

# A case of evolutionary convergence? Striking resemblance between a cockroach (Blattodea) and a frog (Anura) living in bromeliads on the Paria Peninsula, northeastern Venezuela

¿Un caso de convergencia evolutiva? Notable semejanza entre una cucaracha (Blattodea) y una rana (Anura) habitantes de bromelias en la península de Paria, noreste de Venezuela

Jorge M. González<sup>1</sup>, Luis E. Sibira<sup>2</sup>, Tito R. Barros<sup>2</sup>, Ángel Fernández del Valle<sup>3</sup>,  
Carlo G. Sormani<sup>4</sup> & Gilson A. Rivas<sup>2</sup>

<sup>1</sup>Austin Achieve Public Schools, Austin, Texas, USA. Research Associate, McGuire Center for Lepidoptera and Biodiversity, USA.  
[gonzalez.jorge.m@gmail.com](mailto:gonzalez.jorge.m@gmail.com); <https://orcid.org/0000-0001-7208-7166>

<sup>2</sup>Museo de Biología, Facultad Experimental de Ciencias, Universidad del Zulia, Maracaibo, Venezuela.  
[anolis30@hotmail.com](mailto:anolis30@hotmail.com); <https://orcid.org/0000-0001-8003-5075>

<sup>3</sup>Herbario IVIC. Instituto Venezolano de Investigaciones Científicas, Caracas. Venezuela.  
[angelfern56@yahoo.com](mailto:angelfern56@yahoo.com)

<sup>4</sup>Musée d'Histoire Naturelle de Genève, Geneva, Switzerland.  
[sormanibc@gmail.com](mailto:sormanibc@gmail.com); <https://orcid.org/0000-0001-6661-6244>

Correspondence: [gonzalez.jorge.m@gmail.com](mailto:gonzalez.jorge.m@gmail.com)

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## ABSTRACT

Recent herpetological explorations carried out in the Serranía de Paria, northeastern Venezuela, allowed the identification of the bromeliad *Glomeropitcairnia erectiflora* Mez as a vital refuge for amphibians of the species *Phytotriades auratus* (Boulenger, 1917), and for cockroaches of the genus *Dryadoblatta* Rehn, 1930. It should be noted that the presence of the frog *Scinax ruber* (Laurenti, 1768), a species typically of lowlands, has been previously reported in bromeliads of Cerro El Copey (Margarita Island), but it is likely that the record is a misidentification of *P. auratus*. The present study also reveals an association between *G. erectiflora* and a cockroach of the genus *Pelmatosilpha* Dohrn, 1887. The similar color patterns of *P. auratus* and a species of *Dryadoblatta* suggest possible evolutionary convergence or mimicry between an anuran amphibian and a blattodean insect, indicating complex ecological relationships in the region.

**Keywords:** *Dryadoblatta* sp., evolutionary convergence, *Glomeropitcairnia erectiflora*, mimicry, *Phytotriades auratus*, *Scinax ruber*.

## RESUMEN

Exploraciones herpetológicas recientes realizadas en la Serranía de Paria, noreste de Venezuela, permitieron identificar a la bromelia *Glomeropitcairnia erectiflora* Mez como refugio vital de anfibios de la especie *Phytotriades auratus* (Boulenger, 1917) y de cucarachas del género *Dryadoblatta* Rehn, 1930. Cabe destacar que se ha informado previamente la presencia de la rana *Scinax ruber* (Laurenti, 1768), una especie típicamente de tierras bajas, en bromelias del Cerro El Copey (Isla de Margarita), pero es probable que el registro se trate de una identificación errónea de *P. auratus*. El presente estudio también revela una asociación entre *G. erectiflora* y una cucaracha del género *Pelmatosilpha* Dohrn, 1887. Los patrones de color

similares de *P. auratus* y de una especie de *Dryadoblatta* sugieren una posible convergencia evolutiva o mimetismo entre un anfibio anuro y un insecto blattodeo, indicando relaciones ecológicas complejas en la región.

**Palabras clave:** convergencia evolutiva, *Dryadoblatta* sp., *Glomeropitcairnia erectiflora*, mimetismo, *Phytotriades auratus*, *Scinax ruber*.

## INTRODUCTION

Coloration patterns in animals serve several functions, one of which is protecting them from predators (Badejo *et al.* 2020). Two basic types of protective coloration patterns are known. The first type is camouflage, which consists of faint or discrete colors that imitate those of the environment, substrate, and plants, allowing the animal to blend in and remain unnoticed by potential predators. This category includes contrasting and striking colors that conceal internal features or disrupt the outline of the potential prey (a phenomenon known as disruptive coloration; Adams *et al.* 2019, Hinkelmann 2023), interfering with visual perception of the predator, thus reducing the likelihood of an attack. The other type is aposematism, a conspicuous and colorful coloration serving as a warning that the potential prey is toxic or inedible, thus inhibiting predation (Eisner & Grant 1981, Santos *et al.* 2003, Hinkelmann 2023).

