

Natural enemies associated with *Dactylopius opuntiae* (Cockerell) (Hemiptera: Dactylopiidae) in Morocco and their population fluctuations

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Abstract

Dactylopius opuntiae (Cockerell) (Hemiptera: Dactylopiidae) is the most important pest of prickly pear cactus *Opuntia ficus-indica* in Morocco in recent years. In order to identify the natural enemies associated with this pest, and determine their population fluctuations, samplings were carried out at two distinct areas, sampling area 1: Zemamra in the Sidi Bennour region (120 km north-west of Marrakech), Morocco and sampling area-2: Gharbia in the same region. 15 species were found and identified: *Episyrphus balteatus* de Geer, *Eupeodes corollae* Fabricius (Diptera: Syrphidae), *Hyperaspis campestris* (Herbst, 1783), *Scymnus interruptus* (Goeze), *Scymnus loewii*, *Nephus redtenbacheri* (Mulsant, 1846), *Scymnus latemaculatus*, *Scymnus guttulatus* LeConte, *Exochomus nigripennis* (Erichson, 1843), *Coccinella septempunctata* (Linnaeus, 1758), *Hippodamia convergens*, *Chilocorus bipustulatus* (Linnaeus, 1758), *Chilocorus politus* (Mulsant, 1850) (Coleoptera: Coccinellidae) and *Emmelina monodactyla* (Lepidoptera: Pterophoridae). *Hyperaspis campestris* was found to be the most important specie associated with *D. opuntiae* in study area-1 and *Chilocorus bipustulatus* in study area 2.

Keywords: *Dactylopius opuntiae*, *Hyperaspis campestris*, *Chilocorus bipustulatus*, biocontrol

Ennemis naturels associés à *Dactylopius opuntiae* (Cockerell) (Hemiptera: Dactylopiidae) au Maroc et leurs fluctuations démographiques

Résumé

Dactylopius opuntiae (Cockerell) (Hemiptera: Dactylopiidae) est le principal ravageur du cactus *Opuntia ficus-indica*, au Maroc, ces dernières années. Afin d'identifier les ennemis naturels associés à cet insecte nuisible et de déterminer leurs fluctuations démographiques, des échantillonnages ont été effectués dans deux zones distinctes durant deux années 2017- 2018, la zone d'échantillonnage 1- Zemamra dans la région de Sidi Bennour (120 km au nord-ouest de Marrakech), au Maroc et zone d'échantillonnage 2- Gharbia localité dans la même région. 15 espèces ont été trouvées et identifiées: *Episyrphus balteatus* de Geer, *Eupeodes corollae* Fabricius (Diptera: Syrphidae), *Hyperaspis campestris* (Herbst, 1783), *Scymnus interruptus* (Goeze), *Scymnus loewii*, *Nephus redtenbacheri* (Mulsant, 1846), *Scymnus latemaculatus*, *Scymnus guttulatus* LeConte, *Exochomus nigripennis* (Erichson, 1843), *Coccinella septempunctata* (Linnaeus, 1758), *Hippodamia convergens*, *Chilocorus bipustulatus* (Linnaeus, 1758), *Chilocorus politus* (Mulsant, 1850) (Coleoptera: Coccinellidae) and *Emmelina monodactyla* (Lepidoptera: Pterophoridae). *Hyperaspis campestris* s'est révélé être l'espèce la plus importante associée à *D. opuntiae* dans la zone d'étude 1 et à *Chilocorus bipustulatus* dans la zone d'étude 2.

Mots-clés: *Dactylopius opuntiae*, *Hyperaspis campestris*, *Chilocorus bipustulatus*, biocontrôle

