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First record of *Brontocoris tabidus* and *Podisus* spp. (Heteroptera: Pentatomidae) as predators of *Actinote* sp. (Lepidoptera: Nymphalidae)

Primer registro de *Brontocoris tabidus* y *Podisus* spp. (Heteroptera: Pentatomidae) como depredadores de *Actinote* sp. (Lepidoptera: Nymphalidae)

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Abstract

The genus *Actinote* is one of the most diverse of Nymphalidae in the Neotropical region, with 35 species. Among them, *Actinote pellenae* Hübner stands out as widely distributed throughout South America. Although aspects of its biology have been documented, little is known about its natural control agents. The objective was to report for the first time the predation by *Podisus nigrispinus*, *P. graziae*, and *Brontocoris tabidus* on different developmental stages of *Actinote* sp. under natural environmental conditions. Sampling was conducted through active observation along a 250-meter transect at a locality in Los Paños, San Antonio Department, Jujuy Province, Argentina. Asopine bugs were collected manually and predation events were documented. One adult of *B. tabidus*, three adults of *P. graziae*, and seven specimens of *P. nigrispinus* (one adult and six nymphs) were recorded. The species *B. tabidus* was observed preying on an *Actinote* pupa, while *Podisus* species

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consumed larvae, pupae, and adults. Most events corresponded to the pupal stage. Attack patterns and preference for specific body regions of the prey were also described. This work represents the first record of *P. graziae* for Argentina and extends the distribution of *B. tabidus* to Jujuy Province. Furthermore, this is the first report of *B. tabidus* and *Podisus* spp. preying on immature stages and adults of *Actinote* under natural conditions. These findings expand knowledge about the trophic behavior of these species in wild environments.

Keywords: Asopine bugs, generalist predators, trophic interactions.

Resumen

El género *Actinote* es uno de los más diversos de Nymphalidae en la región Neotropical, con 35 especies. Entre ellas destaca *Actinote pellenea* Hübner ampliamente distribuida en América del Sur. Aunque se han documentado aspectos de su biología, poco se conoce sobre sus controladores naturales. El objetivo fue reportar por primera vez la depredación de *Podisus nigrispinus*, *P. graziae* y *Brontocoris tabidus* sobre diferentes estados de desarrollo de *Actinote* sp. bajo condiciones ambientales naturales. Los muestreos se realizaron mediante observación activa a lo largo de una transecta de 250 metros en una localidad de Los Paños, departamento San Antonio, provincia de Jujuy, Argentina. Los asópinos se recolectaron manualmente y se documentaron los eventos de depredación. Se registró un adulto de *B. tabidus*, tres adultos de *P. graziae* y siete ejemplares de *P. nigrispinus* (un adulto y seis ninfas). La especie *B. tabidus* fue observada depredando una pupa de *Actinote*, mientras que las especies de *Podisus* consumieron larvas, pupas y adultos. La mayoría de los eventos correspondieron al estado pupal. Se describieron además patrones de ataque y preferencia por regiones específicas del cuerpo de la presa. Este trabajo representa el primer registro de *P. graziae* para Argentina y amplía la distribución de *B. tabidus* a la provincia de Jujuy. Además, se presenta el primer reporte de *B. tabidus* y *Podisus* spp. depredando estados inmaduros y adultos de *Actinote* en condiciones naturales. Estos hallazgos amplían el conocimiento sobre el comportamiento trófico de estas especies en ambientes silvestres.

Palabras clave: Chinchas asopinas, depredadores generalistas, interacciones tróficas.

INTRODUCTION

The genus *Actinote* Hübner, [1819] (Nymphalidae: Heliconiinae), is the most diverse of the tribe Acraeini in the Neotropics, including around 35 species (Paluch, 2006). These butterflies exhibit gregarious behavior, territorial males, and a close association with their host plants, commonly found in forest edges, disturbed areas, and urban environments. In Argentina, at least four species of the genus *Actinote* have been recorded (Nuñez Bustos, 2020), including *A. pellenaea* (Hübner, 1821), which is widely distributed from Mexico to northern Argentina (Mattos, 2010). It is a polymorphic species with 18 recognized subspecies, differentiated morphologically and geographically (Nuñez Bustos, 2020; Silva-Brandão et al., 2021). In Argentina, it is present from spring to autumn and is considered a key pest of sunflower crops (Nuñez Bustos, 2010; Guanuco & Barrionuevo, 2022; Acosta Parra et al., 2023).