In the case of aposematism, some organisms mimic other aposematic ones, hence taking advantage of the protective coloration. The imitators (mimics) could be either more or less toxic/repulsive than the species that they imitate (Müllerian mimicry), or the mimic could be harmless (Batesian mimicry) (Bates 1862, 2020, Müller 1878, Wickler 1968).

Mimicry, in general, is one of the most striking phenomena in evolutionary ecology, occurring in a wide range of organisms, including unrelated ones (Wickler 1968, Matthews & Matthews 2010, Schmied *et al.* 2012). Mimicry systems are ecologically defined as assemblages in which at least two organisms should be able to play up to three possible roles: being a model, being a mimic, or being a deceiver (Wickler 1968, Schmied *et al.* 2012). Such systems necessarily contain at least one defended prey that exhibits a warning signal, which helps reduce predation pressure, and at least one associated species that derives a benefit from mimicking the aposematic organism (Kunte *et al.* 2021).

Over the past few decades, there has been a wealth of research showing “mimicry rings” (assemblages of species sharing a similar appearance which serves as an effective signal to potential predators), Müllerian and Batesian, involving various groups of insects (*i.e.*, butterflies and

moths, beetles, wasps and bees, and flies) and vertebrates (*i.e.*, fish, snakes, birds) (Wickler 1968, Pasteur 1982, Schmied *et al.* 2012, Kunte *et al.* 2021). Aposematism, through bright or flashy color patterns, is a known warning sign in frogs, which exhibit it to “advertise” their toxicity or lack of palatability to potential predators (Stuckert *et al.* 2014a, Lorigou-Chevalier *et al.* 2023). It is worth mentioning that although several types of insects mimicking vertebrates have been documented, we know of only one recent record of an insect (*Cratosomus* sp.; Curculionidae) mimicking a frog [*Ameerega trivittata* (Spix, 1824): Dendrobatidae] (Ferreira *et al.* 2024).

Convergence is another ecological phenomenon (not mutually exclusive with mimicry or camouflage) that operates at both the species and community levels. It may also be observed in what we perceive as mimicry or camouflage among several organisms. Convergence in ecology is the independent evolution of similar traits in unrelated organisms due to similar environmental pressures or ecological roles (Matthews & Matthews 2010). This process happens because natural selection favors adaptations that are best suited for survival and reproduction in a particular environment, leading distantly related species to develop analogous structures, behaviors, or even behavioral and physiological processes (Bittleston *et al.* 2016, Sackton & Clark 2019).

Several frog groups are well known for including species resembling other frogs, either to share a warning signal with a toxic species (Müllerian mimicry), or to deter predators (Batesian mimicry), forming mimicry rings where several species benefit from an aposematic coloration (Darst & Cummings 2006, Prates *et al.* 2012, Stuckert *et al.* 2014b, Ferreira Souza *et al.* 2024).

Among cockroaches, however, their scavenging and cryptic habits, as well as the high speed of some, allow them to frequently escape predators (Evans 1968, Bastidas Pérez & Zavala Gómez 1995, González 2005, Marshall 2017). Although many cockroach species are cryptic and dark-colored, allowing them to “disappear” visually in their environment, it appears to be rare for certain cockroach species to become members of mimetic rings by exhibiting characteristics that allow them to resemble unpleasant or poisonous models providing them protection from potential predators (Shelford 1912, Roth & Naskrecki 2001,

Deans & Roth 2003, Schmied *et al.* 2012). At the same time, some cockroaches are known to produce defensive secretions and produce pungent-smelling compounds that potentially make them become models in mimicry rings (Roth & Willis 1960, Evans 1968, Farine *et al.* 1997, O'Connell & Reagle 2002).

To our knowledge, the case presented here may be the first reported case of a frog and a cockroach involved in a possible mimicry ring, in what appears to be an interesting case of evolutionary convergence.

## MATERIALS AND METHODS

On July 2016, a week of fieldwork was conducted in the Cordillera de Paria (*sensu* Rivas *et al.* 2021), the easternmost portion of the Cordillera de la Costa in northern Venezuela, specifically at Cerro Humo, the highest summit of the Paria Peninsula (~1,250 m elevation). This fieldwork was carried out as part of a project on the conservation status of endemic frog species inhabiting the region. Invertebrate and small vertebrate specimens were found in the phytotelmata of the bromeliad *Glomeropitcairnia erectiflora* Mez (Bromeliaceae) (Fig. 1).

