SCIENTIFIC PAPER

Quadrastichus mendeli IN MEXICO: ¿THE BEGINNING OF AN IMP AGAIN *Leptocybe invasa sensu lato* AT THIS COUNTRY? (HYMENOPTERA: EULOPHIDAE)

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Quadrastichus mendeli IN MEXICO: ¿THE BEGINNING OF AN IMP AGAIN *Leptocybe invasa sensu lato* AT THIS COUNTRY? (HYMENOPTERA: EULOPHIDAE)

Quadrastichus mendeli en México: ¿El inicio de un MIP otra vez *Leptocybe invasa sensu lato* en este país? (Hymenoptera: Eulophidae)

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ABSTRACT. *Leptocybe invasa* is a worldwide pest of eucalypts in many forestry regions. This wasp causes galls, weakening and even killing young trees. Classic biological control with parasitoids is developed in some countries, but in Mexico is a slow process introducing them. We report the presence of the parasitoid *Quadrastichus mendeli* in Mexico, a biocontrol agent used against *L. invasa* that has spread naturally. Biology of both species, in addition to other studies, suggest the possibility of implement an Integrated Pest Management in Mexico's urban areas, as a preventive way before the pest arrival and infests the eucalypts forestry zones.

Palabras clave: *Eucalyptus camaldulensis*, Mexico City, urban pest.

RESUMEN. *Leptocybe invasa* es una plaga de eucaliptos mundialmente distribuida en varias de las regiones con plantaciones de eucaliptos. Esta avispa causa agallas, lo que debilita e inclusive causa la muerte de árboles jóvenes. El control biológico clásico con parasitoides se desarrolla en algunos países, aunque en México, es un proceso lento para introducirlos. Se reporta por primera vez la presencia del parasitoide *Quadrastichus mendeli* in México, un agente de control biológico usado contra *L. invasa* que se está dispersando naturalmente. La biología de ambas especies es adición con otros estudios, sugiere la posibilidad de implementar un Programa de manejo de plagas en áreas urbanas como una forma preventiva antes de que esta plaga llegue e infeste las zonas de plantaciones forestales de eucaliptos.

Keywords: *Eucalyptus camaldulensis*, Ciudad de México, plaga urbana.

INTRODUCTION

Eucalypts are native to Oceania, with wide distribution induced in the tropical and subtropical regions of the world (Turnbull, 1999).

This presence is encouraged by the paper, wood and charcoal industry, and to a lesser extent for reforestation or as an ornamental tree (Turnbull, 2000). In the last twenty years, some insects associated with eucalypts have colonized the regions of the world where these trees develop, causing ecological and economic losses (Paine *et al*., 2011; Hurley *et al*., 2016).

The eucalyptus gall wasp *Leptocybe invasa* Fisher & La Salle (Hymenoptera: Eulophidae) is a pest that develops galls on branches, leaves and petioles, reducing the vitality of woodlands, mainly in young plants (Mendel *et al*., 2004). The presence of this insect stopped the production of eucalyptus greenhouses in Israel (Mendel *et al*. 2004), and damage was also recorded in plantations in Africa and Asia (Wu *et al*., 2009).

In America, the pest was detected in Argentina (Aquino *et al*., 2011), Brazil (Costa *et al*., 2008), Chile (SAG, 2020a), Mexico (Vanegas-Rico *et al*., 2015), Paraguay (Benítez *et al*., 2014), USA (Wiley and Skelley, 2008), and Uruguay (Jorge *et al*., 2014). Molecular studies with various countries surveyed (not including Mexico) suggest a species complex (Nugnes *et al*., 2015; Dittrich-Schröder *et al*., 2018).

Due to the damage caused by these wasps, natural

enemies were searched in their region of origin, where new species of parasitoids were obtained and described (Kim *et al*., 2008).

The effectiveness of these wasps was recorded in Israel and this breeding technology was subsequently transferred to South Africa and India (Mitutu *et al*., 2009). Biological control management actions in the Americas began in Brazil (Masson *et al.,* 2017), Chile (SAG, 2020b) and Uruguay (Martínez-Crosa *et al*., 2019) with the importation of these parasitoids, while in Mexico the management continues in the monitoring stage with yellow traps.

This management situation is due, in part, to the trilateral agreements with Canada and the USA; they must approve the introduction of exotic organisms. In addition, quarantine procedures are required, which are described in detail by other authors in other regions of the world (Mutitu *et al*., 2009).

This last aspect is one limitation in the biological control programs on the cryptic complex *L. invasa* (Huang *et al*., 2018). Therefore, the search for natural enemies present in Mexico could facilitate the development of an integrated pest management program on this wasp.

Material and Method

Study area. Monthly surveys (Feb 2018-Feb 2019) were made in the urban trees *Eucalyptus camaldulensis* Dehnhardt from five sites (Table 1), where the pest was originally detected (Vanegas-Rico *et al*., 2015). Climatic data at the surveyed period of 11.0 ± 0.5 ºC media temperature, Min 3 ºC Max 24.4 ºC, and pluvial of 84.4 ± 22.4 mm. Ten trees were randomly selected, and four branches of 20 cm (at a height between one and two meters) were collected with the presence of galls and they were kept in hermetic plastic bags at room temperature (Vanegas-Rico *et al*., 2015).

Only in Texcoco did sampling continue in the same trees, due to the disposition of the galls. Additional surveys of six total specimens of *Eucalyptus globulus* Labill. (four in Gustavo A. Madero, and two in Nezahualcoyotl) to search parasitoids; in Feb 2020 additional samples were surveyed in the same positive and 20 negative trees surveyed per site (except in Texcoco). The insects obtained were preserved in ethanol and reviewed with Kim *et al*. (2008) keys. Some specimens collected in 2018 were sent to specialist Zvi Mendel (Volcani Center, Israel) for corroboration. Specimens of 2020 was compared with personal collection.

