Abstract. Assassin bugs are one of the most diverse families of cimicomorphan Heteroptera and are known from all biogeographic regions. Except for the kissing bugs (Triatominae) that are hemathophagous, reduviids show a predatory behavior and are usually study as potential biocontrollers of crop pests. In this way, Harpactorines have been specially studied as they are mostly diurnal and live on the vegetation. In this contribution, the complete life cycle of Harpactor angulosus (Lepeletier & Serville, 1825) is described and illustrated. Specimens were collected in the field in El Manantial, San Miguel de Tucumán, Argentina, and were reared in laboratory to obtain all immatures (eggs and nymphs) and to observe its feeding habits, molting, mating, and oviposition. Collection specimens as well as online resources such as iNaturalist records were also studied to know the current distribution of the species. This resulted in the expansion of H. angulosus distribution in Argentina to Tucumán and Buenos Aires provinces and to the recording of the species in Ecuador, Peru and Paraguay for the first time. Our findings reveal that H. angulosus would be studied as a potential biocontroller of Agraulis sp., an important pest of maracuyá crops in several South American countries.

Key words. Assassin bug; Immature; Behavior; Distribution; Harpactorini.

INTRODUCTION

Harpactorinae is the most specious subfamily of the Reduviidae, with ca. 2,800 described species, and more than 300 genera (Maldonado Capriles, 1990; Weirauch et al., 2014). They are mostly diurnal predators that are frequently found on the vegetation (Schuh & Weirauch, 2020). Noteworthy, some species have been observed using other resources such as extrafloral nectary secretions as a food source (Alvarez et al., 2019; Gil-Santana & Keller, 2022), and plant resins as sticky material for prey capture (Forero et al., 2011).

Harpactor Laporte, 1833 was created to include three species, although the only one that persisted in the genus is the type species: H. angulosus (Lepeletier & Serville, 1825). Nowadays, it includes another three species all from the Neotropics: H. tuberculatus Stål, 1872 known from Argentina, Bolivia, Brazil, and Uruguay; H. distinguendus (Stål, 1859) from Brazil; and H. rhombeus (Erichson, 1848) from Brazil, Colombia, Guiana, Mexico and Venezuela (Wygodzinsky, 1946; Maldonado Capriles, 1990; Gil-Santana & Forero, 2009). They are large reduviids (ca. 20 mm) with inconspicuous coloration, mostly grey by a dense waxy secretion of the cuticle covering all over the body.

Harpactor angulosus was described from Brazil, and later, its known distribution expanded to northern Argentina (Melo et al., 2023). It can be recognized by the posterior lobe of pronotum with 1+1+1 distinct tubercles, the emarginate humeral angles with spiniform process at the anterior border of the emargination; the strongly dilated abdomen, and the postero-lateral angles of connexival segments with a short dentiform process (Wygodzinsky, 1946).

In this contribution, we describe and illustrate the complete life cycle of Harpactor angulosus, and give biological observations of their feeding, mating and oviposition behavior under laboratory conditions. We also give an accurate distribution of the species.

MATERIAL AND METHODS

Specimens of Harpactor angulosus (Fig. 1A) were collected in the locality of El Manantial, in
the province of Tucumán, Argentina (26°50’S, 65°19’W) during 22/XII/2022 and 10/V/2023 by NM. They were found on native vegetation, with predominance of Solanum mauritianum Scopoli, Phenax hirtus (Sw.) Wedd., Ipomoea alba L., and Passiflora edulis Sims. Specimens collected were reared in the laboratory in plastic cages of 20 × 7 cm (Fig. 1B) and in big plastic bottles of 5 lts (Fig. 1C). The main open of both kinds of cages were covered with voile to allow ventilation. For the study of the “Developmental stages” we separate the egg clutches into plastic cages of 22 cm diameter and 7 cm high (Fig. 1B). The specimens from the clutch we obtained by a female collected in the field were fed with different arthropods (Coleoptera, Lepidoptera, Hemiptera, etc.), and the ones obtained by a female raised in the laboratory were fed with third instar larvae of Diatraea saccharalis (Fabricius, 1794), in both cases the feeding was ad libitum. We registered daily the state of development of each specimen.

The statistical analysis were conducted using InfoStat version 2020 (Di Rienzo et al., 2020). The response variables by development time, defined as the relationship between the number of days that pass in each stage/instars, and the total number of individuals, were analyzed using Wilcoxon (Mann-Whitney U) with egg stage/nymphal instars, and origin of the female as factors.

Images and videos were taken in the field and in the lab with a cellphone (Motorola Edge 30 Fusion), and to take close up images in the lab the cellphone was attached to a Leica EZ4 microscope. These data is deposited in the https://ri.conicet.gov.ar.