Several individuals of the tank bromeliad *G. erectiflora* from Cerro Humo were examined for small vertebrates such as lizards and frogs. The plants were epiphytes on branches of an unidentified tree, probably of the genus *Miconia* (Melastomataceae).

Although there are no meteorological data from the summits of Paria, it has been mentioned that in Cerro Humo there are two thermal floors: the subtropical one from 400 to 1,000 m above sea level, and the temperate one restricted to the mountain tops. In these thermal floors, mean annual temperatures could respectively be 24 and 19 °C, while precipitation is around 2,000 mm per year (Motta 2001, Fernández & Michelangeli 2003).

## RESULTS AND DISCUSSION

### *The host plant*

The genus *Glomeropitcairnia* Harms (Bromeliaceae) contains two species native to the Lesser Antilles, Trinidad, and Venezuela (Smith 1971, Smith & Downs 1977, Howard 1979, Hoyos 1985, Ulloa *et al.* 2018). One of these species, *Glomeropitcairnia penduliflora* (Griseb.) Mez, is an endemic epiphyte to the islands of Montserrat, Guadeloupe, Martinique, and Dominica. The other one, *G. erectiflora* Mez, which is also epiphytic and occasionally terrestrial, and is endemic to the montane cloud forests of northeastern Venezuela (including Margarita Island) and northern Trinidad (Smith & Downs 1977, Oliva Esteve &



**Figure 1.** Live individual of the golden tree frog, *Phytotriades auratus* (Hylidae, Anura), from the Paria Peninsula, Venezuela (A), and preserved type of the cockroach *Dryadoblatta scotti* (Blaberidae, Blattodea) (B) from Trinidad showing their similarity in dorsal coloration (“Horseshoe pattern”). Photos: M. De Freitas (left); Amoret Spooner, Hope Entomological Collection, Oxford University Museum of Natural History (right).

Steyermark 1987, Holst 1994, Hokche *et al.* 2008). Steyermark (1974, 1976) highlighted that the cloud forests of the Cordillera de la Costa in Venezuela host a unique and endemic Amazonian-Guyanese flora element, confined to elevations between 800 and 1,500 meters, which is crucial for conserving these ecosystems and their biodiversity. Such environment and flora (and associated fauna) are currently threatened, despite being located within two National Parks (Cerro El Copey, Margarita Island, Nueva Esparta State; and Paria Peninsula, Sucre State).

It is well known that many bromeliad species generate microhabitats for arthropods and amphibians that partially or totally depend on the ecological niche so created to complete their life cycle (Richardson 1999, Kitching 2000, Srivastava & Kortright 2006). Such symbiotic relationship allows plants to obtain nutrients from the activity of the associated fauna while the animals obtain food, shelter, and substrate (Frank & Lounibos 2009, Sabagh *et al.* 2017).

This bromeliad, originally described from Margarita Island, Venezuela, from an altitude of 700 m (Mez 1904), has been found in other areas of northeastern Venezuela, in the state of Sucre. It inhabits cloud forests above 700 m above sea level and up to 1,250 m. The plant can also be found along the Northern Coast Range of the island of Trinidad (Jowers *et al.* 2008). This bromeliad was considered Vulnerable due to habitat destruction caused by anthropogenic interference in the forests where it is found (Llamozas *et al.* 2003), but is currently considered Near Threatened (Huérffano *et al.* 2020). It might be categorized as Vulnerable again due to increased forest destruction.

*Anuran found inside the bromeliad tank*

*Phytotriades auratus* (Boulenger, 1917) is a frog known to occur on three small summits in Trinidad and on a peak in the Paria Peninsula, northeastern Venezuela, where it is considered endangered (IUCN SSC Amphibian Specialist Group 2020). The species thrives at an altitudinal range from 700 to 1,250 m above sea level, and inhabits the tank bromeliad *G. erectifolia* (Rivas & De Freitas 2015, Jowers *et al.* 2024).

This rare and endangered anuran ranges in size from small to medium; males can be up to 29–30 mm long, while females can reach 35 mm in length from snout to cloaca (Gray 2003, Jowers *et al.* 2008). Their base color is chocolate brown with two distinctive iridescent golden yellow dorsal stripes running from head to back (Jowers *et al.* 2008). Curiously, other frogs exhibit a somewhat similar pattern (Lehtinen 2020, Ferreira Souza 2024; G. Becaloni, *pers. comm.*)

*Cockroaches inside a bromeliad*

On July 2016, a specimen of a dark brown (almost black) cockroach with translucent mustard-yellow pronotum and tegmina edges was collected inside the bromeliad tank of a *G. erectiflora* individual plant (Fig. 2). The plant was found on the summit of Cerro Humo, at its highest elevation (1,250 m above sea level).

