

Sex dimorphism in pupae and adults of the specialist *Ipomoea batatas* defoliator *Bedellia somnulentella* (Lepidoptera: Bedelliidae)

Rodrigo Almeida Pinheiro

bio.rodrigopinheiro@gmail.com

Universidade Federal dos Vales do Jequitinhonha e Mucuri <https://orcid.org/0000-0001-5642-5065>

Maria Jéssica S. Cabral

UFVJM: Universidade Federal dos Vales do Jequitinhonha e Mucuri

Samuel C. O. Giordani

UFVJM: Universidade Federal dos Vales do Jequitinhonha e Mucuri

José C. Zanuncio

UFV: Universidade Federal de Vicosa

José Eduardo Serrão

UFV: Universidade Federal de Vicosa

Conceição A. Santos

UFVJM: Universidade Federal dos Vales do Jequitinhonha e Mucuri

Marcus A. Soares

UFVJM: Universidade Federal dos Vales do Jequitinhonha e Mucuri

Research Article

Keywords: Leafminer, Morphology, Sweet potato

Posted Date: April 18th, 2024

DOI: <https://doi.org/10.21203/rs.3.rs-4238358/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Bedellia somnulentella Zeller, 1847 (Lepidoptera: Bedelliidae), a global pest of the sweet potato *Ipomoea batatas*, was recorded in Brazil, but morphological information on sexual dimorphism of this insect is scarce. The objective was to evaluate morphological characters of sexual dimorphism of *B. somnulentella* pupae and adults. External structures with sexual dimorphism were not detected in the last abdominal segments of *B. somnulentella* pupae, but the females are heavier and could be a distinctive sex characteristic in this insect. A pair of frenulum on the hind wings of females and only one on those of males, in addition to elongated cerci and bipartite genitalia in the latter and smaller cerci involving the last abdominal segment and an ovipositor in females, differentiate sexes of *B. somnulentella*.

Full Text

Two genital openings, one for mating and one for oviposition, are reported for Ditrysia (Lepidoptera) female, which includes 98% of the world butterfly and moth species (Kristensen & Skalski, 1999; Capinera, 2008). Yponomeutoidea, with approximately 230 genera and 1,800 described species, includes microlepidoptera, such as those in the Bedelliidae family, with one genus and 16 species (Van Nieukerken, 2011).

The microlepidopteran *Bedellia somnulentella* Zeller, 1847 (Lepidoptera: Bedelliidae) was recorded in Brazil defoliating sweet potato plants *Ipomoea batatas* (Convolvulaceae) (Santos et al., 2018). The life cycle of *B. somnulentella* is approximately 30 days, with five and seven for the pupal and adult stages, respectively, both without apparent sexual dimorphism (Santos et al., 2021).

Sex dimorphism in Lepidoptera is based on life history, behavioral, and morphological traits (Allen et al., 2011), including color pattern, body shape and size, antennae, wings, and adult abdomen morphology. Sex determination in immature stages of moths (e.g., pupae) is necessary for studies such as behavioral tests with pheromones and ecotoxicological tests using virgin insects (Posada et al., 2011). The objective was to identify morphological characters of sexual dimorphism in *B. somnulentella* pupae and adults.

Bedellia somnulentella was reared in the Cellular Biology laboratory of the “Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM)” in Diamantina, Minas Gerais state, Brazil, in wooden cages (33 × 33 × 33 cm), with screened sides and a glass lid at room temperature. Images of *B. somnulentella* adults were obtained with a CANON EOS Rebel 850D camera.

Bedellia somnulentella pupae were collected from mass rearing and the body length of two groups of 15 individuals was measured using the Image J2 software (Rueden et al., 2017) and obtained 3.0 and 3.5mm long for those in both groups. These pupae were individualized in Petri dishes (60 x 15 mm) and the sex of the resulting adults confirmed and used in other analyses.

