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PENSOFT

The *curvicauda* species group of *Anastrepha* Schiner, 1868 (Diptera, Tephritidae, Trypetinae) in Uruguay: new records of species and host plant

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Abstract
We report for the first time the occurrence in Uruguay of three species of *Anastrepha*, which belong to the *curvicauda* species group. Specimens of *Anastrepha australis* (Blanchard, 1959), *Anastrepha littoralis* (Blanchard, 1959), and *Anastrepha nigra* (Blanchard, 1959) were collected with McPhail traps baited with PBX® yeast/borax placed in fruit orchards. These records represent the most southern distribution known for *A. littoralis* and *A. nigra*, in addition to the first host plant records for *A. nigra*, which were reared from larvae on fruits of *Araujia hortorum* E. Fourn. (Apocynaceae).

Keywords
Araujia hortorum, common moth vine, fruit flies, *Toxotrypana.*

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Introduction

Based on a recent phylogenetic analysis (Mengual et al. 2017), the tephritid genus *Toxotrypana* Gerstaecker, 1860 has been proposed as a synonym of *Anastrepha* Schiner, 1868 (Norrbom et al. 2018a, 2018b). Although *Toxotrypana* is the senior name, *Anastrepha* was proposed as a valid genus due to the much greater economic significance of its species (Norrbom et al. 2018a). Therefore, all seven species previously classified in *Toxotrypana* are recognized as the *curvicauda* species group of *Anastrepha* (Norrbom et al. 2018b).

Most of the studies on the biology, behavior, and distribution of the *curvicauda* species group refer to a single species, *Anastrepha curvicauda* (Gerstaecker, 1860), the papaya fruit fly. This is the only species in the group that has an economic impact on fruit production and has, therefore, received more attention by researchers. Information on the other species of the *curvicauda* species group includes a taxonomic revision of the genus *Toxotrypana* (Blanchard 1959; Norrbom et al. 2012), as well as studies on their distribution (Lobos 1997), host plants, and phenology (Carpintero and Testoni 2013; Savaris et al. 2016; Bertolaccini et al. 2017). Photographs of

specimens are quite difficult to find, making it difficult to use taxonomic keys for species identification.

The *curvicauda* species group is found exclusively in the Neotropical region (Blanchard 1959; Norrbom et al. 1999). *Anastrepha australis* (Blanchard, 1959) is present in the Argentine provinces of Tucumán, Corrientes, Buenos Aires, Santa Fe, and Santiago del Estero (Blanchard 1959; Bertolaccini et al. 2017) as well as in southern Brazil (Garcia and Corseuil 2004) and Uruguay (Silveira-Guido and Habeck 1976). *Anastrepha littoralis* (Blanchard, 1959) is distributed from Guatemala to Venezuela and Colombia, following the Andes up to Corrientes, Argentina (Blanchard 1959; Savaris et al. 2016; Bertolaccini et al. 2017; Norbom et al. 2018b). *Anastrepha nigra* (Blanchard, 1959) has only been recorded in Argentina in the provinces of Jujuy, Córdoba, Entre Ríos, and Santa Fe (Blanchard 1959; Bertolaccini et al. 2017; Norbom et al. 2018b).

Most species of the *curvicauda* species group are associated with latex-bearing plants belonging to the Caricaceae, Asclepiadaceae, Annonaceae, and Apocynaceae families. Host-plant records are mostly documented for the pest species *A. curvicauda* (Landolt 1994, 1999; Tigrero 2009). In Ecuador, *Anastrepha recurcauda* (Tigrero, 1992) was reported on *Carica papaya* L. (Caricaceae) and *Annona cherimola* Mill. (Annonaceae) (Tigrero 1992, 2009). In Argentina, *A. littoralis* was first described from a specimen that emerged from fruits of *C. papaya*, and *A. nigra* was reported emerging from an unconfirmed species of the genus *Morrenia* Lindl. (Apocynaceae) (Blanchard 1959). *Anastrepha australis*, in turn, was first described from two females that emerged from a *Morrenia* species. Indeed, *A. australis* is regarded as a natural control agent of Apocynaceae species such as *Morrenia odorata* (Hook. & Arn.) Lindl., *Morrenia brachystephana* Griseb., and *Araujia hortorum* E. Fourn, (Blanchard 1959; Silveira-Guido and Habeck 1976). Interestingly, the later has been reported as an invasive weed in Europe, New Zealand, Australia, United States, and South Africa (Vivian-Smith and Panetta 2005) and *A. australis* has been proposed as a potential biological control agent (Silveira-Guido and Habeck 1976; Carpintero and Testoni 2013).

