

Two new records of Gynandromorphs in *Xylocopa* (Hymenoptera, Apidae s.l.)

Rony Peterson Santos Almeida^{1,2}; Luis Anderson Ribeiro Leite^{2,4} & Kelli dos Santos Ramos³

- ¹ Museu Paraense "Emílio Goeldi" (MPEG), Programa de Pós-Graduação em Zoologia (PPGZ00L), Coordenação de Ciências da Terra e Ecologia (CCTE). Belém, PA, Brasil. ORCID: 0000-0003-0681-0357. E-mail: rony__peterson@hotmail.com
- ² Universidade Federal de Sergipe (UFS), Centro de Ciências Biológicas e da Saúde (CCBS), Departamento de Biologia (DBI), Laboratório de Entomologia (LABENTO). São Cristóvão, SE, Brasil.
- ³ Universidade de São Paulo (USP), Museu de Zoologia (MZUSP). São Paulo, SP, Brasil. ORCID: 0000-0003-1453-5885. E-mail: kellisramos@gmail.com
- ⁴ ORCID: 0000-0002-3702-4925. E-mail: landersonleite@gmail.com

Abstract. Two new records of gynandromorphs in *Xylocopa* Latreille, 1802 (Hymenoptera, Apidae). Gynandromorphs are deviant morphological individuals with genetically distinct male and female tissues. Records of sex anomalies seems to be important to better understand the mechanisms regulating phenotypic expression. Herein, two new cases of gynandromorphs in carpenter bee species of *Xylocopa* from Brazil are described and figured: a mixed gynandromorph of the *X. (Neoxylocopa) brasilianorum* (Linnaeus, 1767) from São Paulo and a bilateral gynandromorph of the *X. (Neoxylocopa) ordinaria* Smith, 1874 from Sergipe.

Key-Words. Anomaly; Brazil; Carpenter bee; Morphology; *Neoxylocopa*.

INTRODUCTION

Intersexes and gynandromorphs are sexual anomaly frequently documented in bees (see Hinojosa-Díaz *et al.*, 2012). Intersex individuals are genetically uniform although exhibits features of the opposite sex, while gynandromorphs (also called gynanders) are genetically chimeric individuals that display characteristics of both sexes simultaneously in the body (Michez *et al.*, 2009; Narita *et al.*, 2010). A precisely classification of the deviant phenotypes into intersexes or gynandromorphs is complicated, especially when the recognition is based only on the external morphologies (Narita *et al.*, 2010, Ramos & Ruz, 2013). According to Michez *et al.* (2009), gynandromorphs are classified into three mains forms: (i) bilateral, when the body is divided in left-right in relation to male and female features, (ii) transverse, is defined when sex characters are distributed in two asymmetrical parts, and (iii) mosaic or mixed, when display randomly female-male characters in different parts of the body. The mosaic class is the most common type of gynandromorphs described for bees (Wcislo *et al.*, 2004; Lucia & Gonzalez, 2013). The hypotheses to explain the causes of gynandromorphism among Apoidea have been related to problems of fertilization, polyspermy, loss or damage of a sex chromosome, and association with symbionts such as *Wolbachia* (see Michez *et al.*, 2009 and Narita *et al.*, 2010 for a thorough discussion).