A pair of hindwings from a female and a male were removed and bleached in 10% potassium hydroxide overnight for 12 h in the cold. The frenulum of these wings was removed and photographed using a Leica

DM 500 microscope with an attached digital camera. Pupae and abdomens of adult *B. somnulentella* were dehydrated in an increasing series of ethanol (70%, 80%, 90%, 95%, 99%) at two-minute intervals per concentration and mounted on aluminium supports with tape adhered to the surface, kept in a desiccator with silica for six hours and analyzed using a Hitachi model TM 3000 microscope (Hitachi High-Technologies Corporation, Tokyo, Japan) of the Jequitinhonha Valley Integrated Research Laboratory.

The weight (mg) of *B. somnulentella* pupae was obtained on a precision scale (Shimadzu Corporation, Kyoto, Japan) and these data were subjected to the Student t-test at 5% significance using R Software (R Core Team 2021).

External structures, such as fissures or pores, were not detected on the abdominal segments (Figure 1C) or on the seventh to ninth tergites of males (Figure 1B) and females (Figure 1D) pupae of *B. somnulentella* as sex dimorphism.

Female pupae (0.99 ± 15 mg) of *B. somnulentella* were heavier than male pupae (0.68 ± 0.15 mg), which may indicate sex dimorphism.

Bronze yellow color pattern of the head, thorax and abdomen and filiform-type appendages and antennae (Figure 2A) are similar for females and males *B. somnulentella*.

One frenulum was observed on the hindwings of males (Figure 2B) and two on those of females *B. somnulentella* (Figure 2C).

Short cerci surround the last sternite (Figure 3B) of the abdomen of *B. somnulentella* females, which is modified into an ovipositor (Figure 3A). A bipartite valve (Figure 3C) and long cerci were observed in the last segment of the abdomen of males (Figure 3D), making it possible to differentiate the sexes of *B. somnulentella* in ventral view.

Anal pore absents in the last three abdominal segments of *B. somnulentella* pupae, of different sizes collected on *I. batatas* plants, makes sexing difficult at this stage. This differs from reports of this structure in other Ditrysia species, such as in pupae of the microlepidopteran *Tonza citrorrhoa* Meyrick, 1905 (Lepidoptera: Tonzidae) in the ninth abdominal segment with a distinct morphology between females and males, allowing sexing this insect (Kobayashi et al., 2018). Anal pores, with a variable shape between immature females and males, were reported in pupae of the microlepidopteran *Tuta absoluta* Meyrick, 1907 (Lepidoptera: Gelechiidae), with an anal fissure in the eighth abdominal segment of the former and in the tenth in the latter, as a dimorphism in this stage (Genc, 2016). A longitudinal ridge was reported on the eighth abdominal segment of female pupae of the butterfly *Nymphalis polychloros* Linnaeus, 1758 (Lepidoptera: Nymphalidae) (Genc, 2015). Genital opening in the middle part of the ninth abdominal segment in a short slit surrounded by a pair of semicircular ridges differentiates females and male pupae of *Mythimna separata* Walker, 1865 (Lepidoptera: Noctuidae) in ventral view (Lin et al., 2020), but this cleft was not detected in *B. somnulentella* pupae.

The greater weight of female than male pupae of *B. somnulentella* is common in butterflies and moths, as reported for male pupae of *N. polychloros* (Genc, 2015), *Syssphinx molina* Crame, 1780 (Lepidoptera: Saturniidae) (Batista et al., 2013), *T. absoluta* (Genc, 2016) and *Lycoriella ingenua* Dufour, 1839 (Diptera: Sciaridae) (Lewandowski et al., 2004). Heavier female pupae indicate sex dimorphism in *B. somnulentella*.

Similar color of the head, thorax and wings and filiform antennae in males and females and the abdomen of males of *B. somnulentella* thinner than that of their females is similar to that reported for *Conopomorpha cramerella* Snellen, 1904 (Lepidoptera: Gracillariidae) (Posada et al., 2011). The sharper body of *B. somnulentella* males is similar to that reported for *T. citrorrhoa* (Kobayashi et al., 2015) and color markings on the forewings of *Spodoptera frugiperda* J.E. Smith, 1797 (Lepidoptera: Noctuidae) (Navasero, 2020) are sex dimorphism.

A pair of frenulum in females and only one in males on the hind wings of *B. somnulentella* is similar to that reported for *Mythimna separata* Walker, 1865 (Lepidoptera: Noctuidae) (Lin et al., 2020), being an adequate parameter to sex *B. somnulentella* adults.

