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# THE OLD WORLD BOLLWORM *Helicoverpa armigera* (HÜBNER) (LEPIDOPTERA: NOCTUIDAE: HELIOTHINAE) ITS BIOLOGY, ECONOMIC IMPORTANCE AND ITS RECENT INTRODUCTION INTO THE WESTERN HEMISPHERE

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Adult *Helicoverpa armigera* foraging in composite flower. Photo Wikipedia

## Introduction

*Helicoverpa armigera* is recognized as one of the most significant agricultural pests in Asia, Europe, Africa, and Australasia, with damages estimated at a couple of billion US dollars annually, not including the socio-economic and environmental costs associated with chemical control and the introduction of GM crops (CABI, EPPO 1996, Tay et al. 2013, Warren 2013). The old world bollworm has been recognized as one of the most serious biosecurity threats to the Americas where it has the potential to become established across much of the South and North American continents with far greater potential economic damage than the native *H. zea* (Pogue 2004, Tay et al. 2013, Venette et al. 2003).

**Natural history**

**Life cycle.** Females of the cotton bollworm start laying eggs 2-6 days after emergence. They can lay between 500 and 3000 eggs, which hatch three days after oviposition. According to AgroAtlas, the complete life cycle can be completed in just over a month if the conditions are favorable.

**Eggs** (figure 2)**.** Spherical, 0.4 to 0.6 mm in diameter. Their color is yellowish-white and glistening at first, changing to greenish and finally turning dark-brown before hatching. In terms of sculpturing, the apical area surrounding the micropyle is smooth and the rest of the surface is sculptured in the form of approximately 24 longitudinal ribs, alternate ones being slightly shorter, with numerous fine transverse ridges between them (CABI, EPPO 1996).

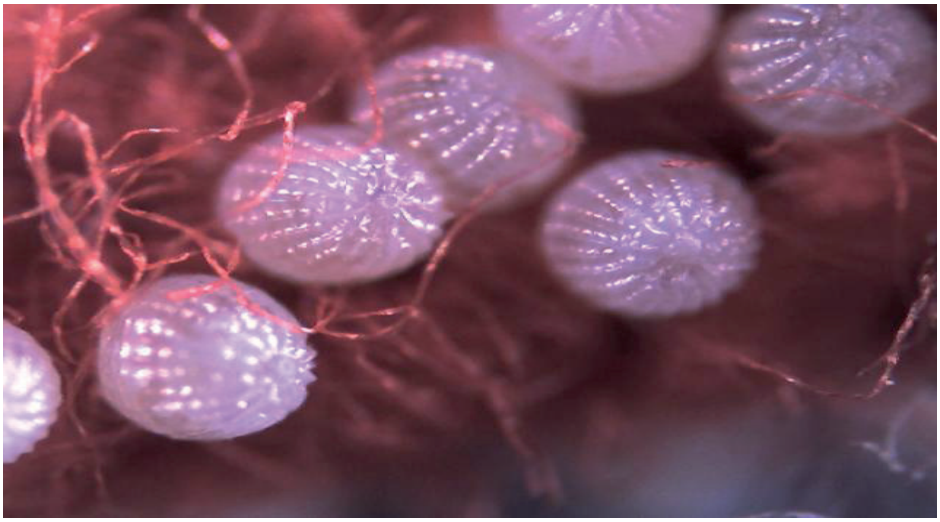

**Figure 2.** Photograph of eggs of *H. armigera*. Photo by Aneel Mohite

**Larvae** (figures 3-4)**.** The 1st and 2nd second instars are generally yellowish-white to reddish-brown in color and lack prominent markings; their head, prothoracic shield, supra-anal shield, prothoracic legs, as well as the spiracles and the tuberculate bases of setae are very dark-brown to black and give the larva a spotted appearance (Figure 3). A characteristic color pattern develops in subsequent instars that can be somewhat variable and is formed from shades of green, straw-yellow and pinkish- to reddish-brown or even black (CABI 2013 and CABI, EPPO 1996).

