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On a finding of the ladybird *Clitostethus arcuatus* (Coleoptera: Coccinellidae) in citrus orchards infested by *Aleurothrixus floccosus* (Hemiptera: Aleyrodidae) at Pica Oasis and Matilla, Tarapacá Region, Chile

Hallazgo de Clitostethus arcuatus *(Coleóptera: Coccinellidae) en huertos de cítricos infestados por* Aleurothrixus floccosus *(Hemíptera: Aleyrodidae) en el Oasis de Pica y Matilla, Región de Tarapacá, Chile*

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ABSTRACT

We report the presence of ladybird *Clitostethus arcuatus* (Rossi) (Coleoptera: Coccinellidae) in citrus orchards infested by the woolly whitefly *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae) at Pica Oasis and Matilla, Tarapacá Region, Chile. In addition, we describe some aspects of its behavior and suggest it use in augmentative control biological programs to management whiteflies populations in desert agroecosystems.

Keyword: Classical biological control, host plant, pests, predator.

RESUMEN

Informamos la presencia de Clitostethus arcuatus *(Rossi) (Coleóptera: Coccinellidae) en huertos de cítricos infestados por la mosquita blanca algodonosa* Aleurothrixus floccosus *(Maskell) (Hemíptera: Aleyrodidae) en el Oasis de Pica y Matilla, Región de Tarapacá, Chile. Adicionalmente, describimos algunos aspectos de su comportamiento y sugerimos su uso en programas de control biológico aumentativo para el manejo poblacional de mosquitas blancas en agroecosistemas desérticos.*

Palabras clave: *Control biológico clásico, planta hospedera, plagas, depredador.*

Introduction

The ladybird *Clitostethus arcuatus* (Rossi) (Coleoptera: Coccinellidae) is the most effective Aleyrodids predator (Yazdani and Samih, 2012), widely distributed in the Palearctic and surrounding regions, including Italy, France, Turkey, Morocco, Greece, Egypt, Syria, Iran, Iraq and America (Argentina, Bolivia, California, Chile and Peru) (Tavadjoh *et al*., 2010; Iqbal *et al*., 2018; Akhatov and Korotyaev, 2019; González, 2021). In Chile, *C. arcuatus* was introduced in 1995 to control the ash whitefly *Siphoninus phillyreae* (Haliday) (Hemiptera: Aleyrodidae) infesting ornamental and olive (*Olea europaea* L.) trees (Ripa and Larral, 2008). Years later, *C. arcuatus* has settled in Arica (Azapa Valley), Huasco and Santiago, at the Arica and Parinacota, Coquimbo and Metropolitan Regions, respectively (Ferrú and Elgueta, 2011; González, 2021).

The coccinelid *C. arcuatus* prefers feed on whiteflies specie as *S. phillyreae* (Haliday), *Bemisia tabaci* (Gennadius), *Trialeurodes vaporariorum* (Westwood), *Dialeurodes citri* (Ashmead), *Aleurodes proletella* (Linnaeus), *Trialeurodes lauri* (Signoret) and *Aleurocanthus spiniferus* (Quaintance) (Tsagkarakis, 2012; Cioffi *et al*., 2013; Akhatov and Korotyaev, 2019); even it has been reported feeding on eggs of *Tetranychus urticae* Koch (Acari: Tetranychidae), aphids, and scales (Tabadjoh *et al*., 2010; González, 2021).

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Furthermore, *C. arcuatus* is also found on citrus trees preying on the woolly whitefly *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae) in Greece, Italy, and Spain (Katsoyannos *et al*., 1997; Alvis *et al*., 2002; Gasparini *et al*., 2007). Ripa and Larral (2008) inform the occasional presence of *C. arcuatus* on citrus plants attacked by *A. floccosus* in the Valparaiso Region of Chile.

The woolly whitefly *A. floccosus* is present in northern and central regions of Chile (Klein Koch and Waterhouse, 2000). At the Pica Oasis localized in the northern region, *A. floccosus* record until seven generations per year, affecting persistently citrus orchards, being the most important foliar pest (Tello *et al*., 2019). The damage caused by *A. floccosus* is due to its feeding behavior. This insect uses its stylet to piercing the plant tissue and secreted of woolly filaments and honeydew, weakening citrus trees by sooty molds grow, affecting leaves and fruits. This whiteflies complete their life cycle on the abaxial surfaces of leaves, laying eggs, and then the sedentary nymphal stages covering the leaf surface with large amount of honeydew and filaments, affecting the performance of biological control agents (Ripa and Larral, 2008; Rioja *et al*., 2021).

