Taxonomic notes on primary and secondary parasitoids (Hymenoptera: Encyrtidae and Signiphoridae) of *Hypogeococcus* spp. (Hemiptera: Pseudococcidae) in Argentina

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➤ **Resumen** — Se presenta una revisión de los himenópteros parasitoides y sus hiperparasitoides, asociados a *Hypogeococcus* spp. (Hemiptera: Pseudococcidae), cochinillas que se alimentan de *Alternanthera* spp., otra Amaranthaceae y diversas cactáceas nativas (Cactaceae). Estas especies de himenópteros parasíticas fueron recogidas y criadas en el curso de un estudio realizado en Argentina durante 2010-2014. De particular interés son los encírtidos (Encyrtidae) parasitoides primarios de *H. pungens* Granara de Willink que son potenciales candidatos de control biológico de *Hypogeococcus* sp. (comúnmente llamado «*Harrisia* cactus mealybug» e identificado como *H. pungens* pero que posiblemente no pertenezca a esta especie) que amenaza cactus nativos de algunas islas del Caribe y Florida, Estados Unidos, y está devastando a los cactus columnares nativos de Puerto Rico. *Leptomastidea* sp. (Encyrtidae) es registrado por primera vez para Argentina como un parasitoide primario de *Hypogeococcus* spp., incluso de *H. pungens*. Los dos hiperparasitoides colectados en Argentina son *Chartocerus ?axillaris* De Santis (Signiphoridae) y *Prochiloneurus* sp. (Encyrtidae); este último pertenece a una especie no descripta. Además se proveen notas taxonómicas de *Gyranusoidea pseudococci* (Brèthes) (Encyrtidae) [= *Leptomastidea pseudococci* Brèthes, para el cual se designó un lectotipo]; también es un parasitoide primario de pseudocóccidos pero no de *Hypogeococcus* spp.

Palabras clave: *Hypogeococcus*, piojo harinoso, parasitoide, *Leptomastidea*, hiperparasitoide, *Chartocerus*, *Prochiloneurus*, Neotrópico.

➤ **Abstract** — A review is presented of the hymenopterous parasitoids, and their hyperparasitoids, associated with *Hypogeococcus* spp. (Hemiptera: Pseudococcidae), mealybugs that feed on *Alternanthera* spp., other Amaranthaceae, and various native cacti (Cactaceae). These parasitic Hymenoptera species were collected and reared in the course of a survey conducted in Argentina during 2010-2014. Of particular interest are the encyrtid (Encyrtidae) primary parasitoids of *H. pungens* Granara de Willink which are potential candidate biological control agents against a *Hypogeococcus* sp. (commonly called the *Harrisia* cactus mealybug and identified as *H. pungens* but possibly not belonging to that species) which threatens the native cacti in some Caribbean islands and Florida, USA, and is devastating the native columnar cacti in Puerto Rico. A *Leptomastidea* sp. (Encyrtidae) is for the first time recorded from Argentina as a primary parasitoid of *Hypogeococcus* spp. including *H. pungens*. The two hyperparasitoids collected in Argentina are *Chartocerus ?axillaris* De Santis (Signiphoridae) and *Prochiloneurus* sp. (Encyrtidae); the latter belongs to an undescribed species. Taxonomic notes are also provided on *Gyranusoidea pseudococci* (Brèthes) (Encyrtidae) [= *Leptomastidea pseudococci* Brèthes, for which a lectotype is designated]; it is also a primary mealybug parasitoid but not of *Hypogeococcus* spp.

Keywords: *Hypogeococcus*, mealybug, parasitoid, *Leptomastidea*, hyperparasitoid, *Chartocerus*, *Prochiloneurus*, Neotropics.

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INTRODUCTION

Triapitsyn *et al.* (2014) described two new species from Argentina, *Anagyrus cachamai* Triapitsyn, Logarzo & Aguirre and *A. quilmes* Triapitsyn, Logarzo & Aguirre (Hymenoptera: Encyrtidae), which are primary parasitoids of the mealybugs *Hypogeococcus* spp. (Hemiptera: Pseudococidae) on *Alternanthera* spp. and some other Amaranthaceae and also on some native cacti (Cactaceae). The mealybug *Hypogeococcus* sp. (commonly called the Harrisia cactus mealybug (HCM) and identified as *H. pungens* Granara de Willink, but possibly not belonging to that species – its true identity is currently under investigation using morphological and molecular methods) is a serious pest of the native columnar cacti in Puerto Rico and is threatening the native cacti in Florida (USA), Barbados, and some other Caribbean islands and also in Hawaii, USA (Williams & Granara de Willink, 1992; German-Ramirez *et al.*, 2014; USDA, ARS, 2014). Because *H. pungens* was originally described from Tucumán Province of Argentina (Granara de Willink, 1981) from *Alternanthera pungens*, a survey of its parasitoids (as part of a classical biological control program) has been conducted in Argentina since 2010 (USDA, ARS, 2014; Triapitsyn *et al.*, 2014). Here we report on an additional primary parasitoid of *Hypogeococcus* spp., *Leptomastidea* sp., collected in Argentina in the course of this survey as well as on the two hyperparasitoid species (most likely on *Anagyrus* spp.). We also provide taxonomic notes on *Gyranusoidea pseudococci* (Brèthes) (Encyrtidae), which is a relative of *Leptomastidea* sp. and a primary mealybug parasitoid but not of *Hypogeococcus* spp.

It is interesting to note that all primary parasitoids of *Hypogeococcus* spp. in the New World turned out to belong to undescribed species; all of them are probably genus host specific.