Numerous studies have addressed the morphology, territorial behavior, and population genetics of *A. pellenaea* (Mattos, 2010; Carvalho, 2011; Carvalho et al. 2016; Nuñez Bustos, 2020). However, information on natural control agents of *Actinote* species is scarce. To date, the only predation record corresponds to the congeneric species *Actinote callianthe* Jordan, 1913, whose larvae were attacked by larvae of *Xanthandrus bucephalus* (Wiedemann, 1830) (Diptera: Syrphidae) (Duque et al., 2014).

In this context, the subfamily Asopinae (Hemiptera: Pentatomidae) is of particular relevance. Comprising predatory stink bugs, this group fulfills a key ecological role and exhibits significant potential for use in biological control programs. Among notable examples are *Podisus* Herrich-Schäffer, 1851 species as effective control agents in various economically important crops, such as tomato (*Solanum lycopersicum*), cotton (*Gossypium hirsutum*), eucalyptus (*Eucalyptus* spp.), soybean (*Glycine max*), and olive (*Olea europaea*) (Bergam et al., 1984; Zanuncio et al., 1994; Oliveira et al., 2000; Matos Neto et al., 2002; Lemos et al., 2003; Scheunemann et al., 2021).

In particular, *Podisus nigrispinus* (Dallas, 1851) is a generalist predator widely distributed in South America. Both nymphs and adults feed on a wide variety of prey, primarily lepidopteran larvae. However, during periods of scarcity, it can supplement its diet with plant tissues for survival (Holtz et al., 2009; Pinto & Cardoso, 2023). While its efficacy as a biological control agent has been well documented, there is a need to deepen the study of its trophic ecology. This would allow evaluation of its potential impact on non-target species, including insects with relevant ecological functions such as pollinators, bioindicators, or those that contribute to the functional biodiversity of agroecosystems.

Another species of interest is *Podisus graziae* Brugnera, Roell & Lemaître, 2021, whose distribution encompasses southern Brazil and Paraguay (Roell et al., 2021) and can be recognized by distinctive morphological traits of adults and immature stages (Roell et al. 2021; Sampaio et al. 2023). Knowledge about its biology, ecology, and potential as a biological control agent remains limited.

On the other hand, *Brontocoris tabidus* (Signoret 1863) is distributed in Argentina, Brazil, Paraguay, and Chile (Grazia & Schwertner, 2008; Grazia et al., 2015; Mc Kay et al., 2019; Dellape, 2021). In Brazil, it has been recorded as a generalist predator of defoliating lepidopteran larvae in eucalyptus plantations (De Menezes et al., 2013), as well as larvae of *Haplostegus nigriscrus* (Hymenoptera: Pergidae), a phytophagous insect associated with *Psidium guajava* (Azevedo Pereira et al., 2008). In Argentina, its predatory activity has been confirmed on larvae of *Heteroperreyia hubrichi* (Hymenoptera: Pergidae) on *Schinus terebinthifolia* (Anacardiaceae), a native plant of the Southern Cone considered invasive in several regions of the United States (McKay et al., 2019). These precedents reflect the trophic plasticity of *B. tabidus* and its capacity to integrate into different food interaction networks, both in natural ecosystems and agroecosystems, which reinforces its interest as a potential biocontrol agent in pest management.

Despite growing interest in Asopinae as biological control agents (De Clercq, 2000, 2004), little information is available about their behavior and ecological functions in natural environments. In this regard, the present study aims to report, for the first time, the predation by *Podisus nigrispinus*, *P. graziae*, and *Brontocoris tabidus* on different developmental stages (larva, pupa, and adult) of *Actinote* species under natural environmental conditions.

MATERIALS AND METHODS

Study Area

The work was carried out in the locality of Los Paños, Jujuy, Argentina (24°17'31" S; 65°24'46" W; 1728 m a.s.l.) in March 2025. The area is located in the Yungas ecoregion, characterized by a warm and humid to subhumid climate. Summer precipitation ranges between 900–1000 mm annually. During the coldest months, condensation and water capture from fog, typical of these “cloud forests”, compensate for the absence of rainfall. Soils have a high organic matter content (Burkart et al., 1999).