The external male genitalia of *B. somnulentella*, surrounded by long cerci in the last segment, and short in its females, are similar to that reported for *T. citrorrhoa* (Kobayashi et al., 2015). Circuses and shape of the genitalia of *B. somnulentella* and the bipartite male genitalia in the eighth male abdominal segment of *Leucoptera coffeella* Guérin & Méneville, 1842 (Lepidoptera: Lyonetiidae) (Posada et al., 2011; Motta et al., 2021) are parameters of sexual dimorphism. A pair of elongated limbs with cerci covering the external genitalia of females in the eighth segment and the last with a tubular shape and ovipositor surrounded by apical bristles in *B. somnulentella* females is similar to that reported for *L. coffeella* (Motta et al., 2021).

External structures of sex dimorphism were not detected in the last abdominal segments of *B. somnulentella* pupae, but females of this stage are heavier, being a parameter of sex dimorphism. The color pattern and general body structures of males and females *B. somnulentella* are similar.

Sexual dimorphism in *B. somnulentella* is characterized by discrete anatomical differences. Females are heavier and with a pair of frenula per wing, whereas only one frenulum was observed on each wing of males. Additionally, elongated and smaller cerci involve the last abdominal segment, along with bipartite genitalia in males. In contrast, a ovipositor was observed on females. These distinct morphological features differentiate between male and female *B. somnulentella* individuals.

Declarations

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest

The authors declare no competing interests. There is no financial interest in this research.

Author contributions

R.A.P.: conceptualization, data curation, research, methodology, validation, original writing; M.J.S.C.: formal analysis, supervision, review and editing; S.C.O.G.: formal analysis, supervision, review and editing; J.C.Z.: formal analysis, supervision, review and editing; J.E.S.: formal analysis, supervision, review and editing; C.A.S.: formal analysis, methodology, project administration, validation, review and editing; M.A.S.: conceptualization, formal analysis, methodology, project administration, validation, review and editing.

Acknowledgments

To the Cellular Biology laboratory of the Department of Biological and Health Sciences (207) of the “Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM)” for providing conditions for carrying out the experiments and rearing the insects. We would like to thank the “laboratório multiusuário de microscopia avançada – LMMA” sponsored by the “Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG (CEX-112-10)” and RQ-MG (FAPEMIG: CEX-RED-00010-14) for supporting the images scanning electron microscopy. To “Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) – Finance Code 001”.

References

1. Allen, C.E., B.J. Zwaan, and P.M. Brakefield. 2011. Evolution of sexual dimorphism in the Lepidoptera. *Annu Rev Entomol* 56: 445–464. doi: <https://doi.org/10.1146/annurev-ento-120709-144828>.
2. Batista, T.F.V., A.M. Lunz, V.D.S.V.D. Rosário, L.J.U. Lemos, R.S. Provenzano, and E.D.S. Monteiro. 2013. Biological and morphometric aspects and rearing of *Syssphinx molina* (Cramer) (Lepidoptera: Saturniidae), a defoliator of parica tree. *Acta Amazon* 43: 191–196. doi: <https://doi.org/10.1590/S0044-59672013000200009>.
3. Capinera, J. 2008. *Encyclopedia of Entomology*, 2nd ed., Springer Verlag, New York.
4. Dallai, R. and B.A. Afzelius. 1990. Microtubular diversity in insect spermatozoa: results obtained with a new fixative. *J Struct Biol* 103: 164-179. doi: [https://doi.org/10.1016/1047-8477\(90\)90020-D](https://doi.org/10.1016/1047-8477(90)90020-D).
5. Genc, H. 2015. Sex differentiation of elm nymphalid (*Nymphalis polychloros* (Linnaeus, 1758) on pupal stage. *J Agric & Biol Eng* 9: 899–902. doi: <https://doi.org/10.5281/zenodo.1107888>.
6. Genc, H. 2016. The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae): pupal key characters for sexing individuals. *Turk J Zool* 40: 801–805. doi: <https://doi.org/10.3906/zoo-1510-59>.
7. Kobayashi, S., H. Matsuoka, M. Kimura, J. Sohn, Y. Yoshiyasu, and D.C. Lees. 2018. Designation of a new family group name, Tonzidae fam. nov., for the genus *Tonza* (Lepidoptera, Yponomeutoidea), based on immature stages of *Tonza citrorrhoa*. *Eur J Taxon* 1: 1–32. doi: <https://doi.org/10.5852/ejt.2018.443>.