MATERIALS AND METHODS

Collecting and rearing. Parasitoids were collected in Argentina (mainly in its northwestern provinces) by searching for parasitized *H. pungens* (and possibly other *Hypogeococcus* spp.) on its known host plants. When *H. pungens* was detected, its nymphs and adults were collected together with plant material and held for parasitoid emergence. Upon their emergence, parasitoid wasps were fed with honey and water and then confined with nymphs (1^{st}-2^{nd} instars) of a *Hypogeococcus* sp. reared in the laboratory on *Cleistocactus baumannii*. Depending on the parasitoid species, progeny emerged within 30-60 days after oviposition. Voucher specimens of both the mealybug hosts and their parasitoids were preserved in 75-80% ethanol.

Parasitoid specimens used in the taxonomic studies were critical point dried from ethanol and point-mounted. Selected specimens were then dissected and slide-mounted in Canada balsam, examined under a Zeiss Axioskop 2 plus compound microscope using Nomarski differential interference contrast optics, and photographed using the Auto-Montage system; the photographs were then retouched where necessary using Adobe Photoshop.

Acronyms for depositories of specimens are as follows: IMLA, Fundación e Instituto Miguel Lillo, San Miguel de Tucumán, Tucumán, Argentina; MACN, Museo Argentino de Ciencias Naturales «Bernardino Rivadavia», Buenos Aires, Argentina; MLPA, Museo de La Plata, La Plata, Buenos Aires, Argentina; UCRC, Entomology Research Museum, University of California, Riverside, California, USA.

RESULTS

Primary parasitoids of *Hypogeococcus* spp. in Argentina (Encyrtidae)

Anagyrus cachamai
Triapitsyn, Logarzo & Aguirre, 2014
(Figs. 1, 2)

Anagyrus cachamai Triapitsyn, Logarzo & Aguirre *in* Triapitsyn *et al.* 2014: 210–216.

Comments.— See Triapitsyn *et al.* (2014) for its description and illustrations, information on the distribution and host associations in Argentina, and brief notes on its biological traits. Illustrated here, to facilitate its recognition, are dry-mounted, critical-point dried female (Fig. 1) and male (Fig. 2) specimens of this species.

Anagyrus quilmes
Triapitsyn, Logarzo & Aguirre, 2014
(Figs. 3–6)

Anagyrus quilmes Triapitsyn, Logarzo & Aguirre *in* Triapitsyn *et al.* 2014: 221, 223–228.

Comments.— See Triapitsyn *et al.* (2014) for its description and illustrations and also for information on its distribution and host associations in Argentina. Illustrated here, to facilitate its recognition, are dry-mounted, critical-point dried female (Fig. 3) and male (Fig. 4) specimens of this species, and also color variations of the third funicular segment of the female antenna taken from non-type, slide-mounted specimens (Figs. 5, 6).

Leptomastidea sp.
(Figs. 7–13)

Material examined.— ARGENTINA: Catamarca, El Portezuelo, 28°26'58.3"S 65°37'59.4"W, 658 m, 2011 [date unknown], M. B. Aguirre, G. A. Logarzo (from *Hypogeococcus* sp. on *Cleistocactus baumannii*) [1 male, UCRC]. Salta, Río Piedras, 25°21'17.9"S 64°54'07.5"W, 715 m, 16.ii.2014, M. B. Aguirre, S. V. Triapitsyn, G. A. Logarzo (from *Hypogeococcus pungens* on *Alternanthera paronychioides*) [5 females, 6 males, IMLA (1 female, 2 males), MLPA (1 female, 2 males), UCRC (3 females, 2 males)]. Tucumán, Trancas: 26°14'12.2"S 65°16'26.4"W, 772 m, 10.ii.2011, G. A. Logarzo, M. B. Aguirre (from *H. pungens* on *Alternanthera pungens*) [1 male, UCRC]; 26°15'30.8"S 65°16'37.4"W, 771 m, 16.ii.2014, G. A. Logarzo, M. B. Aguirre, S. V. Triapitsyn (from *H. pungens* on *A. paronychioides*) [2 males, IMLA, UCRC].

Taxonomic notes.— Illustrated here, to facilitate their recognition, are a female (Figs. 7–9) and a male (Figs. 10–13) from Argentina.

Leptomastidea sp. does not resemble any other described species of *Leptomastidea* Mercet, keyed for the world by Trjapitzin (2009). It will be described taxonomically as a new species in the upcoming publication (Verle Rodrigues *et al.*, in review) based on material from Barbados, Florida (USA), and Puerto Rico (USA), with which our specimens from Argentina are undoubtedly conspecific. As other *Leptomastidea* spp. (Noyes 2000), *Leptomastidea* sp. from Argentina holds the wings erect over the back and not flat along the gaster like most other encyrtids including *Anagyrus* spp. and *Gyranusoidea* spp.

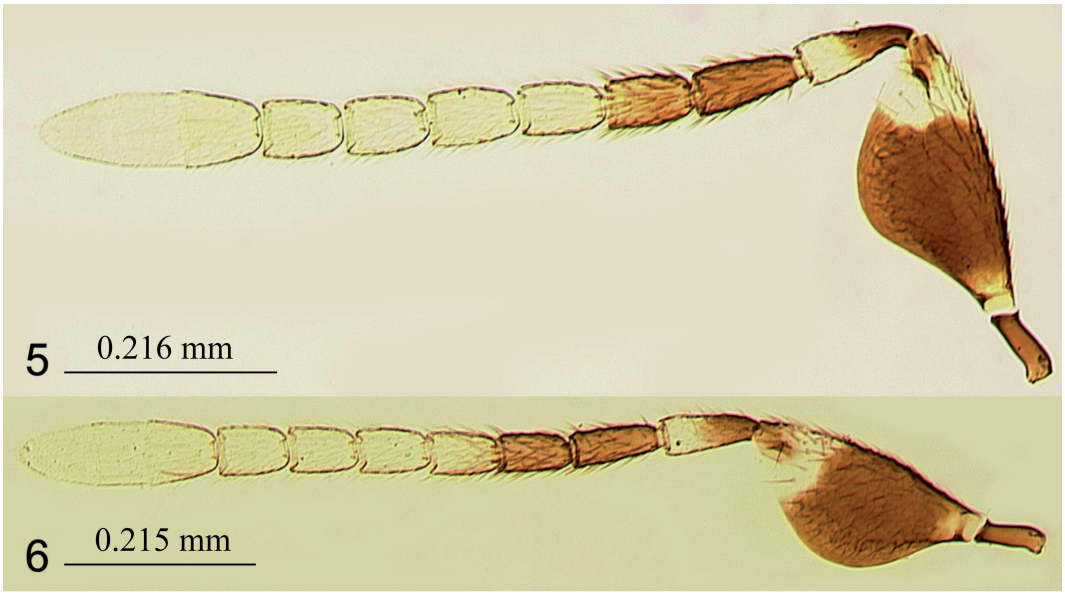
Distribution.—Argentina, as well as Barbados, Florida, and Puerto Rico (Verle Rodrigues *et al.*, in review).