INTRODUCTION

As a result of drought, the cactus cultivation in Morocco has evolved significantly in the past two decades, from 50 000 ha in 1998 to more than 120 000 ha at present. The region of Guelmin-Sidi Ifni accounts for over 50% (> 50000 ha) of the national cactus area, followed by Haouz-El Kelaa of the Sraghnas with 30% (about 33 000 ha). Khourigba is in third place (12000 ha) and Doukkala fourth (about 1500 ha) (Anonymous, 2009). Cactus is represented in the Moroccan rural landscape in anarchic plantations in almost all villages and douars, in hedges bordering cultivated lands, orchards or trails. Cactus has become widely appreciated by a large majority of farmers for its fruit and forage production. Also, a considerable effort to support planting and valorization of the cactus

has been deployed by the Ministry of Agriculture in different regions of the Morocco. Through investment by the Ministry and the farmers' commitment to cultivate the cactus, the target of reaching a target area of 160 000 for 2020 has already been achieved (MAPMDREF, 2016). Unfortunately, the sustainability of this extremely resilient ecosystem has become seriously threatened by the appearance of an invasive and devastating pest of the cactus, *Dactylopius opuntiae*. This cochineal which is specific to cacti (Bouharroud *et al.*, 2016), was introduced in Morocco in 2014. Since its appearance in Sidi Bennour-Doukkala region, it has caused enormous damage in several areas of the cactus cultivation. The spread of the infestation by this pest is fast and unpredictable, and consequently, the destruction of large areas planted with cactus in several regions of Morocco, in particular in Doukkala, Rhamna,

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Bengrir, Abda, Azilal, Benimellal, Taourirt, Haouz and Chaouia where tens of thousands hectares of cactus were totally destroyed, causing enormous socio-economic and environmental losses. Similar cases have been reported by Lopes *et al.* (2009), when *D. opuntiae* attacked a fodder species of cactus, *Opuntia ficus indica*, in Brazil where 100,000 ha were damaged, estimated at about \$ 25 million.

Given the urgency of the cochineal, and in order to prevent further spread of the pest, the Moroccan Ministry of Agriculture has set in place a major emergency plan for the control of this pest in 2016. This plan also included a research program covering the most important management components (host plant resistance, biopesticides and beneficial insects). Features of *D. opuntiae*, such as soft body, slow movement and most importantly, feeding in groups, make these pests easy preys for natural enemies (Ebling, 1959). The aim of this study was to identify the natural enemies of *D. opuntiae* and their activity periods in Morocco.

MATERIAL AND METHODS

After the first record of *D. opuntiae*, surveys have been conducted in different production areas of cactus in order to identify natural enemies with potential as a biological control agents during 2017-2018. The collection, sampling, stretching, pinning, labeling and preservation methods for the study of adult, larvae, and pupa stages of natural enemies were made according to Gullan and Cranston (2004 and 2010). The identification of the specimens was done using the following keys: Canepari *et al.* (1985), Fursch (1992), Brunetti (1923), Vockeroth (1969),

Stubbs and Falk (1996), Van Veen (2004), Speight (2005), DeGroot and Govedic (2008) and Gielis (1990).

To determine population fluctuation of natural enemies associated with *D. opuntiae*, samplings were carried out at two distinct areas, about 15 kilometers apart: sampling area 1- Zemamra locality in the Sidi Bennour region (120 km North-West of Marrakech), Morocco and sampling area 2- Gharbia locality in the same region. In each sampling date, 2500 m² of infested plants were checked and the collected natural enemies were transferred to the laboratory in test tube containing 95% ethanol (Alizadeh *et al.*, 2013). Then they were identified and counted. Voucher specimens of identified natural enemies were labeled and deposited at the laboratory of entomology at National Institute of Agronomic Research (INRA-Agadir).

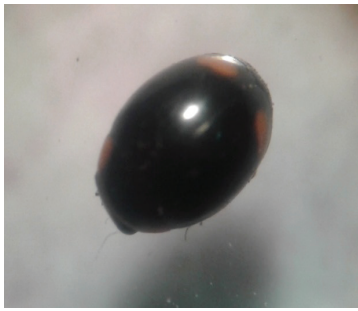
RESULTS AND DISCUSSION

In this study, a total of 14 species belonging to three orders and three families of natural enemies associated with *D. opuntiae* were identified: *Episyrphus balteatus* de Geer, *Eupeodes corollae* Fabricius (Diptera: Syrphidae), *Hyperaspis campestris* (Herbst, 1783), *Scymnus interruptus* (Goeze), *Scymnus loewii*, *Nephus redtenbacheri* (Mulsant, 1846), *Scymnus latemaculatus*, *Scymnus guttulatus* LeConte, *Exochomus nigripennis* (Erichson, 1843), *Coccinella septempunctata* (Linnaeus, 1758), *Hippodamia convergens*, *Chilocorus bipustulatus* (Linnaeus, 1758), *Chilocorus politus* (Mulsant, 1850) (Coleoptera: Coccinellidae) and *Emmelina monodactyla* (Lepidoptera: Pterophoridae) (Table 1 and Figure 1).

