

New records of leatherleaf slugs (Gastropoda: Veronicellidae) for Nuevo León, Mexico, with an updated checklist of the species found in North America

Nuevos registros de babosas de cuero (Gastropoda: Veronicellidae) para Nuevo León, México, con un listado actualizado de las especies registradas en Norteamérica



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ABSTRACT. New records of two species of leatherleaf slugs
(Gastropoda: Veronicellidae) are presented for Nuevo León,
Mexico: the black-velvet leatherleaf slug *Belocaulus*
angustipes (Heynemann, 1885) and the bean slug *Sarasinula*
plebeia (Fischer, 1868). The checklist of leatherleaf slugs
recorded in continental North America is updated.

Key words: species; invasive species; Systellommatophora;
land gastropods

RESUMEN. Se presentan nuevos registros de dos especies de babosas veronicélidas (Gastropoda: Veronicellidae) para Nuevo León, México: la babosa de terciopelo negro *Belocaulus angustipes* (Heynemann, 1885) y la babosa frijol *Sarasinula plebeia* (Fischer, 1868). Se actualiza el listado de babosas veronicélidas registradas para Norteamérica continental.

Palabras clave: especies exóticas; especies invasoras; Systellommatophora; gasterópodos terrestres

INTRODUCTION

Slug is a common term used to refer to a shell-less gastropod or one that has a reduced shell which is often internal and not visible, they do not form a natural monophyletic group, as the "slug" condition appears in several unrelated gastropod families (Wade *et al.*, 2001). In Mexico, 8 gastropod families have slugs among their ranks: Agriolimacidae, Arionidae, Boettgerillidae, Echinichidae, Limacidae, Milacidae, Philomycidae and Veronicellidae (Naranjo-García, 2014; Araiza-Gómez *et al.*, 2016, 2017; Naranjo-García *et al.*, 2007), although there are possible observations in citizen science platforms of members of yet another family of slugs, Testacellidae (iNaturalist, 2024a).

The Veronicellidae Gray (Gastropoda: Stylommatophora), commonly known as leatherleaf slugs, are terrestrial shell-less herbivorous gastropods characterized by an oval and dorsoventrally flattened body with a notum that is completely covered by the mantle; they also possess a terminally located anus and contractile tentacles (Burch & Pearce, 1990; South, 1992). This family of slugs is composed of around 300 species which are distributed in Africa, America and Asia, although some species show a pantropical distribution (South, 1992).

Among the species included in this family there are some of economic importance, as they are pests to several crops (Andrews, 1987; Andrews & Dundee, 1987; Rueda *et al.*, 2002; Velázquez-Montes de Oca *et al.*, 2014). There are also some species of medical importance, as they serve as the intermediate host of two species of nematodes of the genus *Angiostrongylus* Kamensky (Rhabditida: Angiostrongylidae), the causing agents of angiostrongyliasis, a life-threatening parasitic disease (Morera, 1987; Caballero *et al.*, 1991).

In this publication we deal with new state records for two species of leatherleaf slugs for the state of Nuevo León, in northeastern Mexico. We also present a state-level checklist for the species recorded for continental North America (Mexico and the USA).

MATERIALS AND METHODS

Slugs were searched for and collected alive from under rocks, wood and debris in four localities in the municipalities of Guadalupe, Juarez and Santiago, state of Nuevo León, northeastern Mexico. Once in the lab, they were rinsed with tap-water to wash off dirt and were then placed in a weak ethanol solution (around 5–10%) for about two hours in order to anesthetize them in a distended state. Once the specimens stopped reacting to stimuli, they were transferred to buffered 70% ethanol (10g of sodium borate added for each liter of ethanol), which was changed two days later as the liquid turned yellowish. Two morphotypes were immediately identified, one large and light brown in color and one smaller and black in color. Adult specimens of each morphotype were dissected and identified with keys and descriptions found in specialized literature (Baker, 1925; Pilsbry, 1948; Branson, 1962, 1980a, 1980b; Burch & Van Devender, 1980; Deisler & Stange, 1984;

Burch & Pearce, 1990; Caballero *et al.*, 1991; Perez & Cordeiro, 2008; McDonnell *et al.*, 2008, 2009; Velázquez-Montes de Oca *et al.*, 2014; Kim *et al.*, 2016).