Gynandromorphs are known to be rare in the nature and in addition to the lack of information, it is difficult to say how common this phenomenon is among bees. However, bees are sexually dimorphic which makes it easier to notice gynandromorphs compared to taxa that do not show remarkable number of secondary sexual characters. Gynander individuals in bees (Apidae s.l.) is known for approximately 138 species belonging to 35 genera in almost all subfamilies (Andreninae, Apinae, Halictinae, Colletinae, Megachilinae, Melittinae) (Sandhouse, 1923; Hicks, 1926; Urban, 1999; Gonzalez, 2004; Wcislo *et al.*, 2004; Oliveira & Andrade, 2006; Michez *et al.*, 2009; Lucia *et al.*, 2009; Sampson *et al.*, 2010; Giangarelli & Sofia, 2011; Fateryga *et al.*, 2011; Hinojosa-Díaz *et al.*, 2012; Lucia *et al.*, 2012; Silveira *et al.*, 2012; Camargo & Gonçalves, 2013; Lucia & Gonzalez, 2013; Alvarez *et al.*, 2014; Lucia *et al.*, 2015; Spring *et al.*, 2015; Suzuki *et al.*, 2015; Vivallo, 2015; Coelho *et al.*, 2016; Zama & Coelho, 2017). Most described of these gynandromorphs are recorded from the long-tongued bees in the genera *Megachile* and *Xylocopa* (Wcislo *et al.*, 2004; Michez *et al.*, 2009; Hinojosa-Díaz *et al.*, 2012; Lucia *et al.*, 2012).

In *Xylocopa* most of the documented gynanders are related to species in the Neotropical subgenus *Neoxylocopa* Michener (Hinojosa-Díaz *et al.*, 2012; Lucia *et al.*, 2012; Lucia & Gonzalez, 2013). The subgenera is composed by large bees (about 20 mm) widely distributed in the Americas

that present a strong sexual dimorphism with black females and yellow or testaceous males (Hurd, 1978; Michener, 2007; Silveira et al., 2002; Marchi & Alves-dos-Santos, 2013). These differences of color among the sexes of *X. (Neoxylocopa)* is probably the easier observed character to diagnose gynandromorphs individuals. Currently, there are 18 listed cases of gynandromorphism in 13 different species of *Xylocopa* with 7 species of these reported for the subgenus *Neoxylocopa*: *X. atamisquensis* Lucia & Abrahamovich, 2010, *X. augusti* Lepeletier, 1841, *X. darwini* Cockerell, 1926, *X. frontalis* (Olivier, 1789), *X. mendozana* Enderlein, 1913, *X. nigrocincta* Smith, 1854, *X. varipuncta* Patton, 1879 (Michez et al., 2009; Lucia & Gonzalez, 2013; Lucia et al., 2015; Vivallo, 2015; Zama & Coelho, 2017).

Descriptions of gynandromorphs can improve the understanding of this spectacular phenomenon and is a relevant data on the current knowledge to the evolution of mechanisms regulating phenotypic expression (Hinojosa-Díaz et al., 2012; Camargo & Gonçalves, 2013). The study of gynandromorphic mutations help to reveal the developmental processes that facilitate the evolution of phenotypes (Yang & Abouheif, 2011). These morphological deviations provide data for a general view that help in understanding the evolution of sexual characteristics or even homologies between male and female structures (Wcislo et al., 2004; Hinojosa-Díaz et al., 2012; Zama & Coelho, 2017). Records of gynander specimens of bees are important in studies that focus on elucidating the mechanisms of sex determination and differentiation (Narita et al., 2010), to study the distribution of deviant phenotypes in tagma (between and within them for different taxa; see Hinojosa-Díaz et al., 2012 for a thorough discussion) and to explore these anomalies in the phylogenetic history of the group.

In this contribution we described and illustrate two new cases of gynandromorphism in carpenter bee species of *Xylocopa (Neoxylocopa)* from Brazil: a mosaic gynandromorph of the *X. (Neoxylocopa) brasilianorum* (Linnaeus, 1767) from São Paulo state and a bilateral gynandromorph of the *X. (Neoxylocopa) ordinaria* Smith, 1874 from Sergipe state. There are two previous cases of gynander reported in the literature that have been attributed to the species names of *X. brasilianorum* and *X. ordinaria*. According to Lucia & Gonzalez (2013) the correct name for the mosaic gynandromorph from Argentina described by Enderlein (1913) as *X. ordinaria* is actually a specimen of *Xylocopa atamisquensis* Lucia & Abrahamovich, 2010 and the other Argentinean gynander described by Benoist & Berland (1935) as *X. brasilianorum* might also be a specimen of *X. atamisquensis*, since that this species does not occur in Argentina. Therefore, the presented work is the first record of a gynandromorphic specimen for these two species.