Hosts.— *Hypogeococcus pungens* Granara de Willink and *Hypogeococcus* sp. in Argentina, as reported herein, as well as *Hypogeococcus* sp. in Barbados, Florida, and Puerto Rico (Verle Rodrigues *et al.*, in review).

Comments.— In Argentina, *Leptomastidea* sp. can only be confused with *Gyranusoidea pseudococci* (Brèthes), which had been originally described as *Leptomastidea pseudococci* Brèthes (Brèthes 1924). Unlike the female of *Leptomastidea* sp., which has three dark bands on the fore wing (Fig. 9), that of *G. pseudococci* has only two such bands on the fore wing (Figs. 25, 27). The first author of this communication examined, during a visit of MACN in February 2014, the original syntype specimens of *L. pseudococci* and selected a lectotype; see rel-

Figures 1, 2. *Anagyrus cachamai* Triapitsyn, Logarzo & Aguirre, habitus (paratypes). (1) Female (Autopista Salta-Güemes (RN9), 24°46'49.3"S 65°18'19.0"W, Salta, Argentina); (2) Male (1 km S of Alemania, Salta, Argentina).

Figures 3, 4. *Anagyrus quilmes* Triapitsyn, Logarzo & Aguirre, habitus (paratypes). (3) Female (Vipos, Tucumán, Argentina); (4) Male (El Portezuelo, Catamarca, Argentina).



Figures 5, 6. *Anagyrus quilmes* Triapitsyn, Logarzo & Aguirre, female antennae (non-type specimens). (5) Third funicular segment completely white (El Portezuelo, Catamarca, Argentina); (6) Third funicular segment partially white, with a brownish shade (Río Piedras, Salta, Argentina).

evant taxonomic notes on this species at the bottom of this article.

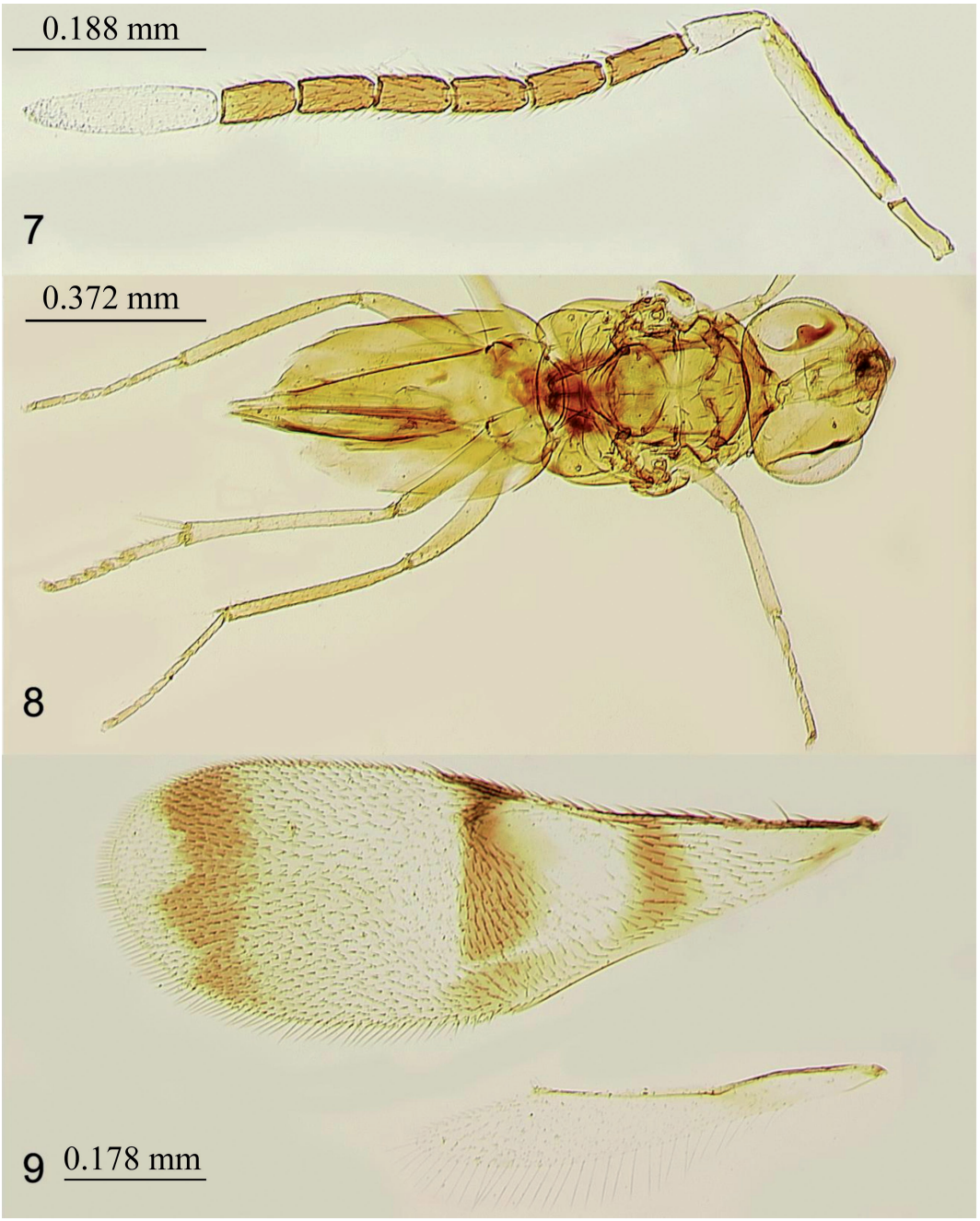
Secondary parasitoids (hyperparasitoids) of *Hypogeococcus* spp. in Argentina

