A NEW SPECIES OF *GALEOPSOMYIA* (HYMENOPTERA: EULOPHIDAE: TETRASTICHINAE): A FORTUITOUS PARASITOID OF THE CITRUS LEAFMINER, *PHYLLOCNISTIS CITRELLA* (LEPIDOPTERA: GRACILLARIIDAE)

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ABSTRACT

Galeopsomyia fausta LaSalle sp.n. (Hymenoptera: Eulophidae: Tetrastichinae) is described as a fortuitous parasitoid of the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae: Phyllocnistinae). This species is widely distributed in the Neotropics, being known from Mexico and Puerto Rico to Argentina. *G. fausta* is the first species of *Galeopsomyia* which is not associated biologically with galls. *G. fausta* represents an example of an indigenous parasitoid recruited onto an invading pest species, and the implications of this for the valuation of biodiversity are discussed.

Key Words: *Phyllocnistis citrella*, parasitoids, biological control, biodiversity

RESUMEN

Se describe *Galeopsomyia fausta* LaSalle sp.n. (Hymenoptera: Eulophidae: Tetrastichinae) un parasitoide fortuito del minador de los citricos, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae: Phyllocnistinae). La especie *G. fausta* esta distribuida ampliamente en el neotrópico, desde México, Puerto Rico hasta Argentina. *G. fausta* es la primera especie de *Galeopsomyia* la cual no se encuentra asociada con insectos productores de agallas. *G. fausta* es un ejemplo característico de un parasitoide nativo atacando una especie plaga invasora. Se toma este ejemplo para discutir sus implicaciones en lo que respecta a el valor de la biodiversidad.

The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae: Phyllocnistinae), has only recently invaded the tropical and semi-tropical areas of the New World. The arrival of *P. citrella* in Florida in 1993, and its rapid spread through the Neotropics, has been documented by Heppner (1993), and Knapp et al. (1995). These papers offer much additional information on the biology, distribution, and management of *P. citrella*.

Heppner (1993) recorded about 30 species of Asian parasitoids of *P. citrella*. There are now almost 80 species of parasitoids which have been reared from *P. citrella* throughout the world (Schauff et al., submitted). Many of these are indigenous parasitoids which have moved over onto *P. citrella* as it has spread, and there are already over 20 such species known from the New World (Schauff et al., submitted; Table 1). A few of these species appear to be capable of exerting substantial levels of control on the *P. citrella* populations. The purpose of this paper is to describe one of these species, *Galeopsomyia fausta* LaSalle sp.n., and comment on the importance these indigenous species can play in biological control programs.

TABLE 1. INDIGENOUS NEW WORLD PARASITOIDS RECORDED ATTACKING CITRUS LEAFMINER (COMPILED FROM SCHAUFF ET AL., SUBMITTED).

Species	
EULOPHIDAE	
Chrysocharis sp.	Honduras
Chrysocharodes sp.	Colombia, Mexico
Cirrospilus nigrivariegatus Girault	USA: Florida
Cirrospilus sp. A	Honduras, Mexico, Nicaragua, USA: Florida, Venezuela
Cirrospilus sp. B	Honduras, Peru
Cirrospilus sp. C	Argentina, Brazil, Colombia, Honduras, Mexico
Closterocerus cinctipennis Ashmead	USA: Florida, Texas
Closterocerus sp. or spp.	Colombia, Honduras, Mexico
Diglyphus begini (Ashmead)	USA: Florida
Elachertus sp. or spp.	Argentina, Honduras, USA: Florida
Galeopsomyia fausta LaSalle sp.n.	Argentina, Brazil, Colombia, Honduras, Mexico, Nicaragua, Puerto Rico
Horismenus sardus (Walker)	USA: Florida
Horismenus sp. or spp.	Brazil, Colombia, Honduras, Mexico, Nicaragua, Puerto Rico
Pnigalio minio (Walker)	USA: Florida
Pnigalio sp. or spp.	Mexico, USA: Florida, Texas
Sympiesis sp.	USA: Florida
Zagrammosoma americanum Girault	USA: Florida
Zagrammosoma multilineatum (Ashmead)	Colombia, Mexico, USA: Florida
Zagrammosoma sp. or spp.	Mexico, Puerto Rico, USA: Texas, Venezuela
ELASMIDAE	
Elasmus tischeriae Howard	Mexico, USA: Florida
Elasmus sp. or spp.	Brazil, Colombia, Mexico, Nicaragua
EUPELMIDAE	
Eupelmus sp.	Brazil
PTEROMALIDAE	
Catolaccus aeneoviridis (Girault)	USA: Florida