We conducted a survey of the *curvicauda* species group of *Anastrepha* in Uruguay, including their host plants. We report new species for this country and provide a taxonomic key and images to aid taxonomic identification.

Methods

Tephritid samplings were conducted in citrus and deciduous fruit orchards located in the regions of San José and Montevideo (Fig. 1). Flies were collected with McPhail traps baited with four PBX® yeast / borax pellets (SUSBIN, Argentina) and 300 mL of water. A total of 36 traps were laid out, three per 1-ha fruit plot. Traps were checked and rebaited every 15 days from August 2013 to May 2015.

A host plant survey was conducted in late summer (February) and early fall (March) in 2018 at the sampling site located in Montevideo, where most specimens and diversity of the *curvicauda* species group was captured in traps. Fruits of *A. hortorum* with symptoms of fruit fly attack, i.e. a visible hole surrounded by latex exudate (Landolt 1999), were collected and taken to the laboratory, stored individually in screen-covered plastic pots containing sterile sand, and kept at 25 °C until adult emergence.

Results

A total of six individuals of the *curvicauda* species group were captured. These six specimens were identified as

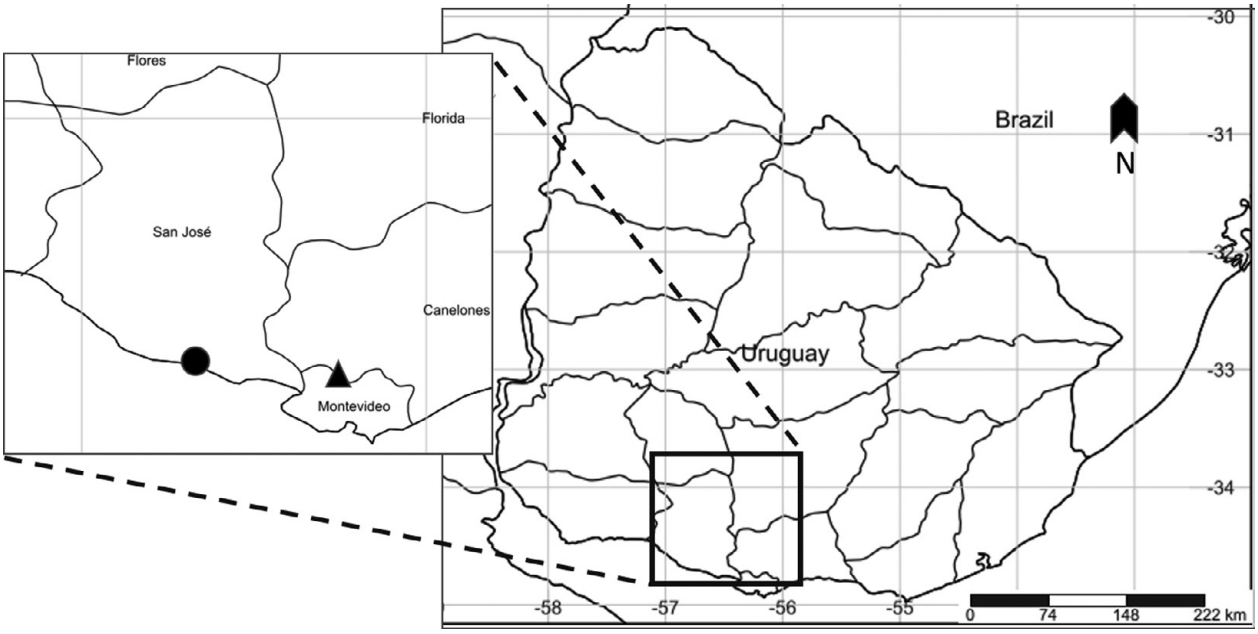

Figure 1. New records of *curvicauda* species group of *Anastrepha* in Uruguay: Melilla (triangle), Kiyú (circle). Simple mappr Shorthouse (2010).

