The association between mites and the *Agave* L. snout weevil, more than phoresis

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ABSTRACT

Objective: to identify the phoretic mites associated with the *Agave* (Maguey) snout weevil *Scyphophorus acupunctatus*.

Materials and methods: manual collections of *Scyphophorus acupunctatus* were carried out in Agave plantations. The daily behavior of mite-infested weevils was documented. The latter were observed and classified according to specialized taxonomic keys.

Results and Conclusions: there was an anomalous behavior of the agave weevil possibly favored by the infestation by mites, which can play an important role in the detriment of the vitality of that pest. *Scyphophorus acupunctatus* (Coleoptera: Curculionidae) interacted with three groups of mites; *Macrocheles merdarius* (Acari: Mesostigmata: Macrochelidae), *Tridiplogynium* sp. (Acari: Mesostigmata: Diplogyniidae) and *Curculanoetus* sp. (Acari: Sarcoptiformes: Histiostomatidae).

Implications: this study is the first to document the presence of phoretic mites on *S. acupunctatus*. It is the first report to document the association between the agave weevil and the aforementioned arachnids (Subclass Acari) that participate and play a desirable role in the biological control of *S. acupunctatus*.

Keywords: chemotaxis, predatory mites, new species, Mezcalero Agave, agave snout weevil, phoresis.

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INTRODUCTION

The Agave snout weevil, *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Curculionidae), is considered the most important pest in plants of the genus Agave (Mezcalero maguey), since it is associated as the cause of the disease called "soft rot" of Agave plants; as well as

the cause of more damage directly and indirectly (Cruz-Esteban *et al.*, 2021; Cuervo-Parra *et al.*, 2020). The control of this pest is done mainly by making use of synthetic chemical insecticides such as malathion, endosulfan, methomyl and fipronil. However, it is difficult to control this pest because the larvae, pupae and adults develop in the roots and the core of the Agave stem base, making it difficult for the products to contact insects (Terán-Vargas *et al.*, 2012).

For the biological control of the Agave snout weevil, some natural enemies of larvae, *Placodes ebeninus*, *Lioderma cacti* and *Phileurus valgus* have been reported, as well as the ants *Odontomachus bauri* and *Ectatomma ruidum* (Hymenoptera: Formicidae). With *Hololepta quadridentata* and *Hololepta yucateca* (Coleoptera: Histeridae) as the main predators with the highest incidence. *Alienoclypeus insolitus* and *Cyclaulacidea* sp. (Hymenoptera: Braconidae) are also known to be parasitoids of larvae and pupae respectively (Velazquez *et al.*, 2008). For the control of adult *S. acupunctatus*, the nematodes *Heterorhabditis bacteriophora*, *Steinernema feltiae* and *Steinernema websteri* (Rhabditida: Heterorhabditidae) and the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* (Ascomycota: Hypocreales) have been reported infecting both adults and larvae in field conditions (Aquino-Bolañoz *et al.*, 2006). Among the groups of mites used in biological control are those of the order Mesostigmata and Prostigmata of which there are commercially important species available (Castilho *et al.*, 2015; Hernandes *et al.*, 2015). However, there are no reports for the control of the Agave snout weevil through the use of mites of these orders.

Therefore, this is the first report of a consortium of mites that use the Agrave snout weevil as a vehicle; that in other species has been reported as phoresis. But which possibly play a role of greater importance pointing towards the biological control of *S. acupunctatus*. This suggests an agroecological management of the pest in wild and domesticated plantations with importance in forestry and agriculture.

MATERIALS AND METHODS

Collection and treatment of agave weevils

In June 2021, manual collections of *S. acupunctatus* were carried out in wild Agave plantations and plantations with some planting management in localities in the central area of the state of Guerrero, Mexico. The Agave snout weevil specimens were transferred to the Mezcal Quality Analysis Laboratory of the DES of Chemical, Biological and Biomedical Sciences of the Autonomous University of Guerrero for the establishment of a breeding stock for future bioassays. They were placed in glass boxes 11 cm×6 cm high and 8 cm deep feeding them with pieces of fresh Agave plant, their behavior was documented every day.

Observation and classification of mites

Each specimen of Agave snout weevil was observed under a stereo microscope at a magnification of between 0.67X and 5X (Nikon SMZ745T); the mites they carried on their outside surface were removed, using a soft bristle brush. Those mites were preserved in 70% ethanol for further analysis and classification.

The mites found in the snout weevils were mounted in the middle of modified Berlese (Schuster and Pritchard, 1963). Assembled specimens were incubated at 40 °C for 15 days and then identified using a phase contrast microscope (Olympus BX41, Olympus Corporation of the Americas, PA, USA). Several keys were used for the identification of genera (Azevedo *et al.*, 2017; Özbek *et al.*, 2015; Hunter, 1993; Kethley, 1977; Evans, 1956).

RESULTS AND DISCUSSION

After 4 days on average, the agave snout weevils associated with mites showed an anomalous behavior (lethargy) until they died. In the meticulous observation of the live and dead specimens under the stereoscopic microscope the consistent presence of a cluster of mites on the thorax of the weevil was evidenced without ruling out that the result of this association could be something more than a phoresis. The mites were identified as *Macrocheles merdarius* (Acari: Mesostigmata: Macrochelidae), *Tridiplogynium* sp. (Acari: Mesostigmata: Diplogyniidae) and *Curculanoetus* sp. (Acari: Sarcoptiformes: Histiostomatidae) (Figure 1). The average number of mites that an adult of *S. acupunctatus* carries on its armor was 30 individuals with no apparent numerical relationship between the infesting species.