Galeopsomyia fausta as a biological control agent of *P. citrella*

G. fausta is a widespread species that has been recorded as a parasitoid of *P. citrella* from throughout the Neotropics. We have examined material from Puerto Rico, Mexico, Nicaragua, Honduras, Colombia, Brazil and Argentina, and it will certainly be present in many other countries in the region.

Surveys have repeatedly identified *G. fausta* as one of the important indigenous parasitoids of *P. citrella* (Cano 1996, Cano et al. 1996, Castaño et al. 1996, Cave 1996, Cobo 1996, de la Llana 1996, Martinez 1996: all as *Galeopsomyia* sp.).

Cano (1996) collected parasitoids in different areas of Nicaragua, and found *G. fausta* to be the most abundant parasitoid, representing 19-59% of the parasitoid species composition collected from pupae of *P. citrella* in 1995 and 1996. Cano (1996) demonstrated that *G. fausta* was abundant in the dry-subtropical region of Nicaragua comprising 45% of the fauna followed by *Horismenus* sp., (36%), *Cirrospilus* sp. (9%) and *Elasmus* sp. (9%). Similar results were reported by de la Llana (1996). *G. fausta* was observed parasitizing *P. citrella* throughout the year, with highest peaks observed in January, July and October 1995-1996 (Cano 1996). Levels of 28 and 68% parasitization of pupae were observed during June 1995 and January 1996 (Cano 1996).

Biological Considerations of *Galeopsomyia fausta*

G. fausta is the first species of *Galeopsomyia* which is known to attack leafminers. All other species of *Galeopsomyia* attack galls, mostly as parasitoids of Cynipidae or Cecidomyiidae, but occasionally as inquilines (LaSalle 1994). The native host of *G. fausta* is not known. The wide distribution of *G. fausta* on *P. citrella* in the short period of time that *P. citrella* has been in the Neotropics suggests that this species has an innate ability to switch hosts onto *P. citrella*, rather than having made a single host switch and then spreading.

Galeopsomyia fausta and Biodiversity Considerations

Various authors have claimed that one of the values of conserved biodiversity is that it represents a pool of potential biological control agents (Waage 1991, LaSalle & Gauld 1993, LaSalle 1993). Thus, we are retaining the ability to control future pest problems in a manner that is both environmentally and economically sound. Without this option for biological control, we may have to rely upon control measures which will accelerate the present decline in environmental quality.

The spread of *P. citrella* in the New World has provided support for these claims. The only species of introduced parasitoid which has been established in the New World is *Ageniaspis citricola* Logvinovskaya in Florida (Hoy & Nguyen 1994, Knapp et al. 1995, Hoy et al. 1995), Louisiana (Johnson et al. 1996), Bahamas (Hoy et al. 1995), and Honduras (Castro et al. 1996, Cave 1996). However, a large complex of native parasitoids are now attacking *P. citrella*, and in many cases native species are providing control which is as effective or more effective than that supplied by *A. citricola* (Cano 1996, Cano et al. 1996, Castaño et al. 1996, Cave 1996, Cobo 1996, de la Llana 1996, French & Legaspi 1996, Gravena 1996, Martinez 1996, Peña et al. 1996, Perales & Garza 1996, Perales et al. 1996).

Table 1 lists over 20 indigenous species which have now been recorded from *P. citrella* in the New World (Schauff et al., submitted). Many of these species are incidental and will offer no substantial control. However, others of these species appear to play a major role in regulating the population levels of *P. citrella* (such as species of *Cirrospilus*, and *G. fausta*).