The specimen was identified as belonging to *Dryadoblatta* Rehn 1930. This genus has two recognized species. One of them, *D. mira* Rehn 1937 was described from the Venezuelan Amazon region, the Cerro Duida at an elevation of 1,370 (Rehn 1937, Cazorla-Perfetti 2019). The other one, *D. scotti* (Shelford, 1912), was initially described within the genus *Homalopteryx* Brunner von Wattenwyl, 1865, to be later placed as the type for the new genus *Dryadoblatta* (Shelford 1912, Rehn 1930). The species has been collected in northern Trinidad at an elevation of 950 m (Shelford 1912).

*Dryadoblatta scotti* is one of more than 60 cockroach species associated with Bromeliaceae (Roth & Willis 1960; Rocha e Silva *et al.* 1976). This beautiful species is considered amphibious or semi-aquatic, and lives at the water surface in or near the bromeliad tank, diving into it to collect food or to escape predators (Princis & Kevan 1955). The species has been found associated with *Tillandsia* sp. and *G. erectiflora*, in the mountains of the northern Cordillera of Trinidad (Shelford 1912, Rehn 1930). *Dryadoblatta scotti* has a chocolate brown coloration contrasting with the edges of the pronotum and tegmina which are of a very striking golden yellow color, and can measure up to 30 mm.

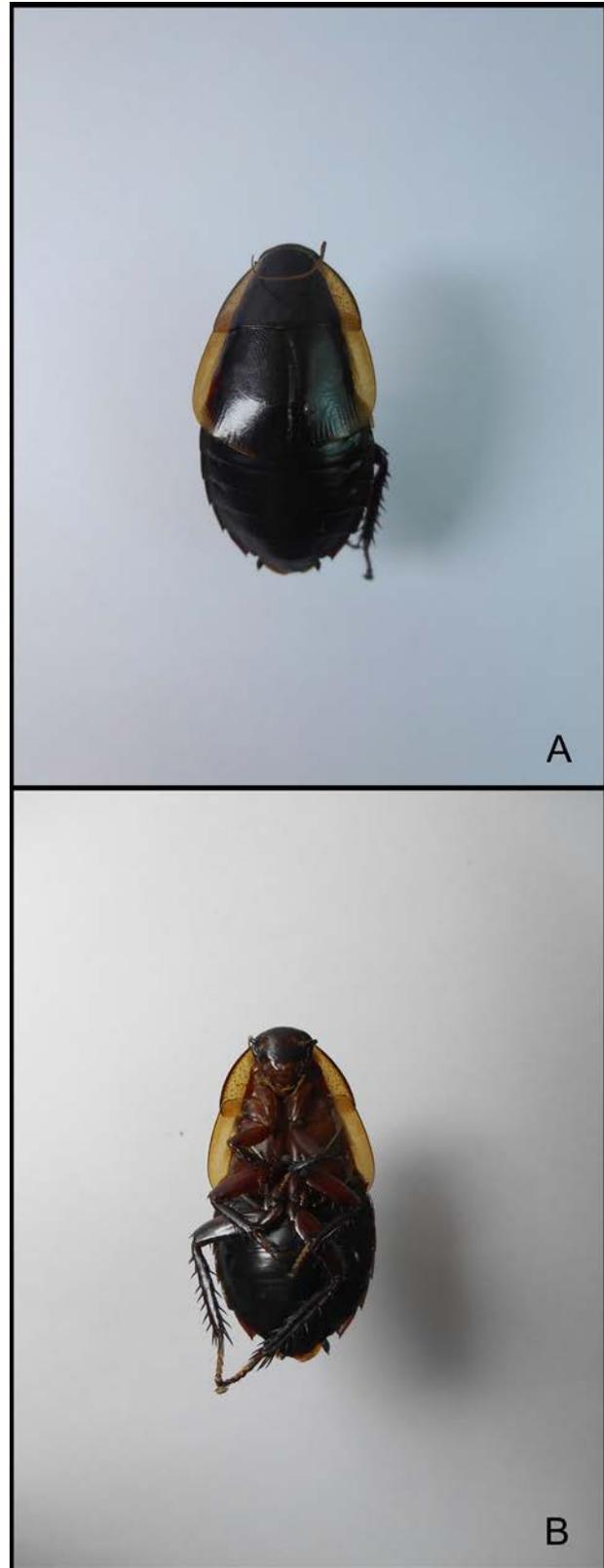


Figure 2. Dorsal (A) and ventral (B) views of a specimen of *Dryadoblatta* sp. collected inside a *Glomeropitcairnia erectiflora* from Cerro Humo, Paria Peninsula, Venezuela. Photo: L. E. Sibira.

