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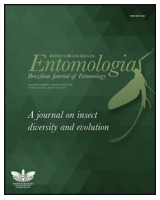

First record of the genus *Lainius* Navás, 1913 (Neuroptera: Chrysopidae) in Mexico, with notes on the distribution of Apochrysinae

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ABSTRACT

The species *Lainius constellatus* Navás is recorded for the first time from Mexico; thus this report represents the northernmost record of the genus and species for the Americas. In addition, it provides data on the variation in color marks and a description of the hypandrium internum. A brief summary of the distribution of the species belonging to the subfamily Apochrysinae is provided, with emphasis on the three American genera, which share distribution mostly in the Pacific domain of the Brazilian subregion, ranging from the Mexican transition zone to possibly the Chacoan subregion.

Introduction

Chrysopidae is one of the largest families within Neuroptera, ranking second in species richness (Henry et al., 1992; Oswald and Machado, 2018; Oswald, 2022). This family is composed of three subfamilies (Brooks and Barnard, 1990): Apochrysinae with 26 species in seven genera (Winterton et al., 2021), Nothochrysinae with 24 species in nine genera, and Chrysopinae with more than 1000 species in 64 genera (Oswald and Machado, 2018). Like other neuropterans, chrysopids present predatory habits, notably during the larval stages, with a great variety of lifestyles (Tauber et al., 2014; Oswald and Machado, 2018). They have a cosmopolitan distribution, except for Antarctica. The small subfamily Apochrysinae is restricted to tropical areas in Africa, Asia, Australia, and the Americas (Winterton and Brooks, 2002; Oswald and Machado, 2018). Adults of the subfamily are characterized by slender bodies and broad wings that are often elaborately marked or densely cross-veined (Tauber et al., 2005). In the New World, the recorded species belong to three of the seven genera: *Domenechus* Navás, 1913, *Lainius* Navás, 1913, and *Loyola* Navás, 1913, and they are restricted to Central and South America. Currently, in Mexico, only one apochrysine species, belonging to the genus *Loyola* has been previously reported in the southern part of the country (Oswald, 2022). Thus, Apochrysinae, together with Nothochrysinae, were known to have a very limited diversity in the country, each known from only one species.

The genus *Lainius* has two described species: *Lainius constellatus* Navás, 1913 and *Lainius decoratus* Navás, 1930. The first species is distributed in Central America and the West Indies (Pérez-Gelabert and Flint, 2000; Winterton et al., 2021), while the second one occurs in South America (Kimmins, 1952; Penny, 1977; Winterton et al., 2021). This genus is characterized by a basally constricted antennal pedicel; wings with numerous transverse veins; subcostal forewing veinlets with four or more irregular rows of crossveins on the basal half of the wing, one or two regular rows on the distal half; numerous irregular cross veins between Radius anterior (RA) and Radius posterior (RP) on forewing; anterior RP vein sigmoid in shape; forewing with numerous conspicuous pustules of variable size in discal area, two small pustules on hindwing; pterostigma with a small dark spot on fore and hind wing; wings with gradate series obscured by irregular

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transverse veins; Pseudo-cubital vein (Psc) extending more than ¾ of total wing length to apex; forewing cubital 2 cell (c2) short and broad, poorly defined due to numerous cross veins; Anal 1 (1A) and Anal 2 (2A) bifurcated; rear marginal area of wings with multiple semiregular rows of crossveins. Male genitalia: Tignum, gonapsis, median plate and entoprocessus absent; gonarcus slender, rarely arcuate; arcessus very small, triangular; pseudopenis, gonosaccus, gonosetae, gonocristae and spinellae absent. Female genitalia: spermatheca with lateral striae, long and tightly coiled spermathecae (Brooks and Barnard, 1990; Winterton et al., 2021).

This genus was previously synonymized under the Old World genus *Joguina* Navás, 1912, as part of a phylogenetic study by Winterton and Brooks (2002), with associated difficulties in reconciling its disparate biogeography. Winterton et al. (2021) examined the status of the genus *Joguina* and they determined that *Lainius* and *Joguina* are sister genera, so the species of *Lainius* turned out to be distinct enough to re-establish its generic status.