Several papers have discussed the relevance of being able to provide direct measures of the value of preserving biodiversity, and methods of attempting to do it (several chapters in Wilson 1988, Orians et al. 1990, Swanson 1995, Kunin & Lawton, 1996). The recruitment of indigenous parasitoids onto an introduced pest provides a direct method of quantifying one small portion of the value of conserved biodiversity. Evaluation of the cost effectiveness of biological control using introduced parasitoids

has been performed on many occasions (e.g. Dean et al. 1979, van den Bosch et al. 1982, Norrgard 1988a, b, DeBach & Rosen 1991). This methodology can just as easily be applied to indigenous parasitoids to quantify one of the financial benefits of biodiversity.

Material and Methods

Terminology follows LaSalle (1994). The term basigastral carina is borrowed from the ant workers to describe a strong, transverse carina along the anterior margin of the first gastral tergite; any longitudinal carinae extending posteriorly from the basigastral are termed basigastral costulae.

Galeopsomyia fausta, LaSalle sp.n.
(Figs. 1-9)

Galeopsomyia sp.: Cano, 1996; Cano et al., 1996; Castaño et al., 1996: Cave, 1996; Cobo, 1996; de la Llana, 1996; Martinez, 1996.

Diagnosis

Body strongly sclerotized. Gaster (Figs. 4, 5) non-collapsing in dried specimens, distinct basigastral carina and basigastral costulae present; petiole (Fig. 4, 6) distinct, wider than long, strongly sculptured dorsally; gastral tergites, and particularly the first one generally lightly sculptured, terminal gastral tergites reticulate dorsally. Propodeum (Figs. 3, 4) strongly reticulate, with a paraspiracular carina, and posterior edge sharply margined. Malar space (Fig. 2) with a triangular fovea below eye, the bottom of this fovea with sculpture. Fore wing (Fig. 7) with 4-5 setae on dorsal surface of submarginal vein.