Chartocerus ?axillaris De Santis (Signiphoridae) (Figs. 14–20)

Material examined.— ARGENTINA: Catamarca, El Portezuelo: 28°26'58.3"S, 65°37'59.4"W, 658 m, 13.ix.2011, G. A. Logarzo, M. B. Aguirre (from *Hypogeococcus* sp. on *Cleistocactus baumannii*) [1 male, UCRC]. 28°28'12.5"S 65°38'07.5"W, 635 m, 15.ii.2014, G. A. Logarzo, M. B. Aguirre (from *Hypogeococcus* sp. on *Cleistocactus smaragdiflorus*) [1 female, UCRC]. Córdoba, Jesús María, 30°58'26.2"S 64°05'02.6"W, 524 m, 14.ii.2014, M. B. Aguirre, G.A. Logarzo (from *H. pungens* on *Alternanthera pungens*) [1 male, UCRC]. Salta, Autopista Salta-Güemes (RN9), 24°46'49.3"S 65°18'19.0"W, 1305 m, 17.ii.2014 (from *H. pungens* on *Alternanthera paronychioides*): M. B. Aguirre, G. A. Logarzo, S. V. Triapitsyn [1 female, UCRC]; S. V. Triapitsyn, G. A. Logarzo, M. B. Aguirre [3 females, IMLA, MLPA, UCRC].

Comments.— Illustrated here are a female (Figs. 14–17) and a male (Figs. 18–20) of the species we have tentatively identified as *Chartocerus ?axillaris* De Santis. The latter is the only species of the genus *Chartocerus* Motschulsky described from Argentina [as *Ch.* (*Xana*) *axillaris*] (De Santis, 1973), which is also known from Paraguay (De Santis 1979), who mentioned a *Hypogeococcus* sp. as its host. The type locality of *Ch. axillaris*, which was described from a single female holotype, is Chacras de Coria, Mendoza; it was reared together with the encyrtid (the primary parasitoid) *Anagyrus lopezi* (De Santis) from a *Pseudococcus* sp. (Pseudococcidae) on *Solanum elaeagnifolium* (De Santis, 1973).

We have compared a nicely slide-mounted female from El Portezuelo, Catamarca with the holotype female of *Ch. axillaris* in MLPA on slide (Fig. 21) labeled: 1. «*Charto-*



Figures 7-9. *Leptomastidea* sp., female (Río Piedras, Salta, Argentina). (7) Antenna; (8) Body; (9) A pair of wings.

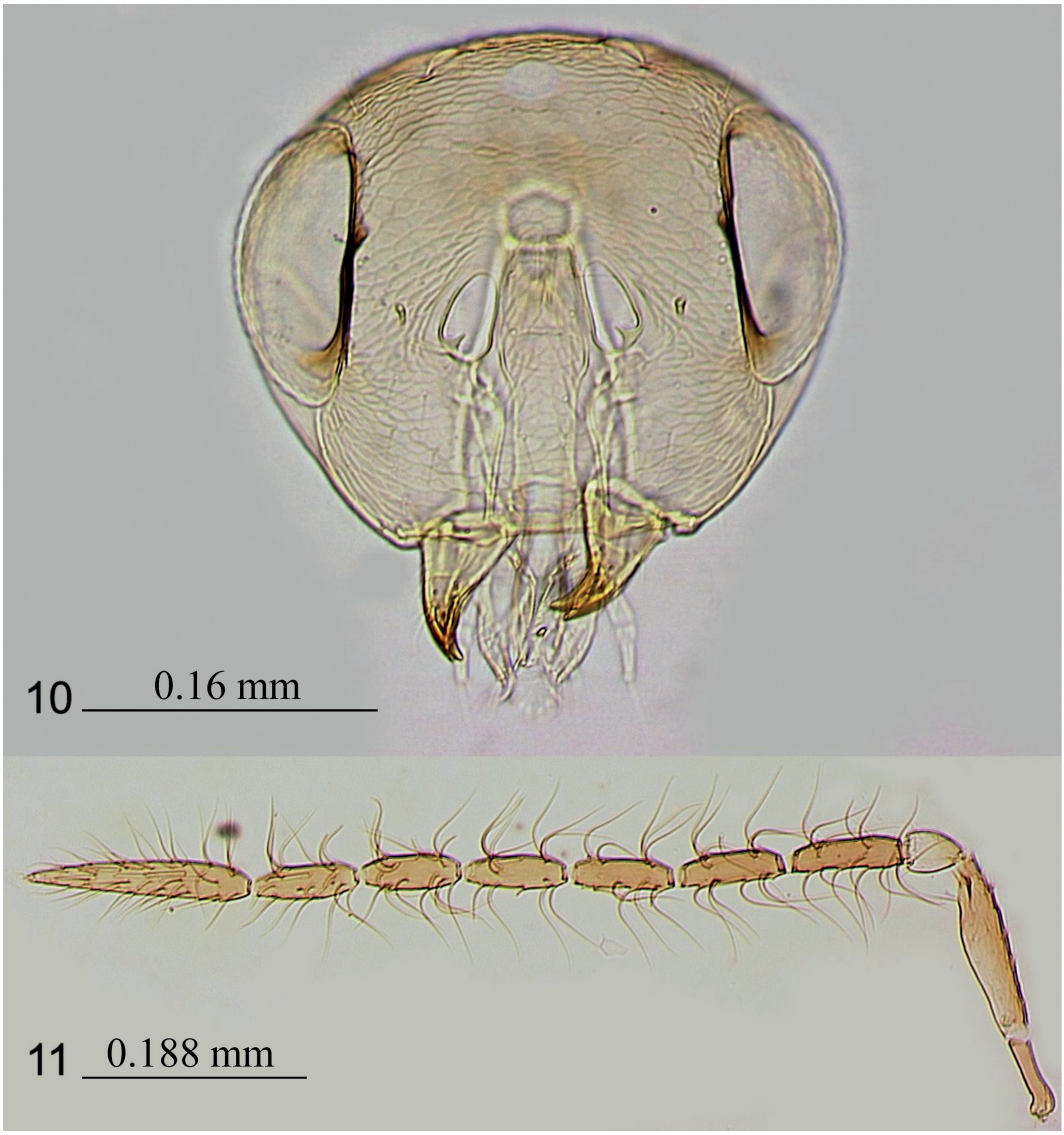
cerus (*Xana*) *axillaris* Det. De Santis HOLOTIPO MUSEO DE LA PLATA»; 2. «CHACRAS de CORIA (Prov. de Mendoza) s/Cochinilla del quillo-quillo. Col: Exp. Museo 25/II/1957 n sp *Chartocerus* (*Xana*)»; 3. [MLPA type number] «3927/1». Their antennae have a slight difference in the relative length of the clava: that of the holotype (Fig. 22) is 3.3 times as long as pedicel whereas that of the female from El Portezuelo is 3.1 times as