Little knowledge is available on the biology and ecology of both adults and larvae of this genus. About *Lainius constellatus* it is known that no remains of insects have been found in its intestinal content (Brooks and Barnard, 1990), that this species shows an altitudinal distribution of 122 to 730 meters above sea level, and that it is associated with mesic deciduous forest with scattered pines (Navás, 1913; Pérez-Gelabert and Flint, 2000). Currently, there is only one geographical record for this species besides its type locality, the Zunil volcano in Guatemala (Navás, 1930), and that record is from the Dominican Republic (Pérez-Gelabert and Flint, 2000). In this article, the genus *Lainius* is recorded for the first time from Mexico, and the distribution of *Lainius constellatus* is expanded northward to southeastern Mexico. Also, new data on morphological variation of this species is provided.

Materials and methods

Six specimens deposited at Colección Nacional de Insectos of Instituto de Biología, Universidad Nacional Autónoma de México (CNIN-IBUNAM), Mexico City, were studied and identified. One male and one female were dissected for the examination of genitalia; the abdomen was removed and cleared in a 10% potassium hydroxide (KOH) solution, heated to 80ºC in a water bath, and later rinsed with distilled water. The cleared genitalia were stained with Chlorazol Black E and then placed each in a microvial with glycerin. Observations of body and genitalia were made under a Zeiss Discovery V8 dissecting microscope. Serial images of different layers were taken with a Zeiss Axio Zoom V16 microscope equipped with an AxioCam MRc5 digital camera and stacked with Zen 2012 (blue edition).

Results

Chrysopidae
Apochrysinae
***Lainius constellatus* Navás, 1913 (**Fig. 1–3**)**

Material examined. Mexico: Oaxaca, Santa Cruz de Tepetotutla, 17°43'12.11"N, 96°32'52.79"W, 1320 m, 1 ♀, 25.vi.2017, F. Acevedo & A. Ramírez; Veracruz, Xalapa, 1984-09 [ix.1984], J. Peña, 2 ♂, 2 ♀; same information except 1985-10-25 [25.x.1985], J. Peña, 1♀.

Notes and morphological variation

Lainius constellatus was previously described by Navás, 1913, which also served as the type for the description of the genus. Afterwards, Brooks and Barnand, 1990 reviewed the Chrysopidae genera of the world with a detailed description of the external and internal morphology of both males and females of the genus *Lainius* (from *Lainius constellatus*). Later, a generic redescription was provided when the genera *Joguina* and *Lainius* were synonymized (Winterton and Brooks, 2002). Recently, Winterton et al., 2020, by restoring *Lainius* as a valid genus, published a diagnosis of the genus (from *Lainius constellatus*), providing information on the external morphology and genitalia of the female. The diagnostic characters are described in the introduction of this article.

The specimens studied in this work, obtained from different localities in Mexico, present a light green head with a transversal red band on the vertex (behind the antennae), on some occasions with a red spot on each side of the eyes (Figs. 1A, B). The vertex is flat, steeply rising anteriorly, as mentioned in Brooks and Barnand, 1990; scape with a red lateral stripe; pedicel constricted medially, with a brown lateral stripe on pedicel and basal flagellomeres; flagellum evenly pale, slightly longer than broad; setae arranged in five rings (Figs. 1C, D); antenna longer than forewing length (a total of 140-150 flagellomeres could be counted in the specimens examined); the front is flat and pale; carina on dorsal torulus margin present; gena, clypeus, and labrum pale; labrum slightly indented; palpus slightly tapered apically. There are variations in the color of the maxillary and labial palps; maxillary and labial palps are uniformly pale (Fig. 1F) or tip of apical palpomere with small dark mark (Fig. 1E).

