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Quantification of prey consumption by the predators *Chauliognathus flavipes* (Coleoptera: Cantharidae), *Cycloneda sanguinea* (Coleoptera: Coccinellidae), and *Orius insidiosus* (Heteroptera: Anthocoridae)

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Mass rearing and release of predatory insects in agricultural and forest areas for biological control programs (Tavares et al. 2012; Naranjo et al. 2015) is dependent on the ecology and biology of a pest species and its associated predator guild (Sørensen et al. 2012; Silva et al. 2013, Grayson et al. 2015). Determination of effective predators for suppression of targeted prey represent the first step for applied biological control programs (De Clercq & Degheele 1997). Prey may affect the development, reproduction, and behavior of predators (Silva et al. 2013). Mass rearing techniques can improve the potential effectiveness of natural enemy production in augmentive biological control, but the use of living prey, or artificial diets, remains problematic when mass rearing of individuals is required (De Clercq et al. 2005).

The families Anthocoridae, Cantharidae, and Coccinellidae contain several important predators (Sobhy et al 2014; Roy & Brown 2015). Specifically, *Chauliognathus flavipes* (F.) (Coleoptera: Cantharidae), *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae), and *Orius insidiosus* (Say) (Hemiptera: Anthocoridae) have been reported to prey upon a variety of aphids, whiteflies, lepidopteran eggs, thrips, and mites (Dode et al. 2008; Schuber et al. 2012). *Chauliognathus flavipes* belongs to a family consisting principally of small arthropod predators, but the importance of this species in biological control programs is poorly understood (Waldner et al. 2013). Júnior et al. (2004) reported that adult *C. sanguinea* reduced *Aphis gossypii* (Glover) (Hemiptera: Aphididae) populations by 93.5% in 2 d in a greenhouse. *Orius insidiosus*, a primary natural enemy of *Frankliniella* spp. (Thysanoptera: Thripidae), has been shown to successfully collapse populations of this pest on *Capsicum annuum* L. (Solanaceae) in the US (Reitz et al. 2003).

Our study was conducted at the Laboratory of Integrated Pest Management, Rio Paranaíba, Universidade Federal de Viçosa, in the municipality of Rio Paranaíba, Minas Gerais State, Brazil. Predators were collected randomly from tomato (*Solanum lycopersicon* L.) (Solana-

ceae) (19.172894°S, 46.113822°W), potato (*S. tuberosum*) (Solanaceae) (19.186200°S, 46.128577°W), corn (*Zea mays* L.) (Poaceae) (19.183688°S, 46.132933°W), and soybean (*Glycine max* [L.] Merrill) (Fabaceae) (19.177755°S, 46.127427°W) (Rio Paranaíba, Minas Gerais State, Brazil). The locations were georeferenced using Garmin E-Trex Summit Hc (Garmin International Ltd., Olathe, Kansas, USA) during 2012 and 2013.

Adult *C. flavipes* and *C. sanguinea* were collected from soybean (*G. max*) plants and separated into plastic pots (250 mL) with 2 circular 1-cm covered with voile and sealed with silicone. The openings in the lids allowed gas to exchange with the external environment. A paper towel was placed in each pot as a substrate for oviposition by the predator. Eggs were transferred to acrylic Petri dishes (15.0 × 2.0 cm) with a moistened cotton swab to prevent desiccation. Individual larvae of each predator species were isolated in 500 mL plastic pots with 15 *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) added per pot per d. Pupae were transferred to a Biochemical Oxygen Demand incubator (Tecnal, São Paulo, Brazil,) at 25.0 ± 0.1 °C, 75.0 ± 0.4% RH, with a 12:12 h (L:D) photoperiod (Oliveira et al. 2005). *Orius insidiosus* adults were collected from maize fields (*Z. mays*) and grouped into mating pairs in acrylic Petri dishes (15.0 × 2.0 cm) sealed with polyethylene film that contained 22 nymphs and 35 adults of *Frankliniella* spp. as food. Dishes contained *Bidens pilosa* L. (Asteraceae) inflorescences that served as oviposition sites for the predator nymphs. Predators were reared in a Biochemical Oxygen Demand chamber at 25.0 ± 1.2 °C, 70.1 ± 10.4% RH, and a 12:12 h (L:D) photoperiod. Inflorescences were observed daily, with a stereoscopic microscope, where *O. insidiosus* eggs were removed and placed in Petri dishes (15.0 × 2.1 cm). A cotton swab moistened with distilled water was placed into each plate as a water source and dishes sealed with polyethylene film.