The specimens are deposited in the Malacological Collection of the Facultad de Ciencias Biológicas (FCB) of the Universidad Autónoma de Nuevo León (UANL). Specimens were photographed with a SONY α -6000 camera with an adapted macro lens (SEL30M35) as well as with the camera integrated in a stereomicroscope (Leica EZ4 W) which was also used for external examination of the specimens. The images obtained were edited using the software GIMP 2.10. An extensive literature search was conducted to find the records of leatherleaf slugs from continental North America to update the checklist of species of the region; the main work used for the Mexican records was Naranjo-García *et al.* (2007), while the main works used for the American records were Dundee (1977), Branson (1980a), Burch and Van Devender (1980), and Walls (2009); no records of these slugs were found from Canada.

RESULTS

I. New records from Nuevo León, Mexico

Belocaulus angustipes (Heynemann, 1885) Figs. 1A–C, 2A.

Diagnosis. Notum velvety black, sometimes with an inconspicuous light stripe (Fig. 1A). Hyponotum laced with black, but without conspicuous black spots (Fig. 1B). Anus ventrally inconspicuous and hidden by a flap of skin on the right side of the hyponotum, causing it to appear longitudinal. Male genitalia as in Fig. 1C–D as well as Figures 24–26 of Pires-Ohlweiler *et al.* (2009); penis papilla with long digitiform tubercles that take the form of an "S" (Fig. 1C) and penis with a very narrow tip (Fig. 1D).

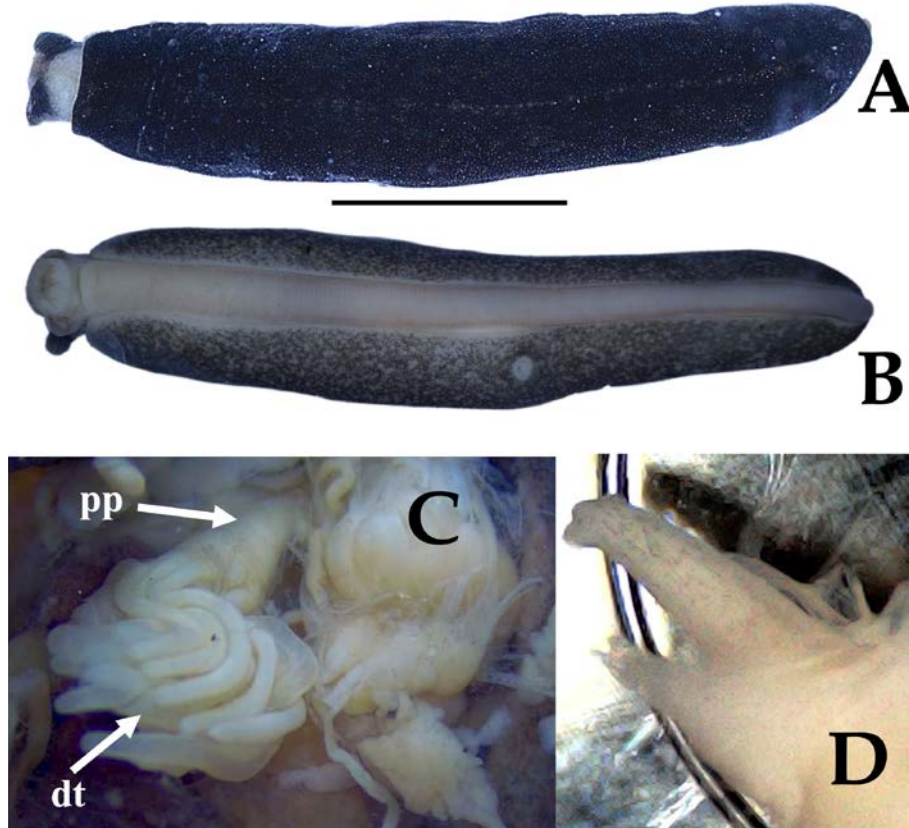


Figure 1. *Belocaulus angustipes*. A) Dorsal view, scale bar = 10 mm. B) Ventral view, scale bar = 10 mm. C) Penis papilla (pp) and digitiform tubules (dt). D) Distal portion of penis. C and D without scale.

