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Engytatus passionarius sp. nov. (Hemiptera: Miridae), a new natural enemy of the invasive stinking passion flower *Passiflora foetida* L.

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Abstract The new plant bug *Engytatus passionarius* **sp. nov.** from Formosa province in northern Argentina is described. This new dicyphine was always found in association with the sticky herbaceous vine *Passiflora (Dysosmia) foetida* L. (Passifloraceae), a species native to the Americas and an important invasive weed in some countries including Australia. The apparent host specificity, the ability to traverse the adhesive exudates of the glandular trichomes and the damage caused by nymphal and adult feeding make *E. passionarius* **sp. nov.** an interesting option for further research as a biological control agent. In this paper, a diagnosis, description and illustrations of adult, including the male genitalia, of this new species, as well as a key to the Argentinian species of *Engytatus* are provided.

Key words Heteroptera, Bryocorinae, *Dysosmia*, Biocontrol, Weeds, Herbivory, Plant bugs, Argentina.

INTRODUCTION

Miridae, with more than 11 300 described species distributed in seven subfamilies, are the largest family of true bugs (Schuh and Weirauch 2020). The tribe Dicyphini contains 16 genera and inhabits all biogeographic regions (Konstantinov *et al*. 2018). This group has a complex taxonomic history, and its phylogenetic position inside the Bryocorinae was recently revised (Namyatova *et al*. 2016).

The genus *Engytatus* was first described by Reuter (1876); China and Carvalho (1952) downgraded it to a subgenus of *Cyrtopeltis* Fieber, 1860, and Cassis (1986), in his doctoral dissertation on the Dicyphinae, restored *Engytatus* to the genus level, comprising 27 species. *Engytatus* males can be recognised by the bifurcate process on the genital capsule, but the females are more difficult to distinguish without association with males (Cassis 1986; Hernández and Henry 2010). Other diagnostic characters are the eyes located laterally at middle of head, the indistinct or weakly delimited calli, the presence of a lateral tubercle on the genital capsule (Ferreira and Henry 2011), the broad shaft of the left paramere and the sac-like membraneous aedeagus (Cassis 1986).

At present, *Engytatus* is represented by 30 species distributed worldwide, with several insular endemisms and a few widely distributed species (Polhemus 2018). Ten species have been reported from the Hawaiian Islands (Polhemus 2018), five in the Marquesas Islands (Knight 1938; Van Duzee 1934) and five in the Galapagos Islands (Carvalho and Gagné 1968). Among the more widely distributed species, *Engytatus nicotianae* (Koningsberger 1903) is present throughout the Pacific Basin (Cassis 1986; Eyles and Schuh 2003), whereas *Engytatus varians* (Distant 1884) and *Engytatus modestus* (Distant 1893) are present in Central and South America, including the West Indies, with the latter also known from southwestern United States (Ferreira and Henry 2011) and introduced to Hawaii as well (Carvalho and Usinger 1960). The remaining species are endemic to the Neotropics and show a restricted geographic distribution known from a few records.

Dicyphines have a broad range of feedings habits ranging from phytophagous to zoophagous, with many exhibiting a combination of both strategies (Konstantinov *et al*. 2018; Wheeler 2001; Wheeler and Krimmel 2015). Most dicyphines are adapted to live on plants that produce sticky exudates. This includes predators and scavengers, which benefit from the relative scarcity of competitors on glandular plants to feed on insects entrapped on the plant exudates, their carrion or the exudates themselves (Voigt and Gorb 2010; Wheeler 2001; Wheeler and Krimmel 2015). This particular adaptation has led to the use of dicyphines as a management tool for phytophagous insect pests in sticky plant crops (Castañé *et al*. 2011). Other Dicyphinae are phytophagous or zoophytophagous and some are pests on glandular plant crops themselves (Knight 1968; Konstantinov

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et al. 2018; Sánchez 2008; Tanada and Holdaway 1954; Wheeler 2001; Wheeler and Krimmel 2015).