The study site is located in a rural area along a path leading to water collection tanks where local rural populations gather spring water (Fig. 1).



Figure 1. Study site in the town of Los Paños, Jujuy, Argentina. **A)** Rural trail where the samples were taken. **B)** Plastic water collection tanks used by local rural populations. **C)** Asopinae bug perched on vegetation (*Dendrophorbium bomanii*).

Collection and Identification of Insects

An active search was conducted every two days along a 250 m transect for one month, with one-hour sampling sessions both in the morning and afternoon, to record the different developmental stages of *Actinote* on the predominant vegetation. This was composed mainly of *Dendrophorbium bomanii* (R.E. Fr.) C. Jeffrey, *Bidens* sp., *Kaunia* sp. (Asteraceae), *Celtis iguanaea* (Jacq.) Sarg. (Cannabaceae), *Zanthoxylum coco* (Gillies ex Hook. f. & Arn.) (Rutaceae), *Juglans australis* Griseb., 1879 (Juglandaceae), some of which act as hosts or resting sites for the lepidopteran.

Particular attention was paid to specific plant substrates where each developmental stage of *Actinote* was found, as well as the substrates where predatory interactions occurred.

Predatory interactions were recorded on field sheets, detailing the developmental stage and number of specimens, both predator and prey, along with observations on behavior associated with attack mode. For each predatory event, the specific substrate (plant species or artificial structure) where the interaction occurred was documented.

Insects were collected with forceps and preserved in entomological boxes for subsequent preparation. Lepidopteran larvae and pupae were preserved in Khan jars with a solution of 80% ethyl alcohol and 20% glacial acetic acid. Adult Lepidoptera and Heteroptera were dry-mounted.

Taxonomic identification was performed using a Leica EZ4 binocular microscope, specialized literature, and dichotomous keys (Thomas, 1992; Hayward, 1935; Nuñez Bustos, 2010, 2020). Determination of Heteroptera specimens was confirmed by a specialist in the group. All material was deposited in the Entomological Collection “Dra. Lilia Estela Neder” (IN-BIAL-UNJu).

RESULTS

Predators Recorded on *Actinote*

From the collected specimens, the adult Lepidoptera was identified as *Actinote pellenae* (Hübner, 1821). The collected larvae and pupae belong to the genus *Actinote*; however, species-level identification was not possible due to the lack of available taxonomic keys for immature stages. The predators were determined as *Podisus nigrispinus* (Dallas 1851), *Podisus graziae* Brugnara, Roell & Lemaître, 2021 and *Brontocoris tabidus* (Signoret 1863).

A total of 11 asopine bugs were collected: one adult specimen of *B. tabidus*, three adult specimens of *P. graziae*, and seven specimens of *P. nigrispinus* (one adult and six nymphs) (Table 1). *Podisus graziae* is recorded for the first time in Argentina, and the known distribution of *B. tabidus* in the country is extended to include Jujuy Province.

Table 1. Observations of predation by *Brontocoris tabidus*, *Podisus nigrispinus*, and *Podisus graziae* on different developmental stages of *Actinote* under natural conditions (Jujuy, Argentina).

Stage of <i>Actinote</i>	Predator species	Predator stage	Body part attacked	Substrate	N° of observed events
Larva (last instar)	<i>P. nigrispinus</i>	Nymph	7th abdominal segment	Vegetation	1
Pupa	<i>P. nigrispinus</i>	Nymph	Thorax, wing case, abdomen	Water tank	5
Pupa	<i>P. nigrispinus</i>	Adult	Thorax	Water tank	1
Pupa	<i>P. graziae</i>	Adult	Thorax, wing case, abdomen	Water tank	2
Pupa	<i>B. tabidus</i>	Adult	Thorax	Water tank	1
Adult	<i>P. graziae</i>	Adult	4th abdominal segment	Vegetation	1

Plant-herbivore-predator Associations and Substrate Preferences

Larval development of *Actinote* was observed exclusively on *Kaunia* sp. (Asteraceae), where larvae completed their feeding stage without observed predation by asopine bugs. Mature larvae dispersed from their host plants to seek pupation sites.

Pupation occurred exclusively on artificial substrates, specifically on plastic water collection tanks used by local rural populations. All observed predatory interactions on pupae took place on these plastic surfaces.