While visiting Cerro Copey, on Margarita Island (Venezuela), a cockroach of the genus *Pelmatosilpha* was photographed walking out of the tank of a *G. erectiflora* plant at 750 m elevation (Fig. 3). *Pelmatosilpha* has 24 recognized species, of which 21 have been found in Central America (Costa Rica and Panama), the Caribbean islands (Trinidad, Grenada, Barbados, St. Lucia, Martinique, Antigua, Dominica, and Puerto Rico), and in South America (Peru, Ecuador, Colombia, Venezuela, Guyana, and Brazil). Three species are known from Venezuela, and at least one of them is also found in Trinidad (<https://cockroach.speciesfile.org/>).

Most known cockroach species are cryptic and appear to be palatable to predators (Evans 1968, Marshall 2017). However, some are known to be unpalatable, while others, after being “crushed” or “torn,” release a foul odor (Evans 1968, Eisner & Grant 1981, Santos *et al.* 2003, Hinkelmann 2023).

#### *The “horseshoe” pattern of roaches and frogs*

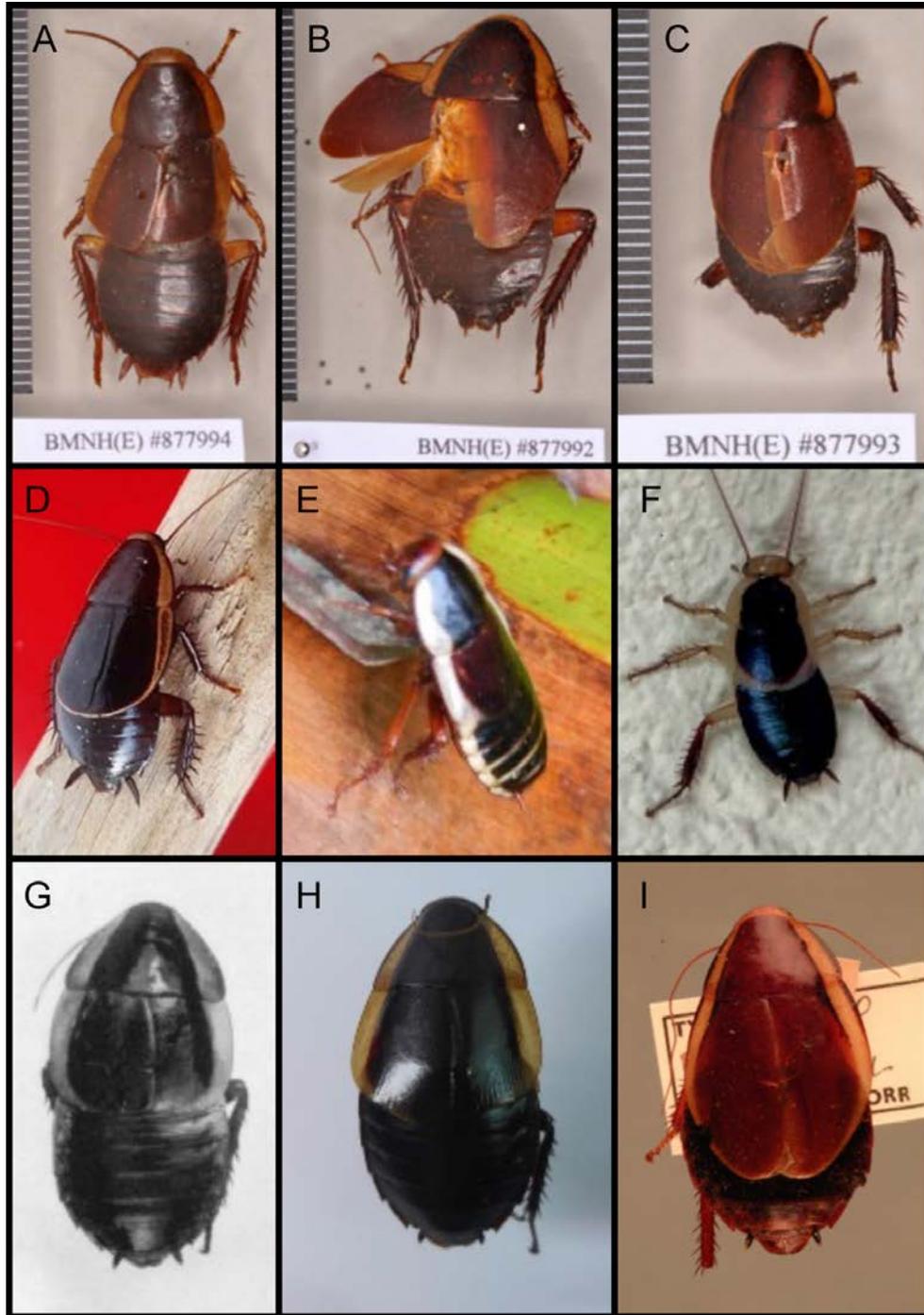
The coloration pattern of *Dryadoblatta scotti*, *Dryadoblatta* sp. (from the Paria Peninsula), and *Pelmatosilpha* sp., consists of brown shades contrasting with light borders.

