



ECOSYSTEMS

Now there are fifteen! A new species of *Amithao* Thomson, 1878 (Coleoptera: Scarabaeidae: Cetoniinae: Gymnetini) from Veracruz, Mexico

HÉCTOR J. GASCA-ÁLVAREZ & CUAUHEMOC DELOYA

Abstract: The new species *Amithao miradorensis* Gasca-Álvarez and Deloya, is described from southern Mexico and compared to related species. Color photographs of habitus and male genitalia of the new species and related species are provided and compared. An updated taxonomic key to species in the genus in both English and Spanish is provided. Diversity and distribution of Mexican *Amithao* species are discussed.

Key words: Flower chafers, morphology, scarab beetles, sympatry, taxonomy.

INTRODUCTION

Thomson (1878) established the American genus *Amithao* to accommodate the transfer of a single Venezuelan species, *Cotinis lafertei*, which he had described previously (Thomson 1860). The genus currently comprises 14 Neotropical species distributed from central Mexico to northern South America, with two species distributed in the Antilles (Ratcliffe 2013). Costa Rica and Mexico have the largest number of species.

Amithao is distinguished from other genera of Gymnetini by bearing a distinctly bilobed and emarginate clypeal apex, frons that lacks armature or projections, and dorso-ventrally flattened, attenuate or bluntly rounded meso-metasternal process that is parallel to the ventral axis of the body in lateral view (Ratcliffe 2013). Adults are typically diurnal and usually collected with fruit traps baited with decaying banana. The larvae apparently feed on decomposing organic matter. The immature stages of most species are still unknown. Morón & Arce (2002) described the larva of *Amithao haematopus* (Schaum).

The genus was comprehensively revised by Ratcliffe (2013). The most recently described species, *Amithao cotopaxicus* Ratcliffe was collected in Ecuador (Ratcliffe 2017). We describe herein a new species of *Amithao* from Veracruz state in Mexico. Diversity and distribution of Mexican *Amithao* species is also discussed. The description of the new species is based on a unique male, which is not recommended in some taxonomic groups. However, in the present work, there is certainty the specimen corresponds to an undescribed species, being quite different morphologically to similar species, using the shape of its unique parameres. The shape of the parameres has been a diagnostic feature of taxonomic and systematic value for species identification of most of the major groups in Scarabaeoidea and for understanding interspecific relationships (D'Hotman & Scholtz 1990a, b, Martín-Piera 1992). Some currently valid Neotropical species of Cetoniinae, such as *Hoplopygothrix boliviensis* Ratcliffe (Ratcliffe 2011), *Giesbertiolus curoei* Ramírez-Ponce (Ramírez-Ponce 2014) and *Hologymnetis reyesi* Gasca-Álvarez and Deloya (Gasca-Álvarez &

Deloya 2015), were also described from one specimen, as well as species of some Neotropical Rutelinae (e.g. Smith 2003) and Dynastinae (López-García & Deloya 2019) genera.

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MATERIALS AND METHODS

Photographs were taken with a Nikon SMZ25 stereomicroscope and its mounted Nikon DS-U3 camera, and processed with the program NIS elements AR version 4.5. Measurements (in mm) were made under a Zeiss Stemi SV6 stereomicroscope with an ocular micrometer and a ruler.

For description, label data is quoted verbatim. A single slash (/) indicates a break between lines on the same label, and a double slash (//) indicates a different label. The phylogenetic species definition of Wheeler & Platnick (2000) is used which considers the species as the smallest aggregation of populations diagnosable by a unique combination of character states. The distribution maps were created using ArcGIS 9.3 (ESRI Inc. 1999–2014).

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RESULTS

Amithao miradorensis Gasca-Álvarez and Deloya, new species

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(Figs. 1–5)

Type Material. Holotype male, labelled “MÉXICO, Veracruz, Totutla, / Finca El Mirador, cafetal / bajo monte, 1100 msnm, / 23-VI-2017 / A. E. DOMINGUEZ ADAME” and with our red holotype label. Type deposited at Colección Nacional de Insectos, Instituto de Biología, UNAM (CNC, IBUNAM), CdMx, México.

Holotype. Male (Fig. 1a-c). Length 22.8 mm; width across humeri 11.4 mm. Color of pronotum, elytra and venter glossy reddish brown; pygidium opaque reddish brown; head and legs glossy black. Elytra with small, pale yellow, cretaceous marks behind middle. **Head:** Lateral margins elevated. Frons and base of clypeus longitudinally tumescent at middle, depressed either side of tumescence. Surface with short, yellow setae; moderately dense to densely punctate; punctures moderate in size. Clypeus with apex broadly bilobed, reflexed. Eyes large, interocular width equals 3.2 x transverse eye diameters. Antenna with 10 antennomeres, club distinctly longer than antennomeres 2–7. **Pronotum:** Surface with small, sparse punctures, punctures usually becoming larger and denser on lateral thirds. Sides with thick marginal bead. **Elytra:** Surface moderate to densely punctate, with 2 distinct, elevated, parallel costae terminating at prominent apical umbone. Punctures moderate to large, becoming larger and denser laterally, in distinct rows on disc. Apices behind apical umbone similar or with slightly larger punctures. Apices at suture acutely produced. **Pygidium:** Surface densely, concentrically strigulose, glabrous. In lateral view, weakly convex. **Venter:** Setae black. Mesometasternal process weakly protuberant in lateral view (Fig. 1c), apex broadly rounded in ventral view (Fig. 1b). Abdominal ventrites nearly smooth in central third; lateral surface of metasternum with moderate to large, dense punctures. **Legs:** Protibia slender strongly tridentate, teeth subequally spaced. **Parameres:** In caudal view, form subrectangular, apices