Laboratory tests on prey consumption by adult *C. flavipes* were conducted using 30 *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and

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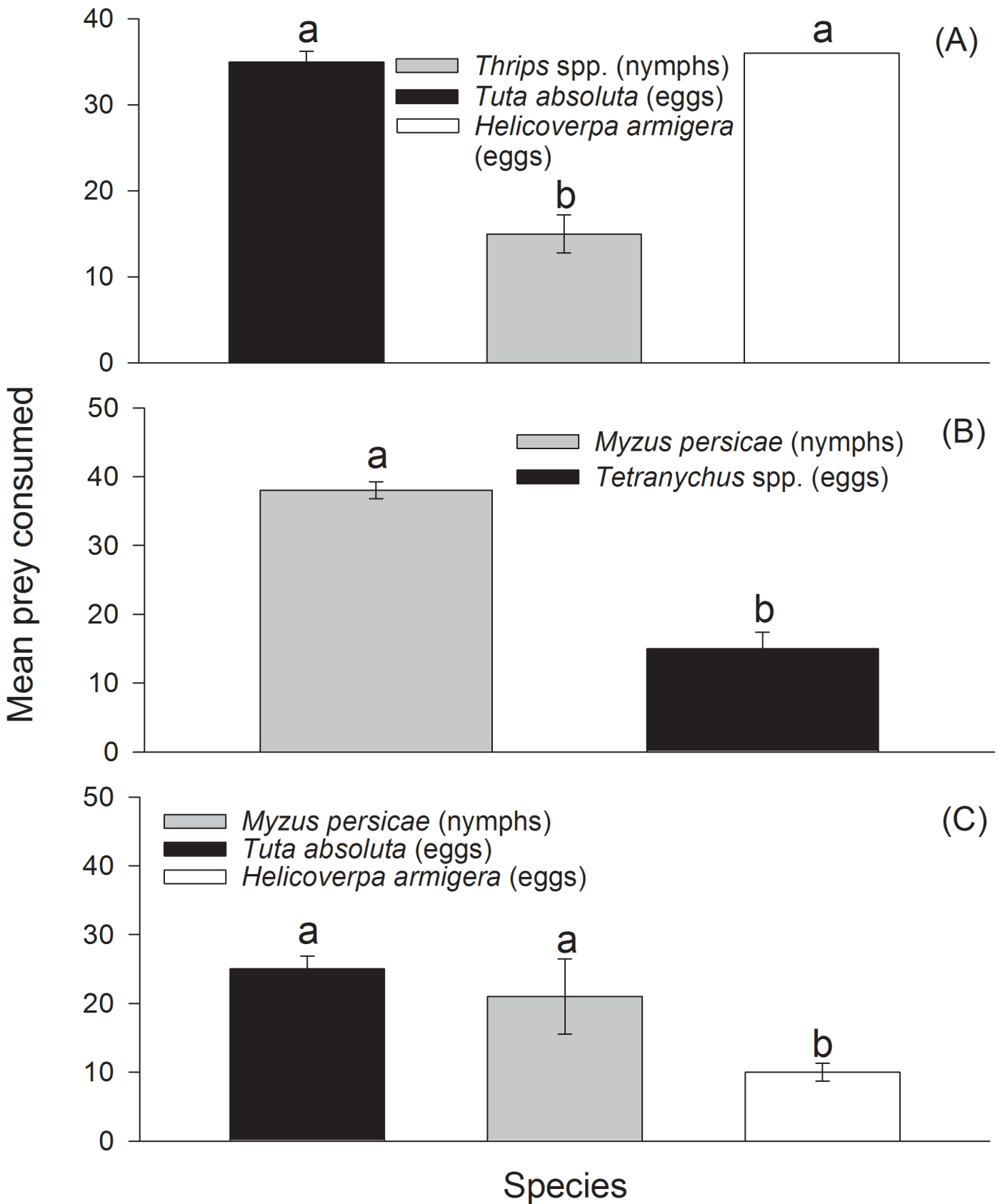


Fig. 1. Mean number of prey (± SE) consumed by (A) *Orius insidiosus*, (B) *Cycloneda sanguinea*, and (C) *Chauliognathus flavipes* predators. Columns with the same letter (within predator species) are not different (Tukey's multiple comparison test, $P < 0.05$).

