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Intraguild predation between the aphidophagous ladybird beetles *Harmonia axyridis* and *Coccinella undecimpunctata* (Coleoptera: Coccinellidae): The role of intra and extraguild prey densities

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Abstract

Laboratory cages were used to evaluate the influence of extraguild (EGprey) and intraguild prey (IGprey) densities on the direction, symmetry and magnitude of the intraguild predation (IGP) of the aphidophagous *Harmonia axyridis* Pallas on *Coccinella undecimpunctata* L. and vice versa. In order to understand the role of competition between IGprey, the experiments included treatments with one IGpredator, with one or four IGprey and EGprey (*Aphis fabae* Scopoli) ranging from zero to sufficient aphids to satiate the predators for 12, 24 or 48 h. Increases in EGprey and IGprey densities did not alter the direction, but decreased the magnitude and symmetry of IGP. Predation on one individual of IGprey decreased from more than 80%, in the absence of EGprey, to from 6% to 53%, at higher EGprey densities. Decrease in IGP was less when *H. axyridis* was the IGpredator. Even at high EGprey densities, eggs and 2nd larval stages of *C. undecimpunctata* were vulnerable to IGP and the level of predation was 40% and 53%. The presence of more than one IGprey increased the magnitude of IGP mainly at EGprey densities sufficient to satiate the predators for 12 and 24 h, suggesting that competition between the IGpredator and IGprey may be one of the processes promoting IGP. These results and those of other authors suggest that *H. axyridis* has the potential to be an IGpredator, mainly of the most vulnerable stages of IGprey. Thus, *H. axyridis* may negatively affect the survival of *C. undecimpunctata*, when these two species exploit the same resources.

Keywords: *Harmonia axyridis*; *Coccinella undecimpunctata*; Intraguild predation; Extraguild and intraguild prey densities; Competition

1. Introduction

The term intraguild predation (IGP) is used to define the interaction between predators that share the same resource, independently of their mode of nutrition, ecology and taxonomic position (Lucas, 2005). Polis et al. (1989) define IGP as the death and consumption of species that use the same resources (food/space), which, are sometimes limiting. The predator is defined as the intraguild predator, the prey (competitor) as the intraguild prey and their common resource as the extraguild prey. They distinguish it from competition by the fact that IGP reduces exploitative competition (Polis et al., 1989). Lucas (2005) recently extended the ambit of the concept to include interspecific death, that is, when prey is killed but not consumed. However, it is not clear from the literature whether the eating of IGprey by an IGpredator is primarily to obtain resources or eliminate potential competitors.

Intraguild predation has direct implications for the fitness of the species implicated, the IGpredator, IGprey and EGprey, and potentially, for the structure and dynamics of populations and communities (Polis et al., 1989; Polis and Holt, 1992). For this reason, IGP can lead to changes in the morphological, behavioral and evolutionary characteristics of the protagonists (Polis et al., 1989). From a practical point of view, it can limit the effectiveness of biological control. Despite the apparent advantage of

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releasing several species of predators, the pest may increase in abundance as a result of unpredictable interactions between the predators (Rosenheim et al., 1995; Lucas, 2005).

There are several factors that may alter the direction, symmetry and magnitude of IGP, such as, the environment, host plant characteristics, predator and prey characteristics, the EGprey and factors related to the protagonists' life histories (Lucas, 2005). The presence or absence of EGprey influences the intensity of the interaction (Johansson, 1993; Rosenheim et al., 1995; Lucas et al., 1998; Hindayana et al., 2001; Meyhöfer, 2001; Burgio et al., 2002; Félix and Soares, 2004). However, the effect of simultaneous influence of extraguild and IGprey densities, on the magnitude, direction and symmetry of the IGP, is unknown. The purposes of this experiment were: (i) to determine the influence of EGprey (*Aphis fabae* Scopoli) and IGprey densities on the direction, magnitude and symmetry of IGP between the aphidophagous ladybeetles *Harmonia axyridis* Pallas and *Coccinella undecimpunctata* L. and (ii) to determine the effect of competition on the magnitude of IGP. If the IGprey is a potential competitor then an increase in the number of IGprey will result in an increase in IGP events. The invasive Asian ladybeetle *H. axyridis* is now a major problem in Europe and its spread across this continent will continue (Roy and Wajnberg, 2008; Soares et al., 2008). This study, thus, may help predict its potential impact on *C. undecimpunctata*, which is one of the most widely distributed ladybeetles in the world, including Europe (Iablokoff-Khnzorian, 1982), where both of these occupy similar habitats.