8. Kobayashi, S., J.C. John, and Y. Yoshiyasu. 2015. Reevaluation of the systematic position of the genus *Tonza* Walker (Yponomeutoidea: family incertae sedis), based on *Tonza citrorrhoa* Meyrick, new to Japan. Lepi Sci 66: 68–76. doi: <https://doi.org/10.18984/lepid.66.268>.
9. Kristensen, N.P. and A.W. Skalski. 1999. Phylogeny and paleontology. Pages 7–25 in: Lepidoptera: Moths and Butterflies. 1. Evolution, Systematics, and Biogeography. Handbook of Zoology Vol. IV, Part 35. N. P. Kristensen, ed. De Gruyter, Berlin and New York.
10. Lewandowski, M., A. Sznyk, and A. Bednarek. 2004. Biology and morphometry of *Lycoriella ingenua* (Diptera: Sciaridae). Biol Lett 41: 41–50.
11. Lin, C.H.E.N., Q.J. Pan, M.S. Waqas, and T.X. Liu. 2020. Morphological traits for sex identification of the oriental armyworm, *Mythimna separata* (Lepidoptera: Noctuidae). J Integr Agr 19: 1458–1463. doi: [https://doi.org/10.1016/S2095-3119\(19\)62862-5](https://doi.org/10.1016/S2095-3119(19)62862-5).
12. Motta, I.O., J. Dantas, L. Vidal, J. Bílio, J.R. Pujol-Luz, and É.V. Albuquerque. 2021. The coffee leaf miner, *Leucoptera coffeella* (Lepidoptera: Lyonetiidae): identification of the larval instars and description of male and female genitalia. Rev Bras Entomol 65: 1.e20200122. doi: <https://doi.org/10.1590/1806-9665-RBENT-2020-0122>.
13. Navasero, M.M., and M.V Navasero. 2020. Life cycle, morphometry and natural enemies of fall armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) on *Zea mays* L. in the Philippines. J Int Soc Southeast Asian Agri Sci 26(2): 17–29. doi: <https://doi.org/10.1653/024.103.0414>.
14. Posada, F.J., I. Virdiana, M. Navies, M. Pava-Ripoll, and P. Hebbar. 2011. Sexual dimorphism of pupae and adults of the cocoa pod borer, *Conopomorpha cramerella*. J Insect Sci 11: 52. doi: <https://doi.org/10.1673/031.011.5201>.
15. Rueden, C.T., J. Schindelin, M.C. Hiner, B.E. DeZonia, A.E. Walter, E.T. Arena, K.W. Eliceiri. 2017. ImageJ2: ImageJ for the next generation of scientific image data. BMC Bioinformatics 18: 529. doi: <https://doi.org/10.1186/s12859-017-1934-z>.
16. Santos, M.M., M.A. Soares, I.M. Silva, P.C.R. Fontes, and J.C. Zanuncio. 2018. First record of the sweet potato pest *Bedellia somnulentella* (Lepidoptera: Bedelliidae) in Brazil. Fla Entomol 101: 315–316. doi: <https://doi.org/10.1653/024.101.0224>.
17. Santos, M.M., M.A. Soares, I.M. Silva, Z.V. Caldeira, C.M. Abreu, M.W.S. Rocha, A.A. Silva, B.M. Castro e Castro and J.C. Zanuncio. 2021. Life History of *Bedellia somnulentella* (Lepidoptera: Bedelliidae) Feeding on *Ipomoea batatas* (Solanales: Convolvulaceae) leaves and survey of parasitoids in Brazil. J Econ Entomol 114: 1631–1637. doi: <https://doi.org/10.1093/jee/toab078>.
18. Van Nieukerken, E. 2011. Order Lepidoptera Linnaeus, 1758. Zootaxa 1: 212–221. doi: <http://dx.doi.org/10.11646/zootaxa.3148.1.41>.