MATERIAL AND METHODS

Gynandromorph descriptions are provided emphasizing the observed sexual features. The general morpho-

logical terminology follows Michener (2007); metasomal terga and sterna are cited as T1-T7, and S1-S8, respectively. Genitalia structures were recognized with assistance of Packer (2003). All measurements are expressed in millimeters (mm). With the purpose of comparison of the morphological variability, normal specimens were studied from the material deposited in the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZSP).

The specimens labels were transcribed with apostrophe marks (' ') indicating information of different labels attached to the same specimens and word between brackets ([]) to explicit abbreviated or important concealed information. The terminalia (genitalia and associated sterna) were detached from the metasoma, cleared in a 10% KOH solution for 24 h, neutralized in acetic acid, and stored in a vial with glycerin. The Figs. 1 and 3 were taken with a Canon EOS Rebel T3i camera with Canon MP-E, StackShot macro-rail and Griffi Equipamentos portable camera stand, using focus stacking performed by software Zerene Stacker. Figs. 2, 4-7 and 12-15 were obtained using a Leica video camera DFC 295 attached to a Leica stereomicroscope (M205C), and the series of images were combined in the software LEICA LAS (Leica Application Suite V3.6.0) or Combine ZP to produce confocal images. Images of adults of *Xylocopa ordinaria* (Figs. 8-11) were taken with a Sony DSC HX-300 camera. Final figures were edited in commercial software for small adjustments, such as brightness and contrast, and for highlight structures.

RESULTS AND DISCUSSION

Xylocopa (Neoxylocopa) brasilianorum (Linnaeus, 1767) Gynandromorph (Figs. 1-7)

Examined material

One gynandromorph specimen, labeled as follows '[Brazil], São Paulo, Jundiáhy[Jundiáí], M. Beron leg., xi.[19]00' '1.932' '102.025' '*Xylocopa brasilianorum* L., Hermaphrodito!, R.v. lhg. det.' and '*Xylocopa brasilianorum*, 1293, Hermaphrodito!, M. Beron 17.ii.00 Jundiáhy' deposited in the collection of the Hymenoptera Laboratory, Museu de Zoologia, Universidade de São Paulo (MZSP).