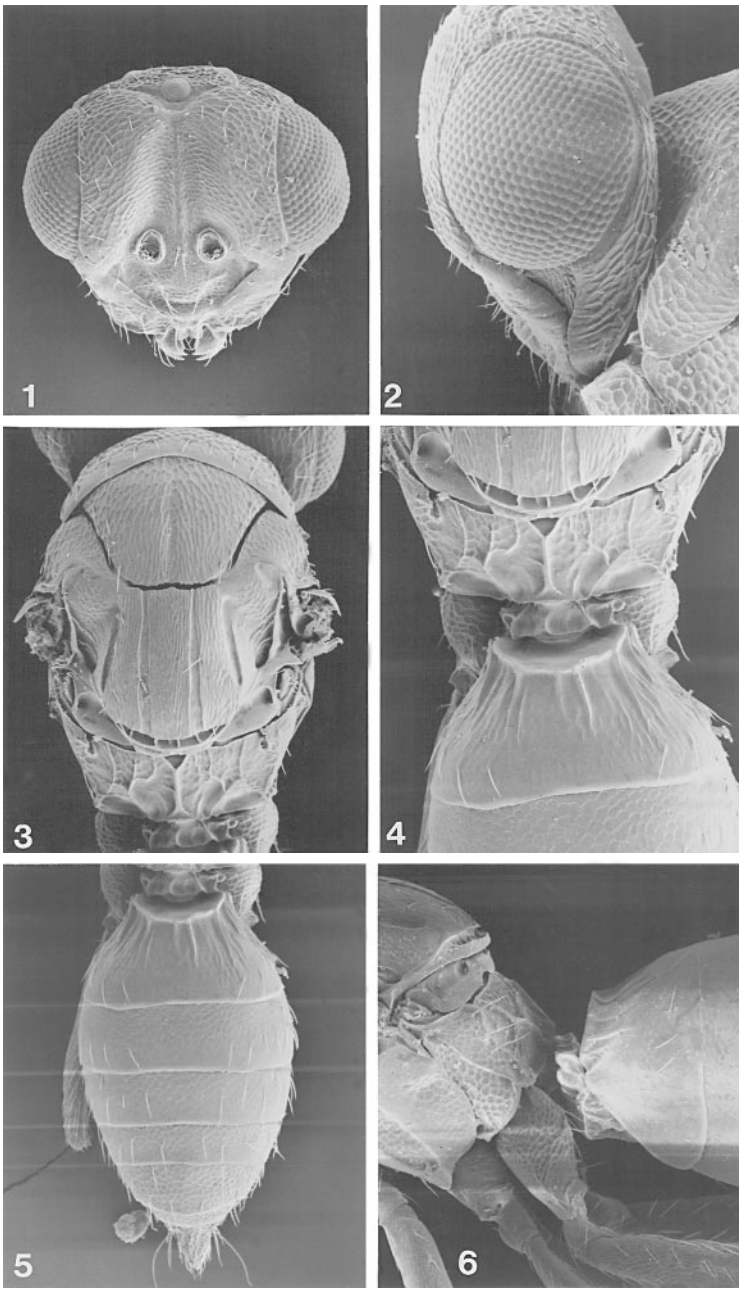
Female

Length 1.15-1.7 mm. Head, mesosoma, metasoma and coxae black, usually with dark blue metallic shine which is particularly strong on the mesosoma. Antenna with scape yellow to light brown; pedicel yellow to light brown, with dark dorsal patch; funicle dark brown. All femora predominantly brown to dark brown, generally brown to yellow apically. Tibiae yellow to light brown. Tarsal segments 1-3 yellow to white, segment 4 brown.

Head (Figs. 1, 2) strongly sculptured. Scrobal cavity without distinct sulci, but with a longitudinal median ridge. Face with strong furrow between torulus and mouth margin; this furrow carinate ventrally. Clypeus distinctly bilobed. Malar space with a triangular fovea below eye, the bottom of this fovea with sculpture.

Antenna (Fig. 8) with 3 anelli, 3 funicular segments, 3 segmented club. Each successive funicular segment only very slightly increasing in length; funicular segments together slightly longer than club.

Mesosoma (Fig. 3) with distinct reticulation. Mesoscutum with notaulus very deep; median line present as a broad, vaguely defined furrow; adnotaular setae in 1-2 rows. Scutellum with submedian lines broad and shallow; sublateral lines broad and laterally carinate; distinct transverse groove along posterior margin; several (4-6) pairs of scattered setae, these small and indistinct when examining specimens under normal magnification. Propodeum strongly reticulate, with a paraspiracular carina, and posterior margin sharply margined.



Figs. 1-6. Galeopsomyia fausta, ♀. 1, head, frontal view. 2, head, side view. 3, mesosoma. 4, propodeum, petiole, base of gaster. 5, gaster. 6, propodeum, petiole, base of gaster, lateral view.

Fore wing (Fig. 7) without even rudimentary postmarginal vein. Dorsal surface of submarginal vein with 4-5 setae.

Metasoma (Figs. 5, 6). Petiole distinct, wider than long, strongly sculptured dorsally. Gaster with distinct basigastral carina and basigastral costulae present; gastral tergites, and particularly the first one generally lightly sculptured, terminal gastral tergites reticulate dorsally. Gastral tergites 1-4 each decreasing slightly in length compared to the previous segment, so that tergite 4 is the shortest gastral tergite; tergite 5 slightly longer than tergite 4, but shorter in length than tergites 1 and 2.

Male

Length 1.15-1.35 mm. Similar to female except in sexual differences in genitalia and antennae. Antenna (Fig. 9) with 4 funicular segments. Funicular segments without basal whorls of long setae, with sparsely scattered setae which are shorter than the width of the funicle. F1 shorter than remaining segments, F2-4 subequal in length. Scape with ventral plaque situated in apical half of scape, 0.25-0.28 the total length of scape.

Discussion

Galeopsomyia may be distinguished from other genera of Tetrastichinae using the key provided by LaSalle (1994). The genus can be recognized by the combination of the following characters: body strongly sclerotized, with gaster non-collapsing and all gastral tergites reticulate dorsally; propodeum strongly reticulate, with a paraspiracular carina, and a transverse carina along posterior margin; malar space with a triangular fovea below eye, this generally with some sculpture; submarginal vein with 2 or more dorsal setae.

G. fausta can be distinguished from other species of *Galeopsomyia* by the combination of the following characters: distinct basigastral carina and basigastral costulae present; petiole distinct, wider than long, strongly sculptured dorsally; gastral tergites, and particularly the first one, not as strongly reticulate dorsally as other members of the genus; fore wing with 4-5 setae on dorsal surface of submarginal vein (as opposed to 2 or 3 in most members of this genus); gastral tergites 1-4 each decreasing slightly in length, tergite 5 slightly longer than tergite 4, but not distinctly longer than segments 1 and 2.