A. australis (two males), *A. nigra* (two females and one male), and *A. littoralis* (one female). The examined specimens of *A. nigra* and *A. australis* are deposited in the Entomological Collection of the Facultad de Agronomía, Universidad de la República (UdelaR), Montevideo, Uruguay. The specimen of *A. littoralis* is deposited in the Entomological Collection of the Laboratorio de Insetos, Universidade Federal de Pelotas (UFPel), Pelotas, Brazil.

Host plant survey. Fruits of *A. hortorum* collected in late summer produced 24 pupae that were sent to Landcare Research, New Zealand, where only *A. australis* adults emerged. Fruits of the same plants collected in early fall were infested with 12 larvae, of which only two completed its development into adults of *A. nigra* (one female and one male), thus indicating *A. hortorum* as a new host plant record for *A. nigra*.

The *curvicauda* species group of Uruguay (Fig. 2A–C). Body of hymenopteroid form with the first abdominal segment elongated and petiolate. The mesonotum, postpronotal, presutural supra-alar, dorsocentral, intra-alar, and scutellar setae absent or small and weak, much shorter than scutellum length. Wings are hyaline, pale yellow and with a dark-yellow band along the length of the costal margin. Wing pattern with very long bcu cell, R2 + 3 vein with three abrupt curves, and M vein ending straight at the wing margin (Fig. 3A–C). Females with ovipositor (sintergosternite 7) usually as long as the length of the body (Fig. 2C), in most species recurved ventrally (Fig. 2B, C) (Blanchard 1959; Norrbom et al. 2012).

Identification key to the *curvicauda* species group from Uruguay (adapted from Blanchard 1959)

1 Mesonotum mostly dark-brown or blackish, usually with narrow yellow stripe in the mid-presutural region, and along transverse suture, pleuron and most of abdominal tergites mostly black. Female with oviscape longer than body (Figs 2B, 4B, 5B) ..... *A. nigra*

1′ Mesonotum yellow brownish with two black submedial bands arising from presutural region to mesoscutum, and a sublateral band at each side usually interrupted on transverse suture, pleuron mostly yellow with some black stripes (Fig. 4A, C). Females with oviscape as long as the length of the body (Fig. 2C) 2

2 Mesonotum with four longitudinal dark brown bands, two submedials arising from anterior scutum extending to mid mesoscutum, but distinctly separated from central black spot on the scuto-scutellar suture; scutellum mostly yellow, excepting some dark-brown lateral spots (Figs 2A, 4A) .....*A. australis*

2′ Mesonotum with four longitudinal brown bands, two submedials extending to the posterior margin of the scutum, connecting with a black spot on the scuto-scutellar suture; scutellum with apical edge blackish (Figs 2C, 4C) ..... *A. littoralis*

***Anastrepha australis* (Blanchard, 1959)**
Figures 2A, 3A, 4A, 5A

Examined material. URUGUAY • 1 ♂; Montevideo, Melilla; McPhail trap hung on *Citrus sinensis* cv Valencia; 21 m elev.; 34°43′49″S, 056°17′02″W; 7.iii.2015; V. Calvo & S. Delgado leg., (deposited at the Entomological Collection, UdelaR) • 1 ♂; San José, Kiyú; McPhail trap hung on *Prunus persica* cv. Elegant Lady; 34°38′16″S, 056°43′34″W; 22.iv.2015; V. Calvo & S. Delgado leg.; (deposited at the Entomological Collection, UdelaR).

Diagnosis. Head: yellow, face without whitish markings, presents a narrow brown band that covers the