Statistical analysis. Parasitism percentage estimated: number of parasitoids obtained / total emerged insects (pest + parasitoid) (Huang *et al*. 2018) per site and month. Due to few positive samples, five leaves with galls (petiole or central vein) per positive trees (with parasitoids) were additional sampled monthly, and testing using a *Chi* square, (probability of 0,05) in SPSS 23 software (IBM, 2015); also, a Mann-U test to compare proportion of parasitism in survey of Feb 2019 versus Feb 2020.

Results and Discussion

Parasitoids of *L. invasa* were obtained only in Nezahualcoyotl, in four of the surveyed trees. These insects emerged of *Eucalyptus camaldulensis* Dehnhardt, from May 2018 and the next months. The parasitoids obtained corresponded to the species *Quadrastichus mendeli* Kim & La Salle (Eulophidae) (Fig. 1), is a beneficial entomophagous present in at least ten countries in the world whose distribution has increased during the years 2015 to 2017 (Huang *et al*., 2018).

The percentage of parasitism in 2018-2019 ranged between 0 and 3.6 ± %; in the surveys of 2020 continued the parasitoid presence in the same trees and additional eight trees with parasitism percentage of 1.5 ± 0.2 to 8.4 ± 0.6% (Table 2). There's no difference between parasitism inter year (χ = 5,273, P = 0.982) but comparison between host surveyed in Feb 2020 was lightly mayor (χ = 3, P = 0.013) than Feb 2019.

Their range of parasitism in Mexico were similar to records (3-10.9 %) in different regions of China (Huang *et al*., 2018); however, can be considered as low parasitism compared to the range of 30.2 ± 8.1 to 50.5 ± 6.2 in fields in Italy (Nunges *et al*., 2016), and Argentina 4.3 to 79.8% (Aquino *et al*., 2018); also compared with laboratory tests: 7.9-84.2% (Kim *et al*., 2008), 58.6-79.3% (Shivaraju,

2012) and 81.7-94.0% (Shylesha, 2008). The differences between these parasitism values can be related to innate biotic factors of insects (Sagtongpraow and Charersom, 2019), in addition to abiotic factors, since the presence of *L. invasa* in the Valley of Mexico occurs at an altitude of 2240 m, the highest record so far for both wasps in the world. It is intended to continue monitoring to find more associated parasitoids in other states of the Mexican Republic where the pest was recently registered.

Table 1. Surveys sites of urban *Eucalyptus* in Mexico Valley

State	Municipality	Locality	Coordinates
Mexico City	Gustavo A. Madero	Deportivo Los Galeana Park	19º 28’ 34” N, 99º 04’ 33” W
	Gustavo A. Madero	Bosque de Aragón Park	19º 27’ 40” N, 99º 04’ 17” W
	Venustiano Carranza	Street garden	19º 27’ 09” N, 99º 06’ 52” W
State of Mexico	Nezahualcoyotl	Street garden	19º 27’ 12” N, 99º 02’ 58” W
	Texcoco	Chapingo University	19º 29’ 38” N, 98º 53’ 40” W

Figure 1. Lateral view of *Quadrastichus mendeli*, and frontal view of head. 0,5 mm scale.

Table 2. Percentage of parasitism of *Quadrastichus mendelli* in Nezahualcoyotl

Year	Months Media ± (S.E.)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dic	Total
2018	*	0 (-)	0 (-)	0 (-)	2.1 (0.0)	3.0 (0.2)	1.3 (0.3)	1.3 (0.2)	2.3 (0.2)	2.0 (0.3)	2.5 (0.4)	2.1 (0.4)	1.5 (0.2)
2019	3.2 (0.3)	3.6 (0.3)		*	*	*	*	*	*	*	*	*	3.4 (0.3)
2020	6.3 (0.4)	4.8 (0.4)	8.4 (0.6)	1.5 (0.2)	*	*	*	*	*	*	*	*	5.2 (0.4)

*not surveyed months

The proximity of airport (less than 300 lineal meters), making it feasible to enter through this way, as occurred in Italy (Nugnes *et al*., 2016) and possibly also in South Africa (Bush *et al*., 2017).

In Argentina, *Q. mendelli* was surveyed since 2016, and later recorded (Aquino *et al*., 2018), these authors even mention breeding attempts in Chile with material imported from Israel.

In Mexico, until now, there has only been one biological control program for these Myrtaceae, developed against *Glycaspis brimblecombei* Moore, the cost-benefit of which resulted in a successful campaign (Cibrián-Tovar, 2015).

Greenhouse studies suggest that there may be compatibility of systemic insecticides with the release of this parasitoid, because the effectiveness of these products occurs on young populations of the pest (Luna-Cruz *et al*., 2020), while the parasitoid preferably selects mature galls that have larvae close to the pupal stage (Kim *et al*., 2008), period in which the systemic insecticide would no longer have an effect (Luna-Cruz *et al*., 2020).

CONCLUSION

Fortuitous presence of the parasitoid *Q. mendeli* can be an opportunity to start a classic biological control program on *L. invasa* in Mexico. Today, this pest has not infested the forestry zones; searching for more sites with this parasitoid would facilitate the development of a mass breeding and subsequent release tests. International cooperation is a critical factor for forest pest control, the positive communication that is maintained with researchers from countries such as Israel, Italy, Chile and Uruguay can provide the transfer of technology necessary to develop a *L. invasa* integrated management program in Mexico.

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