Material examined. MEXICO: Nuevo León: Santiago, GPS: 25.4590°N, -100.1557°W, 492 m a.s.l., 15 June 2022, col. Roberto García-Barrios, 15 adults, 4 juveniles (UANL-1733). Guadalupe, GPS: 25.6335°N, -100.2060°W, 999 m a.s.l., 9 July 2023, col. Roberto García-Barrios, 6 adults (UANL-1730).

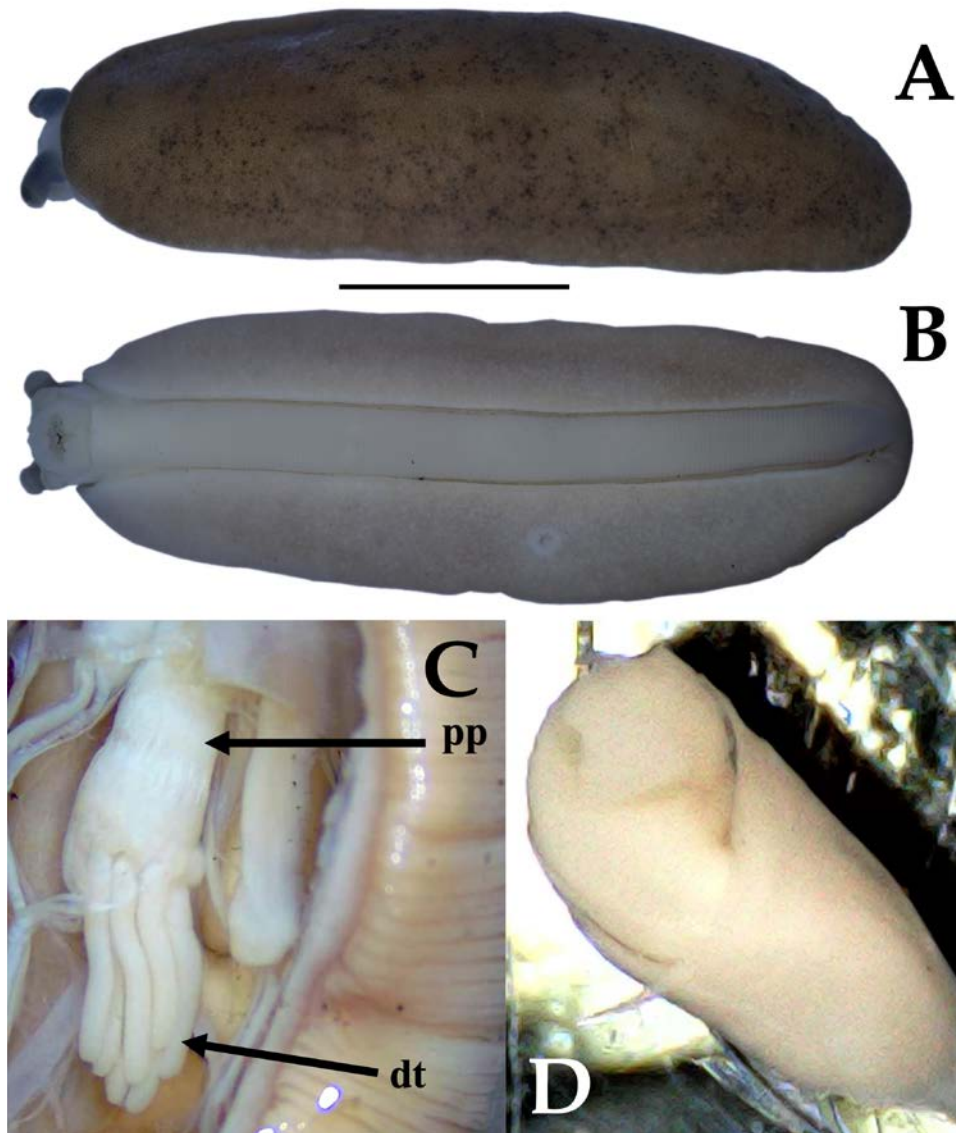


Figure 2. *Sarasinula plebeia*. A) Dorsal view, scale bar = 10 mm. B) Ventral view, scale bar = 10 mm. C) Penis papilla (pp) and digitiform tubules (dt). D) Distal portion of penis. C and D without scale.

Sarasinula plebeia (Fischer, 1868) Figs. 2A–D, 3D.

Diagnosis. Notum light brown, without discernible pattern (Fig. 2A). Hyponotum light brown and spotless, with a genital pore located at a subequal distance from the perinotum than from the foot (Fig. 2B). Anus notorious and ventrally protected by an anterior flap of skin, causing it to appear crescenting. Male genitalia as in Fig. 2C–D as well as Figure 27 of Baker (1925) and Figure 2.3 of Kim *et al.* (2016); penis papilla with short and almost straight digitiform tubercles (Fig. 2C) and penis with a wide and round apex (Fig. 2D).

Material examined. MEXICO: Nuevo León: Juárez, GPS: 25.6498°N, -100.0988°W, 392 m a.s.l., 8 November 2021, col. Víctor Alonso Hernández-González, 2 adults (UANL-1732). Santiago, GPS: 25.4590°N, -100.1557°W, 492 m a.s.l., 21 June 2022, col. Roberto García-Barrios, 2 adults (UANL-1731).

