Revista Brasileira de Entomologia 65(2):e20200116, 2021

SOCIEDADE BRASILEIRA DE ENTOMOLOGIA
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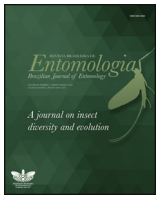
REVISTA BRASILEIRA DE
Entomologia
A Journal on Insect Diversity and Evolution



Description of a bilateral gynandromorph in *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae) from Brazil

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ARTICLE INFO

Article history:
Received 23 November 2020
Accepted 26 April 2021
Available online 12 May 2021
Associate Editor: Héctor Vargas

Keywords:
Fall armyworm
Faxitron X-Ray Corp
Morphology
Gynandromorphic

ABSTRACT

A bilateral gynandromorph of *Spodoptera frugiperda* was reported for the first time from Minas Gerais State, Brazil. The specimen with this trait was found among the progeny of a laboratory rearing population and exhibited dimorphism in the antennae, wings, head, thorax, and abdomen. It had a male left side and a female right side. Both the external and internal genitalia were typically those of a male.

Gynandromorphs are chimeric individuals that present masculine and feminine tissues in its body (Narita et al., 2010). They have been found in natural and laboratory populations of arthropods (Maeno and Tanaka, 2007; Sagar et al., 2020). According to the distribution of male and female features throughout the body, gynandromorphs are classified into anteroposterior (anterior and posterior sides are of different sexes), bilateral (right and left sides are of different sexes), transversal (asymmetric distribution), or mosaic distribution (random distribution of characters along the body) (Michez et al., 2009). The bilateral gynandromorphism is more frequent among insects, although other forms with any distribution of sexual characters are also known (Dutto et al., 1767; Dang and Peterson, 1979; Davis, 1994; D'Entreves and Roggero, 2013; Renjith and Chandran, 2020). This phenomenon is more frequent in invertebrates than vertebrates, with some reports in birds (Zhao et al., 2010; Morris et al., 2018). Even in invertebrates, it is considered rare in nature, but relatively common among bees, especially in *Megachile* sp. (Wcislo et al., 2004).

In Lepidopterans, sexual dichromatism is present and evident, principally in the wing color. Many gynandromorph specimens have been reported for butterflies (e.g. in Lycaenidae, Nymphalidae, Pieridae, Papilionidae, Geometridae) (Emmel and Boender, 1990; Kutis and Heppner, 1990; Bernardino et al., 2007; Nielsen, 2010; Jahner et al., 2015; Bollino and Padrón, 2016; Seven and Özdemir, 2017), but also for some moths, like in Noctuidae species as *Agrotis segetum* and *A. ipsilon* (Blair, 1976; Gemeno et al., 1998).

The fall armyworm (FAW) *Spodoptera frugiperda* (Smith, 1797) is the most important corn pest in South America and is a global pest of corn occurs worldwide (Blanco et al., 2016; Fan et al., 2020). A gynandromorph FAW adult was found and reported for the first time in Minas Gerais State, Brazil, among the progeny of a transgenic Bt corn susceptible laboratory rearing population (Bahia-Cv) (Santos-Amaya et al., 2016). This population was maintained in controlled conditions (27 ± 3ºC, 70 ± 15% RH, and 14:10 h L/D photoperiod) in the Semiochemical Laboratory of the Entomology Department in the Federal University of Viçosa, Brazil.

The gynandromorph moth emerged from a male pupa that had been sexed using the morphological features on the terminal abdominal segments. Prior to imaging, the specimen was maintained at -15ºC for 5 minutes to remain immobile. We used a Faxitron X-Ray Corp (Wheeling, IL, USA) and a LEICA M205 A Stereomicroscope coupled

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https://doi.org/10.1590/1806-9665-RBENT-2020-0116