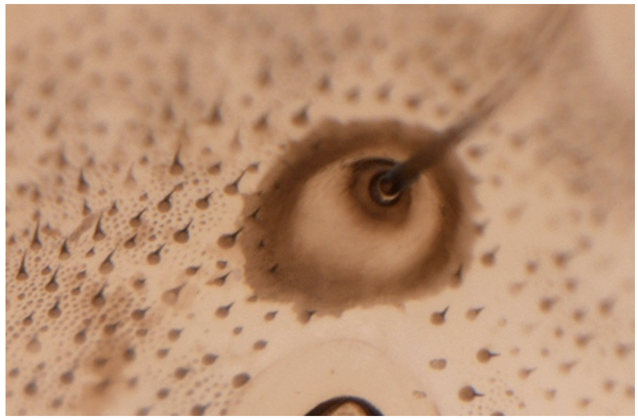

**Figure 3**. Detail of a tuberculate setal base and part of a spiracle showing the dark brown to black coloration that gives the larva a spotted appearance.

**Figure 4.** Lateral views of different instars of *H. armigera* (early instars to more advanced instars from left to right). Photographs: Entomology Lab at USDA-APHIS-PPQ, PIS South San Francisco.

**Pupae** (figure 5)**.** Pupae are mahogany-brown, with a length of 14-18 mm; their surface is smooth and rounded at both ends and they have two tapering parallel spines at their posterior tip. The pupae normally develop inside a silken cocoon in soil (about 1.6-3.9 in depth) or in some instances inside cotton bolls or maize ears.


**Figure 5.** Pupa of *H. armigera* excavated from the soil next to the host plant. Photo by Invasive. org.

**Adult** (figures 6-7)**.** Body shape of typical noctuid appearance. Body length 12-20 mm (0.47-0.79 in) and wingspan between 30 – 40 mm (1.2-1.6 in). The forewings are yellowish to orange-brown in females and greenish-gray in males and usually have a line of seven to eight blackish spots on the margin (Figure 7) and a broad, irregular, transverse brown band. The hindwings are pale yellow with dark-brown band along the external edge that contains a paler patch in the middle.

**Figure 6.** Adult female of *H. armigera* (top: dorsal view, bottom: ventral view). Photos by PaDIL, Government of Australia.

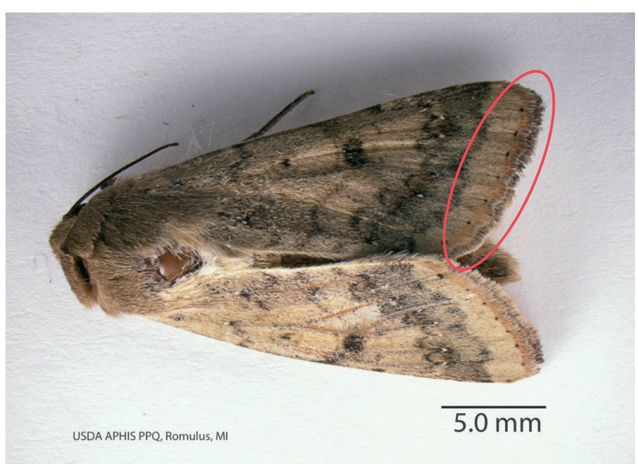


**Figure 7.** Adult female of *H. armigera* intercepted at a U.S. Port of Entry showing the characteristic line of seven to eight blackish spots on the margin of the forewing. Photo by USDA-APHIS-PPQ, PIS Romulus, MI.

**Hosts and identification of damage.** The Old World bollworm is considered omnivorous, with the larvae attacking at least 60 cultivated and 67 wild host plants from numerous families including Asteraceae, Fabaceae, Malvaceae, Poaceae and Solanaceae (Fitt 1989, Pogue 2004). Fitt and Wilson (2000) and Tang et al. (2013) report more than 180 species of plants as hosts distributed in nearly 45 families.

Although feeding larvae can sometimes be seen on the surfaces of plants, they are often hidden within plant organs (i.e. flowers or fruits), in which case bore holes may be visible. If bore holes are not visible, finding larvae may require dissection of the plant (CABI & EPPO 1996).

**Distribution** (figure 8)**.** CABI (2013) and AgroAtlas (2013) present an updated list of countries and a map for the distribution of *H. armigera* worldwide and the Far East, respectively, and CABI, EPPO (1996) present the geographic distribution of this pest in the area covered by EPPO (European and Mediterranean Plant Protection Organization) and worldwide.