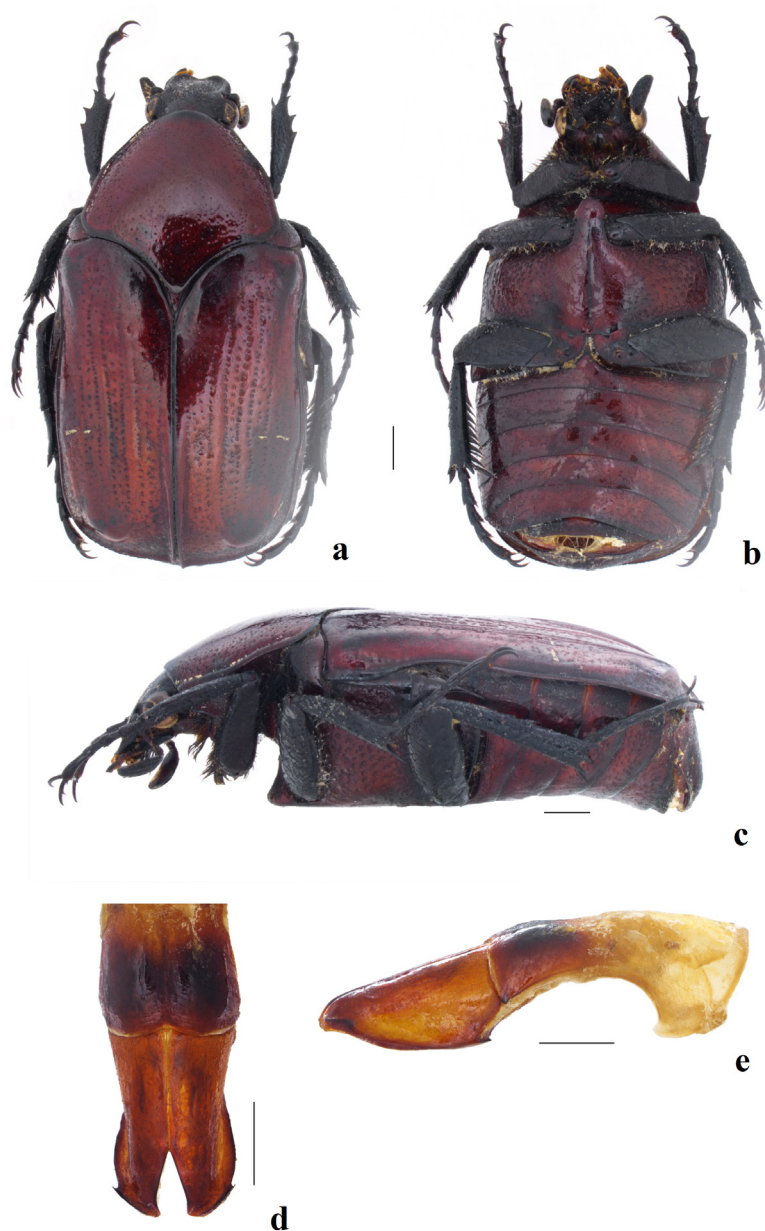


Figure 1. *Amithao miradorensis* new species. Habitus a) Dorsal view, b) Ventral view, c) Lateral view (scale bar = 1 mm); Parameres d) Caudal view, e) lateral view (scale bar = 1.2 mm).

rounded and with acuminate spur laterally (Fig. 1d). In lateral view, phallobase slightly longer than parameres (Fig. 1e).

Etymology. The specific epithet derives from “El Mirador”, the name of the coffee farm in Veracruz, where the new species was collected. In their gazetteer to accompany the “Insecta” volumes of the “Biologia Centrali Americana”, Selander & Vaurie (1962) mentioned “... Mirador o El Mirador” probably always refers to the

hacienda of Mirador in western central Veracruz. Hooper (1952, p. 236) places in 43 km. south of Jalapa and about 16 km. north-northeast of Huatusco; 19°17', 96°54'. Goldman's account (1951, pp. 275–276) of his visit to the hacienda in 1894 includes the following information: “The hacienda had been in the possession of the Sartorius family for many years. It is located on the slope of the mountain at 3,800 feet, with higher and lower levels easily accessible, in a