long as pedicel. We consider that to be likely within the limits of intraspecific variation. Otherwise, our female specimens are very similar to the holotype of *Ch. axillaris* including its fore wing venation (Fig. 23).

Prochiloneurus sp. (Encyrtidae)
(Fig. 24)

Material examined.— ARGENTINA: Catamarca, El Portezuelo, 28°28'12.5"S 65°38' 07.5"W, 635 m, 15.ii.2014, M. B. Aguirre, G. A. Logarzo (from *H. pungens* on *Alternanthera pungens*) [1 female, UCRC].

This species is definitely not conspecific to any of the known species of the genus *Prochiloneurus* Silvestri from the New World, but we are reluctant to describe it as new from the single female (Fig. 24).



Figures 10, 11. *Leptomastidea* sp., male (El Portezuelo, Catamarca, Argentina). (10) Head (frontal view); (11) Antenna.

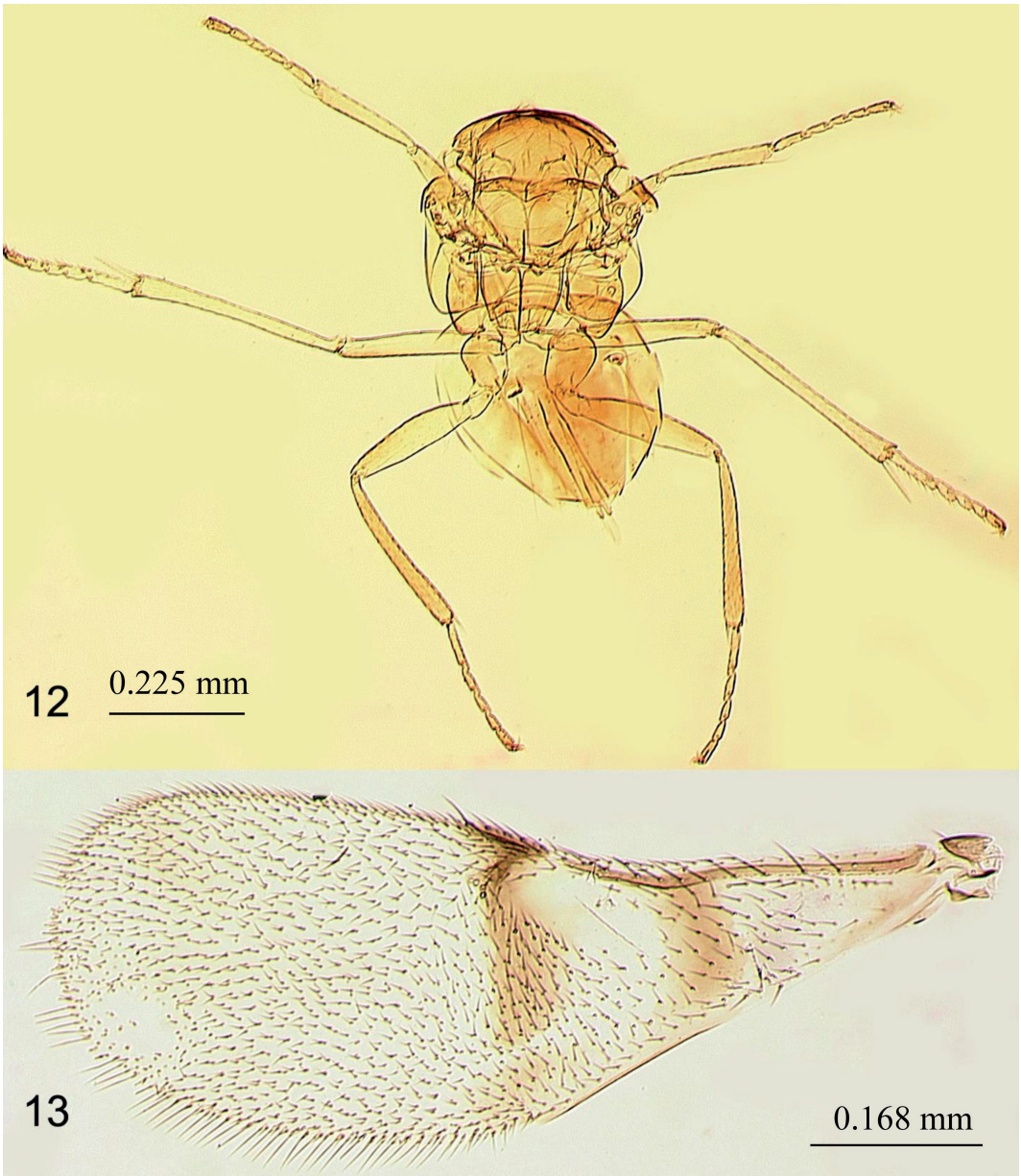
TAXONOMIC NOTES ON *GYRANUSOIDEA PSEUDOCOCCI* (BRÈTHES) (ENCYRTIDAE, NOT A *HYPOGEOCOCCUS* SPP. PARASITOID)