Regarding the thorax, in the pronotum, we observed that there are two different patterns. The first one shows diffuses red marks on the lateral margin of the pronotum (Fig. 1B) and the second one with two lateral red spots apically of the pronotum (Fig. 1A). Sometimes, the mesonotum and metanotum have two red spots on the basolateral position on each side of the scutellum (Fig. 2A). Legs, unmarked; setae long, pale; claws with basal dilation, with four tarsal setae. Forewing broad, rounded apically; pustules marked with dark shading (9 to11- variable disposition) (Figs. 2C, D); veins C and Sc not fused; costal area broad; costal setae long, erect; pterostigma marked with brown spot; Sc and R quite close; basal Sc crossvein absent, 4-10 Sc crossveins present in apical half of wing; Rs sinuate, arising basally; wing highly reticulated particularly in basal half; c1, c2 indistinct; Psm and Psc very close together, upturned apically (Figs. 2E, F); Psm continuous with outer gradate series; 28-33 crossveins between Psm and Psc. Hind wing narrower than forewing, pustules marked with dark shading (2- 3); 0-3 Sc-R crossveins below pterostigma; 26 to 32 crossveins between Psm and Psc; pterostigma marked with brown spot.

The abdomen was green and swollen apically; with red dorsal markings on tergites (alternating color intensity) (Fig. 2B); with short, dense setae interspersed with long, scanty setae. Males presented rounded callus cerci, with 38-40 trichobothria, ectoprocts slightly invaginated dorso-apically, not fused dorsally; with a suture between ectoprocts and tergite 9; sternum 8+9 is fused, short, and broad. A simple weakly sclerotized apodemes (Fig. 3A). Females with sternum seven apically straight (Fig. 3B).

Male genitalia: Tignum absent; gonarcus medially fused, median arch without expansion medially, lateral arms simple; entoprocessus absent; lateral arms of gonarcus pointing backwards; mediuncus triangular attached to gonarcus, without membranous connection, shorter than lateral arms of gonarcus, with eight short setae on apex of each side (Fig. 3C); parameres absent; gonosetae present (>20); gonocristae absent; microtholi absent. The internal hypandrium had not been described previously for this species; it has a shape similar to *Loyola croesus* (Gerstaecker) previously described by Tauber et al., (2005), the internal hypandrium of *Lainius*