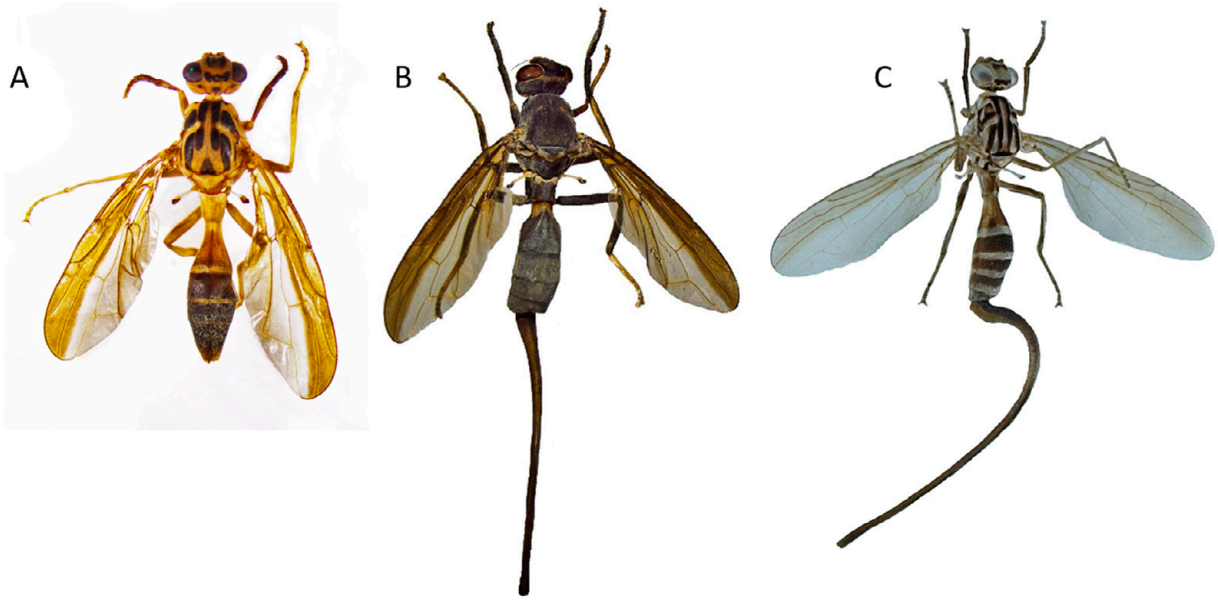

Figure 2. Specimens of the *curvicauda* species group of *Anastrepha*. **A.** *Anastrepha australis* male. **B.** *Anastrepha nigra* female. **C.** *Anastrepha littoralis* female.

Figure 3. Wing details. **A.** *Anastrepha australis*. **B.** *Anastrepha nigra*. **C.** *Anastrepha littoralis*.

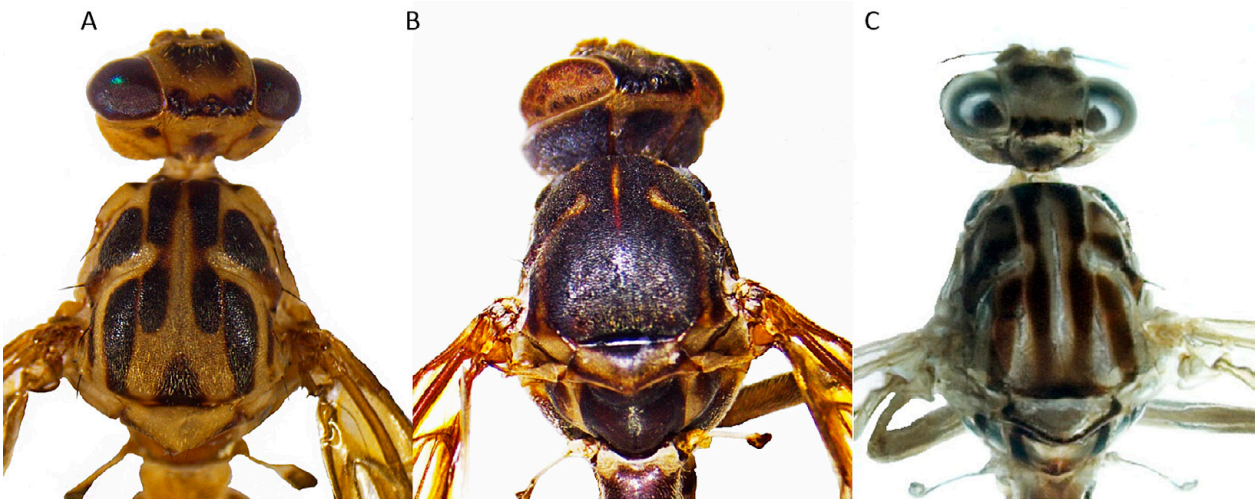

Figure 4. Head and thorax details. **A.** *Anastrepha australis*. **B.** *Anastrepha nigra*. **C.** *Anastrepha littoralis*.