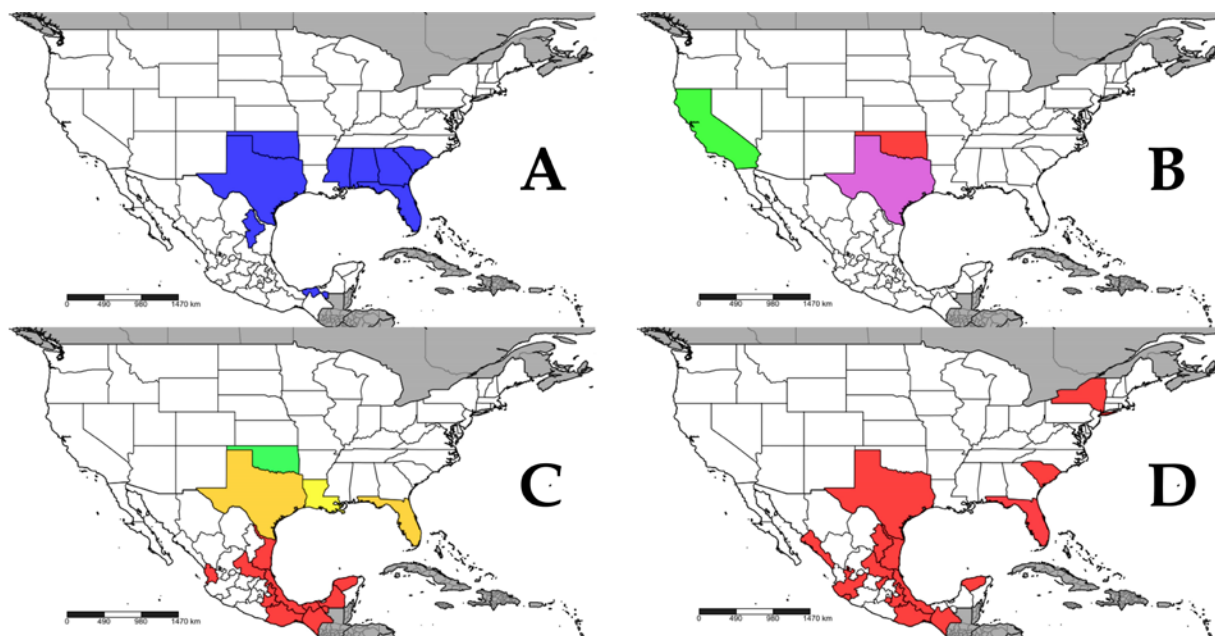


Figure 3. Maps of Mexico and the U.S.A. showing the distribution of the Veronicellidae at state level. A) *Belocaulus angustipes* in blue. B) *Diplosolenodes occidentalis* in red; both *D. occidentalis* and *Laevicaulis alte* in pink; *Veronicella cubensis* in green. C) *Leidyula moreleti* in red; *Leidyula floridana* in yellow; both *L. moreleti* and *L. floridana* in orange; *Leidyula kraussii* in green. D) *Sarasinula plebeia* in red. Made with Shorthouse (2010).

II. Checklist of species of leatherleaf slugs (Gastropoda: Systellommatophora: Veronicellidae) found in continental North America

Phylum **MOLLUSCA** Linnaeus

Class **GASTROPODA** Cuvier

Order **SYSTELLOMMATOPHORA** Pilsbry

Family **VERONICELLIDAE** Gray

Genus *Belocaulus* Hoffman, 1925

1. *Belocaulus angustipes* (Heynemann, 1885) Fig. 2A.

MEXICO: Nuevo León (this study, see above); **Tabasco** (Rangel-Ruiz & Gamboa-Aguilar, 2005).

USA: **Alabama** (Dundee, 1977, as *Veronicella ameghini*; Thomé et al., 1997; Walls, 2009); **Florida** (Deisler & Phelps, 1985, as *Angustipes ameghini*; Deisler & Stange, 1984, as *Angustipes ameghini*; Dundee, 1977, as *Veronicella ameghini*; Thomé et al., 1997; Walls, 2009); **Georgia** (Texas Invasive Species Institute, 2021); **Louisiana** (Dundee, 1977, as *Veronicella ameghini*; Thomé et al., 1997; Walls, 2009); **Mississippi** (Dundee, 1977, as *Veronicella ameghini*; Walls, 2009); **Oklahoma** (Robinson, 2014); **South Carolina** (Robinson, 2014); **Texas** (Neck, 1976, as *Veronicella ameghini*, 1990; Texas Invasive Species Institute, 2021; Thomé et al., 1997).