This pattern resembles that of frogs such as *Phytotriades auratus*, that have a similar size and share the same environment. Perhaps one should refer to the frog resembling the cockroach in terms of the evolutionary scenario resulting in these similarities. This type of coloration on these and other cockroaches is known as the “horseshoe pattern,” which has also been observed in at least one beetle (see Ferreira Souza *et al.* 2024), and may be disruptive and/or aposematic due to its contrasting nature (Fig. 4). The association of such pattern with some degree of toxicity is observed in the cockroach, *Pelmatosilpha coriacea* Rehn, 1903, from Puerto Rico. This species is known to release a repellent secretion which is effective against ants (Blum 1964). A closely related species, *Eurycotis floridana* (Walker, 1868), has been studied for its repellent efficacy against mice and some insects (Turnbull & Fashing 2002).

Although the “horseshoe” pattern observed involves cockroach species associated with phytotelmata, this pattern might not be a recent adaptation. It appears to be an ancestral coloration shared by several other cockroach species, including terrestrial ones such as *Methana marginalis* (Saussure, 1864) from Australia and *Dorylaea* spp. from Southeast Asia (Mackerras 1968; G. Beccaloni, *pers.*



**Figure 3.** *Pelmatosilpha* sp. (male) on a leaf of *Glomeropitcairnia erectifolia*, from Cerro Copey, Margarita Island, Venezuela, photographed on 2017. Photo: G. A. Rivas.



**Figure 4.** *Dryadoblatta* and *Pelmatosilpha* species showing the “horseshoe pattern” coloration: A. *Pelmatosilpha purpurascens*, Puerto Rico [Beccaloni, 2025. Cockroach Species File. [Cockroach Species File - Pelmatosilpha purpurascens Kirby, 1903](#)]; B. *P. larifuga* [Beccaloni, 2025. Cockroach Species File. [Cockroach Species File - Pelmatosilpha larifuga Gurney, 1965](#)]; C. *P. marginalis* [Beccaloni, 2025. Cockroach Species File. [Cockroach Species File - Pelmatosilpha marginalis Brunner von Wattenwyl, 1893](#)]; D. *P. coriacea*, Puerto Rico [Beccaloni, 2025. Cockroach Species File. [Cucaracha Arborea \(Pelmatosilpha coriacea\) Arboreal Cockroach](#)]; E. *Pelmatosilpha* sp. Venezuela (Cerro Copey, Margarita Island) [this work]; F. *P. erythrocephala* Colombia (Cerro Pintado) [*Pelmatosilpha erythrocephala*. Photo: ©nmoorhatch. Licenced under Creative Common License Attribution 4.0 International (CC BY 4.0). URL: <https://www.inaturalist.org/observations/172533741> and <https://www.gbif.org/occurrence/5167126518>]; G. *Dryadoblatta mira* (male), Venezuela (Cerro Duida) [Taken from Rehn 1937: Pl. XV: fig. 21]; H. *Dryadoblatta* sp. (female), Venezuela (Cerro Humo, Paria Peninsula) [this work]; I. *Dryadoblatta scotti* (female), northern Trinidad [Beccaloni, 2025. Cockroach Species File. [Cockroach Species File - Dryadoblatta scotti \(Shelford, 1912\)](#)].