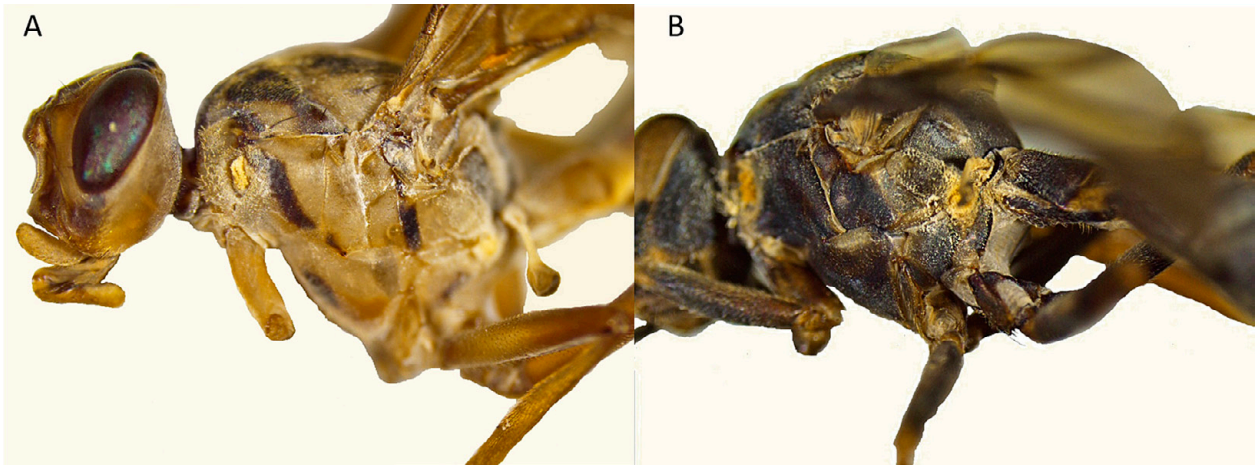

Figure 5. Lateral view of the thorax. **A.** *Anastrepha australis*. **B.** *Anastrepha nigra*.

ocellar triangle and extends to the eye margin with forehead slightly sunken. Antennae brownish-yellow. Gena with a brown spot below the eyes. Thorax: mesonotum light ocher-colored with blackish bands, densely coated with bright yellow pubescence. Submedian bands of the mesonotum ending far from the basal suture of the scutellum. Mesopleuron mostly yellow to orange, with dark brown spots or bands on at least anepisternum, katepisternum, and anepimeron. Subscutellum and mediotergite yellow to red-brown medially, dark brown laterally. Scutellum yellow with blackened edges. Legs: Femurs entirely yellow to orange-black, nails with a light-yellow base. Abdomen: Blackish with segments II–V with light-yellow narrow apical bands (Blanchard 1959; Norrbom et al. 2012).

***Anastrepha littoralis* (Blanchard, 1959)**
Figures 2C, 3C, 4C

Examined material. URUGUAY • 1 ♀; Montevideo, Melilla; McPhail trap hung on *Prunus persica* cv. Elegant Lady; 29 m elev., 34°43′49″S, 056°17′04″W; 30.i. 2014; S. Delgado & E. Silva Araujo leg.; (deposited in the Entomological Collection, UFPel).

Identification. Head: yellow, with an interocular brown band that covers the ocellar triangle and a supra antennal frontal transverse spot. Antennae yellowish-brown. Thorax: Mesonotum yellow colored with dark bands along, covered with dark brown pubescences, with four longitudinal dark bands, the middle pair almost united in the front edge. Mesopleuron is mostly yellow to orange,

with dark-brown spots or bands on at least in the anepisternum, katepisternum, and anepimeron. Scutellum lightcolored, with darkened lateral and posterior edges. Subscutellum yellow to red-brown medially, dark brown laterally. Abdomen: Abdominal tergites at least with syntergite 1+2 with a dark-brown band. Females with brown oviscape strongly dorsally arched, length 11–20 mm, with apex remarkably widened.