Host plants of *Engytatus* are taxonomically diverse, comprising several families (Cassis 1986), and several species of *Engytatus* are known to feed on plants of more than one family. However, other species of this genus have been reported to feed only on a narrow range of hosts, although it is uncertain whether this is due to actual host specificity or to limited sampling.

In this contribution, we describe and illustrate a new species of *Engytatus* collected in northwestern Argentina, on wild patches of the sticky herbaceous vine *Passiflora* (*Dysosmia*) *foetida* L. (stinking passionflower) (Passifloraceae), a species native to the Americas that is invasive in Australia and several countries in Africa and Southeast Asia.

MATERIALS AND METHODS

Specimens were observed in the field in northern Argentina during two surveys conducted in October and November 2019. Specimens were collected in Formosa province, near Ingeniero Juárez (23°47′54.3″S 62°03′27.2″W) and deposited in the entomological collections of the Museo de La Plata, Buenos Aires, Argentina (MLP); the Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires, Argentina (MACN); and the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (USNM).

All measurements are given in millimetres. The genital structures were dissected under a stereomicroscope, cleared in an 85% lactic acid solution for 5 min, washed in distilled water and preserved in vials with glycerine. Photographs were captured using a digital camera (Micrometrics 391CU, 3.2 m) mounted on a Nikon SMZ1000 stereomicroscope. Multiple focal planes were taken using micrometrics SE PREMIUM4 software and merged using HELICON FOCUS software. Plates were created and numbered in Corel Draw X8.

TAXONOMY

Key to Argentinian species of *Engytatus* (modified from Hernández and Henry 2010)

1 Eyes relatively small, with the interocular space more than two times the eye width; antennal segments II with a subbasal dark fascia and slightly darkened on the distal third; apex of scutellum dark; total length less than 3.11 mm ..... *E. passionarius* sp. nov.

- Eyes large, each eye equal to or wider than interocular space; antennal segments II brownish with yellowish base and apex or slightly paler at middle; apex of scutellum pale; total length equal to or more than 3.20 mm 2

2 Head uniformly pale green to greenish yellow; antennal segments I dark brown, with apex narrowly pale; hind femora immaculate or with only a few indistinct spots; total length 3.75–4.00 mm ..... *E. modestus*

- Head pale, with a dark brown ring around neck behind eye, frons and clypeus dark brown, leaving a narrow pale ring around eye; antennal segments I dark brown on basal half (except narrowly pale at base) and pale or white on distal half; hind femora distinctly spotted; total length 3.20 mm ..... *E. varians*

Engytatus passionarius sp. nov.

(Figs. 1-4a)
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Material examined

Holotype

♂ ARGENTINA: Formosa, Ingeniero Juárez, 23°47′54.3″S 62°03′27.2″W. 21/10/2019. Mariano Maestro col. Collected on *P. foetida* (MLP).

Paratypes

Same data as for holotype. 20♂, 20♀. ARGENTINA: Province of Formosa, Ingeniero Juárez, 23°47′54.3″S 62°03′27.2″W. 21/10/2019. Mariano Maestro col. Collected on *P. foetida* (MLP); 5♂ 2♀ (MACN); 5♂ 2♀ (USNM).

Diagnosis

Engytatus passionarius differs from all the known *Engytatus* by the combination of the following characters: eyes relatively small and interocular width more than half the width of the head across the eyes; the colouration pattern, with a broad dark fascia medially on the antennal segments I and a subbasal dark fascia on the antennal segments II, the dark apex of the scutellum and the darkened distal part of the corium, cuneus and adjacent vein; and by the male genitalia, with a genital capsule extremely elongated posteriorly.

Description

Male

Based on holotype (Figs. 1,2).

