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Geographical distribution and phenotypic variation of *Anovia punica* Gordon (Coleoptera: Coccinellidae: Noviini), a predatory ladybeetle of fluted scales (Hemiptera: Coccoidea: Monophlebidae)

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Abstract. The ladybeetle *Anovia* sp. (Coleoptera: Coccinellidae: Noviini), known as an important natural enemy of the Colombian fluted scale, *Crypticeria muticatricipes* Kondo and Gullan (Hemiptera: Coccoidea: Monophlebidae) is here identified as *A. punica* Gordon, 1972, and reported for the first time from Peru. Here we provide information and illustrations of the great variation in color and dorsal patterns of *A. punica* found in Colombia and Peru.

Resumen. El coccinélido *Anovia* sp. (Coleoptera: Coccinellidae: Noviini), importante enemigo natural de la cochinilla acanalada de Colombia, *Crypticeria muticatricipes* Kondo y Gullan (Hemiptera: Coccoidea: Monophlebidae), es identificado como *A. punica* Gordon y reportado por primera vez para Perú. Se ilustran numerosas variaciones en coloración y patrones dorsales de *A. punica* en Colombia y Perú.

Introduction

Recently, Kondo et al. (2014) documented a surprising and fortuitous spontaneous biological control case in which the ladybeetle *Anovia* sp. (Coleoptera: Coccinellidae: Noviini) controlled a serious invasion of the Colombian fluted scale (CFS), *Crypticeria muticatricipes* Kondo and Unruh (Hemiptera: Monophlebidae: Iceryini), which had become a major pest in the Colombian archipelago of San Andres, located in the Caribbean Sea. The adventive ladybeetle *Anovia* sp. was found for the first time on San Andres Island on February 2013 (Kondo et al. 2014). According to Kondo et al. (2014), outbreaks of the CFS were observed from 2010 until February 2013; but in October 2013, only eight months after the ladybeetle was first sighted, *Anovia* sp. had spread to the entire island and populations of the CFS had been decimated to the point that it was very difficult to find any specimens of the fluted scale on the island. The closely related species, *A. circumclusa* (Gorham), along with the phorid fly *Syneura coc-ciphila* (Coquillett, 1895) (Diptera: Phoridae) are probably at least partly responsible for the significant reductions in the prevalence of the invasive pest *C. genistae* in Barbados and Florida (Ciomperlik 2010).

The ladybeetle on San Andres Island was not identified to the species level when it was first reported on the island, since at that time the species did not appear to correspond to any of the described species in the genus *Anovia* Casey, 1908, both by its habitus as well as by the morphology of the male genitalia. Subsequently, through an analysis of many samples of specimens of *Anovia* collected in Colombia and Peru, the species was finally identified as *Anovia punica* Gordon, 1972, a species originally described from Venezuela (type locality) and recorded also from Colombia, Honduras, Panama and Trinidad. Herein we report *A. punica* for the first time from Peru. A diagnosis of the male genitalia of *A. punica* is provided based on material collected in Colombia and Peru, and the various color patterns found on these specimens are reported also.

Materials and Methods

The genitalia of the male specimens were extracted by macerating the abdomens in 10% KOH solution inside a glass tube submerged in hot water for 20-30 minutes, and later washed with distilled water. Components of the genitalia were separated under a stereo-microscope using insect pins and then preserved in glycerin on glass vials in order to photograph the important morphological features. For subsequent storage, the genitalia were put into micro vials filled with glycerin and attached to the insect pin of the specimen from which they were extracted.

Remarks. Here we describe the male genitalia only because the female genitalia are of limited taxonomic use in the genus *Anovia*. In his review of the genus *Anovia*, Gordon (1972) illustrated the spermatheca of only one species and made a brief description of the female genitalia at the generic level.

Depositories

GGPC	Guillermo González Personal Collection, Santiago, Chile.
ICN	Instituto de Ciencias Naturales, Universidad, Nacional de Colombia, Bogotá, Colombia.
MECP	Museo de Entomología, Corporación Colombiana de Investigación Agropecuaria, Centro de Investigación Palmira, Palmira, Valle del Cauca, Colombia.
MEFLG	Museo Entomológico Francisco Luis Gallego, Universidad Nacional de Colombia, Sede Medellín, Medellín, Colombia.
SNSA	Colección Entomológica del Servicio Nacional de Sanidad Agraria SENASA, Lima, Peru.