Heteropteran nymphs were frequently observed resting on *Dendrophorbium bomanii* (R.E. Fr.) C. Jeffrey, although no predatory behavior was recorded on this plant species. Adults of the three asopine species were found both on vegetation and on the tanks where predation events occurred.

Hunting Strategy and Attack Mode

The *Actinote* larva was attacked by a *P. nigrispinus* nymph while suspended from vegetation by its anal prolegs. The heteropteran inserted its mouthparts into the seventh abdominal segment of the larva (Table 1, Fig. 2a). This single predation event on larvae occurred on vegetation during the larval dispersal phase.

Pupae were exclusively found on plastic water tank surfaces. Pupae were preyed upon by nymphs and adults of *P. nigrispinus* and by adults of *P. graziae* and *B. tabidus*. The predators introduced their mouthparts into different regions of the pupal body, including the thorax, wing cases, and abdominal segments (Table 1, Fig. 2b–d).

Regarding the adult stage of *A. pellenea*, a single predation event was observed, in which an adult specimen of *P. graziae* inserted its mouthparts into the fourth abdominal segment of the butterfly while it was perched on vegetation (Table 1, Fig. 2e).

During all observed events, the presence of only one adult specimen of *B. tabidus*, *P. nigrispinus* and *P. graziae* was recorded, or in some cases, up to two *P. nigrispinus* nymphs feeding simultaneously on one prey.

It should be noted that no attacks by asopine bugs on the egg stage of *Actinote* were recorded. Additionally, despite the presence of *Actinote* larvae feeding on *Kaunia* sp., no predation events were observed on this host plant.