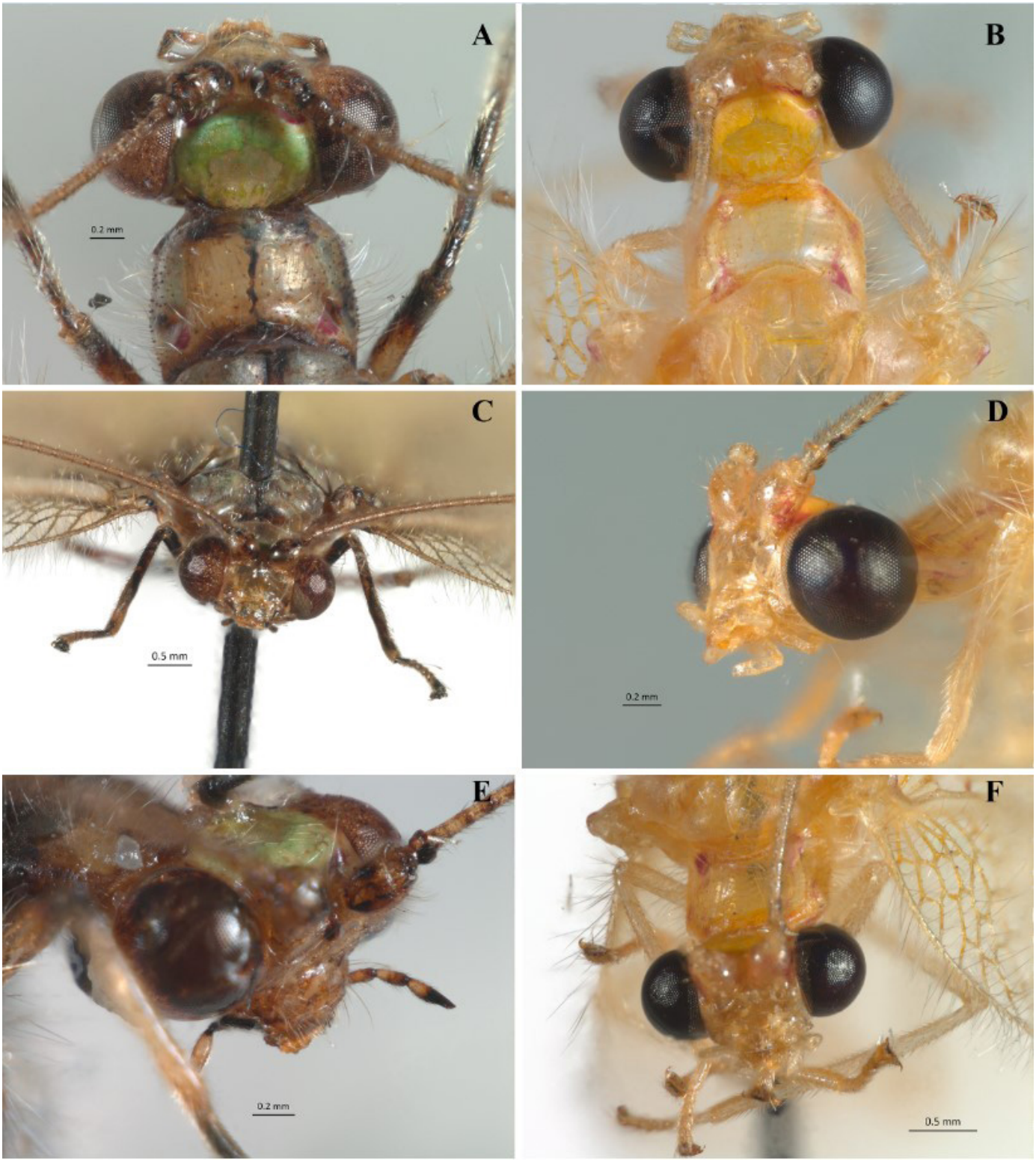

Figure 1 *Lainius constellatus* Navás head and prothorax. A) Head and prothorax in dorsal view (two lateral red spots apically on pronotum), B) Head and prothorax in dorsal view (diffused red marks on lateral margin of pronotum), C) Head frontal view (palps with dark marks), D) Head and prothorax in lateral view (palps pale), E) Head in latero-dorsal view, F) Head in fronto-dorsal view.

constellatus is large broadly V-shaped, with delicate internal rods; comb long, crescent-shaped laterally (Fig. 3E-Left) and hook-shaped, extending upwards distally in dorsal view (Fig. 3E-Right).

Female genitalia: subgenitale as long as broad, bilobed apically (Fig. 3F); spermatheca large, with more than 10 lateral striations; vela smaller than spermatheca; spermathecal duct long and with four turns without being tightly coiled (Fig. 3D); this contrasts with the drawings presented in Brooks and Barnard, 1990, where fewer striations are observed in the spermatheca and the spermathecal duct is clearly more coiled than the one present in these specimens.