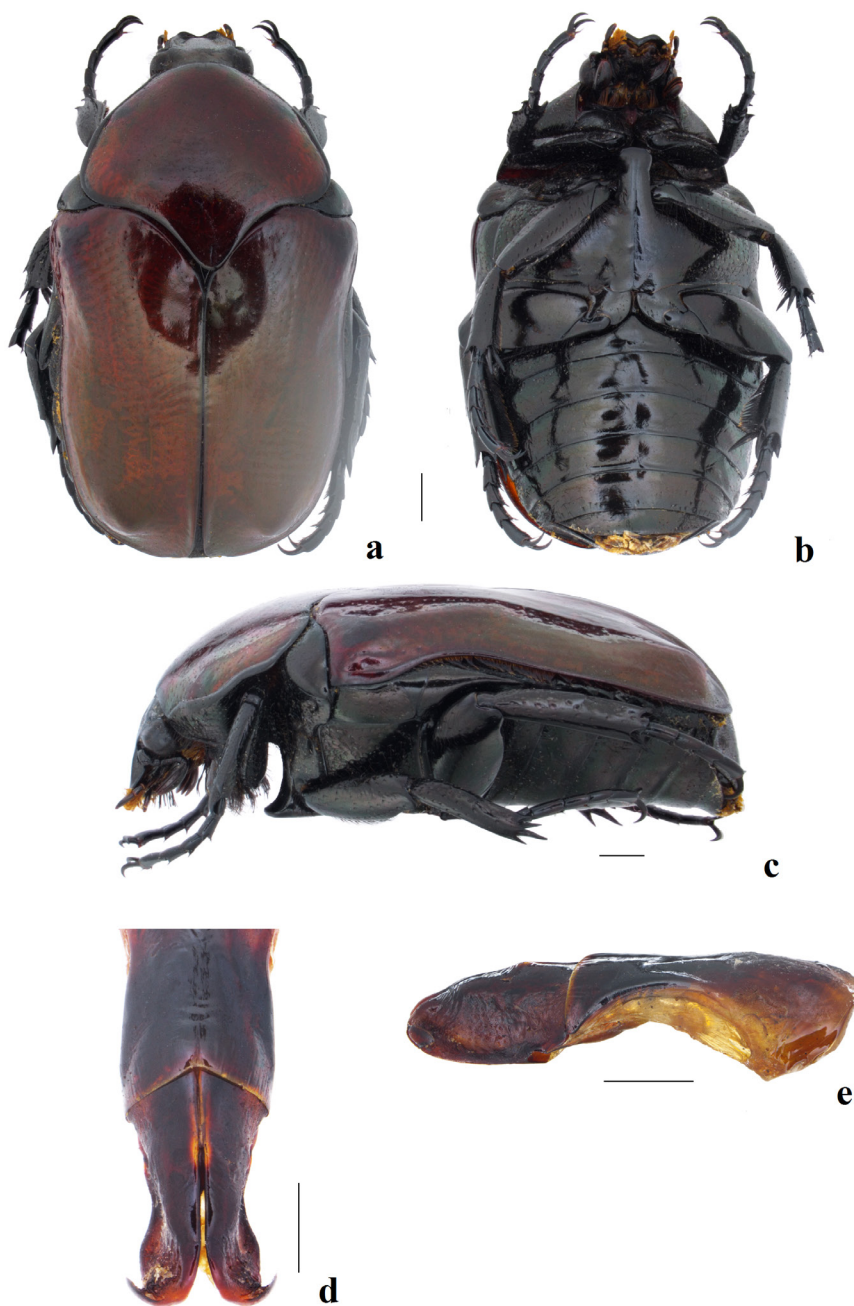


Figure 2. *Amithao pyrrhonotus*. Habitus a) Dorsal view, b) Ventral view, c) Lateral view (scale bar = 1 mm); Parameres d) Caudal view, e) Lateral view (scale bar = 1.2 mm).

region presenting faunal and floral richness in extraordinary variety. Elder members of the Sartorius family were interested in natural history. El Mirador was visited by various early naturalists, including Sumichrast, who made extensive collections there”.

Diagnosis. *Amithao miradorensis* is externally similar to *A. pyrrhonotus* (Burmeister)

(Fig. 2a-c) by its reddish-brown color and form of the clypeus. The new species is distinguished among others (Table I) by its strongly punctate elytra with small, pale yellow marks and the form of the parameres. In caudal view, the parameres of *A. miradorensis* resembles those of *A. decemguttatus* (Waterhouse), but *A. decemguttatus* can be separated by its body



Figure 3. “El Mirador” farm, Totutla, Veracruz (MÉXICO). Shade-grown coffee, habitat of *Amithao miradorensis* sp. nov.

color pattern and the presence of numerous cretaceous spots on the elytra, pygidium, and ventrites (see Ratcliffe 2013).

Distribution. *Amithao miradorensis* is known from Veracruz, México (Fig. 5).

Natural History. *Amithao miradorensis* was collected on the “El Mirador” farm, located at an elevation between 1000 and 1100 m. This location is characterized by a disturbed evergreen tropical forest with interspersed coffee trees (Fig. 3) and small fragments of preserved forest (a management approach used for growing “rustic” or “low-mountain” coffee, Fig. 4). It has a temperate, semi-warm climate with an average annual temperature of 18.1°C and rainfall of 1862 mm (INEGI 1988). A diverse assemblage of plants have been recorded at El Mirador, including 46 species representing 26 families (Actidiaceae, Anacardaceae, Araliaceae,

Bignonaceae, Cannabaceae, Clusiaceae, Euphorbiaceae, Fabaceae, Hipericaceae, Loganiaceae, Malphigiaceae, Melastomataceae, Meliaceae, Monimiaceae, Moraceae, Myrtaceae, Piperaceae, Primulaceae, Rubiaceae, Rutaceae, Salicaceae, Sapindaceae, Solanaceae, Tiliaceae, Urticaceae and Verbenaceae) (Gonzalo-Castillo, com pers.), which could provide fruit and sweet secretions on which species of adult Gymnetini feed.