Description

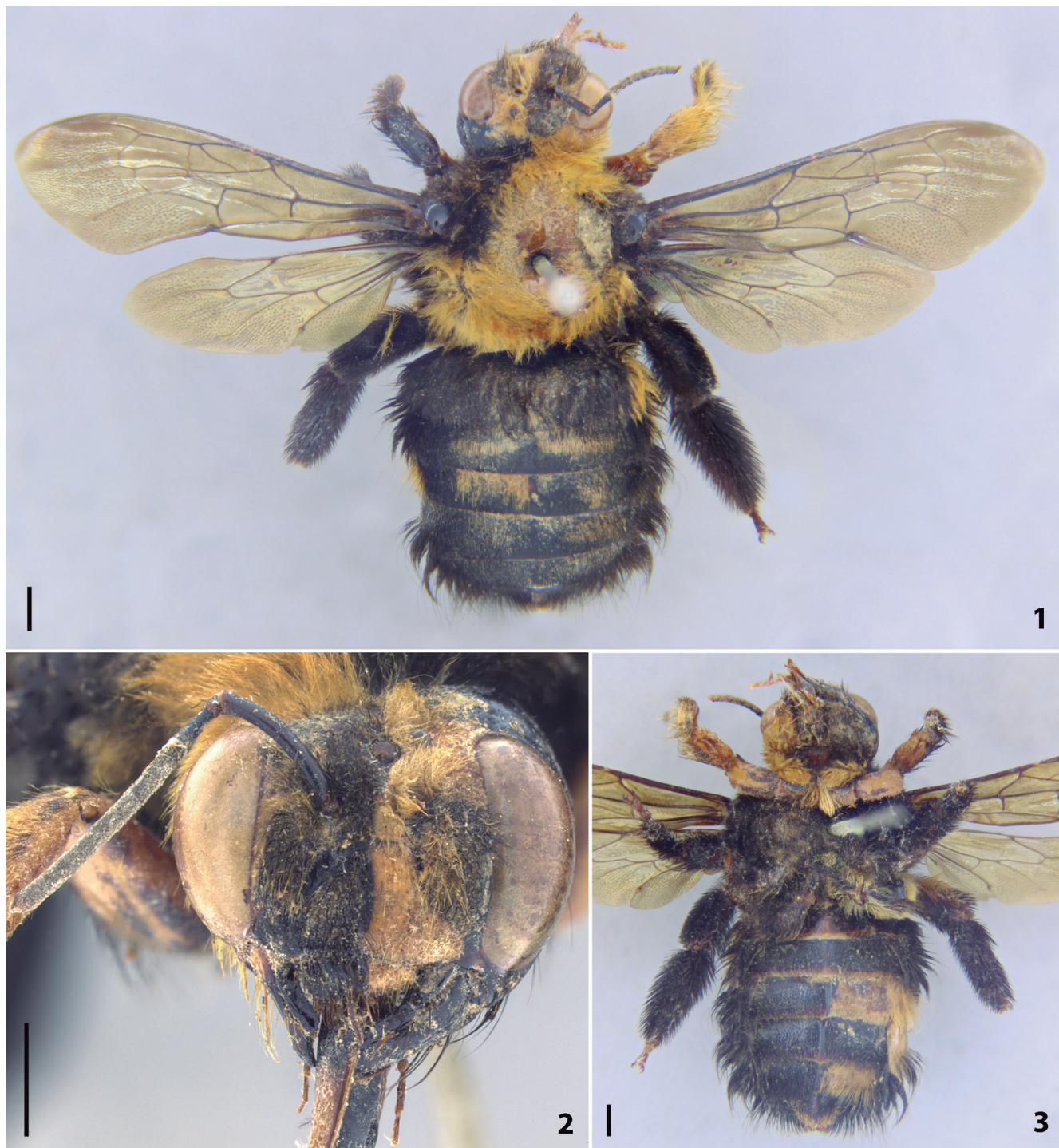
Body length: 24.1 mm; maximum head width: 7.0 mm; right forewing length: 20.8 mm; left forewing length: 20.7 mm; maximum mesoscutum width: 10.5 mm; maximum metasoma width: 11.0 mm. This gynandromorph specimen is well defined as mosaic pattern. Female and male traits are distributed irregularly along the body.

Head: The head presents a mixed constitution of female and male. The right half of vertex, frons, paraocular area,