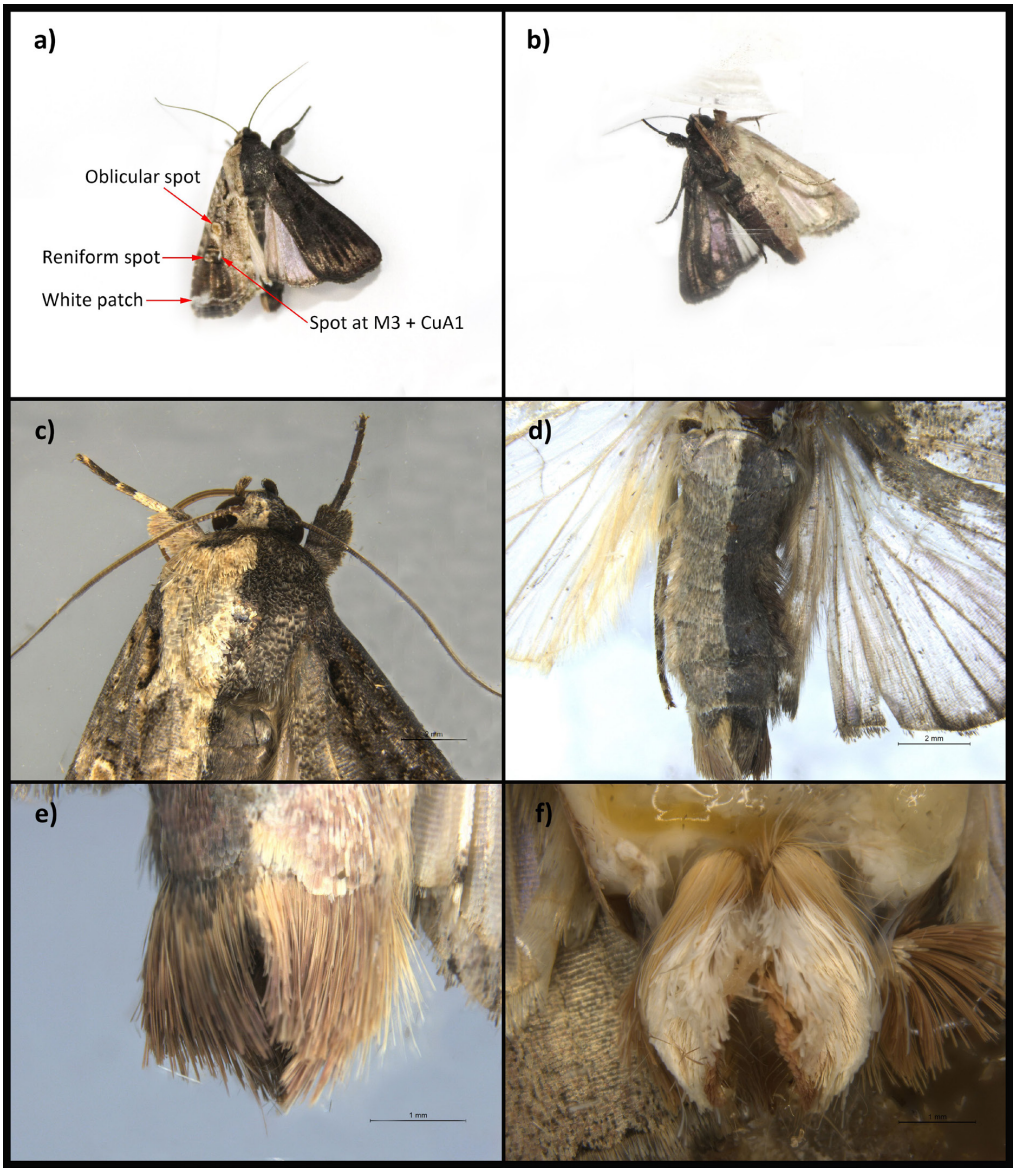

Figure 1 Gynandromorph adult of the fall armyworm (FAW) *Spodoptera frugiperda*. A. Habitus in dorsal view, with a male left side and a female right side, showing oblicular spot, reniform spot, white patch, and spot at M3 + CuA1; B. Habitus in ventral view; C. Detail of a dimorphism in the antennae, wings, head, and thorax; D. Detail of a dimorphism in the abdomen; E. Last abdominal segment; F. Last abdominal segment of a normal male FAW.

with a LEICA MC170 HD camera in the Ecotoxicology and Ecophysiology Laboratory and in the Termitology Laboratory of the Federal University of Viçosa, respectively. The gynandromorph specimen was deposited in the Entomology Museum of the Federal University of Viçosa.

The moth (Fig. 1a-f) exhibited bilateral dimorphism in the antennae, wings, head, thorax, and abdomen. It had a male left side and a female right side (Fig. 1a). The genitalia were typically those of a male (Fig. 1e, 1f) and (Fig. 2a-c). The clasper was visible in the X-ray image, but it appears to be less developed than that of a normal FAW (Fig. 2a, 2c) (Quimbayo et al., 2010). Sagar et al. (2020) already reported a bilateral gynandromorph for a FAW in natural conditions, although the specimen presented asymmetrical genitalia with male structures in one half of the body and female in the other.

The forewing of the male side had a brownish to rusty brown color, with a white patch near to the apical margin and a longitudinal black line near to the basal margin (Fig. 1a). It had an oval yellowish-brown oblicular spot and a reniform spot with an outline partially black washed, with a small white v-like marking (Fig. 1a). In addition, a conspicuous transparent spot in the M3 and CuA1 veins junction was seen (Fig. 1a). The forewing of the female side had a greyish-black color (Figs. 1a, 1b). Both hindwings were white, with outer, anal, and inner margins black washed, mainly on the female side (Fig. 1d). The male side abdomen had a brownish color and the female side a greyish-black color (Fig. 1d). In ventral view, each abdominal sternite had a central black marking (Fig. 1b). All these traits were similar to those of a normal FAW specimen (Brévault et al., 2018; Sharanabasappa et al., 2018; Bajracharya et al., 2019).

