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First report on *Plodia interpunctella* (Lepidoptera: Pyralidae) in stored Amaranth grains (*Amaranthus* spp.)

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ABSTRACT

Objective: To identify and describe the species of lepidopteran that causes damage to amaranth grains.

Design/Methodology/Approach: During six months, amaranth cereal bars were obtained to collect the larvae of the lepidopteran, a pest that consumes the grains. Larvae were kept under laboratory conditions until adults emerged. For the identification of the adults, the genitalia were extracted and photographs were taken by confocal laser scanning microscopy; and those of abdominal termination, egg and larvae of the first stage, by scanning electron microscopy.

Results: The first report on the appearance of the flour moth *Plodia interpunctella* in stored amaranth grains in Mexico is presented. This is the first known record of damage to amaranth grains by this pest in the world.

Study limitations/implications: In the Amaranth-producing region of Morelos, Mexico, there is no information on the pests of stored amaranth grains. Therefore, the need arises to deepen the study of the reproductive biology and ecology of *Plodia interpunctella* on this new host.

Findings/Conclusions: The identification of *Plodia interpunctella* in amaranth grains will allow the development of a management strategy to prevent the spread of this new pest in the Amaranth-producing region.

Keywords: flour moth, *Amaranthus*, cereal.

INTRODUCTION

Amaranth is a crop that is booming around the world because of its nutritional properties and contributions to food safety (Nampeera *et al*., 2019). In Mexico, the species *Amaranthus caudatus* and *A. hypocondriacus* are the most cultivated (Gimplinger *et al*., 2008) with a production of more than seven thousand tons (SIAP, 2018). In certain regions, amaranth is consumed as a cereal and it is considered an important income source (Gimplinger *et al*., 2008; Kagali *et al*., 2013). Pest insects are the major factor affecting crop performance and its quality, causing losses up to 100% (Kagali *et al*., 2013). In Mexico, more than ten phytophagous species associated with this crop have been reported (Bautista-Martínez *et al*., 1997; Oliveira *et al*., 2012). However, there is no record of any pest insect reported in amaranth grains. Thus, the objective of this study was to identify and describe the species of Lepidoptera that causes damage to stored amaranth grains in Morelos, Mexico.

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MATERIALS AND METHODS

For six months, recollections of amaranth cereal bars with larvae were made (Figure 1, photographs were taken with a Nikon AF-S DX Nikkor) in the commoners´ locality of Huazulco, Temoac, Morelos (18° 44' 47'' N; 98° 46' 58'' W at an altitude of 1511 m). Insects were fed with amaranth grains in Laboratorio de Ecología Química of the Escuela de Estudios Superiores Jicarero, under the Universidad Autónoma del Estado de México, at laboratory conditions: 28±2 °C, 50-70% HR and 12:12 h light:darkness.

Obtaining genitalia

To obtain the genitalia, the abdomen was separated from the rest of the body and placed in a beaker with 10 mL of 10% KOH; subsequently, it was heated in a thermal dish for 15 min at 80 °C. The abdomen was placed in a watch glass and distilled water was injected to separate the adipose tissue from the organs, then the genitalia was removed with fine-tipped pliers, under a stereoscopic magnifying glass. Subsequently, the scales and tissue foreign to the genital structure were removed, a drop of clove oil was added to maintain lubrication and stain the tissue (Ramos, 2015). A drop of Hoyer's solution (Anderson, 1954) was placed on a concave slide, and the genitalia was placed, arranged so that the genital structure was facing the front and the valves (in the case of the male) were separated. Once an adequate preparation was made, a coverslip was placed to seal the sample and it was gently pushed to avoid bubbling. In case of the presence of bubbles in the mounting, the slide was heated in a thermal plate for a few seconds until they were eliminated (Ramos, 2015).