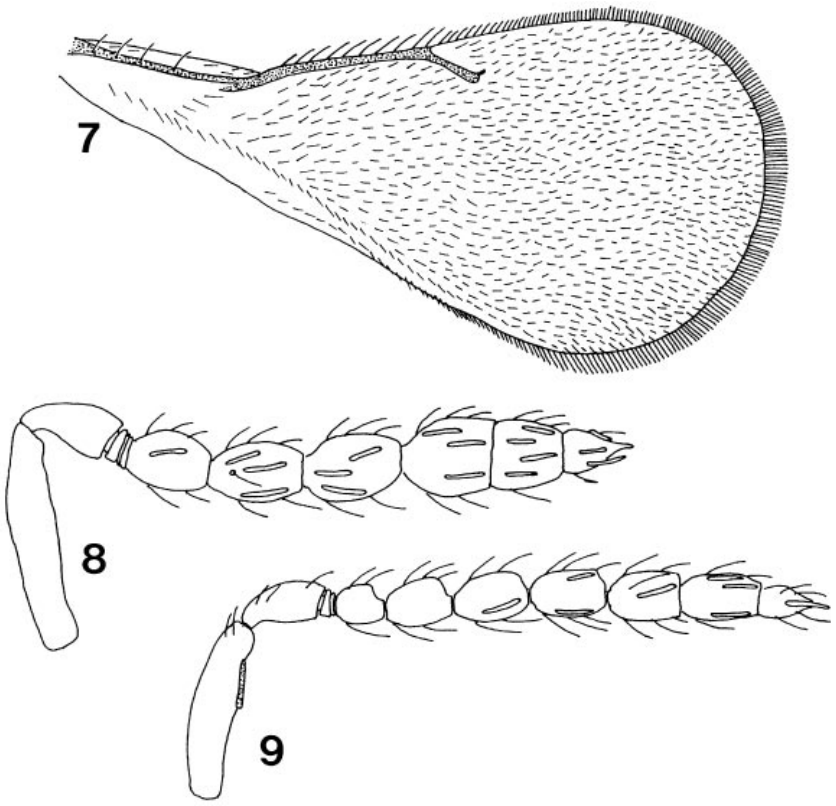
G. fausta is the only species of *Galeopsomyia* with a distinct petiole. Other members of *Galeopsomyia* are also generally lacking a basigastral carina. The only other *Galeopsomyia* species which has a basigastral carina like *G. fausta* is the Brazilian *G. viridicyanea* (Ashmead). This species differs from *G. fausta* in lacking a distinctly visible petiole, having all gastral tergites with very strong reticulate sculpture, and having gastral tergites 1-5 each increasing slightly in length compared to the previous segment, so that tergite 5 is distinctly the longest gastral tergite.

Material Examined

Note: all specimens ex. *Phyllocnistis citrella* on citrus.

Holotype ♀, MEXICO, Veracruz, Cuitlahuac, 20-xi.1995, N. Bautista Mtz. (BMNH).

67♀, 6♂ Paratypes: PUERTO RICO: Adjuntas, 6.ii.1996 (2♀ UPRM). MEXICO: Veracruz, Cuitlahuac, 20-xi.1995, N. Bautista Mtz. (3♀ CPMM, 2♀ INIA, 2♀ BMNH); Veracruz, Cruz Naranjos, 9.iii.1995, R. Mateos C. (1♀ CPMM). HONDURAS: Fco



Figs. 7-9. Galeopsomyia fausta. 7, ♀ forewing. 8, ♀ antenna. 9, ♂ antenna.