Specimens studied are deposited in the entomological collection of La Plata Museum, La Plata, Argentina (MLP), and voucher specimens in the Zoología Agrícola Lab, Facultad de Agronomía, Zootecnia y Veterinaria, Universidad Nacional de Tucumán, Argentina (FAZyV, UNT). Additional material studied belongs to the entomological collection of the MLP.

**Material studied:** Argentina: Buenos Aires: 1 male, Carmen de Patagones, ex coll. Berg (MLP); Misiones: 1 female, Puerto Peninsula, 25°44.142S, 54°32.124W, 271 m,
RESULTS AND DISCUSSION

Feeding behavior: Nymphs and adults were mostly fed with larvae (Figs. 1D, 2A-B) of Spodoptera cosmioides (Walker, 1858), Rachipusia nu Guenée, 1852 (Lepidoptera, Noctuidae), and Diatraea saccharalis (Fabricius, 1794) (Lepidoptera, Crambidae) raised in the laboratory during ca. 22 days (Fig. 3A). After the oviposition began, no more mating events were registered and after 8 days, the male died. For coupling, the male gets its anterior and posterior legs, and juxtaposing his genital capsule to the female terminalia. This behavior is common among reduviids and many other insects (Manrique & Lazzari, 1994; Huber, 2010).

Mating: Multiple events of mating were observed in the laboratory during ca. 22 days (Fig. 3A). After the oviposition began, no more mating events were registered and after 8 days, the male died. For coupling, the male gets its anterior and posterior legs, and juxtaposing his genital capsule to the female terminalia. This behavior is common among reduviids and many other insects (Manrique & Lazzari, 1994; Huber, 2010).

Oviposition: Eggs were always laid aligned (Figs. 3B-D), mostly upside down on the voile of the cages, but also at the bottom of the handle of the container with water of the cage where a female was kept (Fig. 3B). The number of eggs ranged from three to 11 (ten, once; five, once; four, twice; eleven, twice; two, once and six, twice). These observations are mostly in accordance with previous ones, as Pikart et al. (2012) reported egg masses of one to seven eggs. Eggs were adhered to the substrate without a great amount of a viscous and sticky yellowish substance between them (Fig. 3C), after the emergence of the nymphs, they become opaque and covered with fungi. Pereira et al. (2009) studied specimens from Minas Gerais (Brazil) and documented the oviposition in the laboratory, where the eggs were aligned on the abaxial side of the guava leaves (Myrtaceae). The position where the eggs were laid suggests their arboreal habits, which
Figure 2. *Harpactor angulosus* (Lepeletier & Serville). (A) N4 feeding on larva; (B) N1 feeding on larva; (C) N4 feeding on the mesocarp of an apple; (D) N2 hydrating from sunken cotton; (E) N5 feeding on fulgoridae (Auchenorrhyncha) in the field; (F) adult feeding on *Epilachna paenulata* Germar (Coleoptera, Coccinellidae).
is in accordance with observations made by Vennison & Ambrose (1990) in Harpactorinae Indian species. Our observations in the field agree with this hypothesis as the specimens were collected over the leaves of plants, mostly Solanaceae, where they fed. All studies agree that the eggs are dark brown to black, with a yellowish operculum (Fig. 3C).

**Developmental time:** From the first clutch of four eggs we obtained by a female collected in the field, and after nine days of oviposition, nymphs hatched. Ecdysis was synchronized from N1 to N4 (Table 1). A male and a female raised in the laboratory copulated and left fertile offspring. This female laid 13 egg clutches with between two and 11 eggs. We could follow the development of eight individ-

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**Figure 3.** *Harpactor angulosus* (Lepeletier & Serville). (A) mating couple; (B) female and eggs; (C) detail of eggs; (D) newly hatched N1; (E) well sclerotized and starved N1; (F) N1 after feeding, with enlarged abdomen.
uals until N4 (Table 1). Unfortunately, the cycle of these nymphs could not be completed because of the voracity of the nymphs and the decline of *D. saccharalis* breeding.

The development time of the egg stage and the nymphal instars (N1, N2 and N3) recorded from a clutch obtained by the female collected in the field compared to a clutch obtained from the female raised in the laboratory were not significant (egg p = 0.26; N1 p = 0.07; N2 p = 0.28; N3 p = 0.33).

### Morphology of nymphs:

**N1**: (Figs. 3D-F) Immediately after hatching N1 shows a pale orange coloration (Fig. 3D) that rapidly turns to black and brightly orange/bright red (Figs. 3E-F). It shows all body polished and black with the distiflagellomere and the abdomen orange; on the abdomen, it shows a black central macula from tergite 3 to the last one, and on the sides, a small black macula is present from segment 2 to 7. From these lateral maculae, appears a black lateral acute projection that increases its size to the back (Fig. 3E). The head shows a short acute spine posteriorly of the antennal tubercles. The pronotum shows a pair of long acute erect spines. After feeding, the abdomen is remarkably much enlarged (Fig. 3F).

