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Nectarivory by the plant-tissue feeding predator *Macrolophus pygmaeus* Rambur (Heteroptera: Miridae): Nutritional redundancy or nutritional benefit?

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ABSTRACT

Most predators and parasitoids feed on plant-provided food (nectar, pollen) or engage in herbivory during at least part of their life stages. Plant feeding by these insects plays an important role in driving predator–herbivore dynamics. Thus, understanding the effects of plant feeding on omnivores could be an important element in improving biological control strategies. The mirid *Macrolophus pygmaeus* is an omnivorous heteropteran predator of whitefly and other pests. Unlike other predators that need to seek out accessible nectar to meet their carbohydrate requirements, mirid bugs can access the plant's carbohydrate resources by feeding directly on plant tissues. Leaf and stem feeding could be seen as a nutritional surrogate that allows mirids to become independent of nectar availability. However, to date feeding experiments have not yet considered nectar feeding by these mirid predators. In this study we demonstrate that *M. pygmaeus* survival is prolonged on broad bean plants featuring extrafloral nectar as compared to broad bean with extrafloral nectaries removed, irrespective of the presence of cattail pollen. Survival on extrafloral nectar was comparable to the survival by individuals kept on broad bean provided with eggs of *Ephestia kuehniella* as prey. Also, a greater proportion of mirid females laid eggs when extrafloral nectar was available as compared to those confined on nectariless plants without supplemental food.

1. Introduction

Plants provide herbivore natural enemies with a range of food resources, such as (extra-) floral nectar, food bodies and pollen, and in return, they may provide plants with protection against herbivores (Wäckers and van Rijn, 2005). Plant-derived sugars are commonly used as an energy source by arthropod predators and parasitoids. Indeed, sugar feeding is essential for survival and fecundity of most parasitoids (Wäckers, 2001; Wade et al., 2008; Winkler et al., 2006; Wyckhuys et al., 2008) and may enhance survival and reproduction of predators in situations of no or low availability of prey (Limburg and Rosenheim, 2001; Lundgren, 2009a; Nomikou et al., 2003; Taylor and Pfannenstiel, 2009; van Rijn and Tanigoshi, 1999a).The implications of sugar feeding in driving carnivore-herbivore dynamics are widely discussed both in theorical (Bianchi and Wäckers, 2008; van Rijn and Sabelis, 2005; Vollhardt et al., 2010) and empirical studies (English-Loeb et al., 2003; Irvin et al., 2006; Lee and Heimpel, 2008; Mathews et al., 2007; Tylianakis et al., 2004). Understanding sugar feeding strategies and their impact on predator–herbivore dynamics is vital to biological control in general, and conservation biological control in particular. The latter, often advocates the inclusion of plant provided foods to support arthropod predators in cropping systems.

Sugar feeding can be important for Heteroptera (Lundgren, 2009b). However, we know little about the sugar sources exploited by predatory Heteroptera in the field. Several species have been recorded feeding on floral and extrafloral nectaries (Lundgren, 2009b; Wheeler, 2001) and reduced populations have been attributed to the nectariless trait in cotton (Naranjo and Gibson, 1996). Despite the evidence of nectar as an important diet component for heteropteran predators, only few species have been shown to benefit from this plant provided sugar-rich food (De Lima and Leigh, 1984; Yong, 2003). The important group of predatory mirids have not been studied in this respect.

Generally regarded as sap feeders, the phytophagous habits of predatory Heteroptera are mainly known in terms of plant-tissue feeding (Alomar and Wiedenmann, 1996; Coll and Ruberson, 1998; Eubanks and Styrsky, 2005; Perdikis and Alomar, 2011). Nymphs and adults of some predatory Heteroptera develop faster (Gillespie and McGregor, 2000) and survive longer (Naranjo and Gibson, 1996) when provided with leaves than with water. Mirids seem unique among predaceous arthropods in their ability to tap into plant nutrients through plant tissue feeding. *Macrolophus pyg-*

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