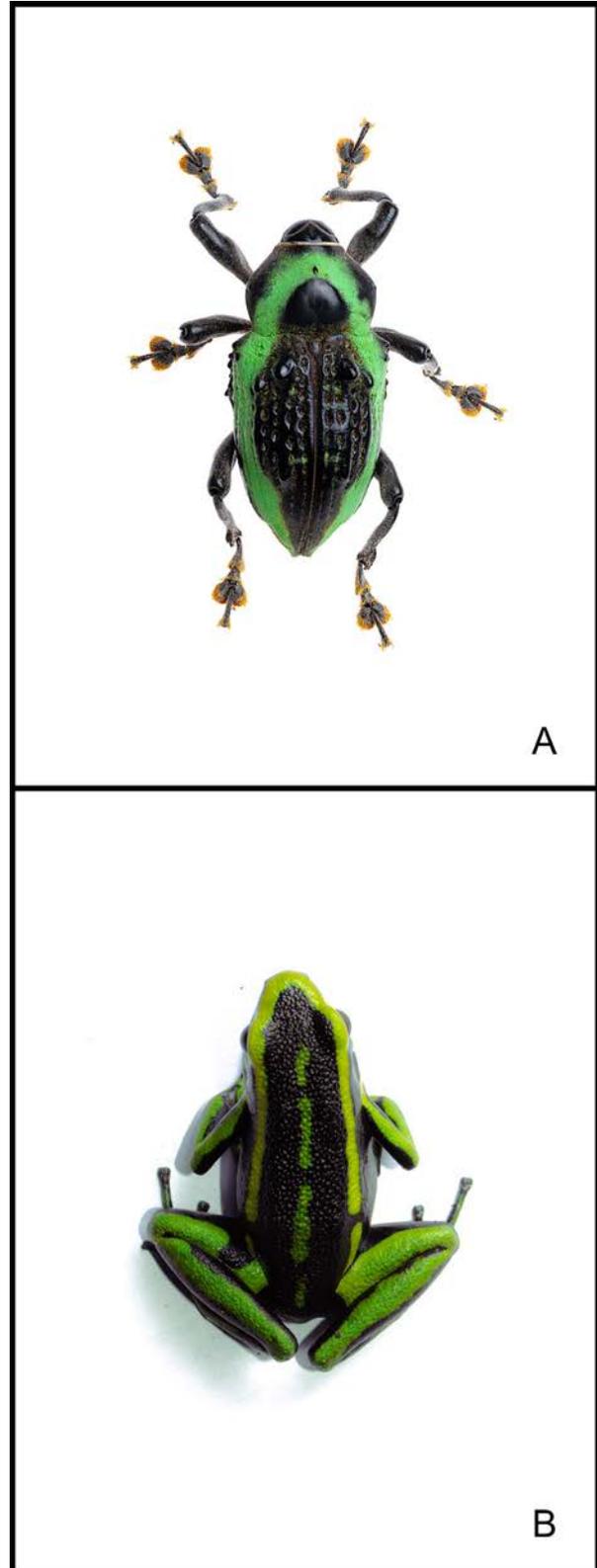
*comm.*). As noted above, a similar pattern has also been reported in at least one member of the Curculionidae (Coleoptera) (Ferreira Souza *et al.* 2024) (Fig. 5).

#### General remarks

In recent years, several localities outside the Paria Peninsula have been surveyed for anurans, encompassing the distribution of the tank bromeliad *G. erectiflora*, a host plant of *P. auratus* (Rivas *in litt.*). The recent discovery of *P. auratus* in Venezuela allows us to solve a puzzling mystery of herpetology in the country. In 1950, two frogs matching the description of *P. auratus* were collected in Cerro Copey, Margarita Island (Roze 1964). Roze (1964) stated that after checking 70 bromeliads from the summit of that mountain, he and his team were able to find two frogs that they identified as *Scinax ruber* (Laurenti, 1768). Unfortunately, the two specimens seem to be lost (we could not find them in the Museo de Historia Natural La Salle, Caracas, where they were originally housed). Those frogs might represent *Phytotriades auratus* and not *Scinax ruber*. Both species have a vague resemblance, but the former is normally found in lowlands, although at least one specimen is known from 800 m above sea level in a highly anthropogenic environment on the Paria peninsula (Fig. 6). In addition, *G. erectifolia* is the most abundant bromeliad on the summit of Cerro Copey, and *P. auratus* is closely associated with this plant species in Trinidad and Paria Peninsula, and both (the plant and the frog) appear to be relict species.

Several organisms linked to the bromeliad *G. erectifolia* have also been found in the Northern Cordillera of Trinidad (Trinidad and Tobago), and Cerro Copey in Margarita Island, and the Paria Peninsula in Sucre State (Venezuela) (Mez 1904, Smith & Downs 1977, Jowers *et al.* 2008). Among them, we collected in Paria Peninsula the endemic lizard *Euspondylus monsumus* Mijares-Urrutia, Señaris, & Arends, 2001, as well as specimens of *P. auratus*, and some isopods. Likewise, we found the two cockroach species observed and mentioned in this study as being associated with *G. erectifolia*.

Besides, sufficient evidence exists for a biotic relationship between amphibians and cockroaches as predator-prey, as several families of amphibians are known to frequently feed on cockroaches (Picado 1913, Princis & Kevan 1955, Roth & Willis 1960). An example of this are cockroaches of the genus *Epilampra* found in the stomach contents of the frog, *Eleutherodactylus maestrensis* Díaz, Cádiz & Navarro, 2005, in Cuba, in tropical mountain and pine forests between 900 and 1,640 m above sea level (Díaz *et al.* 2005).