2. Materials and methods

2.1. Biological material

Harmonia axyridis and *C. undecimpunctata* individuals came from a stock culture and were reared at 22 ± 1 °C, with 75 ± 5% RH and a photoperiod of 16L:8D, using fluorescent lamps (Philips Ref.: TDL 23W/54 and TDL 18W/54). In order to avoid food adaptation and consanguinity ladybeetles were fed *ad libitum* on a mixed diet of the aphids *A. fabae* Scopoli and *Myzus persicae* (Sulzer), and eggs of *Ephestia kuehniella* Zeller and field collected ladybeetles were added regularly to the stock culture.

2.2. Intraguild predation experiments

2.2.1. Influence of the extraguild prey density on the direction, magnitude and symmetry of intraguild predation

To assess the influence of EGprey density on the magnitude, direction and symmetry of IGP between *H. axyridis* and *C. undecimpunctata*, five experiments were carried out. Three experiments were used to assess the effect of EGprey density when *H. axyridis* was the IGpredator [(i) 4th larval stage of *H. axyridis vs* eggs of *C. undecimpunctata*, (ii) 4th larval of *H. axyridis vs* 2nd larval stage of *C. undecimpunctata*, (iii) 4th larval of *H. axyridis vs* 4th larval stage of *C. undecimpunctata*] and two experiments when *C. undecimpunctata* was the IG predator [(iv) 4th larval stage of *C. undecimpunctata vs* eggs of *H. axyridis* and (v) 4th larval stage of *C. undecimpunctata vs* 1st larval stage of *H. axyridis*].

2.2.2. The effect of extraguild and intraguild prey densities on the direction, magnitude and symmetry of intraguild predation

To assess the effect of extraguild and IGprey densities, two experiments were performed. In one *H. axyridis* was the IGpredator [(vi) 4th larval of *H. axyridis vs* four individuals of the 4th larval stage of *C. undecimpunctata*] and in the other *C. undecimpunctata* [(vii) 4th larval stage of *C. undecimpunctata vs* four individuals of the 1st larval stage of *H. axyridis*]. IGP between these two ladybeetles is asymmetrical (Félix and Soares, 2004).

Each experiment consisted of four treatments with different densities of EGprey (apterous females of *A. fabae*). The prey densities were as follows: (i) absent, (ii) sufficient to meet the food requirements of the predators for 12 h, (iii) sufficient for 24 h and (iv) sufficient for 48 h. The amount of prey provided in each treatment was based on the results of Soares et al. (2004) and Moura et al. (2006).

The methodology used is that of Félix and Soares (2004). Larvae and eggs were 24 h old. Larvae were starved for 24 h before the experiments, except first instar individuals (to avoid a high rate of mortality). One individual was placed with one (or four) of the other species in a 2L transparent plastic box containing a potted broad bean plant (approximately 15 cm tall) with a particular number of aphids. Five eggs were provided in the combinations that used eggs. Eggs were placed on plant leaves and larvae at the base of the plant. The second individual (or the four individuals) was released after the first larva had moved up the stem. Twenty-four hours later, the box was checked to determine which individuals had survived. There were 15 replicates of each treatment. The natural mortality of each instar and occurrence of cannibalism in the two species when kept in similar conditions, but in the absence of the other ladybeetle, were used as a control. These results were used in the calculation of IGP for both species. All experiments were carried out at 20 ± 1 °C, 75 ± 5% of RH and a photoperiod of 16L:8D, under fluorescent lamps (Philips Ref.: TDL 23W/54 and TDL 18W/54).

IGP levels were estimated from the rates of predation (that is the proportion of replicates where IGP has occurred) for *H. axyridis* (RPha) and *C. undecimpunctata* (RPcu), which were calculated as follows:

To determine influence of the EGprey density,

$$\mathrm{RPha} = [(P\mathrm{cu},\mathrm{ha})\ \mathrm{SRcu}/N]100$$

$$\mathrm{RPcu} = [(P\mathrm{ha},\mathrm{cu})\ \mathrm{SRha}/N]100$$

To determine the effect of extraguild and intraguild prey densities,