The new species was attracted using fruit traps baited with decaying banana and pineapple, during a six-month sampling (June–November) in 2017. It was collected along with eight other species of Gymnetini: *Amithao pyrhoneotus* (Burmeister, 1842), *A. cavifrons* (Burmeister, 1842), *Cotinis mutabilis* (Gory & Percheron, 1833), *C. subviolacea* (Gory & Percheron, 1833), *Gymnetis difficilis* Burmeister, 1842, *G. sallei* Schaum 1848, *Hoplopyga liturata* (Oliver, 1789) and *Hologymnetis cinerea* (Gory & Percheron, 1833). By comparison, in the same area, but in another fragment with preserved evergreen tropical forest, only three species were collected during the same period (*G. difficilis*, *G. sallei*, and *H. liturata*).

Key to the species of adult *Amithao* (modified from Ratcliffe 2017)

1. Dorsal surface lustrous, smooth or punctate, bright reddish brown or dark metallic green, punctate or velutinous, with or without cretaceous marks, shiny (but not highly lustrous) or opaque2
 - Dorsal and ventral surfaces black, brown, or green, punctate or velutinous, glossy or opaque 5
2. Dorsal surface bright reddish brown3
 - Dorsal surface metallic dark green or copper..... 4
3. Ventral surface entirely black, highly lustrous. Elytra with small and sparse punctures, surface

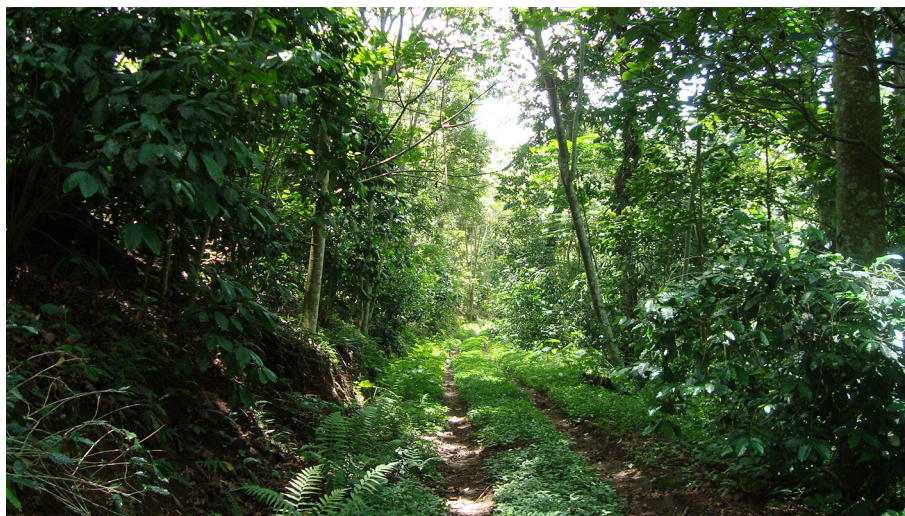


Figure 4. “El Mirador” farm, Totutla, Veracruz (MÉXICO). Tropical forest disturbed fragment with shade-grown coffee, habitat of *Amithao miradorensis* sp. nov.

with nearly obsolete costae. Mexico
 *Amithao pyrthonotus* (**Burmeister**)
 -♂. Ventral surface reddish brown, weakly
 lustrous to opaque. Elytra with moderate to large
 dense punctures, surface with distinct costae.
 Mexico.....
Amithao miradorensis **Gasca-Álvarez and**
Deloya, new species
 4. Color dorsally black with a weak green
 or copper sheen. Pygidium and abdominal
 ventrites usually with cretaceous marks. Femora
 and coxae dark reddish brown. Pronotum on
 central third with moderately dense, moderately
 large punctures. Costa Rica and Panama
 *Amithao metallicus* (**Janson**),
 in part
 -♂. Color dorsally distinctively metallic dark
 green with strong copper reflections. Pygidium
 and abdominal ventrites never with cretaceous
 marks. Femora and coxae metallic copper or dark
 green. Pronotum on central third with sparse,
 small punctures. Guatemala
 *Amithao staudingeri* **Schürhoff**
 5. Body with cretaceous spots, speckles, or bands
6
 -♂. Body without cretaceous marks 13
 6. Length less than 17 mm 7
 -♂. Length greater than 18 mm9