The first two species of the aforementioned mites were found attached to both the head and the thorax and abdomen of the Agave snout weevil (Figure 2). It was also recorded that these mites might express potential chemotaxis to the Agave snout weevil because the specimens detached from their host began to search, quickly returning and climbing on the host body in their original locations. Finally, it was observed that the mite *Curculanoetus* sp. (Acari: Sarcoptiformes: Histiostomatidae) is found colonizing inside the elytra of the beetle where significant deterioration was observed in the wings of the Agave snout weevil, thereby limiting its natural mobility. Similarly, to this latter mite, the presence of hyaline eggs has been documented without learning at the moment to which species they correspond (Figure 3).

Findings on the associations between mites and beetles have been described. Francesco Porcelli *et al.* (2009) pointed out the possible introduction of new species of mites in Malta

Figure 1. Observation of specimens through a stereoscope. (a) *Macrocheles merdarius*, (b) *Tridiplogynium* sp., and (c) Deutonymph of *Curculanoetus* sp. The scale shown represents 1 mm, with divisions of 0.1 mm.

Figure 2. Mite-infested agave weevil (*Macrocheles merdarius*, *Tridiplogynium* sp. and *Curculanoetus* sp.); as observed in a stereoscopic microscope. The bar represents 0.5 cm

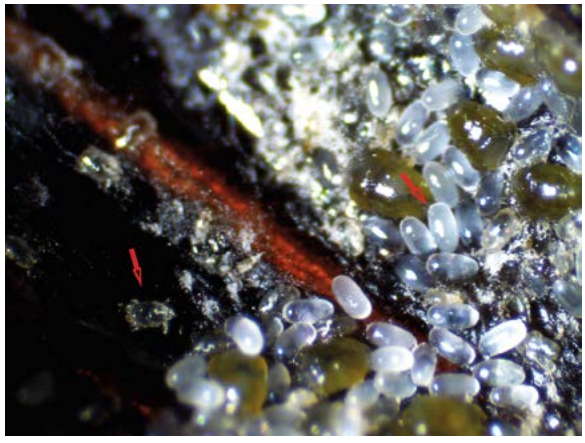

Figure 3: Dissection of the elytra of *S. acupunctatus*. Anterior surface of an elytra of the Agave snout weevil. The arrows indicate hyaline eggs not yet classified and individuals of *Curculanoetus* sp. in the deutonymph phase.

through the red palm weevil. Those authors also indicated that *Centrouropoda almerodai* and *Uroobovella marginata* were housed in the elytra of *Rhynchophorus ferrugineus* from the first moment of the observations. That differ to what was documented by Gómez-Marco *et al*. (2021), who pointed out that a close related taxon *Rhynchophorus palmarum* (the South American palm weevil), initially did not present development of mites under the elytra, but after a couple of years they began to colonize this part of the beetle. Those authors identified three species of mites moved by the beetle, within which *Centrouropoda* n. sp. and *Dinychus* n. sp. were considered as new species in the United States of America, where it was only recorded *Fuscuropoda marginata*. All these species were associated with the beetle as their causal disperser.

These associations have been described as an adaptation of the needs of the mite on its prospects of dispersion documenting a large number of arachnids on the exoskeletons of

the hosts in a multispecies set where up to 14 species come to be represented in association. Or else, a large number of individuals that belong to fewer species, but always located on the outer surface of the host and even inside the elytra (Milan Pernek, 2012; Quintero-Gutiérrez, and Romero-García, 2014). To add to those records on the mobilization of mites within the aforementioned type of association, in another study by Mohammad Ali Al-Deeb *et al*. (2011) where they collected the red palm weevil *Rhynchophorus ferrugines* Oliver in the Arab Emirates; they reported for the first time that these exotic species of mites *Uroobovella* sp. *Curculansoetus* sp. and *Uropoda orbicularis* were presented in the country as representatives of three families. Those authors also pointed to the beetle as the responsible and means of transportation that facilitated the mobilization of the arachnids. In addition, those authors concluded suggesting that the presence of this consortium of mites implies something more than phoresis, then arguing that their numerical abundance is to the detriment of the host.

In Mexico the presence of *S. acupunctatus* as well as its economic importance in commercial and wild agave plantations (National Service of Health, Safety and Food Quality, 2016), and other types of vegetation (Servin *et al*., 2016) has been widely reported. However, this study shows the first evidence that it can also be associated with mites as do other beetles previously cited. In addition, a behavioral change of the hosts was observed that make possible to infer that mites might be proposed as an interesting means towards the biological control of the Agave snout weevil pest.

CONCLUSIONS

The hypothesis raised on this bipartite interaction (insect-mites) is the existence of a natural enemy of *S. acupunctatus* in plantations of wild and semi-domesticated agaves where the applications of synthetic chemicals have been null, moreover, few losses of agaves are reported due to the damages attributed to *S. acupunctatus*. Nonetheless, this study describes for the first time, the natural interaction between the Agave snout weevil (pest of the Mezcalero maguey) and a group of mites that possibly means something more than just a phoresis, which also had not been described among these participants.

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