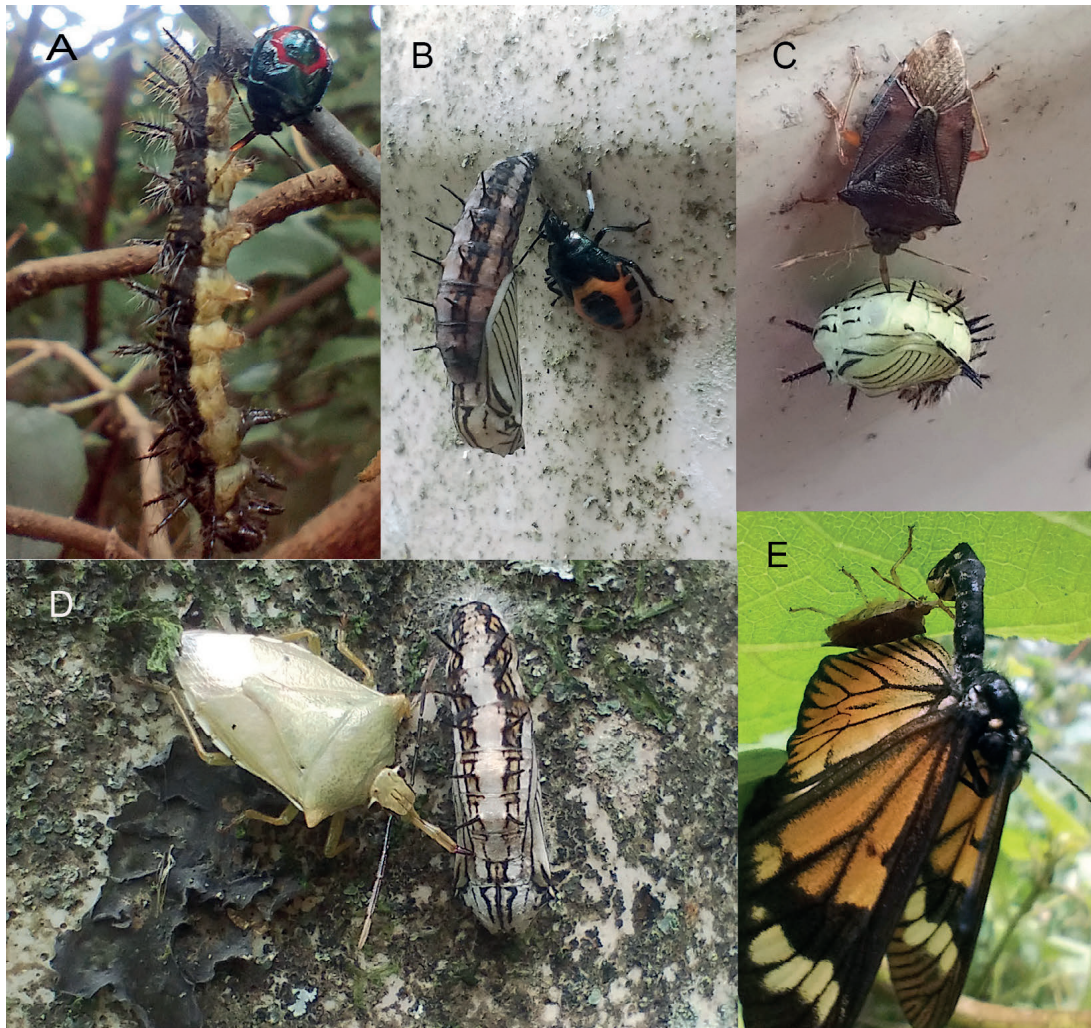


Figure 2. Predation records of *P. nigrispinus*, *P. graziae*, and *B. tabidus* on different developmental stages of *Actinote* under natural conditions (Los Paños, Jujuy, Argentina). **A)** larva, **B-D)** pupa, **E)** adult.

DISCUSSION

The results of this study constitute the first record of *Podisus graziae* in Argentina and of *Brontocoris tabidus* in Jujuy Province, expanding the known distribution of both species. In particular, *P. graziae* was previously recorded in southern Brazil (Paraná, Santa Catarina, and Rio Grande do Sul) and Paraguay (Alto Paraná) (Roell et al., 2021). Therefore, the present finding represents a significant extension of its distribution range toward north-western Argentina.

On the other hand, *B. tabidus* had been recorded in the provinces of Buenos Aires, Chubut, Mendoza, Misiones, Santiago del Estero, and more recently in Salta (Dellapé, 2021).

Likewise, this work provides the first report of predation by *B. tabidus*, *P. nigrispinus*, and *P. graziae* on different developmental stages of *Actinote* under natural conditions.

Most cases of predation on *Actinote* were observed in pupae. Although our sampling did not include a systematic quantification of the total abundance of each developmental stage, which limits definitive conclusions about relative vulnerability, this pattern could be related to several factors. The pupal stage, characterized by immobility and exclusive presence on exposed artificial substrates (such as plastic water tanks), may have facilitated detection and access by predators. Furthermore, research on other members of the subfamily Asopinae has indicated that prey selection may be influenced by factors such as mobility, availability, and chemical composition of prey species (Lemos et al., 2003; Pinto & Cardoso, 2023). The combination of substrate exposure, immobility, and potentially favorable size and nutritional content could explain the higher frequency of predation events observed in pupae compared to larvae and adults, although further quantitative studies would be needed to confirm this pattern.

The absence of predation on *Actinote* eggs could indicate that these asopine bugs prefer more advanced stages of their prey's life cycle, possibly due to the greater biomass and nutritional content they provide. Some authors point out that predators require obtaining a greater amount of food for their optimal biological development (Altieri & Nicholls, 2004; García Vallejo, 2020).

Regarding attack mode, it was observed that adults of *B. tabidus*, *P. graziae*, and *P. nigrispinus* preyed alone, and occasionally nymphs attacked in pairs. In this regard, García Vallejo (2020) observed a similar pattern in *Podisus congrex*, where nymphs, from the second instar onward, initiate active prey searching and exhibit collective attack behavior when prey is larger. This suggests that the transition from group hunting in nymphs to solitary behavior in adults could be related to greater efficiency in prey capture and consumption, as well as to the reduction of intraspecific competition for resources.

These reports highlight the importance of expanding studies on the prey spectrum of *B. tabidus*, *P. graziae*, and *P. nigrispinus* beyond their role as biological control agents in commercial crops. The predation of *Actinote*, an abundant genus in natural ecosystems, raises questions about the role of these heteropterans in insect population dynamics in non-agricultural environments.

Future research should address the interaction between these species with insects not considered pests, evaluating their impact on natural communities and broader food webs.

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AUTHOR CONTRIBUTIONS

GCG participated in the conceptualization of the work, insect collection, and figure editing. MCM participated in the identification of Asopinae specimens. MJB participated in the identification of *Actinote* specimens. GCG, MCM, and MJB participated in manuscript writing.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest among themselves or with third parties.

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