Gyranusoidea pseudococci
(Brèthes, 1924)
(Figs. 25–27)

Leptomastidea pseudococci Brèthes 1924: 69–70. Type locality: Asunción, Paraguay.

Leptomastix bahiensis Compere 1939: 59. Type locality: [São] Salvador, Bahia, Brazil. Synonymized under *Gyranusoidea pseudococci* (Brèthes) by Noyes 2000: 161.

Leptomastidea brethesi Blanchard 1940: 106 (key), 118–120 (as *Leptomastides* [sic]



Figures 12, 13. *Leptomastidea* sp., male (El Portezuelo, Catamarca, Argentina). (12) Mesosoma and metasoma; (13) Fore wing.

brethesi). Type locality: Aimogasta, La Rioja, Argentina. Synonymized under *Leptanusia pseudococci* (Brèthes) by De Santis 1964: 82.

Leptanusia pseudococci (Brèthes): De Santis 1964: 82–83 (redescription, illustration of female, type information); De Santis 1967: 152 (catalog); De Santis 1979: 192 (catalog).

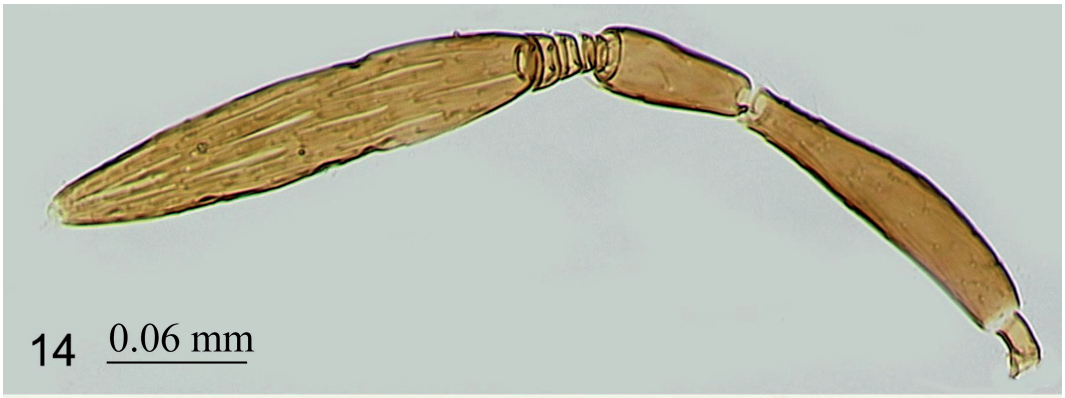
Leptomastix bahiensis Compere: De Santis 1979: 184 (catalog).

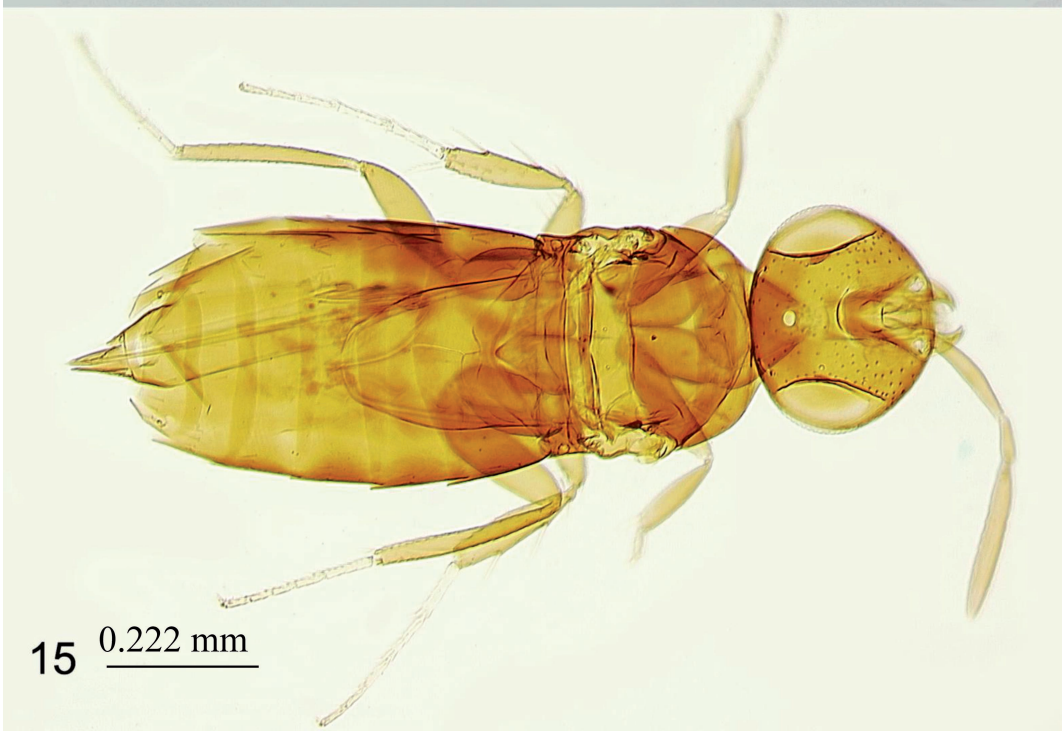
Leptomastidea bahiensis (Compere): Noyes 1980: 206; Kerrich 1982: 403 (mentioned).