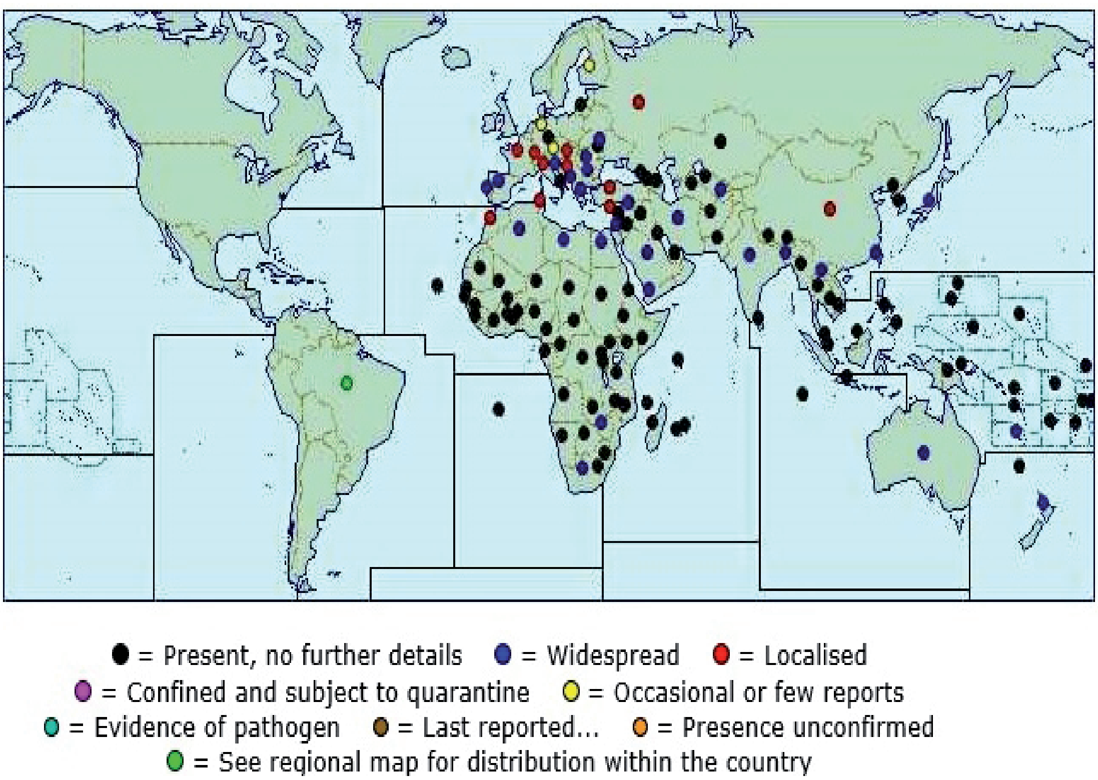


**Figure 8.** World distribution of *Helicoverpa armigera* (CABI 2013).

**Taxonomy and identification.** The identification of species is complicated and presents multiple problems. It was Hardwick (1965) who reviewed the complex of species in the New and Old World (Lepidoptera, Noctuidae, Heliothinae), most of which were previously referred as a single species in the genus *Heliothis* (either as *H. armigera* or *H. obsoleta*), and pointed out that this was actually a species complex. Hardwick (1965, 1970) also proposed that *H. zea* (New World) and *H. armigera* (New World) were distinct species based on differences in the genitalia and that both species belonged to the genus *Helicoverpa*, which compromises 17 species (Hardwick 1965, 1970).

More recently, Pogue (2004) reported some problems associated with using the genitalia for species identification (including some overlapping dimensions in the male's vesica of *H. zea* and *H. armigera*) and defined the best characters on the male genitalia for the identification of species (number of diverticula at the base, length and number of coils, number of cornuti visible on the vesicula inside the aedeagus and the valve length). Figures 9-10 show some characters used by Pogue (2004) to identify *H. zea* and *H. armigera* based on the 8$^{th}$ sternite and the genitalia of the male.