Figures

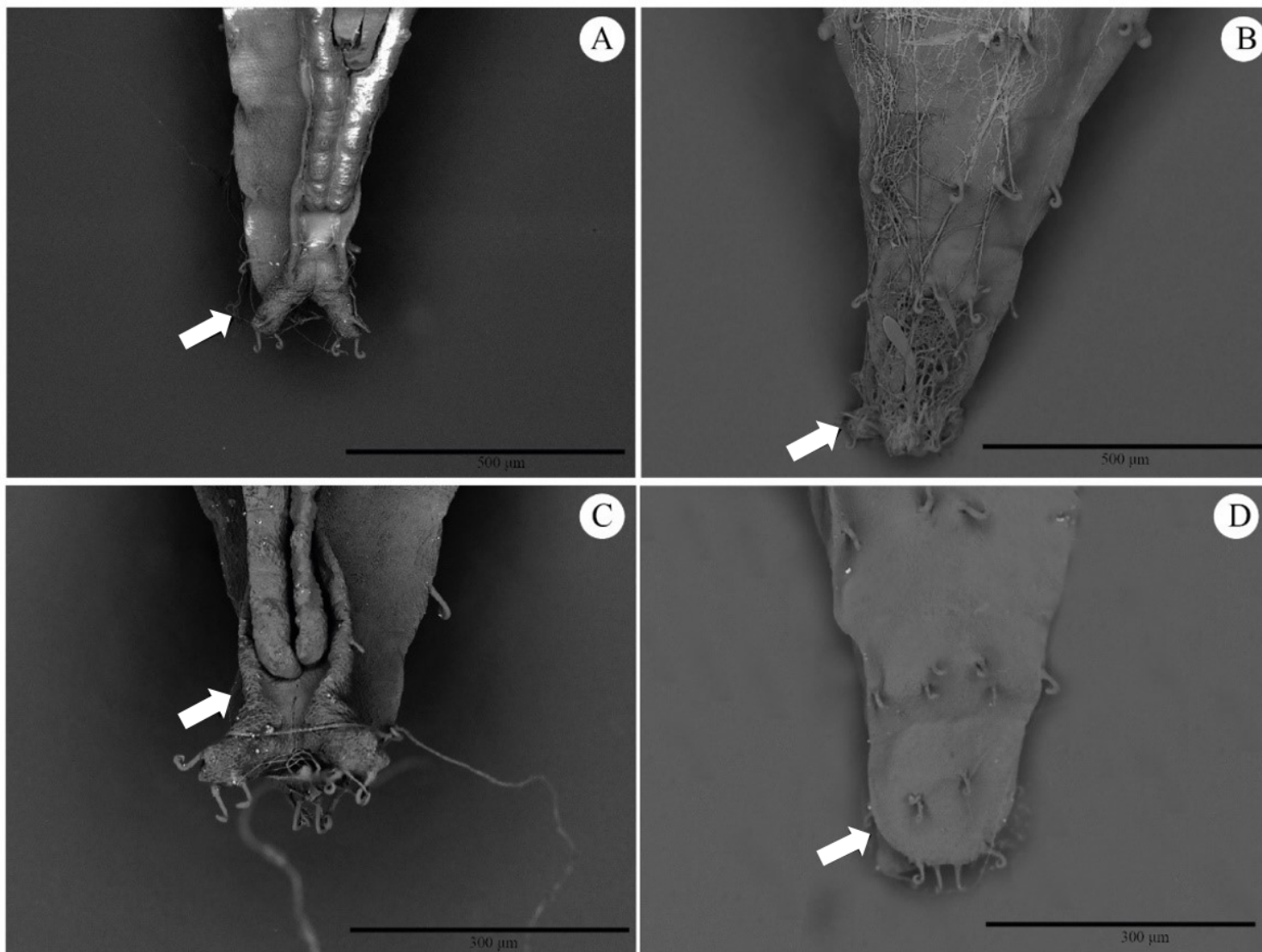


Figure 1

Final part of the abdomen of male pupa in ventral (A) and dorsal (B) views and female in ventral (C) and dorsal (D) views of *Bedellia somnulentella* (Lepidoptera: Bedelliidae).