Genus **Diplosolenodes Thomé, 1975**

2. *Diplosolenodes occidentalis* (Guilding, 1824) Fig. 2B.

USA: Oklahoma (Branson, 1962, 1980a, in both as *Vaginulus occidentalis*); **Texas** (Dundee, 1977, as *Vaginulus occidentalis*).

Remarks. It apparently has not established breeding populations outside of greenhouses. Despite the previous records, Cowie *et al.* (2009) marked this species as “Not present” in the USA.

Genus **Laevicaulis Simroth, 1913**

3. *Laevicaulis alte* (Férussac, 1822) Fig. 2B.

USA: Texas (Neck, 1980, as *Pseudoveronicella liberiana*, 1985, 1990; Thomé *et al.*, 1997).

Genus **Leidyula Baker, 1925**

4. *Leidyula floridana* (Leidy, 1851) Fig. 2C.

USA: Florida (Deisler & Stange, 1984; Dundee, 1977, as *Veronicella floridana*; Fischer, 1871, as *Vaginula floridana*; Perez & Cordeiro, 2008; Pilsbry, 1984, as *Veronicella floridana*; Von Martens 1890–1901, as *Veronicella moreleti*); **Louisiana** (Dundee, 1977, as *Veronicella floridana*; Perez & Cordeiro, 2008); **Texas** (Neck, 1976, as *Veronicella floridana*; Thomé *et al.*, 1997).

Remarks. This is a native species of southern Florida, USA (as well as some Caribbean islands), but the populations in the states of Louisiana and Texas, USA, are a product of human introduction. It has been previously mentioned for the Mexican states of Chiapas (Naranjo-García *et al.*, 2007), Nuevo León (Contreras-Arquieta, 1995; Naranjo-García *et al.*, 2007) and Veracruz (Naranjo-García *et al.*, 2007); however, these mentions are merely speculative, as no specimens have been formally collected and positively identified as this species in the country.