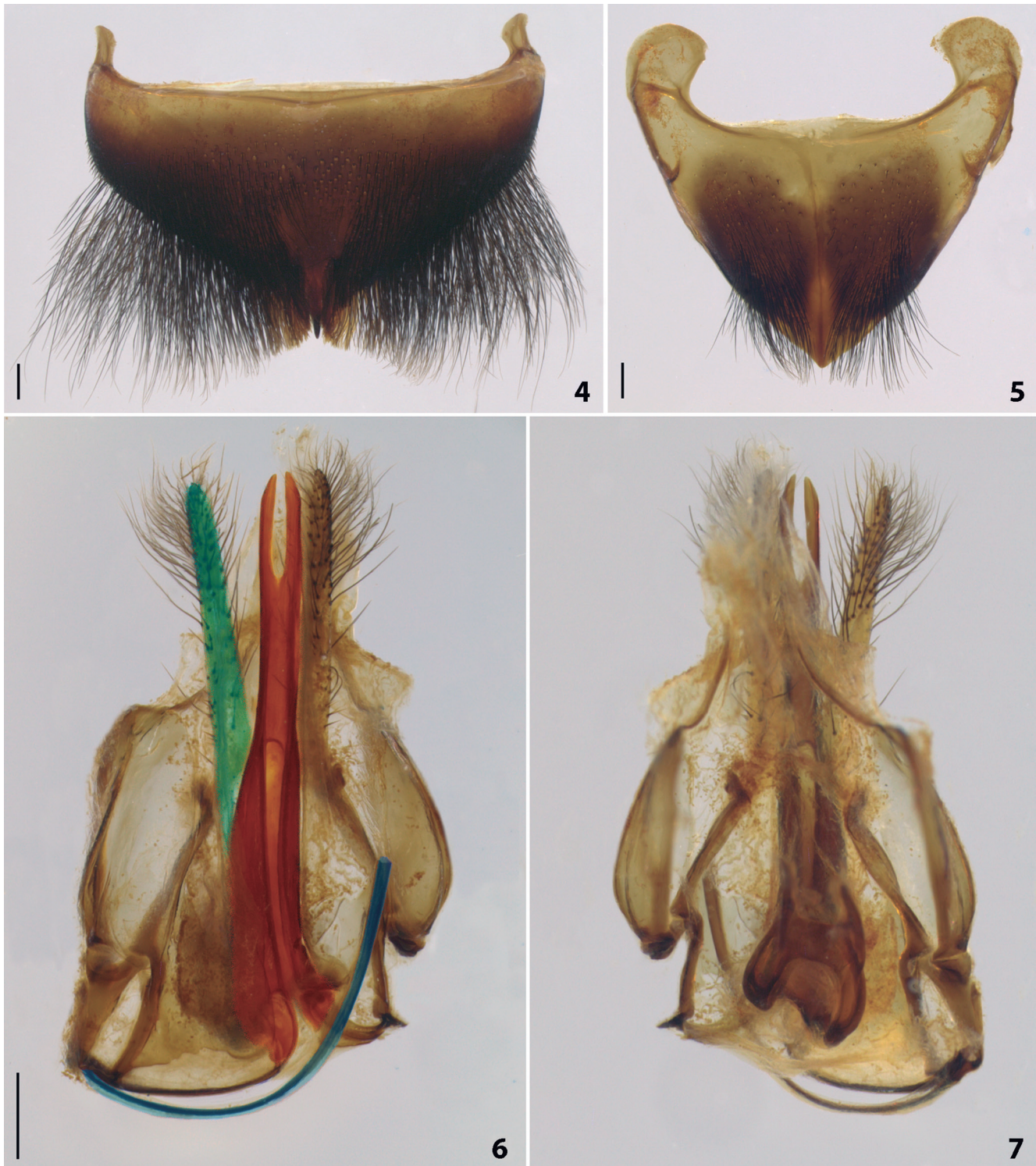
supraclypeal area, clypeus, and labrum with female features and predominantly male in the left side; right antenna as female with 10 flagellomeres; left antenna is missing; mandibles and proboscidean structures male in the right side and female in the left side; genal area and occiput with male features in the right side and female on left half.

Mesosoma: Displaying a mosaic of male and female characters. The right half of pronotum and mesoscu-

tum is male (except by the black pronotal lobe) and the left side is female. Mesepisternum and metepisternum as female. Scutellum and metanotum entirely male. Propodeum female on the right side and male on left side. The right forewing as male in which the second submarginal cell show the first and second r-m veins strongly convergent (almost touching on upper side); the first and second r-m veins of the left forewing is relatively less convergent, similar to female. The legs show a mixture of male and female characters. Right foreleg



Figures 1-3. Gynandromorph of *Xylocopa* (*Neoxylocopa*) *brasilianorum* from Jundiá, São Paulo (Brazil). (1) Habitus in dorsal view. (2) Head in frontal view. (3) Habitus in ventral view. Scale bars = 2 mm.