At the Pica Oasis, there are parasitoid species such as the micro-wasp aphelinids *Cales noacki* Howard, and *Eretmocerus paulistus* Hempel (Hymenoptera: Aphelinidae), and *Amitus spiniferus* (Brèthes) (Hymenoptera Platygasteidae) (Tello *et al*., 2014); but their effectiveness is affected by an excess of woolly substances and honeydew. There are no reports of predators specialized on *A. floccosus* at the Pica Oasis.

In the search of potential predators for *A. floccosus*, we collected to the exotic ladybird *C. arcuatus* naturally colonizing citrus orchards infested by the woolly whitefly *A. floccosus* at the Pica Oasis (19º58' S, 69º46' W; 1117 m. a. s.l.) and Matilla locality (20º32' S, 69º21' W; 1325 m. .a s. l.), Tarapacá Region, Chile.

Adults of *C. arcuatus* were collected using a manual entomological aspirator, and maintained at laboratory conditions (Figure 1 A-F). The predators were released on eggplant (*Solanum melongena* (L.) var. early long purple) leaves infested by *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), into Petri dishes. *Clitostethus arcuatus* females laid one-off eggs cream-colored and ovoid on eggplant leaves. The immatures stage is called "larvae" demonstrated limited movement, and they attached to the leaves using a sucker-like structure of the last ventral abdominal segment (Figure 1G); this helps them as a safe support to complete their development until the pupa stage on the abaxial surface of the leaves (Figure 1H). In preliminary tests to check alternative host plants, the emerged adults (first generation) were released on tomato (*Solanum lycopersicum* L.) cv. Micro-Tom, broadleaf plantain (*Plantago major* L.), sweet potato (*Ipomoea batatas* (L.)) and common bean (*Phaseolus vulgaris* L.) cv. Magnum plants attacked by *B. tabaci* finding that *C. arcuatus* settled on broadleaf plantain and eggplants plants, where their offspring (second generation) completed it biological cycle.

In the field, the adults and larvae of *C. arcuatus* were mainly found in new shoots with yellowish green leaves and sucker-branch infested by adults of *A. floccosus* (Figure 2A-C). This behavior ensures the development of the larvae feeding on eggs and nymphs of whiteflies, before that, they completely covered the underside of the citrus leaves with filaments and honeydew secreted by nymphs and adults of *A. floccosus*, making it difficult for predators to move and foraging (Figure 2D-E). Thus, the populations of *C. arcuatus* were increased shortly after that adults of *A. floccosus* colonized citrus trees.

On the other way, adults of *C. arcuatus* showed sensitive to vibrations in the citrus leaves caused by external agents, reacting and jumped into space to avoid presumably bigger predators. This behavior occurred when we touched leaves to collect adults of *C. arcuatus*.

Our record of natural colonization of *C. arcuatus* on citrus orchards attacked by *A. floccosus* is important, because the Pica Oasis and Matilla are localized in the Atacama Desert with barriers difficult to trespass for it. Presumably, predators may have been unintentionally introduced by the exchange of plants between regions. In addition, their adaptability to arid agroecosystems is interesting to exploit it, inside the context of augmentative biological control, verifying their establishment in citrus orchards, and that the initial classical biological control for which it was introduced to Chile it worked.

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Figure 1. Stages of *Clitostethus arcuatus* (Rossi) (Coleoptera: Coccinellidae) on citrus leaves. (A-D) Lateral and dorsal view of adults. (E) Adult feed on eggs, (F) Sexual dimorphism, copula of *C. arcuatus*. (G) Dorsal view of larva, and (H) pupa of the ladybird.

Figure 2. *Aleurothrixus floccosus* (Hemiptera: Aleyrodidae) on citrus trees. (A-C) Adults and egg laying in the shape of semicircle. (D-E) Heavy infestation of *A. floccosus* on adaxial surfaces of citrus leaves, with excess of woolly filaments and honeydew secreted by sedentary nymphal stages.

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