Results

Taxonomy

Anovia punica Gordon, 1972: 29.

Diagnosis. Male genitalia: Basal lobe narrowed abruptly at one third of its length from the distal end; basal lobe shorter than parameres (Fig. 9–17).

Anovia punica is the only species of the genus known to occur in Colombia and Venezuela, whereas in Peru *A. punica* coexists with *A. peruviana*, a species noticeably larger (4 mm in length) (*A. punica*: 2.5–3.6 mm in length). In Central America (Honduras and Panama), where *A. punica* coexists with *A. circumclusa*, the only way of separating *A. punica* from the latter is by a careful examination of the male genitalia. Gordon (1972) provides a good description of *A. punica* and a key to the genus. Forrester et al. (2009) give a good redescription for the closely related species, *A. circumclusa*, which is associated with the fluted scale *Icerya genistae* Hempel (Forrester and Vandenberg 2008).

Morphological Variation

Total length of *A. punica*: 2.5 to 3.6 mm. *Anovia punica* is an extremely polymorphic species, not just when compared to other species within the genus, but even when compared to species in other genera within the family Coccinellidae. Examination of the majority of the world's holdings of *Anovia* showed that coloration is not a reliable feature for diagnosing any species in the tribe *Noviini*, including members of *Anovia* (Forrester et al. 2009). Both Gordon (1972) and Forrester et al. (2009) compared the color and elytral pattern variation of *A. punica* with *A. circumclusa* (Gorham). Gordon (1972) reported three color forms of *A. punica*: 1) reddish purple with edges of elytra and pronotum red; 2) completely red; and 3) red with black lateral band, but none of these correspond exactly with the color and elytral patterns of the specimens herein examined.

Based on the material examined, the predominant color of *A. punica* can be light brown, dark brown, purple, black opaque or black with tinges of shiny green or blue. The color patterns may correspond to reddish or brown areas on black background or black areas on brown or reddish background. These

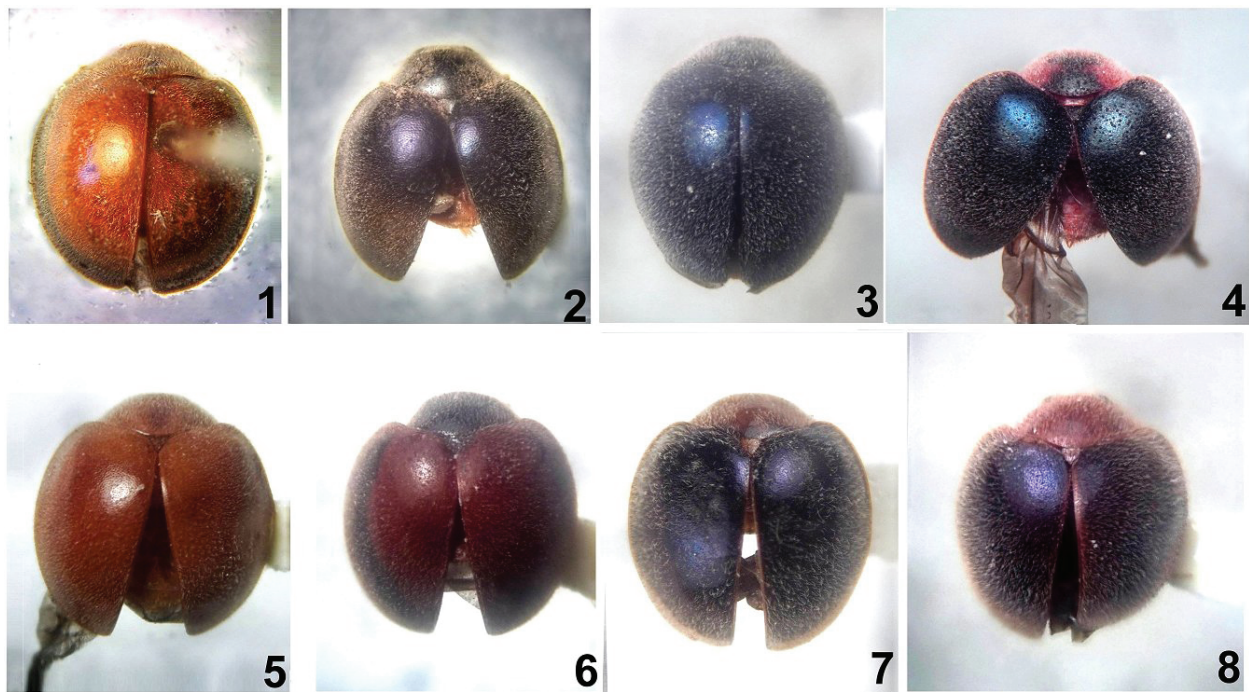
patterns are usually seen on the front edge and the lateral 1/3rd of the pronotum, scutellum, and the lateral edges of the elytra. Colored patterns may form a band of variable width and length, present submarginally or marginally on the elytra or sometimes found at the basal area of the elytra near the scutellum. Some of these color patterns are shown in Figures 1–5.