***Anastrepha nigra* (Blanchard, 1959)**
Figures 2B, 3B, 4B, 5B

Examined material. URUGUAY • 1 ♂, 1 ♀; Montevideo, Melilla; McPhail trap hung on *Citrus sinensis* cv Valencia; 21 m elev., 34°43′49″S, 056°17′02″W, 22.i.2015, V. Calvo & S. Delgado leg.; (deposited at the Entomological Collection, UdelaR). • 1 ♀, same collection data but 6.v.2015, V. Calvo & S. Delgado leg.; (deposited at the Entomological Collection, UdelaR). • 1 ♂, 1 ♀, same locality data but reared from fruits of *A. hortorum*, 8 m elev., 34°44′05″S, 056°19′01″W, 21.iii.2018, Calvo V & Delgado S, (deposited at Entomological Collection, UdelaR).

Identification. Head: black or dark brown, face without whitish markings, frons with a brown band or mark that includes the ocellar tubercle and extends to the eye margin, or mostly entirely brown. Facial carina mostly brown. Antennae blackish or dark brown. Thorax: blackish mesonotum with or without yellowish spots or lines. Blackish or brownish pleura with light ocher sutures. Black scutellum with a small yellow spot at each anterolateral angle. Postscutellum, subscutellum, and mediotergite entirely brown to dark brown (usually), or yellow to red-brown medially, dark brown laterally. Basal scutellar and katepisternal setae absent. Legs: anterior legs black, brown intermediate femurs and tarsi, blackish hind legs with light ocher tars. Abdomen: black without clear apical bands, pubescent coated with whitish reflections. Females have the ovipositor longer than the body with the oviscape strongly dorsally arched with the aculeus tip lateral margins not curved dorsally (Blanchard 1959; Norrbom et al. 2012).

Discussion

The *curvicauda* species group of *Anastrepha* in Uruguay is represented by three species, *A. australis*, *A. littoralis*, and *A. nigra*. In this work, *A. littoralis* and *A. nigra* are reported for the first time for Uruguay, representing the southern distribution for both species (Blanchard 1959; Savaris et al. 2016; Bertolaccini et al. 2017). *Anastrepha australis* is also confirmed for Uruguay, as it had previously been recorded by Silveira-Guido and Habeck (1976) in a survey of natural enemies of *M. odorata* and related weeds.

Our survey yielded few specimens of all three species, which is often the case for field studies on *curvicauda* species group (Bertolaccini et al. 2017). Indeed, despite intensive monitoring of *Anastrepha* species with food baits, reports of specimens of the *curvicauda* species group are rare (Lobos 1997; Malavasi and Zucchi 2000; Garcia and Corseuil 2004; Shelly et al. 2014). It is possible that these species do not require protein feeding to develop mature oocytes, and therefore protein hydrolysate baits may not be attractive to them, as has been shown for *A. curvicauda* (Landolt 1999). More studies are therefore needed to develop specific attractants for the *curvicauda* species group to further study their distribution, abundance, and population fluctuations.

Anastrepha australis and *A. nigra* emerged from fruits of the native vine *A. hortorum*, which were collected in the field and maintained in the laboratory in our study. Thus, *A. hortorum* is here reported as a new host plant record for *A. nigra*. Similarly, Blanchard (1959) reported that native vines of the genus *Morrenia*, also from the Apocynaceae family, are hosts for *A. australis* and *A. nigra* in Argentina. *Araujia hortorum* grows in natural and disturbed habitats, where it is associated with forest and riparian vegetation, as well as with species of economic interest, such as citrus and deciduous trees. When present in dense foliage, this vine may damage shrubs and trees (Santa Cruz and Cordero 2018). *Araujia hortorum* is an invasive species in New Zealand, Australia, Spain, and North America, often regarded as a weed pest (Vivian-Smith and Panetta 2005). Surveys for potential biological control agents have therefore been undertaken, with *A. australis* currently as the main candidate (Silveira-Guido and Habeck 1976; Waipara et al. 2006; Carpintero and Testoni 2013). Given our results, *A. nigra* can be considered as an alternative option for the biological control of *A. hortorum* and related vines in Uruguay. More comprehensive studies of the *curvicauda* species group and their native host plants are needed to improve our knowledge of these insect-plant systems, with both fundamental and applied implications.

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Authors' Contributions

The paper was originally conceived by VC, FRMG, AG and IS. The study was designed by VC, FRMG and IS. VC, SD, and FD carried out the field work. VC and SD processed collected material; VC and SD identified the specimens and performed the curatorial work; FRMG identified and photographed the *A. littoralis* female. VC analyzed the data and made the distribution map. All authors wrote the final version of the manuscript.

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