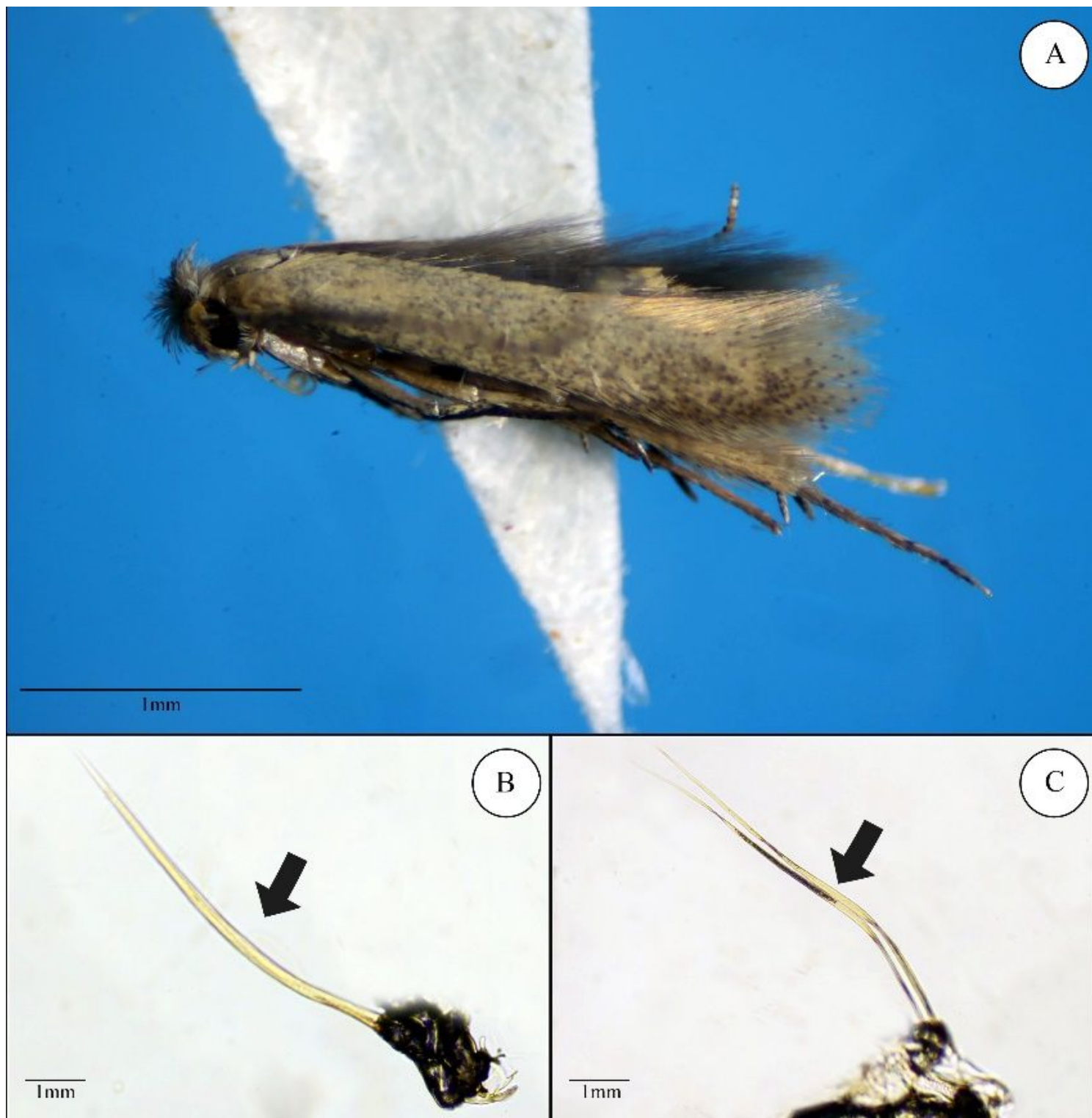


Figure 2

Adult (a) and frenulum of the hind wing of male (b) and female (c) *Bedellia somnulentella* (Lepidoptera: Bedelliidae).