7. Male genitalia with basal pieces subequal in length
 to parameres. Mexico.....
 *Amithao marginicollis* (**Burmeister**)
 -♂. Male genitalia with basal piece about 3
 times longer than parameres. West Indies8
 8. Pronotum and elytra velutinous. Elytra black
 with 3 cretaceous spots or short bands on
 each lateral margin. Parameres with apices
 approximate. Hispaniola.....
 *Amithao incertus* (**Gory and Percheron**)
 -♂. Pronotum and elytra opaque or weakly
 glossy. Elytra black or reddish brown, if reddish
 brown then with numerous, small, cretaceous
 speckles. Parameres with apices diverging.
 Jamaica *Amithao tristis* (**Fabricius**)
 9. Pronotum (usually) and elytra (always)
 velutinous, dark reddish brown to black10
 -♂. Pronotum and elytra glossy. Elytra with
 cretaceous spots, speckles, or bands11
 10. Pronotum and elytra with numerous, small,
 cretaceous speckles. Panama and Colombia
 *Amithao lafertei* (**Thomson**)
 -♂. Pronotum lacking cretaceous
 speckles; elytra with pale yellow band along
 lateral.....margins.
 Ecuador..... *Amithao cotopaxicus* **Ratcliffe**
 11. Mesometasternal projection in lateral view
 elongate, distinctly attenuate. Honduras (?),

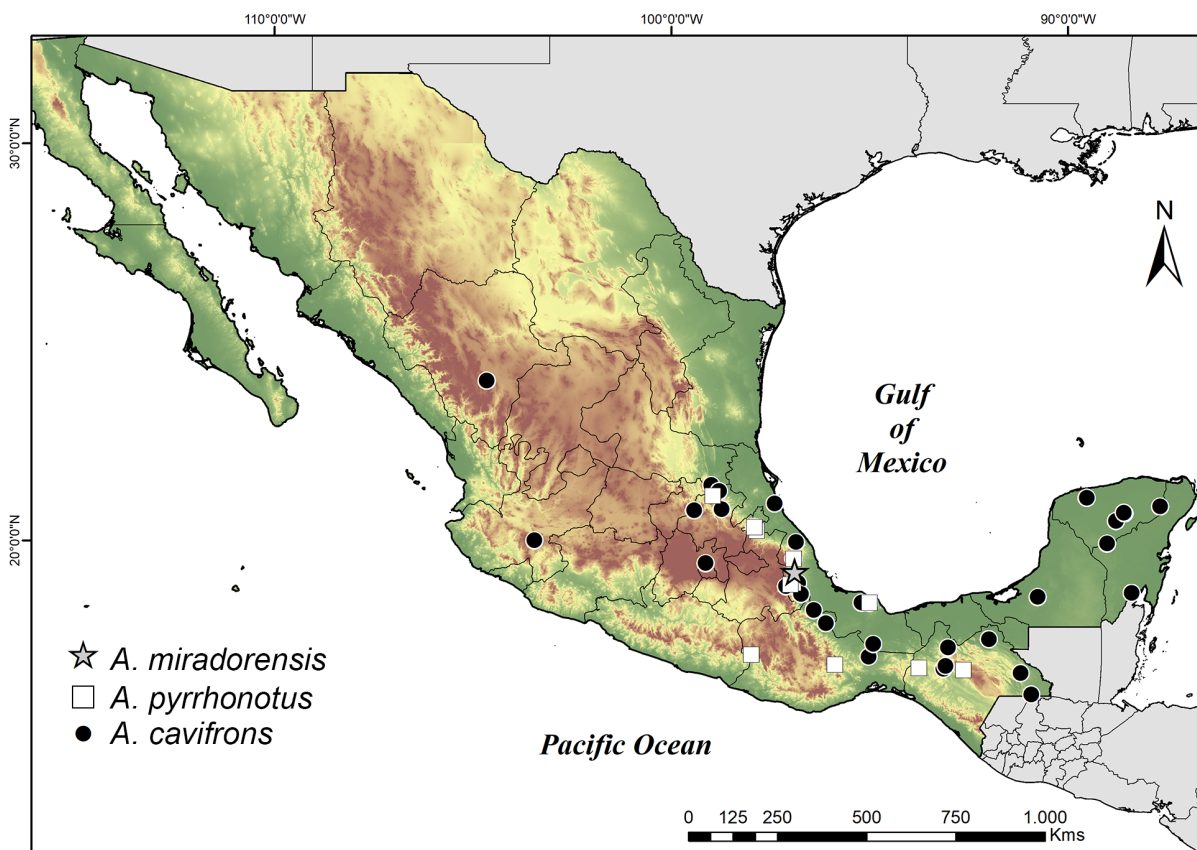


Figure 5. Distribution map for *Amithao miradorensis*, *A. pyrhnotus* and *A. cavifrons* in Mexico

Costa Rica, Panama, Colombia, and Ecuador *Amithao decemguttatus* (**Waterhouse**)
 -¹. Mesometasternal projection in lateral view bluntly rounded or only weakly attenuate.....12
 12. Femora and tibiae always black. Pronotum distinctly punctate, punctures moderate in density and size. Parameres with apices bluntly rounded, curving towards one another. Nicaragua, Costa Rica, and Panama
Amithao albopictus **Neervoort van de Poll**
 -¹. Femora and tibiae reddish brown or black. Pronotum with minute to small, sparse punctures, often appearing smooth. Parameres diverging from about mid-shaft, with a small tooth externoapically. Mexico to northern Costa Rica
*Amithao erythropus* (**Burmeister**), in part

13. Elytra densely, finely rugulopunctate. Color usually with olive green metallic sheen over black or coppery ground color. Each elytron with 2 distinctly elevated, parallel costae terminating at prominent apical umbone. Mexico to Costa Rica (rarely into Colombia)
 *Amithao cavifrons* (**Burmeister**)
 -¹. Elytra punctate. Color black or dark reddish brown, glossy, without metallic green sheen. Each elytron lacking distinctly elevated costae 14
 14. Mesometasternal process in lateral view bluntly rounded, short. Pronotum with minute to small, sparse punctures, often appearing smooth. Length less than 22 mm. Mexico to northern Costa Rica
 *Amithao erythropus* (**Burmeister**), in part

Table I. Differential characters between *Amithao miradorensis* and *A. pyrrhonotus*.