5. *Leidyula kraussii* (Férussac, 1823) Fig. 2C.

USA: Oklahoma (Branson, 1962, as *Veronicella kraussi*, 1980, as *Veronicella kraussi*; Dundee, 1977, as *Veronicella kraussi*).

Remarks. It apparently has not established breeding populations outside of greenhouses.

6. *Leidyula moreleti* (Fischer, 1871) Fig. 2C.

MEXICO: Campeche (Baker, 1925, as *Veronicella (Leidyula) moreleti*; Fischer & Crosse, 1870–1878, as *Vaginula moreleti*; Thomé *et al.*, 1997; Thompson, 1967, as *Veronicella moreleti*; Von Martens 1890–1901, as *Veronicella moreleti*); **Chiapas** (Baker, 1925, as *Veronicella (Leidyula) moreleti*; Fischer, 1871, as *Vaginula moreleti*; Fischer & Crosse, 1870–1878, as *Vaginula moreleti*; Von Martens, 1890–1901, as *Veronicella moreleti*; Thomé *et al.*, 1997); **Nayarit** (Baker, 1925, as *Veronicella (Leidyula) moreleti*); **Oaxaca** (Baker, 1925, as *Veronicella (Leidyula) moreleti*; Fischer, 1871, as *Vaginula moreleti*; Fischer & Crosse, 1870–1878, as *Vaginula moreleti*; Von Martens, 1890–1901, as *Veronicella moreleti*); **Puebla** (Velázquez-Montes de Oca *et al.*, 2014); **San Luis Potosí** (Baker, 1925, as *Veronicella (Leidyula) moreleti*; Correa-Sandoval, 1997); **Tabasco** (Deisler & Phelps, 1985; Thomé *et al.*, 1997; Von Martens 1890–1901, as *Veronicella moreleti*); **Tamaulipas** (Correa-Sandoval & Rodríguez-Castro, 2005); **Veracruz** (Baker, 1923, as *Veronicella (Leidyula) moreleti*, 1925 as *Veronicella (Leidyula) moreleti*; Correa-Sandoval, 1997, as *Veronicella moreleti*; Naranjo-García *et al.*, 2007; Thomé *et al.*, 1997; Velázquez-Montes de Oca *et al.*, 2014); **Yucatán** (Bequaert & Clench, 1936; Naranjo-García *et al.*, 2007).

USA: Florida (Deisler & Phelps, 1985; Deisler & Stange, 1984; Thomé *et al.*, 1997); and **Texas** (Dundee, 1977, as *Veronicella moreleti*; Thomé *et al.*, 1997, intercepted).

Remarks. It has been recorded as introduced in Florida and extreme southern Texas, USA, but apparently has not established breeding populations outside of greenhouses. The type locality of this species, Palenque, does not belong to the state of Tabasco, but to Chiapas (Baker, 1925; Fischer, 1871), however, there are records from the former state. Despite the previous records for Florida and Texas, Cowie *et al.* (2009) marked this species as "Not present" in the USA.

Genus **Sarasinula** Grimpe & Hoffman, 1924

7. *Sarasinula plebeia* (Fischer, 1868) Fig. 2D.

MEXICO: **Chiapas** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Colima** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Jalisco** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Morelos** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Nuevo León** (this study, see above); **Oaxaca** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Querétaro** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Puebla** (Velázquez-Montes de Oca *et al.*, 2014); **San Luis Potosí** (Naranjo-García *et al.*, 2007, as both *Sarasinula dubia* and *S. plebeia*); **Sinaloa** (Naranjo-García *et al.*, 2007, as *Sarasinula dubia*); **Tamaulipas** (de Luna *et al.*, 2021); **Veracruz** (Naranjo-García *et al.*, 2007, as both *Sarasinula dubia* and *S. plebeia*; Velázquez-Montes de Oca *et al.*, 2014); and **Yucatán** (Andrews & Dundee, 1987; Naranjo-García *et al.*, 2007).