Microscopy studies

Photographs of the genitalia were taken under a confocal scanning laser microscope (Carl Zeiss LSM 800 ZEN Software 2.6 Blue Edition, Germany). In addition, other photographs were taken by a scanning electron microscope

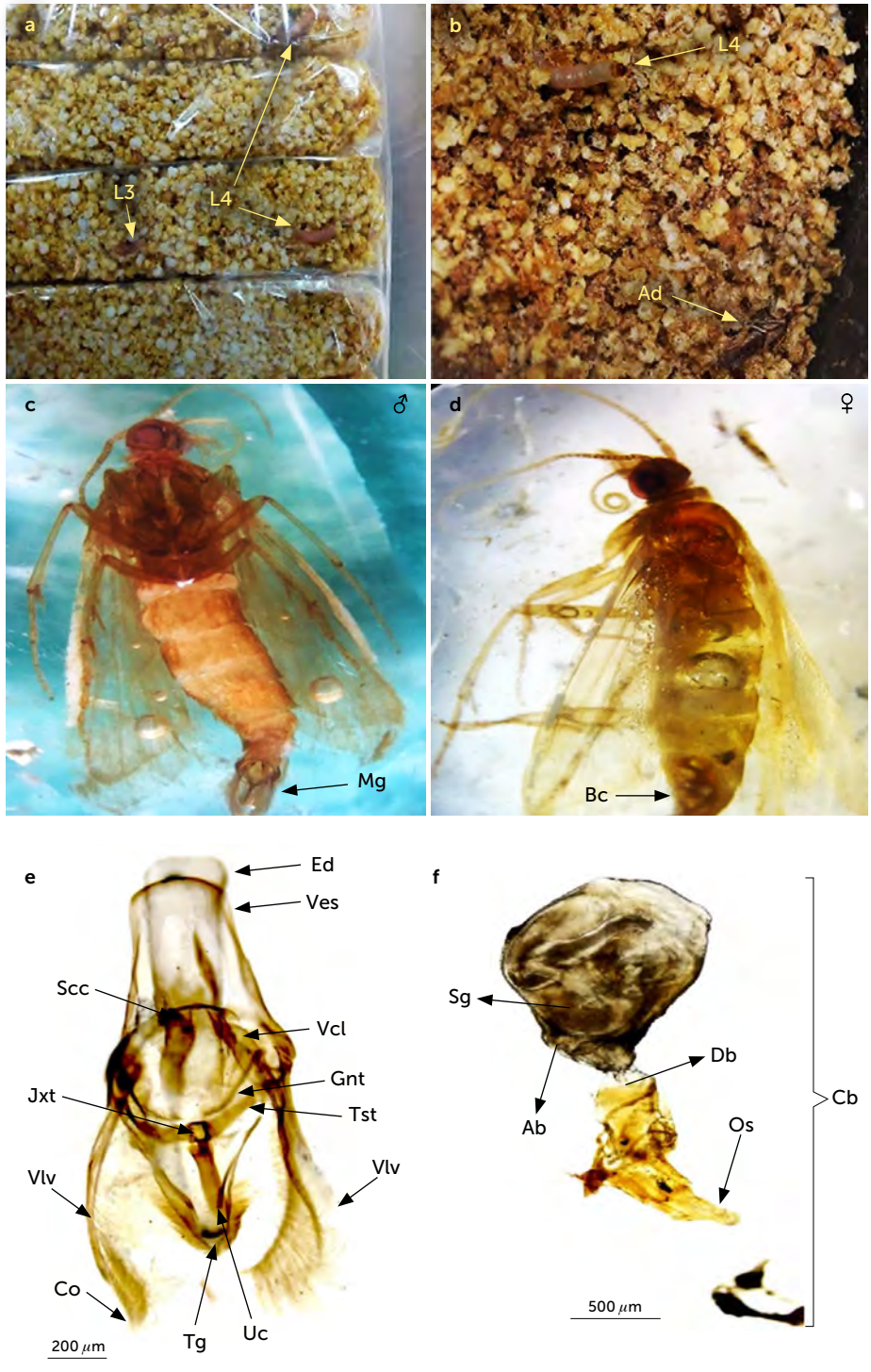

Figure 1. a. Third and fourth instar larvae (L3 and L4) in packages of amaranth cereal bars wrapped in cellophane lining; b. Larva of fourth instar (L4) and adult (Ad) reared on amaranth grains; c. Male Genitalia (Mg); d. Female genitalia, Bc: *Bursa copulatrix* and eggs; e. Internal genitalia, Ed: Edeago, Ves: Vesica, Vcl: Vinculum, Gnt: Ganathos, Tst: Transtilla, Vlv: Valvas, Uc: Uncus, Tg: Tegumen, Co: Cornutos, Jxt: Juxta, Scc: Sacculus; f. Internal genitalia Cb: *Corpus bursae*, Sg: Signum, Ab: *Appendice bursae*, Db: *Ductor bursae*, Os: *Ostium bursae*.

(Zeiss, EVO LS10, Germany) of the abdominal ending of the adults, as well as of the first instar egg and larvae.

RESULTS AND DISCUSSION

In this study, it was determined that the species found inside amaranth cereal bars is *Plodia interpunctella*. When examining the amaranth grain on which the breed was placed, different stages of development of this pest insect were found (Figure 1b). The adults had a white band with dark spots on the forewings. The abdomen showed a brown appearance similar to the wings (Figure 1c and 1d), in the females the presence of eggs was observed (Figure 1d) (García-Barros *et al*., 2015). Also, the internal genitalia of the male (Figure 1e) and the female (Figure 1f) are described; as well as the external genitalia of the male (Figure 2a) and of the female (Figure 2b) (Klots, 1970). The egg had a white oval shape and cell-shaped borders (Figure 2c). The larval development went through five instars, which were differentiated by their color, size and cephalic capsule. The first (Figure 2d) and the second larval stages were characterized by a whitish color, with translucent setae dorsally and laterally. The larvae of the third and fourth instar presented a yellowish body with pink tones and a dark brown cephalic capsule,