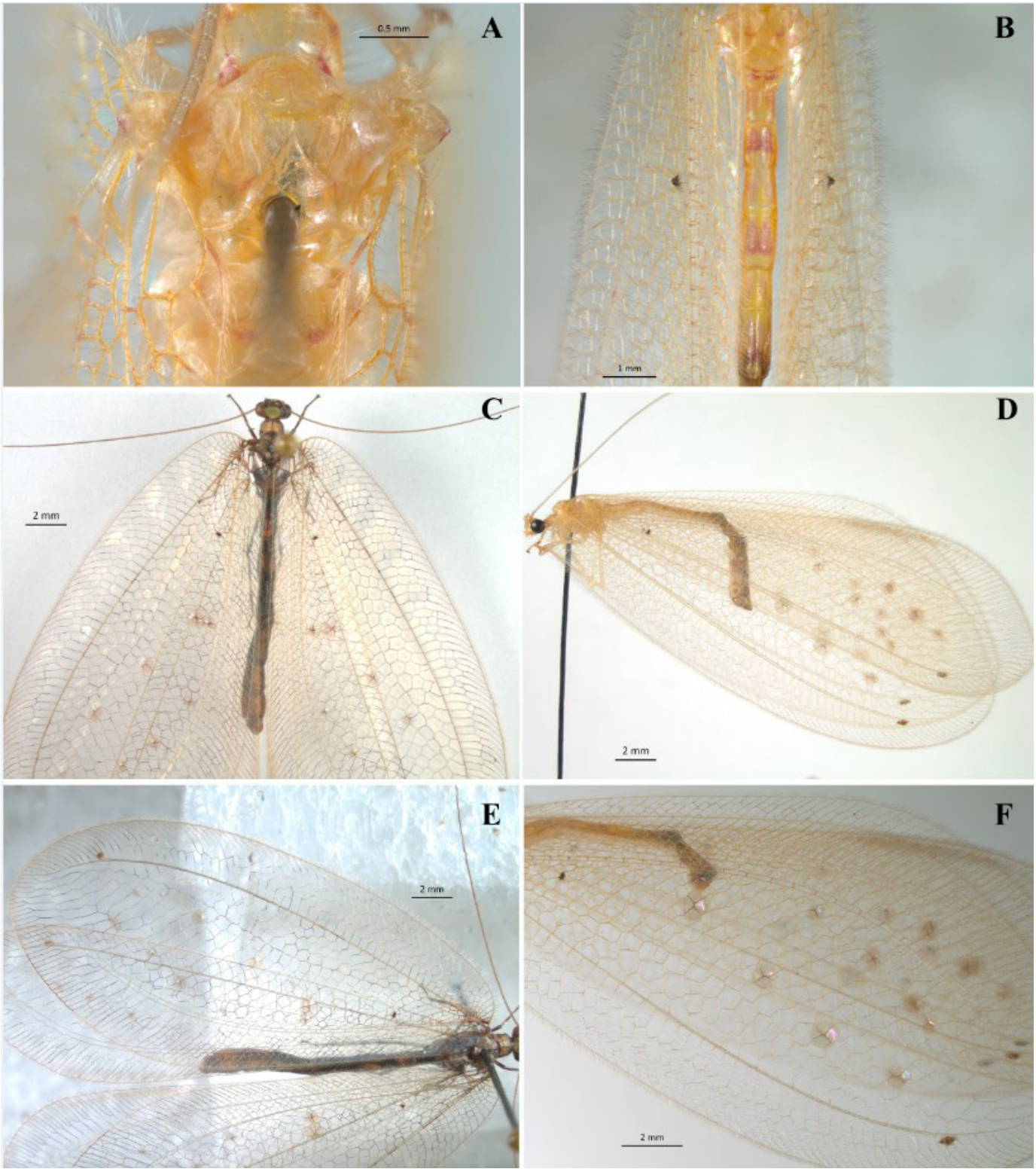

Figure 2 *Lainius constellatus* Navás, thorax, wings and abdomen. A) Pterothorax in dorsal view, B) Abdomen in dorsal view, C) Habitus in dorsal view, D) Habitus in lateral view, E) Wings, F) Forewing.

Comments. Individuals of *Lainius constellatus* were collected in cloud forest using an entomological net over the tree canopy during the day, at approximately 12:00 a.m. This species has few collection records since its original description from Guatemala in 1913. These new records from Mexico are the northernmost in the Americas and include the highest altitude recorded so far (1320 m). Based on current records, we may infer that this species has a Neotropical distribution, present in the Mexican transition zone and the Antillean subregion (Fig. 4). It is likely distributed