Figures 4-7. Gynandromorph of *Xylocopa* (*Neoxylocopa*) *brasilianorum* from Jundiá, São Paulo (Brazil). (4) Tergum 6 in dorsal view. (5) Sternum 6 in ventral view. (6) Genitalia in ventral view. (7) Genitalia in dorsal view. Green: gonostylus, red: sting shaft, blue: lancet. Scale bars = 0.5 mm.

entirely as male. Left foreleg mostly female with yellow integument and pubescence (male traits) on the coxa, trochanter, and underside portion of tibia; left femur of fore leg with rounded margin on posterior portion and yellow integument and pubescence underside as male. Mid legs as female. Hind legs predominantly female except by some yellow pubescence (male attribute) on the left coxa, trochanter, and posterior portion of femur and inner portion of tibia.

Metasoma: Predominantly female with some male areas, visible by yellow pilosity. Metasomal terga and sterna as female, with six exposed segments. Pigdial plate and fimbria on T6 as female (Figs. 4-5). Pubescence, punctuation, and color as female, except by yellow pilosity typical of male in the lateral of right side on T1 and T2, left side on T3 and T4, left half of S3 and S5 (Fig. 3). The genital structure as female with evident sting apparatus, slightly asymmetric; first valvifer

(lancet), second valvifer (gonostylus), and sting shaft visible (Figs. 6-7).

***Xylocopa (Neoxylocopa) ordinaria* Smith, 1874**
Gynandromorph
(Figs. 8-15)

Examined material

One gynandromorph specimen, labeled as follows 'Brasil, Sergipe, Itabaiana, Campus UFS, vii.2012, Almeida, R.P.S. leg' 'CEUFS 4300' '*Xylocopa* cfr. *ordinaria*, GAR Melo 2014 det.' and deposited in the Laboratory of Entomology, Coleção Entomológica, Universidade Federal de Sergipe, Aracaju, Sergipe (CEUFS).