Table 1. Field and laboratory observations about the feeding of predators of *D. opuntiae*

Natural enemies	Development stages of <i>Dactylopius opuntiae</i>		
	1 st instar nymphs	2 nd instar nymphs	Adult
<i>Episyrphus balteatus</i> larvae	+	+	-
<i>Eupeodes corolla</i> larvae	+	+	-
<i>Hyperaspis campestris</i> adults	+	+	-
<i>Scymnus interruptus</i> adults	+	+	-
<i>Nephus redtenbacheri</i> adults	+	-	-
<i>Exochomus nigripennis</i> adults	+	+	-
<i>Chilocorus bipustulatus</i> adults	+	+	+
<i>Emmelina monodactyla</i> adults	-	-	-
<i>Coccinella septempunctata</i> (larvae and adults)	-	-	-
<i>Emmelina monodactyla</i> larvae	+	+	-
<i>Scymnus latemaculatus</i> adults	+	+	-
<i>Scymnus guttulatus</i> adults	+	+	-
<i>Hippodamia convergens</i> adults	+	+	-
<i>Chilocorus politus</i> adults	+	+	+
<i>Scymnus loewii</i> adults	+	+	-

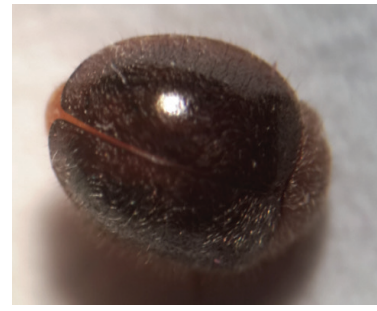
+ : They feed. - : They do not feed.



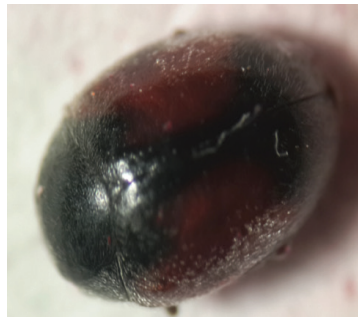
Hyperaspis campestris



Chilocorus bipustulatus



Exochomus nigripennis



Scymnus interruptus



Nephus redtenbacheri



Eupeodes corolla



Episyrrhus balteatus



Emmelina monodactyla



Emmelina monodactyla larvae



Chilocorus politus



Scymnus latemaculatus



Hippodamia convergens



Scymnus guttulatus



Coccinella septempunctata



Scymnus loewii

Figure 1. Natural enemies associated with *D. opuntiae* in two study areas in Morocco

Many natural enemies were found associated with *D. opuntiae* around the world, among them are immature stages of Lepidoptera, Coleoptera, Diptera and Neuroptera (Vanegas Rico *et al.*, 2010, Grissell, 2004). The main natural enemies of *D. opuntiae* reported in the literature have been found in Mexico. In this study, the coccinellid *H. campestris* was found to be the most important specie associated with *D. opuntiae* in study area-1, and *C. bipustulatus* in study area-2. Other species were also observed, but with low populations and during a short period of time (Figure 2 and Figure 3).

We have observed that adults of *H. campestris* and *C. bipustulatus* feed on both first and second instar nymphs of *D. opuntiae*. Other species of *Hyperaspis* and *Chilocorus* have been reported feeding on *D. opuntiae*. *Hyperaspis trifurcata* is a highly specific predator on the *Dactylopius* genus (Gilreath and Smith, 1988). Vanegas-Rico *et al.* (2010) have reported that *H. trifurcata* preys on all developmental stages of Dactylopiidae. Also, *Chilocorus cacti* and *H. trifurcata* are the most abundant natural enemies associated with the genus *Dactylopius* in Mexico and USA (Vanegas-Rico *et al.*, 2016). All-natural enemies identified