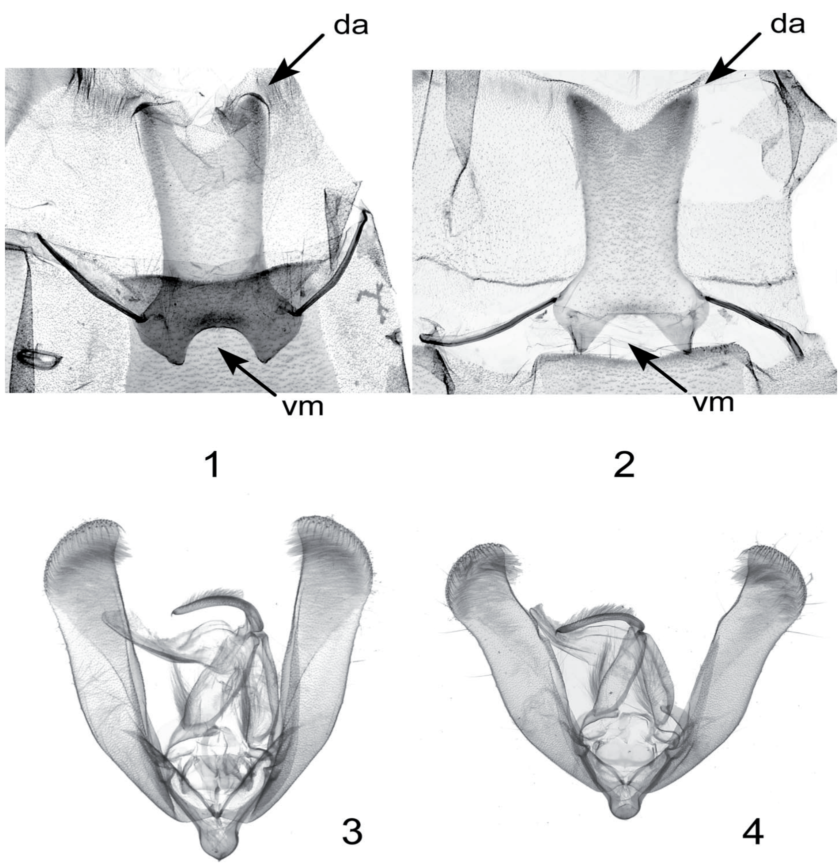


**Figure 9.** The eighth sternite (S8) and the male genitalia of *H. zea* and *H. armigera* according (from Pogue 2004): (1) Eighth sternite of *H. zea.* (2) Eighth sternite of *H. armigera.* (3) Male genitalia of *H. zea.* (4) Male genitalia of *H. armigera.* da, distal apex; vm, ventral margin.

