

Slide of mounted Female Insect

Figure 3

Plant Infested by cochineal scale Insect

Figure 4

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

Figure 5

Destroyed Vegetation due to Heavy Infestation

Supplementary Files

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- MAP1.png