	<i>Amithao miradorensis</i>	<i>Amithao pyrrhonotus</i>
Venter	Reddish Brown	Black
Surface of elytra	Strongly punctate, punctures large and dense	Weakly punctate, punctures small and sparse
Cretaceous mark on elytra	Present	Absent
Elytral costae	Distinct	Nearly obsolete
Protibia in males	Tridentate	Bidentate
Parameres	Straight at middle	Lobed at middle

-¹. Mesometasternal process in lateral view narrowly attenuate, elongate. Pronotum distinctly punctate. Length greater than 25 mm 15
 15. Femora, tibiae, and coxae entirely black. Panama.....*Amithao anthracinus* **Ratcliffe**

-¹. Femora and/or tibiae and/or coxae reddish brown 16
 16. Femora and tibiae reddish brown, coxae black. Mexico to Panama
 *Amithao haematopus* (**Schaum**)

-¹. Femora and usually coxae reddish brown, tibiae black. Costa Rica and Panama
 *Amithao metallicus* (**Janson**), in part

Clave para las especies de adultos de *Amithao* (modificada de Ratcliffe 2017).

- 1. Superficie dorsal lustrosa, lisa o punteada, marrón rojizo brillante o verde metálico oscuro, punteada o velutinoso, con o sin marcas cretáceas, brillante (pero no muy lustroso) u opaco.....2
 - Superficie dorsal y ventral negra, marrón o verde, punteada o aterciopelada, opaca o brillante. 5
- 2. Superficie dorsal marrón rojizo brillante3
 - ¹. Superficie dorsal verde metálico oscuro o cobrizo. 4
- 3. Superficie ventral completamente negra, muy lustrosa. Élitros con puntos pequeños y escasos,

superficie con costillas casi obsoletas. México
 *Amithao pyrrhonotus* (**Burmeister**)

-¹. Superficie ventral marrón rojizo, débilmente lustrosa a opaca. Élitros con puntos moderados a grandes y densos, superficie con costillas evidentes. México
 *Amithao miradorensis* **Gasca-Álvarez y Deloya, nueva especie**

4. Color negro dorsalmente con un débil brillo verde o cobrizo. Pigidio y ventritos abdominales generalmente con marcas cretáceas. Fémures y coxas marrón rojizo oscuro. Tercio central del pronoto con puntos densos moderadamente grandes. Costa Rica y Panamá
 *Amithao metallicus* (**Janson**), en parte

-¹. Color dorsal y ventral verde metálico oscuro con fuertes reflejos cobrizos. Pigidio y ventritos abdominales nunca con marcas cretáceas. Fémures y coxas cobre metálico o verde oscuro. Tercio central del pronoto con puntos pequeños puntos escasos. Guatemala
 *Amithao staudingeri* **Schürhoff**

- 5. Cuerpo con marcas cretáceas o bandas 6
 - ¹. Cuerpo y/o élitros sin marcas cretáceas o bandas13
- 6. Longitud inferior a 17 mm 7
 - ¹. Longitud superior a 18 mm 9

7. Genitalia del macho con la pieza basal subigual en longitud a los parámetros. México
 *Amithao marginicollis* (**Burmeister**)
 -♂. Genitalia del macho con la pieza basal aproximadamente 3 veces más larga que los parámetros. Antillas8
 8. Pronoto y élitros aterciopelados. Élitros negros con tres marcas cretáceas o bandas cortas en cada margen lateral. Parámetros con ápices convergentes. La Española
 *Amithao incertus* (**Gory y Percheron**)
 -♂. Pronoto y élitros opacos o débilmente brillantes. Élitros negros o marrón rojizo, si es marrón rojizo entonces con numerosas marcas cretáceas pequeñas. Parámetros con ápices divergentes. Jamaica
 *Amithao tristis* (**Fabricius**)

9. Pronoto (generalmente) y élitros (siempre) aterciopelados, marrón rojizo oscuro o blanco ...
 10
 -♂. Pronoto y élitros brillantes. Élitros con bandas o marcas cretáceas 11
 10. Pronoto y élitros con numerosas marcas cretáceas pequeñas. Panamá y Colombia
 *Amithao lafertei* (**Thomson**)
 -♂. Pronoto sin marcas cretáceas; élitros con una banda amarilla pálida a lo largo de los márgenes laterales. Ecuador
 *Amithao cotopaxicus* **Ratcliffe**
 11. Proyección meso-metaesternal elongada en vista lateral, distintamente atenuada. Honduras (?), Costa Rica, Panamá, Colombia y Ecuador
 *Amithao decemguttatus* (**Waterhouse**)

Table II. State distribution of the Mexican species of *Amithao* Thomson (Ratcliffe 2013, present work). Abbreviations: (QR: Quintana Roo, SLP: San Luis Potosí).