Description

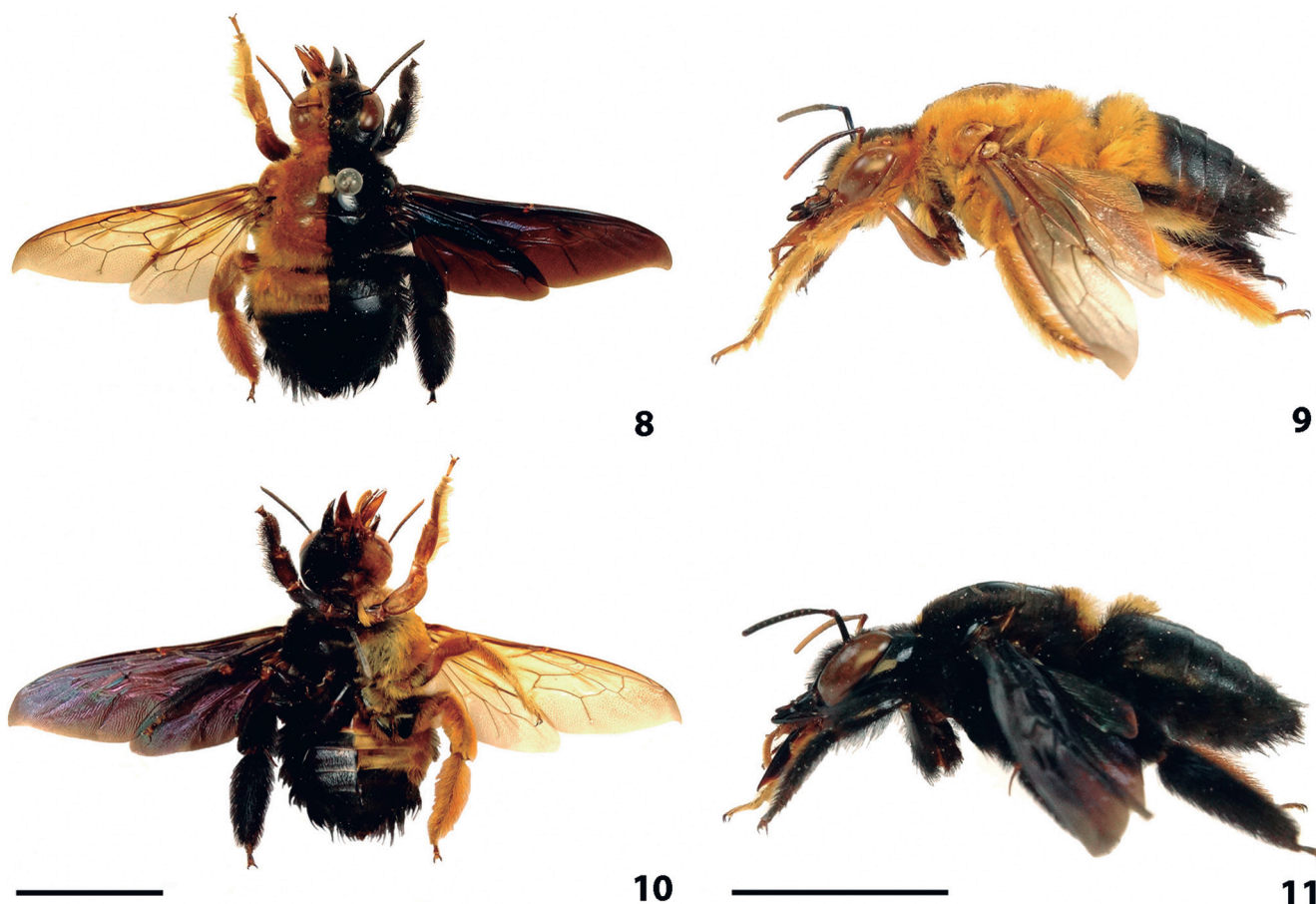
Body length: 21.7 mm; maximum head width: 7.0 mm; right forewing length: 23.3 mm; left forewing length: 21.3 mm; maximum mesosoma width: 7.2 mm; maximum metasoma width: 11.3 mm. The gynandromorph presents a bilateral symmetry condition.

Head, mesosoma and metasoma: Body structures, integument, and pubescence on right side females and