The different color forms appear to have a significant genetic component, since different individuals often found in collections of a particular area are quite similar, showing color patterns which are not found in other collecting sites. The specimens found on the island of San Andres, for example, always have a black design with shiny blue suggesting that this population of *A. punica* probably comes from a single introduction. Some forms are known only from female specimens with particular elytral patterns, which have been herein tentatively identified as *A. punica*, and the specimens studied are listed under “Other material studied” (Fig. 6–8).

Male Genitalia

The male genitalia is rather homogeneous in all specimens examined (Fig. 9–17). However, the basal lobe illustrated by Gordon (1972) is considerably shorter than that observed in the specimens herein studied. In the illustration of *A. punica* given by Gordon (1972), the length to width ratio of the basal lobe is 2.5, whereas in the specimens examined, the length to width ratio of the basal lobe varies between 3.0 and 3.3. This is probably because Gordon (1972) may have drawn the genitalia of the specimen he studied in a non-horizontal position, because when the tip of a basal lobe in the material herein studied is tilted under the microscope at 30-40 degree angle, the male genitalia perfectly matches the illustration by Gordon (1972).

As can be observed in the figures, the curvature of the tube of the siphon is quite variable, ranging from almost absent (as illustrated in Gordon, 1972) to highly curved forming an “S” letter-shape (Fig. 17). The curvature of the siphon may be affected by the dissection treatment.



Figures 1–8. Morphological variation of *Anovia punica*. Peru. 1–2) San Martín State. Colombia: 3) San Andres Island. 4) Magdalena State. 5) Valle del Cauca State. 6–7) Antioquia State. 8) Atlantico State.

Biological Notes

Kondo et al. (2014) reported that *A. punica* was an effective predator of *Crypticerya multicatrices* in the archipelago of San Andres (Colombia). The nymphs and adults of *A. punica* (as *Anovia* sp.) prey on eggs of *C. multicatrices* by burrowing inside the adult ovisacs (Kondo et al. 2014).

Gordon (1972) reported *A. punica* feeding on *Icerya purchasi* Maskell and *Crypticerya montserratensis* (Riley and Howard) in Panama and Venezuela. All the known prey of *A. punica* are fluted scales of the genera *Crypticerya* Cockerell and *Icerya* Maskell, members of the tribe Iceryini (Hemiptera: Coccoidea: Monophlebidae). It is likely that *A. punica* effectively controls several species of fluted scales in South America.