STATE	<i>A. cavifrons</i>	<i>A. erythropus</i>	<i>A. haematopus</i>	<i>A. marginicollis</i>	<i>A. pyrrhonotus</i>	<i>A. miradorensis</i>	TOTAL
Campeche	X	X					2
Chiapas	X	X	X	X	X		5
Colima				X			1
Durango	X						1
Guerrero				X			1
Hidalgo	X				X		2
Jalisco	X			X			2
Mexico State	X		X	X			3
Michoacán				X			1
Oaxaca	X	X	X	X	X		5
Puebla	X				X		2
QR	X						1
SLP	X	X					2
Tabasco		X					1
Veracruz	X	X		X	X	X	5
Yucatán	X	X	X				3

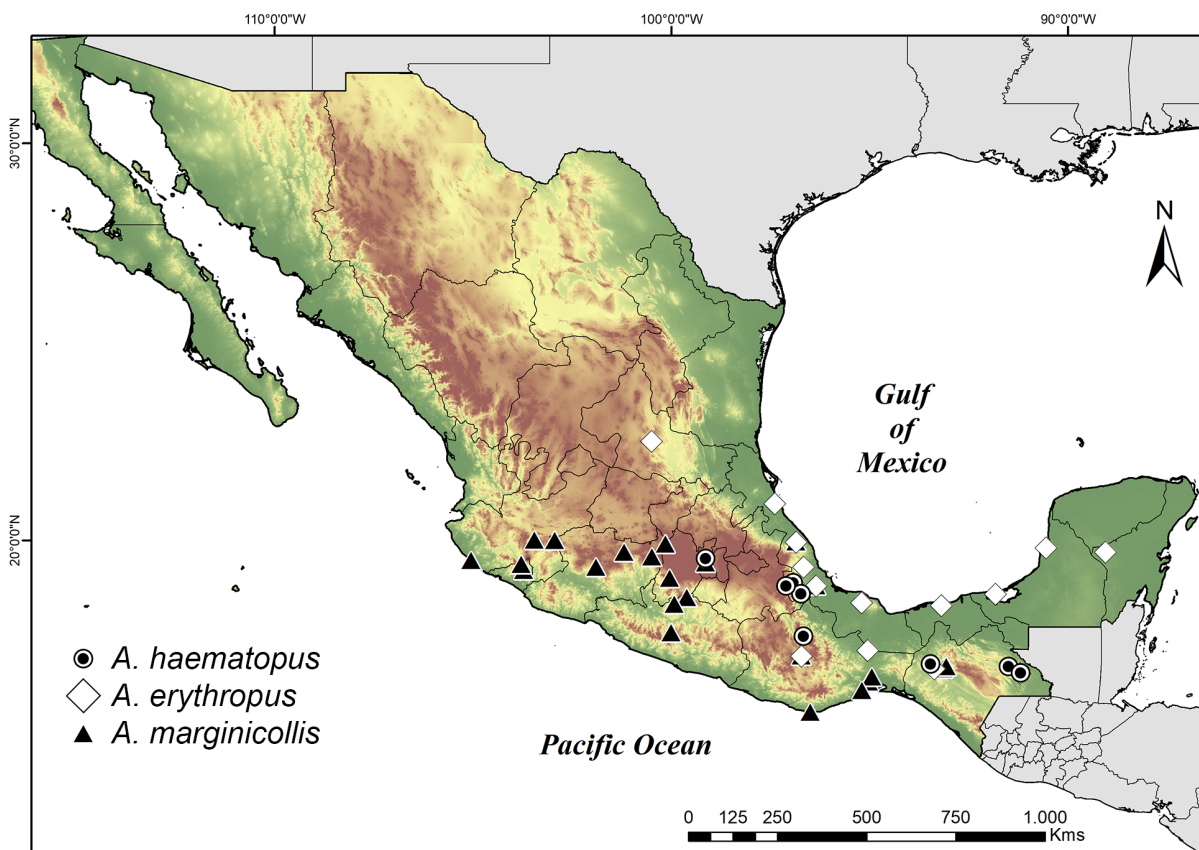


Figure 6. Distribution map for *Amithao haematopus*, *A. erythropus* and *A. marginicollis* in Mexico.

- 1. Proyección meso-metaesternal claramente redondeada en vista lateral o débilmente atenuada12

12. Tibias y fémures siempre negros. Pronoto distintamente punteado, puntos moderados en densidad y tamaño. Parámetros con ápices claramente redondeados, curvados el uno hacia el otro. Nicaragua, Costa Rica y Panamá

Amithao albopictus **Neervoort van de Poll**

- 1. Tibias y fémures marrón rojizo o negros. Pronoto con diminutos a pequeños puntos esparcidos, a menudo con apariencia suave. Parámetros divergiendo aproximadamente desde el medio, con un pequeño diente externo apical. México hasta norte de Costa Rica