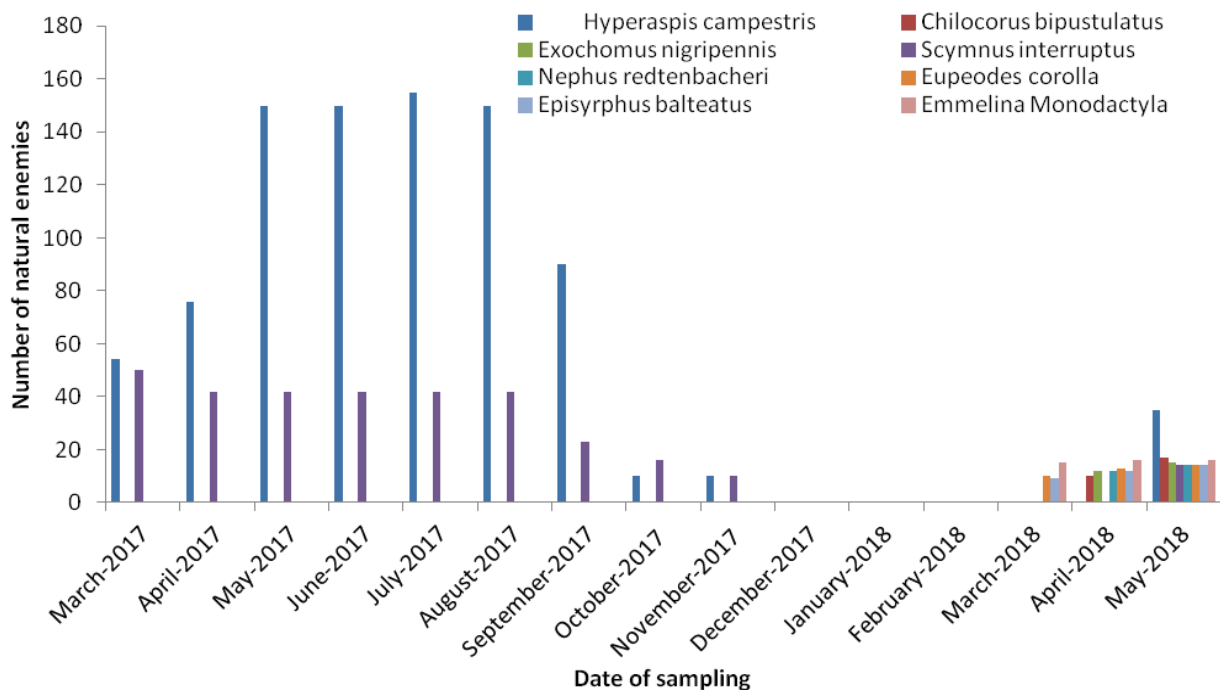


Figure 2. Population fluctuations of natural enemies of *D. opuntiae* in 2017-2018, at sampling area 1 in Morocco