Morazan, El Zamorano, 31.x.1995, A. Guillen (3♀ BMNH, 2♀ CNC); Fco Morazan, El Zamorano, 8.xi.1995, A. Guillen (1♀ BMNH, 2♀ FSCA); Fco Morazan, San Antonio de Oriente, El Zamorano, 17.xi.1994, R. Cordero (4♀ EAPZ); Fco Morazan, San Antonio de Oriente, El Zamorano, 12.xii.1994, R. Cordero (1♀ USNM); El Paraiso, Yuscarán, 15 km antes de Yuscarán, 8.ii.1995, R. Cordero (1♀ USNM); Atlantida, La Ceiba, Buena Vista, 3.iii.1995, R. Chavez (1♀ USNM); Atlantida, La Ceiba, Buena Vista, 22.ix.1995, J. Ortega (1♀ USNM); Atlantida, 45 km W Tela, 22.i.1996, A. Guillen (1♀ USNM). NICARAGUA: C. Azules, Masatepe, 1.viii.1995, A. de la Llana (2♀ SEA); C. Azules, Masatepe, 14.viii.1995, A. de la Llana (1♀ CENA); C. Azules, Masatepe, 4.ix.1995, A. de la Llana (1♀ CENA); Jinotéga, Dorranli, 19.vii.1995, A. de la Llana (1♀ SEA); León, León, 26.vii.1995, J. Hernandez (1♀ BMNH); León, León, 28.vii.1995, J. Hernandez (1♀ CENA). COLOMBIA: Valle, Palmira, viii.1995, L. Rojas & F. Garcia (3♀ 3♂ BMNH, 2♀ 3♂ USNM). BRAZIL: São Paulo, Jaguariuna, 15.viii.1996, J. L. de Silva (4♀ DCBU, 2♀ BMNH, 1♀ USNM, 1♀ CNC); São Paulo, Valinhos, 24.v.1996 (2♀ DCBU); São Paulo, Valinhos, vi.1996, Paiva (1♀ DCBU). ARGENTINA: Tucumán, El Cadillal, 12.iii.1997, E. Frías & P. Colombres (9♀ IML, 4♀ MLP, 2♀ BMNH, 2♀ CNC).

Etymology

The species name fausta comes from the Latin for favorable or fortunate. It signifies that this species is a fortuitous biological control agent.

Biology

G. fausta has clearly moved over onto *P. citrella* from some other host(s), but the identity of its native host or hosts remains unknown.

Cobo (1996) studied Colombian parasitoids of CLM. She reported that *G. fausta* (as *Galeopsomyia* sp.) was an important parasitoid of *P. citrella*, which attacked the larva, prepupa and pupa. It paralyzes the host, and later deposits its eggs near the host. When several eggs are deposited at the same time, the first eclosing larva feeds on the remaining eggs. Eggs are hymenopteriform, round in one end and sharp at the opposite end, and small and almost transparent when newly oviposited. After oviposition, the host stops any movement and becomes darker. The parasitoid larva develops quickly, pupating at a distance from the host. The pupa is initially pale yellow, and darkens to a shiny black color. *G. fausta* is mostly a pupal parasitoid, parasitizing 87.77% pupae, 9.83% prepupae, 2.39% larvae (Cobo, 1996).

G. fausta appears to be mainly thelytokous, with only occasional males. Of the 74 type specimens mentioned in this paper, only 6 were males, and these were all from the same locality (Colombia) and date. Since this paper was submitted, another 150 specimens were sent to us from Brazil, all of which were female.

ABBREVIATIONS

BMNH	The Natural History Museum, London, UK
CNC	Canadian National Collection, Ottawa, CANADA
CPMM	Coleccion de Insetos, Instituto de Fitosanidad, Colegio de Postgraduados, Montecillo, MEXICO
DCBU	Departemento de Ciências Biológicas, Universidade Federal de São Carlos, São Carlos, SP (São Paulo), BRAZIL
EAPZ	Departemento de Proteccion Vegetal, Escuela Agricola Panamericana, El Zamorano, HONDURAS
FSCA	Florida State Collection of Arthropods, Gainesville, Florida, USA
IML	Fundación e Instituto Miguel Lillo, Universidad Nacional de Tucumán, San Miguel de Tucumán, ARGENTINA
INIA	Instituto Nacional de Investigaciones Agricolas, Secretaria de Agricultura y Ganaderia, Chapingo, MEXICO
CENA	Museo de Entomologia, Centro Nacional de Protectión Vegetal, Ministerio de Agricultura y Ganadería, Managua, NICARAGUA
MLP	Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata, ARGENTINA
SEA	Servicio Entomológico Autónomo, Museo Entomológico, SEA, León, NICARAGUA
UPRM	Department of Entomology, University of Puerto Rico, Mayaguez, PUERTO RICO
USNM	United States National Museum (Natural History), Washington, D.C., USA

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