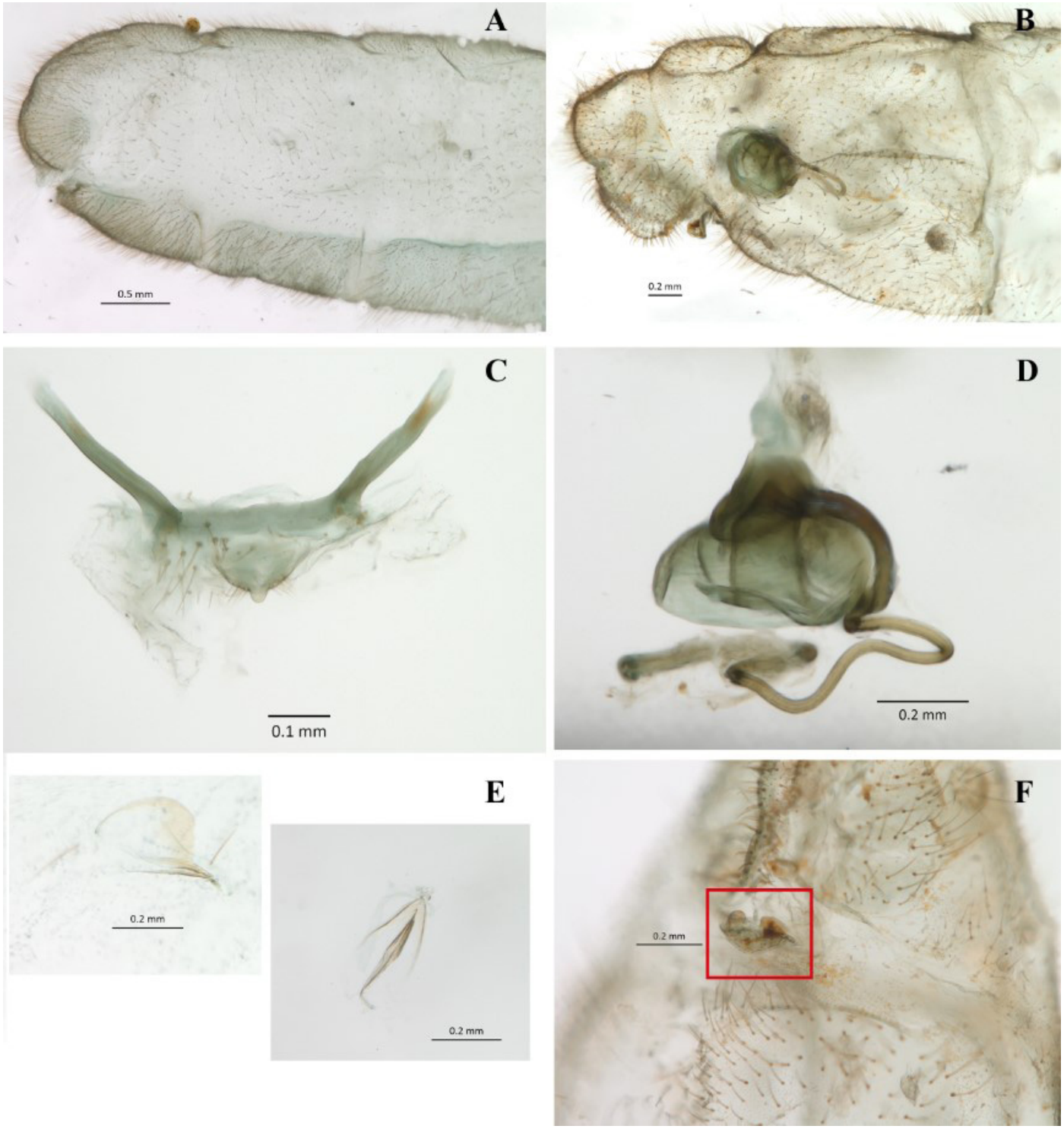

Figure 3 *Lainius constellatus* Navás, terminalia and genitalia. A) Male terminal abdominal segments in lateral view, B) Female terminal abdominal segments in lateral view, C) Gonarcus and mediuncus in frontal view, D) Spermatheca, E) Hypandrium internum (left, lateral view; right, dorsal view), F) Subgenitalia (in box).

through the mountains of southeastern Mexico, however further faunistic studies in Mexico, Central-, and South America are needed to better delimit the distribution of *Lainius*, particularly *Lainius decoratus*.