Gyranusoidea bahiensis (Compere): Noyes & Hayat 1994: 309.

Gyranusoidea pseudococci (Brèthes): Noyes & Hayat 1994: 309.

Type material examined.— Lectotype female [MACN] of *Leptomastidea pseudococci* Brèthes, here designated to avoid any possi-





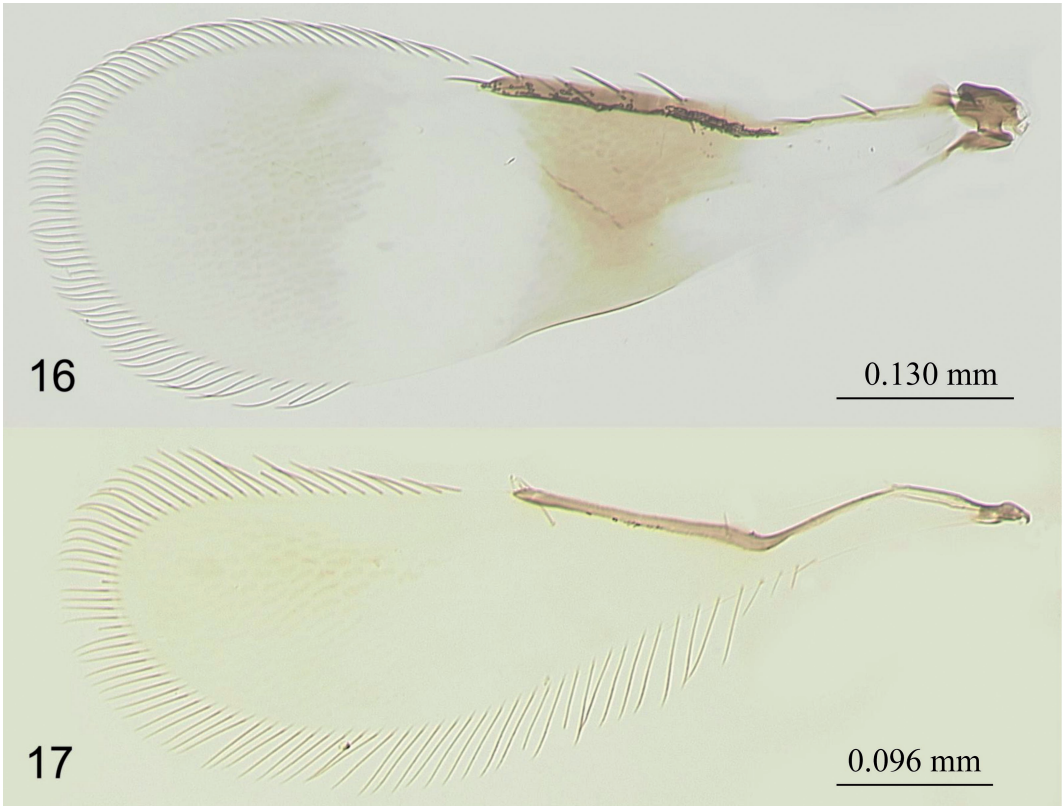
Figures 14, 15. *Chartocerus ?axillaris* De Santis, female (El Portezuelo, Catamarca, Argentina). (14) Antenna; (15) Body.

ble confusion regarding the status of the type specimens of this taxon, on card labeled: 1. «Paraguay Asunción W. Bertoni»; 2. «s/ *Pseudococcus citri*»; 3. [type number] «11'20"; 4. «*Leptomastidea pseudococci* Brèthes». The dry-mounted lectotype (Fig. 25) is almost complete and glued dorsoventrally; it agrees in all regards with the original description (Brèthes, 1924) and the illustration and redescription of the female of this species in De Santis (1964) [as *Leptanusia pseudococci* (Brèthes)]. Paralectotypes of *L. pseudococci*: 1 female [MACN] on slide labeled: 1. «*Leptomastidea pseudococci* Brèthes Type [faint] Paraguay: Asunción W. Bertoni s/*Pseudococcus citri* 11'20", 2. [original type number] «L7»; 2 females [MACN] on a slide, similarly labeled; one specimen is complete (Fig. 27) and the other has the head + antennae detached from the body (Fig. 26).