20 *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) eggs as well as 30 nymphal *M. persicae*. The effectiveness of adult *C. sanguinea* predation on eggs of *Tetranychus* spp. (Prostigmata: Tetranychidae) and nymphs of *M. persicae* also was evaluated using 50 and 20 individuals per Petri dish, respectively. Evaluation of egg predation by adult *O. insidiosus* on *T. absoluta* and *H. armigera* eggs, including nymphs of *Thrips* spp. (Thysanoptera: Thripidae), was conducted using 20, 40, or 45 individuals per Petri dish, respectively.

The number of prey consumed was evaluated 5 h after predator and prey were added. The experimental design was completely randomized with 10 replications per dish of a specific predator-prey species combination ($n = 40$ dishes per combination). Prey survival in dishes without predators was 100% during the 5-h evaluation. Mean numbers of prey consumed initially were subjected to a goodness of fit test for normality and homogeneity of variance (SAS Institute 2001). Results of this analysis revealed that data were normal and homogenous in variance; therefore, data were analyzed using a 1-way ANOVA without transformation. Mean numbers of prey consumed by each predator species were compared using Tukey's multiple comparison test and differences considered significant at $P < 0.05$.

All predators evaluated in this study fed on the prey species offered to them, although the amount of eggs and nymphs consumed by *C. flavipes*, *C. sanguinea*, and *O. insidiosus* varied according to prey species. Predation by *O. insidiosus* adults on *T. absoluta* and *H. armigera* eggs was significantly greater (35.0 ± 1.2 and 36.0 ± 0.0 , respectively) than *Thrips* spp. nymphs (Fig. 1A). *Cycloneda sanguinea* fed considerably more on aphids (38.0 ± 1.3) than eggs of *Tetranychus* spp. (Fig. 1B). *Chauliognathus flavipes* preyed significantly more on *T. absoluta* eggs (25.5 ± 1.9) and *M. persicae* nymphs (21.3 ± 5.5) compared with *H. armigera* eggs (Fig. 1C).

Consumption of *Thrips* nymphs, *T. absoluta*, and *H. armigera* eggs by *O. insidiosus* was higher than those reported in the study by Coll & Ridgeway (1995), probably because we only offered only prey and no other supplementary sources of food, such as pollen or nectar (Bernardo et al. 2017). We also found that *C. sanguinea* fed on more *M. persicae* than *Tetranychus* spp., probably because this predator commonly preys on the former species under field conditions (Oliveira et al. 2005). However, the factor(s) responsible for higher consumption of *M. persicae* nymphs and *T. absoluta* eggs than *H. armigera* eggs by *C. flavipes* is unknown.

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Summary

We report on the predatory consumption of prey by adult *Chauliognathus flavipes* (F.) (Coleoptera: Cantharidae), *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae), and *Orius insidiosus* (Say) (Hemiptera: Anthocoridae) in laboratory no-choice feeding tests. *Chauliognathus flavipes* more commonly preyed on eggs of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and nymphs of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Cycloneda sanguinea* fed on more *M. persicae* nymphs while *O. insidiosus* fed slightly more on *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) and *T. absoluta* eggs compared with *Thrips* spp. nymphs.

Sumario

Nós reportamos a eficácia predatória das presas dos adultos de *Chauliognathus flavipes* (F.) (Coleoptera: Cantharidae), *Cycloneda sanguinea* (L.) (Coleoptera: Coccinellidae) e *Orius insidiosus* (Say) (Hemip-

tera: Anthocoridae) alimentados com diferentes presas. A predação de *C. flavipes* foi maior em ovos de *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) e ninfas de *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Cycloneda sanguinea* alimentou-se mais de ninfas de *M. persicae* enquanto *O. insidiosus* alimentou um pouco mais com ovos de *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) e *T. absoluta* em comparação com ninfas de *Thrips* spp.

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