The new record also widens the known distribution of the genus. Yet, distribution of American Apochrysinae is fragmented, so more sampling effort is required to have a general idea of the distribution pattern of these genera. It seems likely that the three genera could have a shared distribution in the Mexican Transition Zone, as well as in the Brazilian subregion, with *Loyola* and *Domenechus* possibly being present in the Chacoan subregion, especially in Brazilian territory. On the other hand, the genus *Lainius* occurs further north, so far not recorded in the Chacoan region. In Central America, mainly at the Pacific domain of the Brazilian subregion, is where the three American genera share distributions (Table 1).

Table 1
Distribution of Apochrysinae species from the New World (- = undetermined).

Species	Distribution	References	Biogeographic distribution (Morrone, 2014)
Lainius constellatus Navás	Dominican Republic, Guatemala, Mexico	Navás (1913), Banks (1945), Penny (1977), Pérez-Gelabert and Flint (2000)	Antillean subregion (Hispaniola province), Mexican Transition Zone (Transmexican Volcanic Belt province, Chiapas Highlands province)
Lainius decoratus Navás	North of South America	Navás (1930), Penny (1977)	-
Loyola croesus (Gerstaecker)	Brazil, Costa Rica, Mexico, Nicaragua, Panama, Peru, Venezuela	Banks (1944, 1945), Penny (1977), Tauber et al. (2005)	Mexican Transition Zone (Chiapas Highlands province), Brazilian subregion (Pacific dominion, Boreal Brazilian dominion, South Brazilian dominion), Chacoan subregion (Parana dominion).
Loyola beata (Walker)	Brazil	Walker (1860), Kimmins (1952)	-
Loyola tripunctata Banks	Brazil	Banks (1924), Kimmins (1952)	-
Domenechus marianellus (Guérin-Méneville)	Brazil	Kimmins (1952), Penny (1977)	-
Domenechus mirificus (Gerstaecker)	Costa Rica, Guatemala, Panama.	Gerstaecker (1887), Navás (1913), Banks (1945), Penny (2002)	Mexican Transition Zone (Chiapas Highlands province), Brazilian subregion (Pacific dominion)

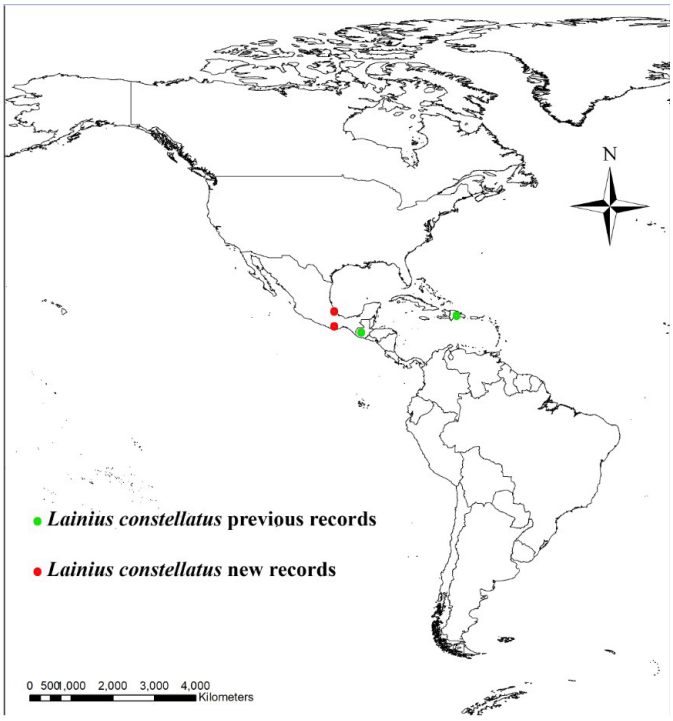

Figure 4 Geographic distribution of the New World apochrysine species, *Lainius constellatus*.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

RJCL, FAR Conceptualization, methodology, writing—original draft preparation; RJCL, FAR and ACR writing—review and editing; ACR Supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

References

Banks, N., 1924. Descriptions of new neuropteroid insects. Bull. Mus. Comp. Zool. 65, 419-455.