**Figure 5.** A weevil (*Cratosoma* sp., Curculionidae, Coleoptera) (A) and a poison dart frog (*Ameerega trivittata*, Dendrobatidae, Anura) (B) from Brazil, showing similar “horseshoe patterns” to those of *Dryadoblatta* spp. and *Phytotriades auratus* (compare with Figure 1). Photo: U. Ferreira Souza.



**Figure 6.** *Scinax ruber* from Cachipal, Península de Paria, Venezuela. Note the general similarity to *Phytotriades auratus*. Photo: L. A. Rodríguez J.

#### *Which arrived first, the cockroach or the frog?*

The ancestors of cockroaches originated during the Carboniferous period, approximately 350–320 million years ago (McKittrick 1964, Djernæs *et al.* 2020). However, modern cockroach lineages emerged around 235 million years ago, predating the earliest confirmed cockroach fossils by about 95 million years (McKittrick 1964, Wegener 1966, Djernaes *et al.* 2020, Jin-Lin *et al.* 2023).

The earliest protofrogs appeared around 250 million years ago, with the lineage leading to modern frogs emerging over 150 million years ago (Blackburn & Wake 2011, Feng *et al.* 2017, Portik *et al.* 2023). Most contemporary lineages, including those of poison dart frogs, diversified approximately 66 million years ago after the dinosaur extinction (Grant *et al.* 2006, Blackburn & Wake 2011, Feng *et al.* 2017, Portik *et al.* 2023). Interestingly, poison dart frogs acquire their toxicity as a result of consuming poisonous insects (Summers & Clough 2001, Vargas-Salinas & Rojas 2024).

#### *Is this mimicry or just convergence?*

Three species of the genus *Dryadoblatta* are now known from northern South America: *D. mira* from the Venezuelan Amazon region, *D. scotti* from northern Trinidad (Roth & Willis 1960, Rehn 1937, Shelford 1913), and *Dryadoblatta* sp. from the Paria peninsula in Venezuela (reported herein). This is particularly interesting because the anuran genus *Phytotriades* is monotypic, and its sister genus *Itapotihyla* Faivovich, Haddad, Garcia, Frost, Campbell & Wheeler, 2005 is also a monotypic, though it is distributed in the Atlantic Forests of Brazil, with isolated populations in eastern Paraguay and northeastern Argentina (Blotto 2021, Frost 2024). *Phytotriades* and

*Dryadoblatta* could be relicts of the former Amazonian refugia of northwestern Venezuela, as established for some other plant and animal species (Steyermark 1974, 1976, 1982, Schargel *et al.* 2005). In turn, the tank bromeliad *G. erectifolia* could also be considered a relict, and it is currently isolated on some peaks of northeastern Venezuela, Margarita Island, and northern Trinidad (this work).

The similarity of color patterns and adult sizes between the frogs and cockroaches that we studied (despite being somewhat variable and alike to those observed in other frog and cockroach groups associated with humid environments; G. Beccaloni, *pers. comm.*), along with their shared *Glomeropitcairnia* phytotelmata habitat, suggest that we are likely observing a convergence system that could be interpreted or associated with mimicry. It is worth mentioning again that the only other insect, namely *Cratosomus* sp. (Curculionidae) associated to a mimicry system involving a frog also exhibits the horseshoe pattern (see Ferreira Souza *et al.* 2024). This reinforces the idea that such a pattern extends to a broader taxonomic level in insect-mimicking frogs (or perhaps the other way around) or even a simple ecological convergence (“a plain coincidence,” G. Beccaloni, *pers. comm.*).

In the case of cockroaches of the subfamily Eurycoitiinae, in which *Pelmatosilpha* sp. is included, they are known to emit repellent secretions effective against other insects and vertebrates (Blum 1964, Turnbull & Fashin 2002). Some frogs of the tribe Lophyohylini, to which *P. auratus* belongs, are also known to exude toxic secretions through serous glands (Blotto *et al.* 2021). Although similar secretions have not been recorded in *P. auratus*, this frog might produce unpleasant or poisonous exudates. These and the coincidental presence of an aposematic color pattern in both species lead us to suspect that we are in the presence of a possible mimetic association. However, we cannot rule out the idea that this is just a case of independent evolutionary convergence.

The frogs and cockroaches in this study, as well as their host plant, appear to be relicts of a wider past distribution in northern South America (*e.g.*, Jowers *et al.* 2024), and are now isolated on some peaks in Venezuela and Trinidad, where they can still find an appropriate microhabitat to live and breed.

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