Material Examined

COLOMBIA (n = 42 specimens). **Antioquia:** Medellin, 06°14'26.9"N, 75°34'31.3"W, 1472 m asl, 7.x.2013, coll. N. Vasco, ex. Feeding on *Crypticerya multicatrices* found on *Caesalpinia peltophoroides* (2 specimens) (MECP); Same data except: 10.x.2013 (3 specimens) (MECP). **Caldas:** Neira, Trocaderos, 3.xii.2009, coll. J. Monsalve, (2 unsexed specimens) (MECP). **Cordoba:** Monteria, Catedral, 08°45'19"N, 75°53'13"W, 21 m asl, 01.x.2013, coll. C. Brochero, Feeding on *C. multicatrices* found on *Siagrus romanzoffiana* (1 specimen) (MECP). **Magdalena:** Santa Marta, Rodadero, 11°12'09"N, 74°13'35"W, 7 m asl, 17.x.2013, coll. C. Brochero, ex. feeding on *C. multicatrices* found on *Mangifera indica* (1 male and 2 females) (MECP). **Nariño:** Tumaco, 01°48'32.5"N, 78°45'59.8"W, 3 m asl, 31.x.2013, coll. T. Kondo, ex. feeding on *C. multicatrices* found on areca palm, *Dypsis lutescens* (1 specimen) (MECP). **San Andres Island:** Sarie Bay, 03°25'16.8"N, 76°32'14.1"W, 12 m asl, 22.ii.2013, coll. M.F. Maya, ex. reared in laboratory (2 males and 1 female) (MEFLG); road close to Muelle Departamental, 12 m asl, 26.ii.2013, coll. T. Kondo & P. Sarmiento, ex. feeding on *C. multicatrices* found on *Pithecellobium dulce* (1 male and 1 female, plus 11 unsexed specimens) (MECP); Same data except: 27.ii.2013 (1 male) (MECP). **Valle del Cauca:** Cali, 03°27'45.7"N, 76°29'2.31"W, 11.ii.2013, 989 m asl, ex *Pithecellobium dulce* (1 specimen) (MECP); Cartago, 04°44'38.9"N, 75°54'40.7"W, 934 m asl, 15.xi.2013, coll. M. Manrique & A. Arias, ex. feeding on *C. multicatrices* found on palm (1 female) (MECP); Buga, 03°55'04.9"N, 76°17'14.6"W, 1002 m asl, 25.ix.2013, coll. R.M. Quintero & A. Arias, ex. feeding on *C. multicatrices* found on *Pithecellobium dulce* (1 male & 3 unsexed specimens) (MECP); Cali, 03°27'45.7"N, 76°29'2.31"W, 11.ii.2013, coll. E.M. Quintero, ex. feeding on *C. multicatrices* found on *Pithecellobium dulce* (5 unsexed specimens) (MECP); Palmira, 03°30'46.8"N, 76°17'46.2"W, 1009 m asl, 19.xi.2012, coll. S. Barrera Lemus, ex. *Citrus* sp. (1 unsexed specimen) (MECP); Jamundi, 03°15'35.5"N, 76°32'13.8"W, 972 m asl, 14.xi.2013,



Figures 9–17. Male genitalia of *Anovia punica*. Peru: 9–11) San Martin State. Colombia: 12–14) San Andres Island. 15–17) Magdalena State. 9), 12), 15) Tegmen in ventral view. 10), 13), 16) Tegmen in lateral view. 11), 14), 17) Siphos.

leg. E.M. Quintero & J.M. Rodríguez, ex. feeding on *C. multicastrices* found on *Pithecellobium dulce* (1 unsexed specimen) (MECP).

Peru (n = 5 specimens). SM [San Martin], Bellavista, Bajo Biavo, 23.iii.2009, coll. A. Sixto. Piñón blanco (1 male and 4 unsexed specimens) (SNSA).

Other Material Examined (Only Females).

Colombia (n = 8 specimens): Antioquia: Medellín, 06°14'26.9"N, 75°34'31.3"W, 1472 m asl, 7.x.2013, coll. N. Vasco, ex. feeding on *C. multicastrices* found on *Caesalpinia peltophoroides* (1 female) (MECP); same data except, 10.x.2013 (2 females) (MECP); 1.x.2013 (1 female) (MECP), 11.x.2013, (1 female) (MECP). **Atlántico:** Puerto Colombia, Plaza principal, 10°59'21"N, 74°57'25"W, 9 m asl, 4.vii.2013, coll. C. Brochero, ex. feeding on *C. multicastrices* found on *Bismarckia nobilis* (2 females) (MECP); Sabana Grande, Parque Dugand Donado, 10°47'35"N, 74°45'18"W, 10 m asl, 19.x.2013, coll. C. Brochero, ex. feeding on *C. multicastrices* found on palm (1 female) (MECP).

Conclusions

The ladybeetle *A. punica* has proven to be an excellent natural enemy of *C. multicastrices* on San Andres Island (Kondo et al. 2014). According to the collecting data, it is likely that this species is maintaining control of populations of CFS naturally on continental Colombia. Moreover, judging by the insect prey reported by Gordon (1972), it could even be controlling other species of fluted scales besides the CFS in Colombia and elsewhere in Central and South America. Developing mass rearing techniques for *A. punica* could help to provide an efficient biological control tool against invasive fluted scales in different parts of the world.

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