Banks, N., 1944. Neuroptera of northern South America. Part III. Chrysopidae. Bol. Entom. Venezol. 3, 1–34.

Banks, N., 1945. A Review of the Chrysopidae (Nothochrysidae) of Central America. Psyche (Camb., Mass.) 52, 139–174. https://doi.org/10.1155/1945/39092.

Brooks, S.J., Barnard, P.C., 1990. The green lacewings of the world: a generic review (Neuroptera: Chrysopidae). Bull. Nat. Hist. Mus. Entomol. 59, 117–286.

Gerstaecker, C.E.A., 1887. Weitere Beiträge zur artenkenntniss der Neuroptera Megaloptera. Mitt[h]eilungen aus dem Naturwissenschaftlichen Verein für Neu-Vorpommern und Rugen 19, 89–130.

Henry, C.S., Penny, N.D., Adams, P.A., 1992. The neuropteroid orders of Central America (Neuroptera and Megaloptera), in: Quintero, D., Aiello, A. (Eds.), Insects of Panama and Mesoamerica. Oxford University Press, Oxford, pp. 432–458.

Kimmins, D.E., 1952. A revision of the genera of the Apochrysinae (Fam. Chrysopidae). Ann. Mag. Nat. Hist. 5, 929-944. https://doi.org/10.1080/00222935208654370.

Morrone, J.J., 2014. Biogeographical regionalisation of the Neotropical region. Zootaxa 3782, 1-110. https://doi.org/10.11646/zootaxa.3782.1.1.

Navás, L., 1913. Les Chrysopides (Ins. Névr.) du Musée de Londres (1ª). Ann. Soc. Sci. Brux. 37, 292-330.

Navás, L., 1930. Insectos del Museo de París. 6.a série. Brotéria (Zoológica) 26, 120-144.

Oswald, J.D., Machado, R.J.P., 2018. Biodiversity of the Neuropterida (Insecta: Neuroptera: Megaloptera, and Raphidioptera). In: Foottit, R.G., Adler, P.H. (Eds.), Insect Biodiversity: Science and Society. Vol. 2, 1st ed. John Wiley & Sons, New York, pp. 627–671.

Oswald, J.D., 2022. Neuropterida Species of the World. Lacewing Digital Library. Available in: https://lacewing.tamu.edu/SpeciesCatalog/Main (accessed 26 June 2022).

Penny, N.D., 1977. Lista de Megaloptera, Neuroptera e Raphidioptera do México, América Central, ilhas Caraíbas e América do Sul. Acta Amazon. 7, 1–61.

Penny, N.D., 2002. A Guide to the Lacewings (Neuroptera) of Costa Rica. Proc. Calif. Acad. Sci. 53, 12, 161–457.

Pérez-Gelabert, D.E., Flint, O.S., Jr., 2000. Annotated list of the Neuroptera of Hispaniola, with new faunistic records of some species. J. Neuropterol. 3, 9–23.

Tauber, C.A., Tauber, M.J., Albuquerque, G.S., 2005. Characteristics of the *Loyola* Navás male (Neuroptera: Chrysopidae: Apochrysinae). Proc. Entomol. Soc. Wash. 107, 543–547.

Tauber, C.A., Tauber, M.J., Albuquerque, G.S., 2014. Debris-carrying in larval Chrysopidae: unraveling its evolutionary history. Ann. Entomol. Soc. Am. 107, 295–314. https://doi.org/10.1603/AN13163.

Walker, F., 1860. Characters of undescribed Neuroptera in the collection of W.W. Saunders. Trans. Ent. Soc. Lond. 10, 176–199.

Winterton, S. L., Brooks, S.J., 2002. Phylogeny of the Apochrysine green lacewings (Neuroptera: Chrysopidae: Apochrysinae). Ann. Entomol. Soc. Am. 95, 16-28.

Winterton, S.L., Balakrishnan, S.T., Chenthamarakshan, B., 2021. A new species of *Joguina* Navás, 1912 from India (Neuroptera: chrysopidae). Zootaxa 4970, 577-585. https://doi.org/10.11646/zootaxa.4970.3.9.