Colouration. General colouration pale green (Fig. 1). *Labium*: pale green with apex of segment IV dark. *Antenna*: general colouration pale greenish; segment I with a broad dark fascia medially; segment II with a subbasal dark fascia and slightly darkened on the distal third. *Mesoscutum*: yellowish. *Scutellum*: paler and more greenish than mesoscutum and apex dark. *Hemelytron*: pale green; clavus slightly darkened on apical part; corium with an irregular dark spot distally; apical margin of cuneus and adjacent vein of membrane darkened. *Legs*: coxae pale green, rest of legs pale greenish with bases of tibiae and apices of the third tarsomere darkened.

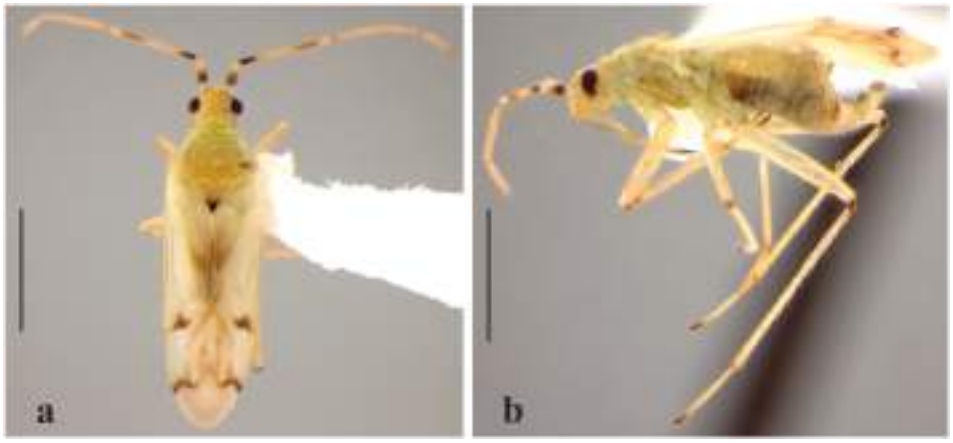

Fig. 1. *Engytatus pasionarius* sp. nov., male holotype: (a) dorsal view; (b) lateral view. Scale bar: 1 mm.

Fig. 2. *Engytatus pasionarius* sp. nov., male holotype: genital capsule: (a) lateral view, left side; (b) posterior view; (c) lateral view, right side; (d) dorsal view. Scale bar: 0.25 mm.

Structure, texture and vestiture. Elongate, subparallel (Fig. 1a). *Head*: with few scattered erect pale setae, more abundant on posterior margin adjacent to collar, clypeus and gular area; head broader than long. *Eyes*: relatively small, bearing short, erect, pale setae, posterior margin distant from collar, interocular width more than half the width across eyes. *Clypeus*: visible from above. *Labium*: attaining mesocoxae (Fig. 1b). *Antenna*: slender, segment I the shortest, stoutest, with scattered short setae and a few longer erect setae internally; rest of antenna with abundant short, semierect pale setae; segment II and segment III subequal in length. *Pronotum*: trapeziform; collar broader or equal to antennal segments I width, anterior margin slightly concave, posterior margin straight; weakly bilobed, calli weakly delimited; basal margin weakly emarginate

at middle; with sparse short pale recumbent setae and long semierect setae. *Mesoscutum*: bearing long semierect setae. *Scutellum*: delimited anteriorly by a transversal furrow, bearing long semierect setae. *Hemelytron*: subparallel, with long semierect and recumbent setae. *Legs*: clothed with semierect setae. *Abdomen*: with semierect and recumbent setae more abundant on distal segments.

Genitalia. Genital capsule (Figs. 1b–3a from a paratype), with a dorsolateral tubercle on left side (Figs. 2b,3a); basal process elongate (Fig. 2a,c), right bifurcation almost vertical, thinner at base and ending in a rounded apex; left bifurcation broader, stout and more slanted (Fig. 2b,d). Left paramere (Figs. 2a,c,d,3b from a paratype): base broad, slightly sclerotized, with long erect setae; shaft sclerotized, narrowed basally, greatly broadened distally and abruptly narrowed towards apex. Right paramere small and slender. Aedeagus (Fig. 3c from a paratype): small, simple and sac-like; phallobase sclerotized; phallotheca entirely membranous, with slightly sclerotized area in the middle of the dorsal wall adjacent to phallobase, broadened basally and narrowed towards apex; seminal duct entirely membranous; vesica simple, membranous and unilobed.