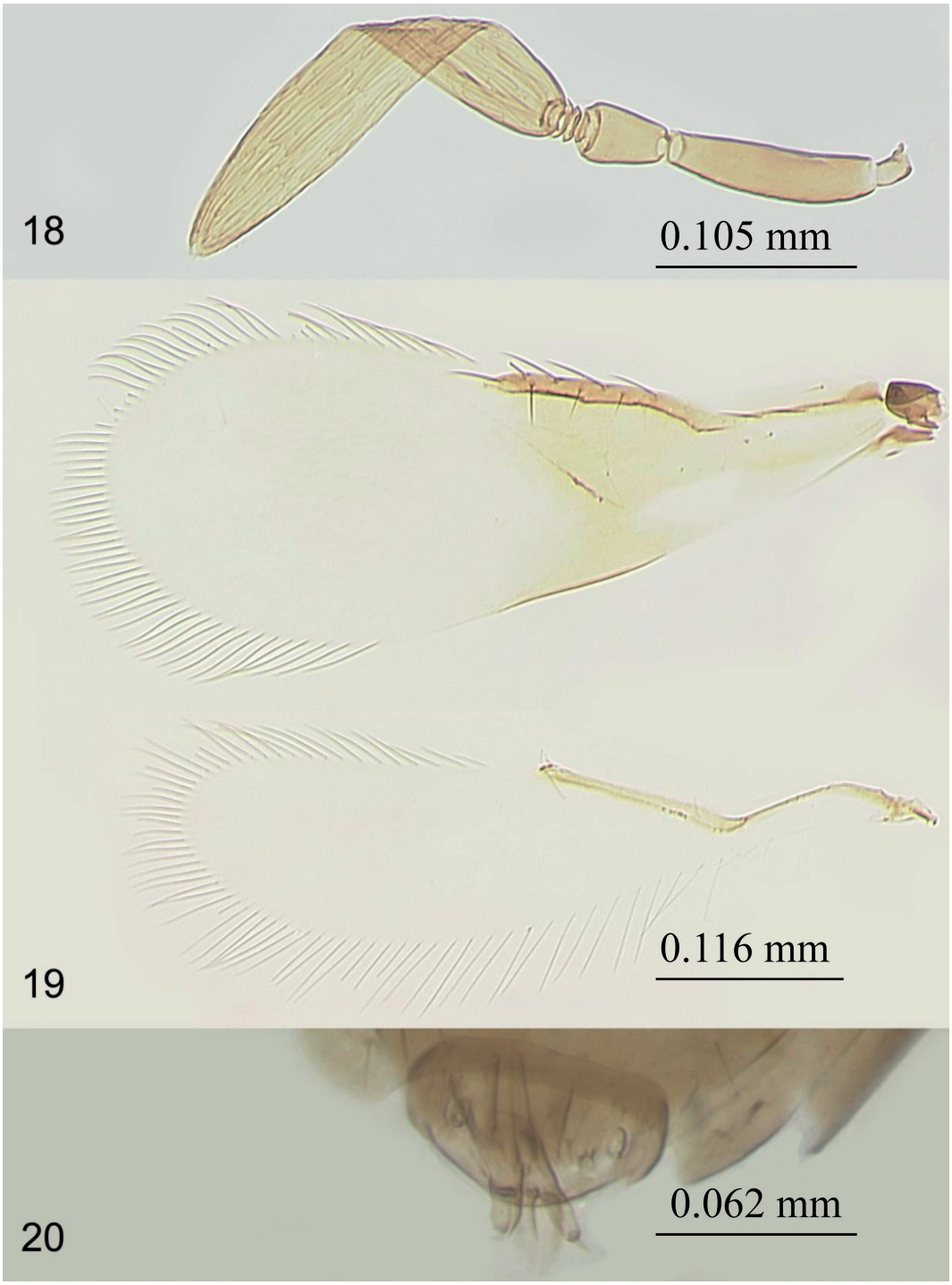
Taxonomic notes.— Female of this species (based on examination of the lectotype and paralectotypes of *Leptomastidea pseudococci*) is characterized by the following morphological features: head (Fig. 26) light brown; antenna (Figs. 26, 27) with scape and pedicel yellowish-brown, funicle dark brown, and clava white; pronotum and mesoscutum contrastingly lighter than the rest of mesosoma; fore wing (Figs. 25, 27) with two bands – the basal band (behind submarginal vein) oblique and faint, and the other band (behind marginal and stigmal veins) oblique, narrow, noticeably darker, and not extending to posterior margin of the wing; legs brown; gaster dark.

Distribution.— Argentina, Barbados, Brazil, Costa Rica, Ecuador, Mexico, Paraguay, Peru, and USA (Florida) (Noyes, 2000).

Hosts.— *Ferrisia virgata* (Cockerell), *Planococcus citri* (Risso), *Planococcus* sp., and



Figures 16, 17. *Chartocerus ?axillaris* De Santis, female (El Portezuelo, Catamarca, Argentina). (16) Fore wing; (17) Hind wing.



Figures 18-20. *Chartocerus ?axillaris* De Santis, male (El Portezuelo, Catamarca, Argentina). (18) Antenna; (19) A pair of wings; (20) Genitalia.

Pseudococcus sp. (Brèthes, 1924; Compere, 1939; Blanchard, 1940; Noyes, 2000).

Comments.— The generic placement of this species follows Noyes (2000). However, the generic limits of *Gyranusoidea* Compere are not well defined: there are no reliable, genus-level morphological features that readily separate it from *Anagyrus* Howard (particularly) or *Leptomastidea*. Indeed, some Afrotropical species of *Leptomastidea* have only two dark bands on the fore wing in females (Prinsloo, 2001), as in some Neo-

Figures 21–23. *Chartocerus axillaris* De Santis, female (holotype). (21) Slide; (22) Antenna; (23) Fore wing venation.

Figure 24. *Prochiloneurus* sp., female (El Portezuelo, Catamarca, Argentina). Habitus.

tropical species of *Gyranusoidea*, and at least two New World species of *Leptomastidea* are undoubtedly native there; both (*L. debachi* Trjapitzin & Ruíz Cancino and *Leptomastidea* sp.) have three dark bands on the fore wing. Re-assessing generic limits within the Anagyrini is, however, beyond the scope of this study.

ACKNOWLEDGEMENTS

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Figure 25. *Gyranusoidea pseudococci* (Brèthes), female (lectotype of *Leptomastidea pseudococci* Brèthes). Habitus.

Figures 26, 27. *Gyranusoidea pseudococci* (Brèthes), female (paralectotypes of *Leptomastidea pseudococci* Brèthes). (26) Head and antenna; (27) Habitus.

tal images. John S. Noyes (The Natural History Museum, London, England, UK) provided valuable consultations on taxonomy of the New World *Prochiloneurus*. We also thank Vladimir V. Berezovskiy (UCRC) for making excellent mounts of the specimens, Eduardo G. Virla (IMLA) for generous assistance on many occasions, Mariel Guala (FuEDEI) and Darío Ruiz for help with collecting, and John Hash (UCRC) for taking several digital images. This study was funded by the USDA-APHIS (Agreement No. 34-WI-14-1001-0861-IA to FuEDEI).

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