..... *Amithao erythropus* (**Burmeister**), en parte

13. Élitros densa y finamente rugoso-punteados. Color usualmente con un brillo metálico verde oliva sobre color negro o cobrizo. Cada élitro con dos costillas paralelas evidentes y elevadas finalizando en el prominente húmero apical. México hasta Costa Rica (rara en Colombia)

Amithao cavifrons (**Burmeister**)

- 1. Élitros punteados. Color negro o marrón rojizo, brillante, sin brillos metálicos verdes. Cada élitro sin costillas elevadas evidentes 14

14. Proyección meso-metaesternal claramente redondeado en vista lateral, corto. Pronoto con diminutos a pequeños puntos escasos, a menudo de apariencia suave. Longitud inferior a 22 mm. México hasta norte de Costa

Rica *Amithao erythropus* (**Burmeister**),
en parte

-¹. Proyección meso-metaesternal estrecho
en vista lateral, elongado. Pronoto distintamente
punteado. Longitud superior a 25 mm 15

15. Fémures, tibias y coxas completamente
negros. Panamá.....

Amithao anthracinus **Ratcliffe**

-¹. Fémures y/o tibias y/o coxas marrón-
rojizo16

16. Fémures y tibias marrón rojizo, coxas
negras. México hasta Panamá

..... *Amithao haematopus* (**Schaum**)

-¹. Fémures y usualmente las coxas marrón-
rojizo, tibias negras. Costa Rica y Panamá.

..... *Amithao metallicus* (**Janson**), en parte

DISCUSSION

Deloya (2006) recorded five species of Gymnetini during a year of sampling between April 2002 and March 2003 at El Mirador (*C. mutabilis*, *G. difficilis*, *G. sallei*, *H. liturata*, *H. cinerea*), while in 2017 nine species were collected, including *A. miradorensis* sp. nov. The increased number (almost double) of Gymnetini species sampled 15 years later in a transition zone of evergreen tropical forest and mountain mesophilic forest could be interpreted as result of interaction between the structure of the original vegetation and the management practices of the farm “El Mirador”, where traditionally coffee (*Coffea arabica* L., SP. PL) and fruit trees have been grown. These resources attract species that feed on the sugary runoff of nectar and fruit produced by trees and shrubs (Deloya & Moron 1997, Deloya et al. 2018). In addition to conserving fragments of the original vegetation, El Mirador could be serving as a “refuge” by attracting visiting and/or “tourist” species that could increase the richness of Gymnetini.

Of the 15 species that now are in *Amithao*, six (40%) occur in Mexico (Table II). The ratio of Mexican species to total species for this genus corresponds closely to the ratio seen for the diversity of Cetoniinae in the Americas. Of the 53 genera and 382 currently recognized species of Cetoniinae, 32 genera (60%) and 147 species (38.5%) occur in Mexico (Deloya et al. 2018, Ratcliffe 2019). *Amithao marginicollis*, *A. pyrrhonotus* and *A. miradorensis* sp. nov., are exclusive to Mexico; while the other three species known from Mexico have ranges that extend further south. *Amithao erythropus* reaches Costa Rica, *A. haematopus* is found in Panama and *A. cavifrons* occurs in Colombia and Ecuador (Ratcliffe 2013).

In Mexico, *Amithao* species are associated with a variety of vegetation types. *Amithao miradorensis* sp. nov., is the only one found in the transition between the tropical evergreen forest (TEF) and mountain mesophilic forest (MMF) in central Veracruz. *Amithao erythropus* is associated with TEF and the Gulf Coastal Plain (GCP), while *A. cavifrons* is associated with TEF and GCP but also penetrates the temperate forests of the Trans-Mexican Volcanic Belt (TMVB) and the internal slope of the Sierra Madre Occidental. *Amithao haematopus* is found in TEF and TMVB, and *A. pyrrhonotus* is associated with TEF, being found in the temperate forest of Sierra Madre of Chiapas, Oaxaca, TMVB in Mexico City and MMF in Veracruz. *Amithao marginicollis* is the only species that has a vicariant distribution across the Atlantic (BTP) and Pacific (deciduous tropical forest) slopes and penetrates into the TMVB in Mexico City (Figs. 5, 6). *Amithao miradorensis* sp. nov., is sympatric with *A. pyrrhonotus* and *A. cavifrons*.

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HÉCTOR J. GASCA-ÁLVAREZ^{1,3}

<https://orcid.org/0000-0002-0070-0715>

CUAUHTEMOC DELOYA²

<https://orcid.org/0000-0002-4774-140X>

¹Grupo Ecología de Organismos (GEO-UPTC), Programa de Biología, Universidad Pedagógica y Tecnológica de Colombia, Avenida Central del Norte 39-115, Sede Central. 150003 Tunja, Boyacá, Colombia

²Red Interacciones Multitróficas, Instituto de Ecología, A.C. Carretera antigua a Coatepec 351, El Haya, 91070 Xalapa, Veracruz, México

³Programa de Investigación, Corporación Sentido Natural, Calle 134 A # 14-44, 110121 Bogotá, Colombia

Correspondence to: **Héctor Jaime Gasca-Álvarez**

E-mail: scarab7@gmail.com

Author contributions

HJGA and CD planned the manuscript design, performed the descriptions and illustrations of the species, and both contributed equally to the preparation and writing of the manuscript.