Gynandromorphism is produced by an unequal distribution of chromosomes, especially the sexual (Mayr et al., 1953). They normally result from either loss or addition of a sex chromosome early during development, from fertilization of a binucleated egg, or delayed syngamy (Cooper, 1959; Homsher and Yunker, 1981; Narita et al., 2010). Some of the known reasons for the gynandromorph abnormalities are extreme temperatures, ultraviolet light, viral infections, and translocations of parts of the sex chromosomes and/or autosomes (Drescher and Rothenbuhler, 1963; Nekrutenko, 1965; Blau, 1978; Riotte, 1978; Marec et al., 2001). For Lepidopteran like *Bombyx mori,* that have a female-heterogametic chromosomal constitution (i.e., ZZ: male; ZW: female), double fertilization of a binucleate egg (ZW) by Z

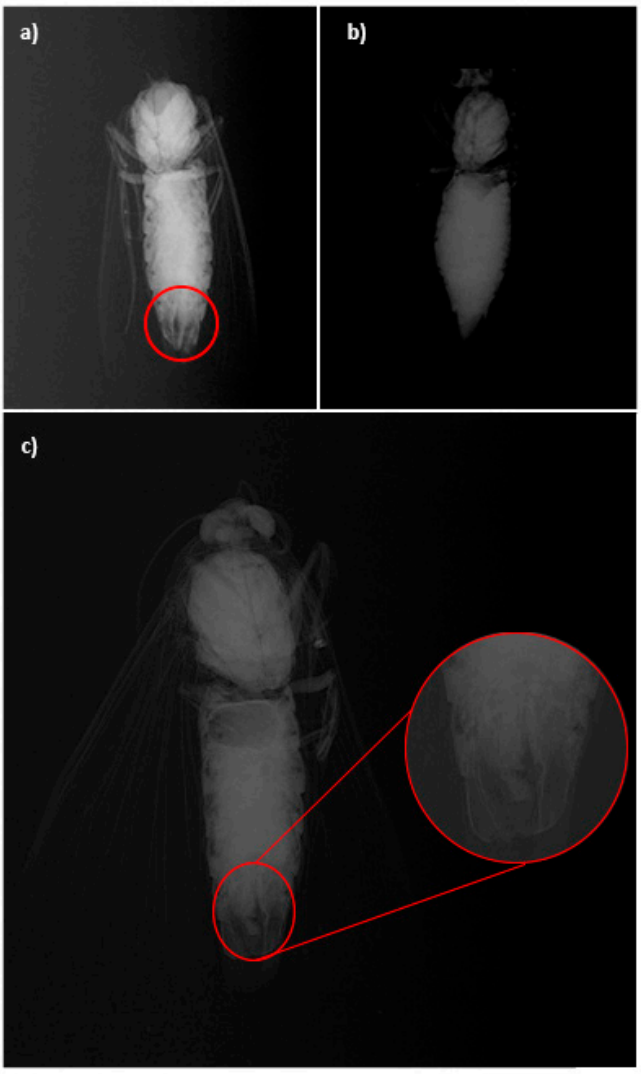

Figure 2 Faxitron X-Ray of a gynandromorph adult of the fall armyworm (FAW) *Spodoptera frugiperda*. A. Faxitron X-Ray of a normal FAW male with a red circle showing the clasper; B. Faxitron X-Ray of a normal FAW female; C. Faxitron X-Ray of a gynandromorph FAW with a red circle with a zoom evidencing the clasper.

sperms is thought to be the major cause of gynandromorphs generation (Goldschmidt and Katsuki, 1927). Other potential causal agents of gynandromorphism are the mutations, genetic incompatibilities, and *Wolbachia* infection (Pereira et al., 2003; Kageyama et al., 2012). We encourage the worldwide biological collections to document the gynandromorphic and aberrant individuals deposited, such as the frequency and morphology of their deformities, an important information with applications in pest management and biomedicine (Narita et al., 2010; Sánchez-Murillo et al., 2013; Eastwood and Wood, 2019).

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001, Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - INCT Semioquímicos na Agricultura. The second author thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for his scholarship (process # 162813/2018-0). We thank Lírio Cosme Júnior and the Laboratório de Ecotoxicologia e Ecofisiologia for the support to use the X-Ray. We also thank Og De Souza and the Termitology Laboratory for making available the optic equipment for image taking. We thank Hernane Dias Araújo for revising the manuscript and also the two anonymous reviewers that helped to improve the final version of this scientific note.

Conflicts of interest

The authors declare that they have no conflict of interest.

Author contribution statement

All authors contributed to the study conception. NDSR conceived the research, conducted the laboratory work and wrote the document. JFML elaborated the final plates and the morphological description of the specimen. ERL supported the rearing of the specimens and disponibilize the laboratory for developing this research. All authors read, critically reviewed and approved the final version of this scientific note.

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