**N2**: (Figs. 4A-B). Similar to N1, but the abdomen is paler, pale yellow to orange and the body starts to be covered with a dense white secretion. This secretion is more abundant on the dorsum, and it is patchy on the legs. The spines of the abdomen are less elongate but more stout.

**N3**: (Fig. 4C) Body mostly black, except for the apical half of basi- and the entire distiflagellomere, and the abdomen that are pale orange. The waxy secretions are more abundant on legs and labium than in previous instar, but it is absent on the most apical part of femora and most basal part of tibiae, and it appears but scarcely on scape and pedicel. Wing pads are short (not exceeding abdominal segment 2), but conspicuous, also covered with waxy whitish secretions.

**N4**: (Fig. 4D) Body black, except for the basal ¼ of the basi- and the entire distiflagellomere. Body densely covered with waxy secretions all over. The lateral projections of the abdomen are shorter than in previous instar, as well as the two projections of the pronotum. The most basal part of the basi- and the entire distiflagellomere remain uncovered of the waxy whitish secretion. Wing pads are longer, exceeding the anterior margin of abdominal segment 3.

**N5**: (Fig. 4E) Body black, setose, covered with waxy whitish secretions but with some parts on pro- and mesonotum uncovered. Wing pads are longer than in previous instar, extending to abdominal segment IV.

Pikart et al. (2014) showed that the waxy secretion appears in N3, but we observed that it appears in N2. We have hypothesized two options that could explain the difference in wax appearance between studies. One explanation could be the different food used in both studies that could affect the epidermal cellular activity. Another option could be related to the need to protect the body from extreme temperatures (and subsequent water loss), as those registered when our study was conducted. One particular difference we observed with Pikart et al. (2014) study is that the N2 shows a bright red head and all the nymphs we studied show a black head.

It should be noted that nymphs raised with different preys did not present differences in coloration with the different diets.

**Ecdysis**: After each molt, the specimens covered their body with the waxy secretion, when turning into adults, the individuals are brightly orange (Fig. 4F), then turning darker and well covered by the waxy secretions.

**Potentiality as a biocontrol agent**:
The voracity of *H. angulosus* to Lepidoptera larvae, and considering that it was observed feeding on larva of *Agraulis vanillae* in the field and in captivity, make us consider this assassin bug as a potential biological controller of *Agraulis* spp. Among other Lepidoptera, this Heliconiid is considered as an important pest of maracuyá crops (*Passiflora edulis* Sims) in Brazil (Fancelli & Martins Mesquita, 1998; Martins de Oliveira & Frizzas, 2014), Colombia (Hernández et al., 2011), Mexico (Ruiz-Coronado et al., 2020), and Venezuela (Dominguez-Gil & McPherson, 1992). The maracuyá is widely distributed in tropical and subtropical South America and it is an important crop in many countries (Ocampo et al., 2007), so the potentiality of *H. angulosus* as a biocontroller of the Lepidoptera larvae that affect the normal development of the plant and the posterior commercialization of the fruit, would be an interesting topic to research.

**Distribution**: *Harpactor angulosus* was described from Brazil, and has been reported from Misiones (Berg, 1879; Pennington, 1920) and Salta (Coscarrón & Martin-Park, 2011) in Argentina (Melo et al., 2023). Here we reported the species for the first time from Buenos Aires and Tucumán provinces in Argentina, and Paraguay from specimens studied and deposited in the Entomological collection of the Museo de La Plata, La Plata, Argentina; and from Ecuador and Peru from observations from the iNaturalist platform.

Additional records from the citizen science platform iNaturalist, with our confident identification are included.

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Table 1. Development time of the immature stages/instars obtained by a female collected in the field and a female raised in the laboratory.

<table>
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<tr>
<th>Stage/instar</th>
<th>Egg</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>N5</th>
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<tr>
<td><strong>Duration (days)</strong></td>
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<td>Female from the field</td>
<td>9 (n = 4)</td>
<td>9 (n = 2)</td>
<td>8 (n = 2)</td>
<td>10 (n = 2)</td>
<td>16 (n = 2)</td>
<td>49 ± 4 (n = 2)</td>
<td>90 ± 30 (n = 2)</td>
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<tr>
<td>Female raised in laboratory</td>
<td>11.2 ± 0.5 (n = 6)</td>
<td>11.7 ± 0.8 (n = 6)</td>
<td>11 ± 1.6 (n = 5)</td>
<td>16 ± 1 (n = 2)</td>
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Figure 4. Harpactor angulosus (Lepeletier & Serville). (A) N2; (B) N2 abdomen; (C) N3; (D) N4; (E) N5; (F) molting adult.
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AUTHORS’ CONTRIBUTIONS: MCM: Supervision; NM, MCM: Conceptualization, Methodology, Data Curation, Formal Analysis, Writing—original draft, Visualization, Investigation, Writing—review & editing, Funding Acquisition. All authors actively participated in the discussion of the results; they reviewed and approved the final version of the paper.

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