USA: **Florida** (Thomé *et al.*, 1997, some intercepted, some established); **New York** (Thomé *et al.*, 1997, intercepted); **South Carolina** (Thomé *et al.*, 1997, intercepted); and **Texas** (Neck, 1990; Thomé *et al.*, 1997, some intercepted, some established).

Remarks. It is speculated that it is of South American origin (Daglio *et al.*, 2020). In this publication, *Sarasinula dubia* (Semper) is treated as a synonym of *S. plebeia*, as previously proposed by several authors (Aguayo, 1964; Hoffman, 1925; Thomé, 1989, 1993).

Genus **Veronicella** de Blainville, 1817

8. *Veronicella cubensis* (Pfeiffer, 1840) Fig. 2C.

USA: **California** (McDonnell *et al.*, 2008, 2009).

Remarks. Likely just a stowaway; apparently it has not established breeding populations in California, USA, as only one specimen was collected (McDonnell *et al.*, 2008, 2009) and none other has been reported afterwards. It is native to Cuba and other Caribbean islands.

DISCUSSION

Belocaulus angustipes had been previously recorded for the Mexican state of Tabasco (Rangel-Ruiz & Gamboa-Aguilar, 2005), this being the second time it is mentioned for the country. Meanwhile, *Sarasinula plebeia* had been recorded for 12 other states, being the most widely distributed species of Veronicellidae in Mexico; the current work adds another state to the count.

Phyllocaulis gayi (Fischer, 1871) was mentioned for Sinaloa, Mexico, almost 100 years ago (Baker, 1925; Hoffman, 1925), however, it apparently did not establish breeding populations, as searches for this species in July 2006 did not yield any specimens (Naranjo-García *et al.*, 2007; Naranjo-García & Castillo-Rodriguez, 2017); because of this, this species was not included in the current listing. Another species which was not included is *Diplosolenodes olivaceus* (Stearns), which was cited for California, USA (Von Martens, 1890-1901, as *Veronicella olivacea*), more than 100 years ago, but has not been reported since; no Californian specimens of this species are known to exist.

Other species not included are those which have been intercepted in the USA but have not establish breeding populations, not even in greenhouses, these are *Heterovaginina limayana*

(Lesson) (Thomé *et al.*, 1997, as *Heterovaginina peruviana*), *Leidyula sloanei* (Cuvier) (Thomé *et al.*, 1997, as *Veronicella sloanei*), *Sarasinula linguaeformis* (C. Semper), and *Simrothula prismatica* (Simroth) (Thomé *et al.*, 1997).

Because of their conspicuous morphology, they are easily distinguished from all other slug families in North America, making citizen science apps a very useful tools for their early detection. However, their broad variation in dorsal pattern and the need to dissect them to observe the male genitalia makes them unsuitable for species-level identification from photographs alone; we recommend taking photographs of both dorsal and ventral habitus when making a record of a leatherleaf slug in a citizen science platform, of course, avoiding contact with the slug itself and its slime, as they are vectors of a life-threatening parasitic disease called angiostrongyliasis. Records from the citizen science platform iNaturalist show that this family has a much wider distribution than the one the literature depicts (iNaturalist, 2024b).

CONCLUSIONS

The leatherleaf slugs (Gastropoda: Stylommatophora: Veronicellidae) are represented in continental North America by eight species: *Belocaulus angustipes* and *Sarasinula plebeia* are introduced and invasive species which can be found in Mexico as well as southern USA. *Laevicaulis alte* is an introduced and invasive species which so far has only been found in Texas, USA. *Diplosolenodes occidentalis* and *Leidyula kraussii* are introduced species restricted so far to greenhouses in Oklahoma, USA. *Leidyula floridana* is a native species of southern Florida, USA, but has been introduced to several nearby states and has even been mentioned for Mexico, albeit without formal collection and identification of specimens. *Leidyula moreleti* is a native species of Mexico and Central America which has been introduced to southern USA. And finally, *Veronicella cubensis* has been reported in California, USA, but its establishment has yet to be confirmed.

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