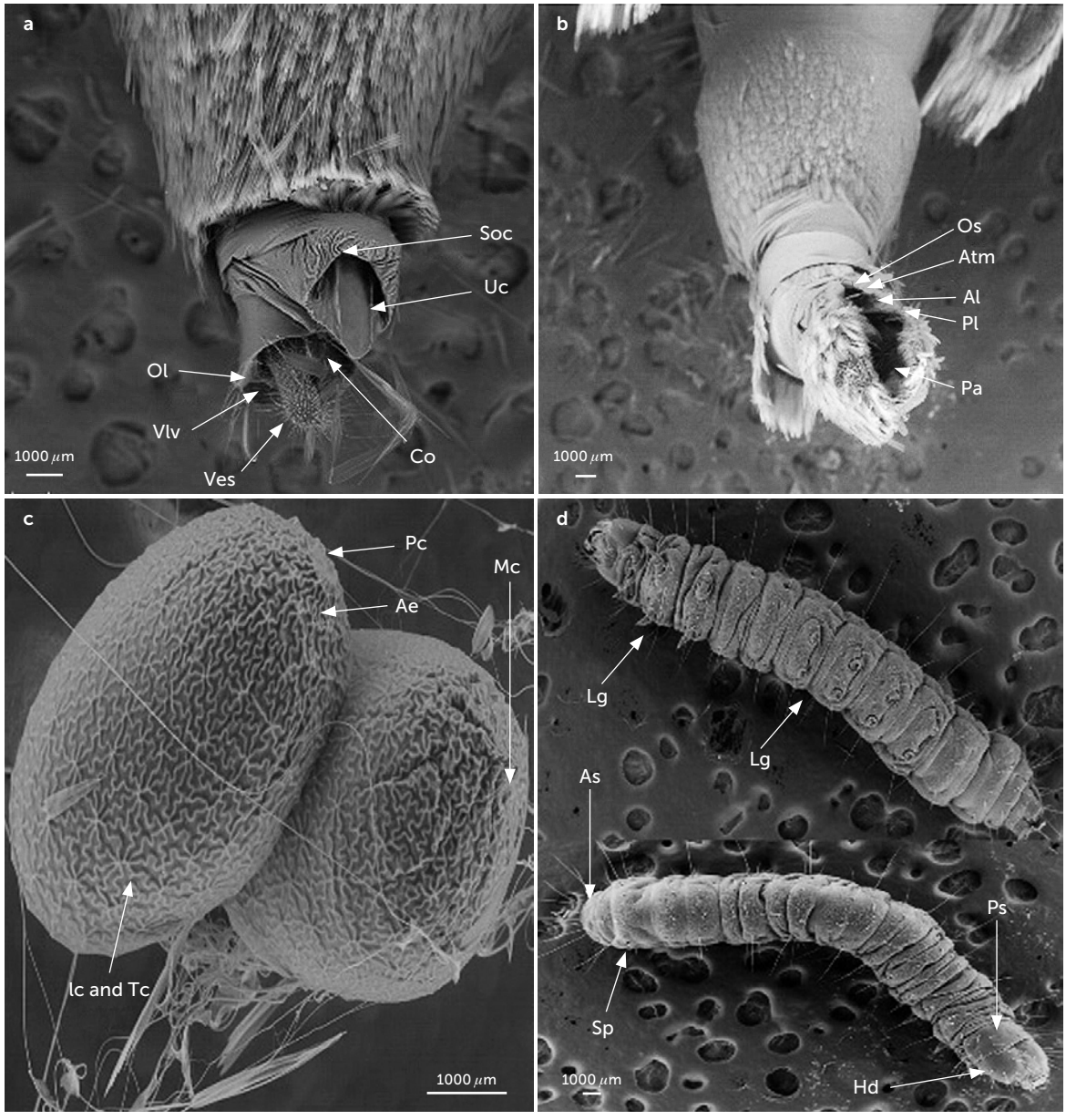

Figure 2. a. Male abdomen, Uc: Uncus, Ves: Vesica, Soc: Socii, Co: Cornutus, Vlv: Valva, Ro Ol: Lining of organs; b. Female abdomen, Os: Ostium bursae, Atm: Antrum, Lav Al: ante vaginal lamellae, Lpv Pl: post vaginal lamellae, Ap Pa: posterior apophysis; c. Egg, Mc: micropyle, Cp Pc: primary cell, Ae: aeropyle, Cl lc and Tc Ct: longitudinal and transverse cells; d. Larva one (L1), Pt Lg: leg, Pf Fl: false leg, Pa As: anal plate, Ep Sp: spiracle, Pp Ps: prothoracic plate, Cb Hd: Head.

while the last instar presented a light brown capsule. At this stage, the insects formed a silk that envelops the pupa; which was characterized by a dark hue.

The specimens described in this study belong to *P. interpunctella*, considered a cosmopolitan pest and of economic importance in stored grains and processed products (Hamlin *et al*., 1931; Heinrich, 1956; Arbogast *et al*., 1980). The survival success of this pest is due to the ability to reproduce on different hosts, where the quality of the food may influence (Marzban *et al*., 2001; Perez-Mendoza and Aguilera-Pena, 2004). It appears than the grain of Amaranth was not the exception, because all the development stages of the moth were observed on this cereal. It was observed that *P. interpunctella* produces a silk on amaranth grains, this factor together with the feces of the larvae causes contamination affecting the quality of the products, causing economic losses (Cox and Bell, 1991). Regarding the larvae found inside the amaranth cereal bars; as one plausible explanation, it may be due to the unnoticed oviposition on the stored grain before making the products. Another explanation would be that, when the female encounters a physical barrier such as plastic linings or paper envelopes, the eggs are deposited on these surfaces close to the food source (Silhacek *et al*., 2003) and, when the larvae emerge, they pierce the packages, or they can also enter through unnoticed existing holes (Mohandass *et al*., 2007); the latter was not observed in this study.

CONCLUSIONS

This is the first study of *P. interpunctella* on amaranth grains in Mexico and it can be considered a potential pest for the cereal; then, there is the need to know more about the species biology and ecology. With this knowledge, a management strategy could be designed against pest insect infestations, not to affect the quality of the stored grain.

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