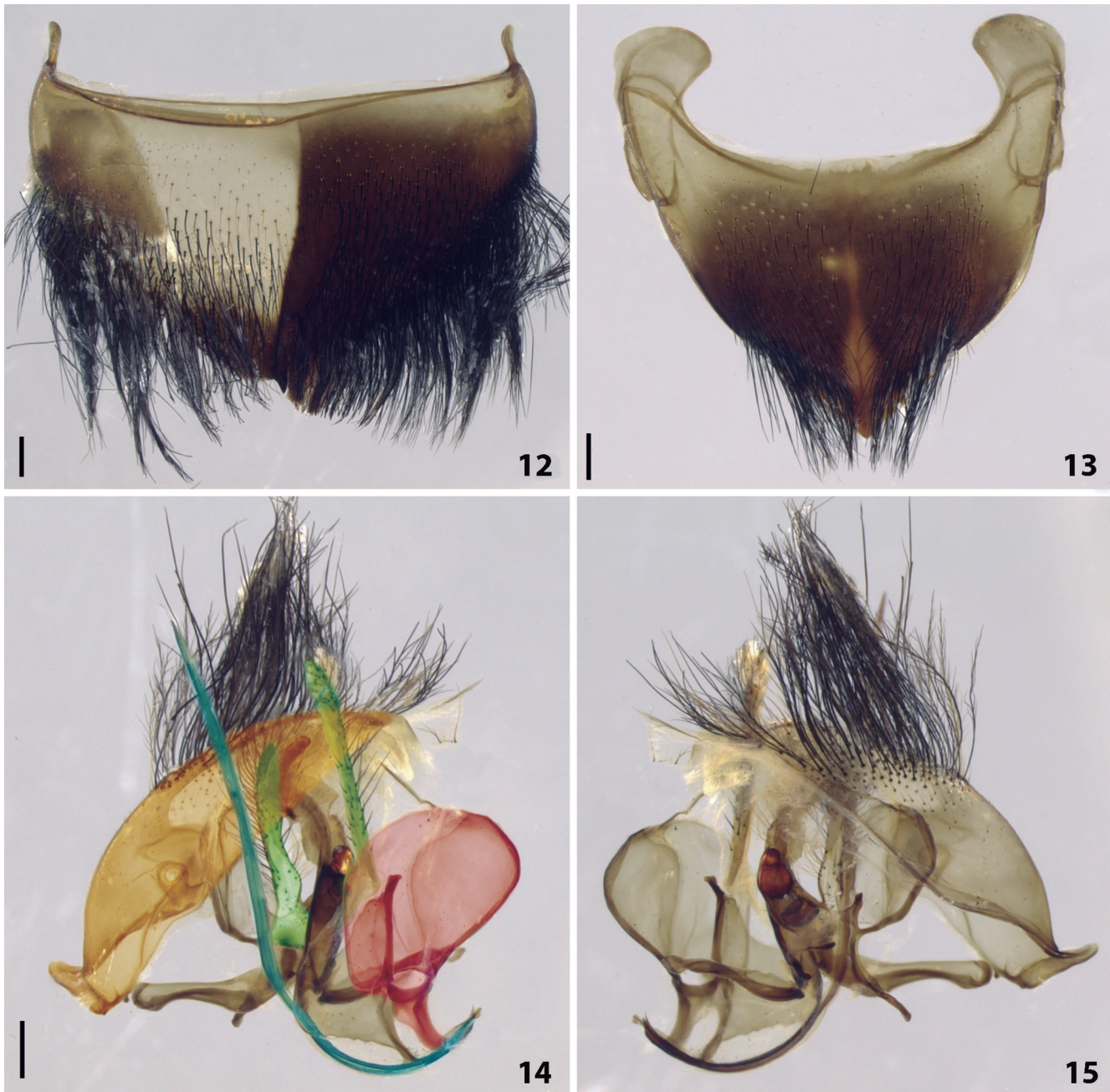
the left side male. Left antenna with 11 flagellomeres and the right with 10 flagellomeres. The sixth segment of metasoma has the appearance of female on the right side with a pygidial process (entirely suppressed on left side). The left side of the metasoma present an evident seventh terga, a typical structure of male, retracted beneath the T6 (Fig. 15). The condition of the genitalia and associated terga and sterna is complex, with anomalous and asymmetric morphology; both female (gonostylus, lancet, and hemitergite 7) and male (T7, only a half portion) structures can be observed (Figs. 14-15).

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Figures 8-11. Gynandromorph of *Xylocopa (Neoxylocopa) ordinaria* from Itabaiana, Sergipe (Brazil). (8) Habitus in dorsal view. (9) Left side with male traits, in lateral view. (10) Habitus in ventral view. (11) Right side with female traits, in lateral view. Scale bars = 1 cm.



Figures 12-15. Gynandromorph of *Xylocopa* (*Neoxylocopa*) *ordinaria* from Itabaiana, Sergipe (Brazil). (12) Tergum 6 in dorsal view. (13) Sternum 6 in ventral view. (14) Genitalia in ventral view. (15) Genitalia in dorsal view. Green: gonostylus, orange: tergum 7 of male, red: hemitergite 7 of female, blue: lancet. Scale bars = 0.5 mm.

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