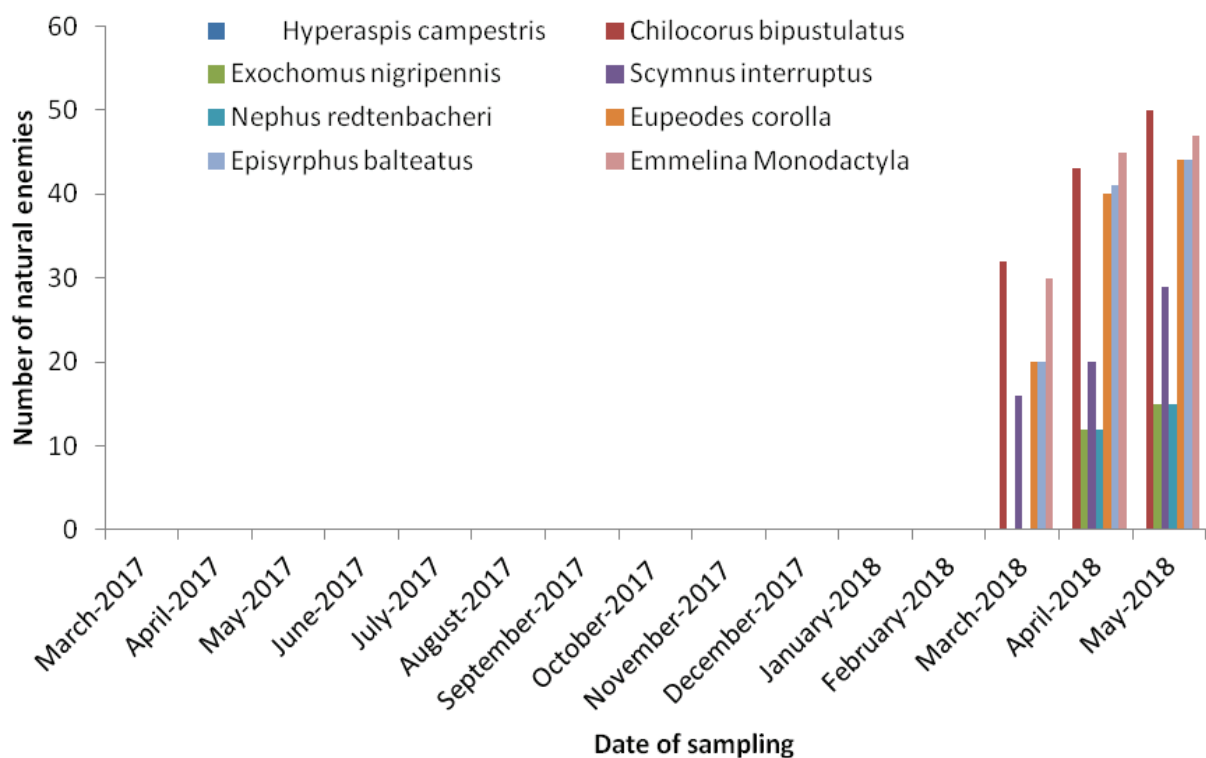


Figure 3. Population fluctuations of natural enemies of *D. opuntiae* in 2017-2018, at sampling area 2 in Morocco

started to build up activity from end of March (Figures 2 and 3). During winter, no natural enemies were found in the samples. In May 2018, *E. balteatus* de Geer, *E. corollae* Fabricius (Diptera: Syrphidae), *S. interruptus* (Goeze), *N. redtenbacheri* (Mulsant, 1846), *E. nigripennis* (Erichson, 1843), *C. bipustulatus* (Linnaeus, 1758) (Coleoptera: Coccinellidae), and *E. monodactyla* were observed together and in high populations (Figures 2 and 3). Also, from early May 2018, a high number of *E. monodactyla* pupa and larvae were observed in infested cladodes in study area-2. Populations of *E. balteatus* de Geer, *E. corollae* Fabricius (Diptera: Syrphidae) and *E. monodactyla* were lower at study area-1 compared to study area-2. In contrast, the population of *E. nigripennis* was lower in study area-2. In Brazil, several groups of predators of which *Exochomus* sp, *Chilocorus* sp, *Cryptolaemus* sp, *Hyperaspis* sp, and *Scymnus* sp have been consistently observed associated with colonies of *D. opuntiae* (Baskaran *et al.*, 1999; Adalma-Aguilera *et al.*, 2005; Vanegas-Rico *et al.*, 2010; Barbosa *et al.*, 2014). The *C. septempunctata* (Linnaeus, 1758) larvae and adults were also observed associated with *D. opuntiae* in the field in the two study areas, but they do were not observed feeding. A few number of *H. convergens*, *C. politus*, *S. latemaculatus*, *S. guttulatus*, and *S. loewii* adults were also found actively feeding on *D. opuntiae* nymphs in the field in study area-1 (Table 1, Figure 1). It is important to note that many abiotic and biotic factors can affect the presence and the distribution of natural enemies. The presence of other crops around the cactus crop also can play a role in change of natural enemies feeding preference. All the predators found in Morocco may contribute to the control of *D. opuntiae*. However, because *H. campestris* and *Chilocorus bipustulatus* sp. were found in high populations during longer periods of activity could be more effective than the other natural enemies and could be mass produced for biocontrol of this mealybug.

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