Size. $n = 10$ (holotype measurement in parentheses): total length 2.69–3.07 (2.82), length from tip of clypeus to apex of cuneus 2.40–2.75 (2.59), maximum width 0.71–0.86 (0.78). *Head*: length 0.28–0.30 (0.28), width across eyes 0.42–0.47 (0.44), vertex width 0.24–0.26 (0.25). *Eyes*: length 0.12–0.14 (0.14), width 0.08–0.11 (0.08). *Labium*: segment I length 0.20–0.24 (0.23), II 0.20–0.26 (0.24), III 0.24–0.29 (0.24), IV 0.23–0.25 (0.24). *Antennae*: segment I length 0.28–0.31 (0.29), II 0.66–0.88 (0.78), III 0.67–0.86 (0.77), IV 0.32–0.41 (0.41). *Pronotum*: length 0.29–0.36 (0.32), width at collar 0.35–0.37 (0.36), width at base 0.70–0.78 (0.74). *Scutellum*: length 0.25–0.31 (0.28); width 0.30–0.36 (0.32). *Genital capsule*: maximum length 0.52–0.65 (0.60). *Left paramere*: shaft length 0.19–0.23 (0.20).

Female (Fig. 4a)

Similar to males in overall colouration, shape, vestiture and structure. Measurements ($n = 10$) total length 2.75–3.10, length from tip of clypeus to apex of cuneus 2.50–2.85, maximum width 0.80–0.88. *Head*: length 0.29–0.31, width across eyes 0.44–0.47, vertex width 0.25–0.26. *Eyes*: length 0.13–0.14, width 0.08–0.11. *Labium*: segment I length 0.22–0.24, II 0.24–0.28, III 0.25–0.30, IV 0.24–0.28. *Antenna*: segment I length 0.26–0.28, II 0.62–0.74, III 0.67–0.78, IV 0.37–0.40. *Pronotum*: length 0.32–0.36, width at collar: 0.36–0.40, width at base: 0.74–0.80. *Scutellum*: length 0.28–0.32, width 0.34–0.38.

Remarks

The diagnostic characters given above allow recognition of this new species. Although there is no available key to all the species included in the genus, there are a few keys mainly based on geographic distribution that allow identification of some *Engytatus* species. Carvalho and Usinger (1960) and Gagné (1968) provided a key to the Hawaiian species and Carvalho and Gagné (1968) to those of the Galapagos Islands (cited in these keys as *Cyrtopeltis* species). Other short keys including a few species are those of Maldonado (1969) for Puerto Rico and Ferreira and Henry (2011) for Minas Gerais, Brazil.

In the key by Carvalho and Gagné (1968), *E. passionarius* is identified in the first couplet as *C yrtopeltis modesta* (Distant 1893) based on colouration of the antennae and hemelytra. *E. modestus*, from Salta and Tucumán provinces and *E. varians*, from Misiones province, are the two *Engytatus* species known from Argentina. *E. modestus* and *E. varians* are larger species, with the length of specimens from 3.20 mm to more than 4 mm, and both have large eyes, each eye equal to or wider than the interocular space. The specimens of *E. passionarius* are shorter than 3.11 mm, and the eyes are relatively small, with the interocular space more than two times the width of an eye.