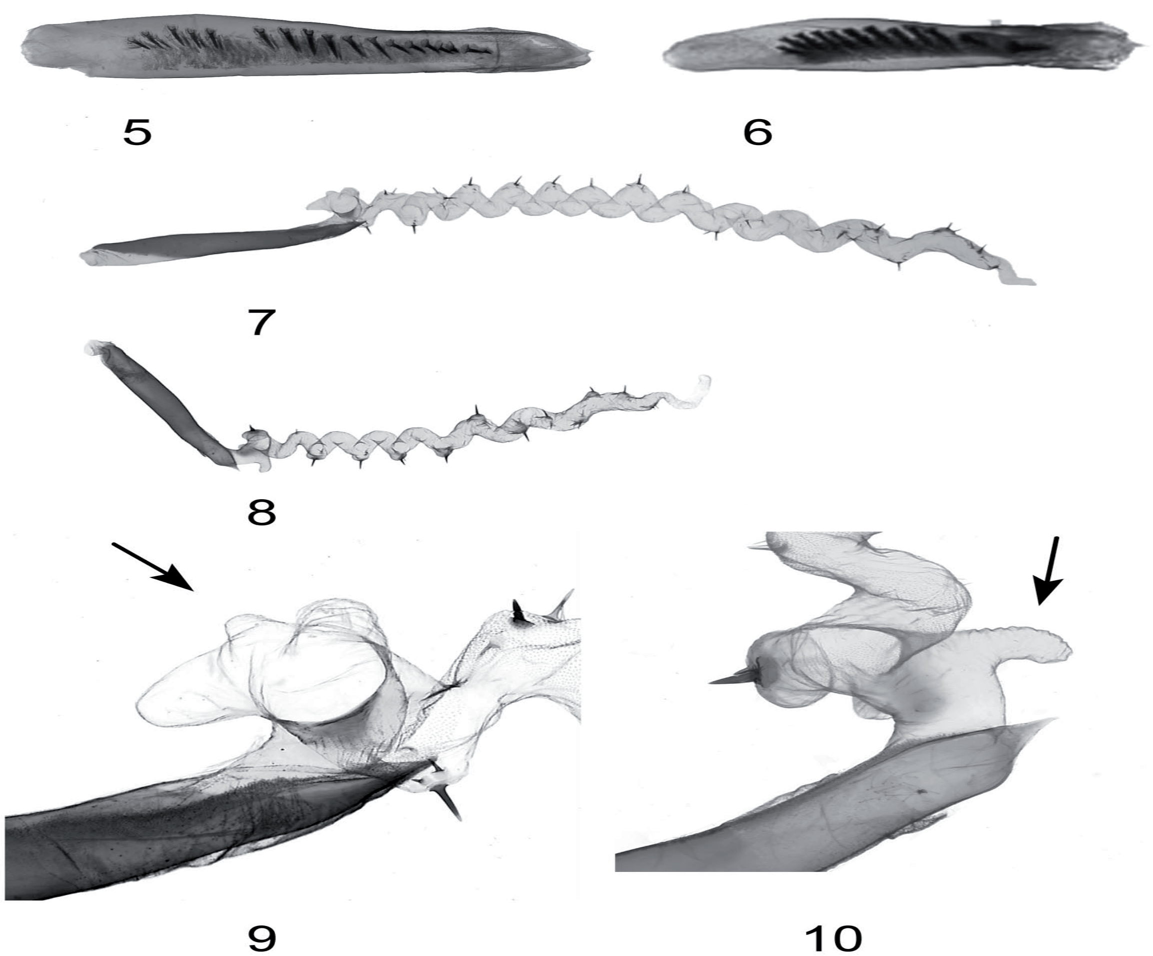

**Figure 10.** Differences in the aedeagus of *H. zea* and *H. armigera* (from Pogue 2004): (5) Aedeagus of *H. zea*, vesica uninflated. (6) Aedeagus of *H. armigera*, vesica uninflated. (7) Aedeagus of *H. zea,* vesica fully inflated. (8) Aedeagus of *H. armigera,* vesica fully inflated. (9) Three lobes at base of vesica in *H. zea.* (10) Single lobe at base of vesica in *H. armigera.*

**Economic importance.** In addition to feeding on a vast array of hosts (more than 180 species of plants in over 45 families), *H. armigera* has rapidly developed resistance to insecticides (Fitt and Wilson 2000, Yang et al. 2013) and there are some documented cases of its resistance to genetically modified crops containing insecticidal proteins from *Bt* (*Bacillus thuringiensis*) (Downes et al. 2010, Tabashnik et al. 2012).

In the Old World the annual cost of the damages caused by *H. armigera* has been estimated to be more than US$ 2 billion annually. According to Warren (2013), infestations of *Helicoverpa* species in Brazil during the last two growing seasons resulted in economic losses of up to US$ 10 billion. According

Hackett and Gatehouse (1982), Pogue (2004), Reed (1965) and Roome (1975), the most important cultivated plants damaged by *H. armigera* worldwide are grain sorghum, corn, and cotton. Other economically important hosts include tobacco, tomatoes, potatoes, flax, soy, Lucerne, beans (*Phaseolus* sp.), chickpeas, other Leguminosae, and a number of fruits (*Prunus*, *Citrus*) and forest trees (CABI, EPPO 1996, CABI 2013). For a complete list of host plants see Matthews (1991) and Robinson et al. (2010).
Agroatlas (2013) reports that in Russia and adjacent countries, *H. armigera* has been found attacking more than 120 plant species (favoring *Solanum*, *Datura*, *Hyoscyamus*, *Atriplex*, and *Amaranthus*).

**Current status in the Americas and number of interceptions at U.S. ports of entry.** According to Tay et al. (2013), higher than usual infestations of *Helicoverpa* species were detected attacking row and cover crops in Brazil during the growing seasons of 2011/ 2012 and 2012/2013. Initially these infestations were presumed to be *H. zea* (a common pest in Brazil), but the unusually large numbers of attacked crops and the reduced efficacy of normal control methods raised some doubts. Recent work has identified *H. armigera* in Brazil based on morphological characteristics of intercepted samples (Czepak et al. 2013, EMBRAPA 2013). More recently Tay et al. (2013) confirmed the presence of *H. armigera* in Brazil using molecular techniques (mtDNA), on samples from the State of Mato Grosso and they reported at least four maternal lineages present in the country.

Venette et al. (2003) report more than 4.400 interceptions of *H. armigera* and *Helicoverpa* sp. in U.S. ports of entry since 1985. Pogue (2004) reported a total of 20 interceptions of *H. armigera* by the Animal and Plant Health Inspection Service (APHIS) at U.S. ports of entry in 2003. More recently, a search performed by the author on the APHIS AQAS database (January 7, 2014) rendered a total of 82 interceptions of confirmed *H. armigera* at U.S. ports of entry in 2013 alone; two of them were from the San Francisco Bay Area (a search for the SF Bay Area revealed a total of 15 interceptions since the end of 2006 ≈ 1.9 interceptions/year).

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