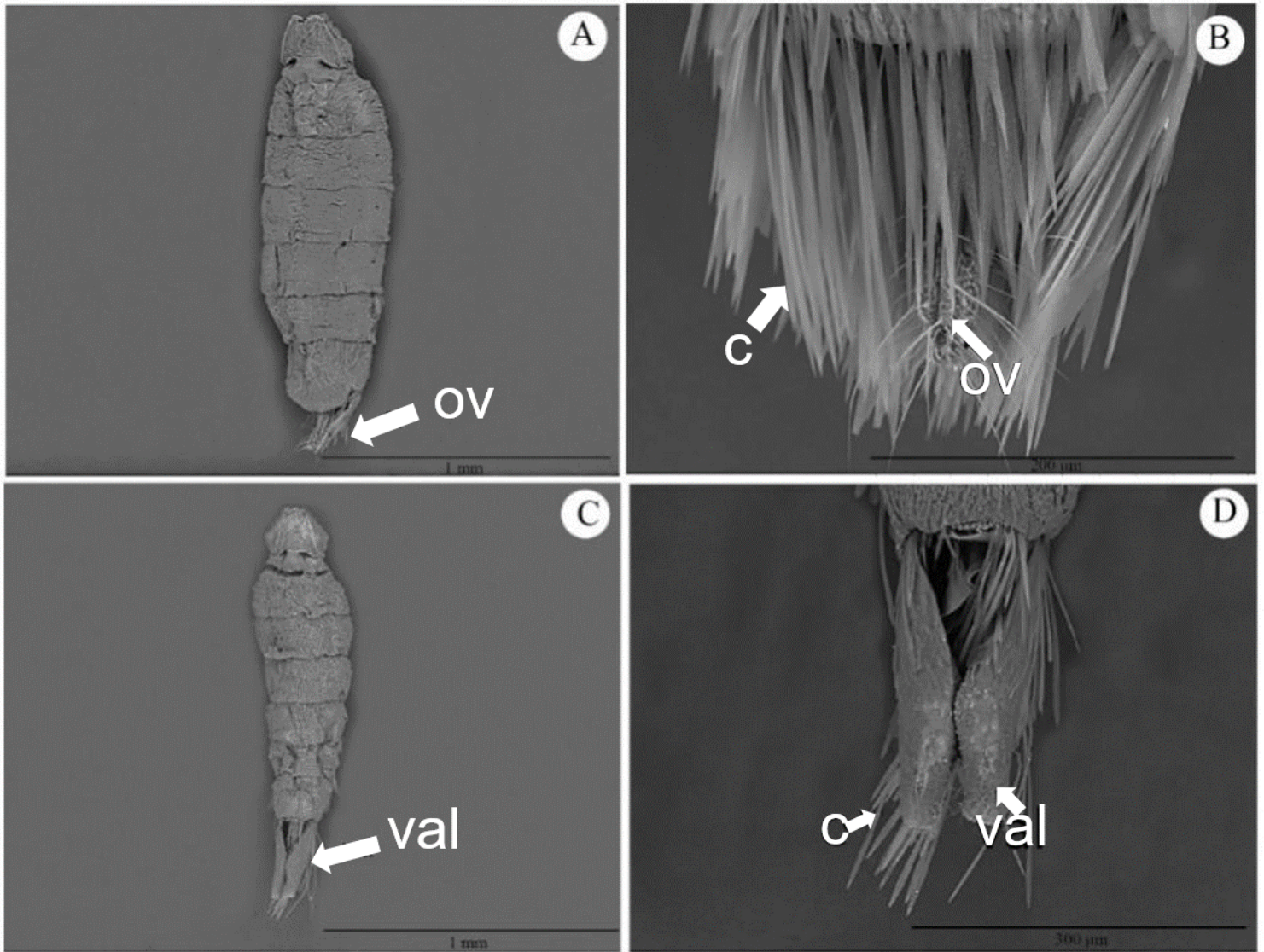


Figure 3

Dorsal view of the abdomen (A), last female abdominal segment in ventral (B) and dorsal view of the abdomen (C) and last abdominal segment (D) of males of *Bedellia somnulentella* (Lepidoptera: Bedelliidae). Caption ov: ovipositor; val: valve.