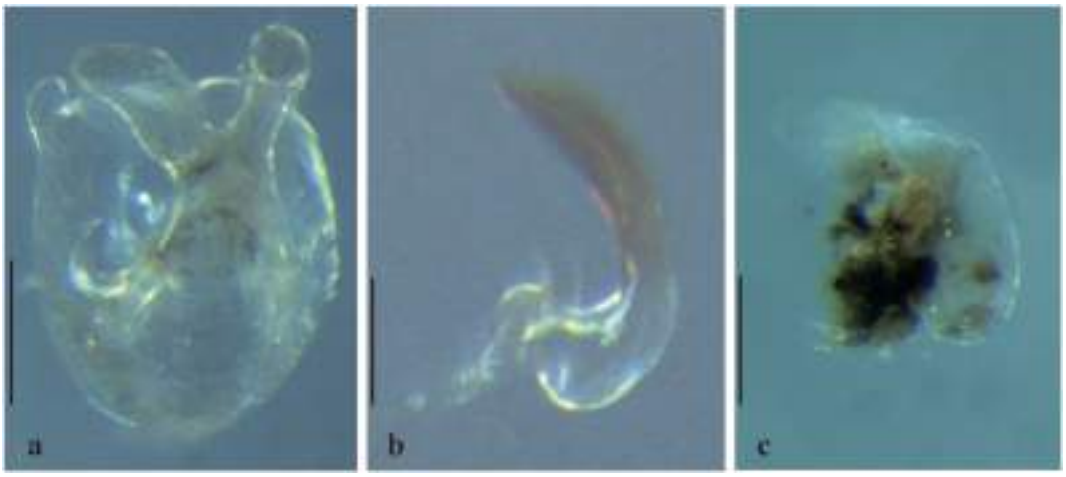

Fig. 3. *Engytatus pasionarius* sp. nov., male paratype: (a) genital capsule, posterior view; scale bar: 0.25 mm; (b) left paramere, near dorsal view; scale bar: 0.10 mm; (c) aedeagus lateral view, left side; scale bar: 0.20 mm.

Fig. 4. *Engytatus pasionarius* sp. nov.: (a) mating pair; (b) sticky herbaceous vine *Passiflora (Dysosmia) foetida*; (c) nymph emerging from egg on abaxial vein of leaf.

Etymology

The specific epithet *passionarius* was chosen to reflect that this species was only found associated with the stinking passionflower *P. foetida*.

Distribution

Formosa, Argentina.

Biology

Engytatus passionarius was always observed in the field on *P. foetida*, even when this plant was in contact with other plants, or in proximity to other *Passiflora* species (Fig. 4b). Females insert single eggs into plant tissue on the abaxial veins of the leaves (Fig. 4c); upon hatching, the nymphs are able to walk and start to feed immediately. All stages walk on the surface of the plant by grasping the leaf trichomes using the pseudopulvilli and tarsal claws. Other insects of similar size were entrapped by the adhesive exudates of the glandular trichomes, suggesting the presence of a specialised adaptation and perhaps a certain degree of co-evolution between *E. passionarius* and *P. foetida*. Both nymphs and adults feed on the underside of leaves producing black spots and eventually causing yellowing and wrinkling.

DISCUSSION

Passiflora foetida has been introduced in several tropical regions around the world. In some countries, it is valued for its applications in traditional medicine. However, in other habitats, it is considered an invasive weed competing with native vegetation and various crops. In several countries in Africa and Southeast Asia, it is a weed in crops such as cassava, sugar cane and corn (Vanderplank 2013). Because it is a fast-growing climbing vine, it not only competes for light and nutrients but it also makes harvesting more laborious and costly. In Australia, where it has invaded an area exceeding a million km^2 (Cowie and Werner 1993; Webber *et al*. 2014; Jucker

et al. 2020), its impacts are more varied and serious. It smothers local vegetation, causing extreme environmental and economic damage. It covers the banks of rivers where crocodiles usually lay their eggs, forcing them to use other, sub-optimal locations. During dry seasons, or if it is not removed after being killed with herbicides, it becomes highly flammable, which increases the risk of wildfires.

At present, the management options for *P. foetida* are limited mostly to cutting, removal and herbicide applications, although the vastness of the invaded area makes these options impractical for anything other than local management. With no adequate management options available, natural enemies of *P. foetida* are being studied in its native range, with the purpose of finding suitable biological control agents. Therefore, the impact of *E. passionarius* on its natural host in Argentina makes it a strong candidate for further biocontrol research.

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