INTRAGUILD PREDATION AMONG THE APHIDOPHAGOUS LADYBIRD BEETLES *Harmonia axyridis* PALLAS AND *Coccinella undecimpunctata* L. (COLEOPTERA: COCCINELLIDAE): CHARACTERIZATION OF THE DIRECTION AND SYMMETRY

S. FÉLIX & A.O. SOARES

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Direction and symmetry of intraguild predation (IGP) between all developmental stages of the aphidophagous *Harmonia axyridis* Pallas and *Coccinella undecimpunctata* L. were characterized.
Our results revealed that *H. axyridis* predation level was significantly higher than *C. undecimpunctata* and eggs were the more vulnerable developmental stage. Significantly asymmetric IGP on eggs occurred after the second and fourth larval stages of *H. axyridis* and *C. undecimpunctata*, respectively. Asymmetric IGP on pupas exclusively occurred in the presence of the fourth larval stage of *H. axyridis.*

Sandra Félix (e-mail: felixs@mail.telepac.pt) and A. O. Soares, Department of Biology, University of the Azores, Rua da Mãe de Deus, Apart. 1422, PT-9501-801 Ponta Delgada, Azores, Portugal.

INTRODUCTION

Intraguild predation is the killing and consumption of a species that uses similar resources being potential competitors. It is a common and often important interaction. In a diverse array of communities, IGP occurs among members of the same guild (POLIS & HOLT 1992). The aggressor is the intraguild predator (IG predator), the victim the intraguild prey (IG prey), and the common resource is the extraguild prey (LUCAS et al. 1998). IGP is considered to be an extreme form of competition or a type of classical predation that may affect the distribution, abundance and evolution of the animal species. IGP not only provides an additional food resource to the IG predators, but it may reduce inter- or intraspecific competition and predation risk for the extraguild prey when mutual IGP occurs (POLIS et al. 1989; POLIS & HOLT 1992; LUCAS et al. 1998; YASUDA et al. 2001). IG prey populations may suffer local extinctions due to IGP, which represents an important mortality factor (LUCAS et al. 1998).

The two most important factors that determine the symmetry and the direction of IGP are the size and the degree of feeding specificity exhibited by the protagonists. IGP occurs mainly with generalist predators attacking prey of smaller size, including conspecifics (POLIS et al. 1989; POLIS & HOLT 1992; LUCAS et al. 1998). The size of the prey attacked generally increases with the size / age of the IG predator (SABELIS 1992), with smaller individuals being more vulnerable to a larger number of predators (WERNER & GILLIAM 1984; LUCAS et al. 1998). In ladybird beetles, large species usually take advantage of small ladybird species in terms of food consumption, and this could result in asymmetrical interactions between the two species (OBRYCHI et al. 1998). A specialized predator should be less adapted to attack a nonpreferred prey, a disadvantage when confronted with a generalist predator (LUCAS et al. 1998).

Coccinella undecimpunctata L. is a native aphidophagous predator of the Azorean ecosystems, which can be found mostly by the sea (salt lands) and also in plants and flowers from where they feed on pollen (RAIMUNDO & ALVES 1986). *Harmonia axyridis* Pallas is a paleartic species native from Asia (TAN 1946, 1949; KOMAI 1956; IABLOKOFF-KHNZORIAN 1982). An euryphagous predator which prefers aphids (HUKUSIMA & KAMEI 1970; HUKUSIMA & OHWAKI 1972; IABLOKOFF-KHNZORIAN 1982; OSAWA 1992), psillids (FYE 1981; DREA & GORDON 1990), coccids (MCLURE 1987; HODEK & HONĚK 1988), the immature stages and eggs of lepidopteran (SCHANDERL et al. 1988; DREA & GORDON 1990), and spider mites (DREA & GORDON 1990; CLOUTIER & CLOUTIER 1991; LUCAS et al. 1997). It was found to be the best biological agent tested in laboratory against many phytophagous species. The possibility to rear this ladybird beetle successfully on eggs of *Ephestia kuehniella* Zeller (SCHANDERL et al. 1988) favors its mass production to sustain inundative releases. However, studies on the possible negative impacts of its presence on native ladybird beetles and on other non-target arthropods are rarely performed (LUCAS et al. 2002).

The aims of this study were to characterize the (i) direction and (ii) the symmetry of intraguild predation (IGP) between the aphidophagous *H. axyridis* and *C. undecimpunctata.*

MATERIAL & METHODS

H. axyridis individuals were mass 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). Coccinellids were fed a mixture of *Aphis fabae* Scopoli and *Myzus persicae* (Sulzer), and eggs of *Ephestia kuehniella* Zeller. *C. undecimpunctata* adults were collected in S. Maria Island and reared under de same biotic and abiotic conditions.

Predation level, direction and symmetry of IGP were characterized and compared between all developmental stages (eggs, 4 larval stages, pupae and adults) of *H. axyridis* and *C. undecimpunctata*.

As there are no possible interaction respectively between eggs and pupae of the two species, there remain 45 experimental combinations. Larvae and adults used in the experiments were 24h old. Prior to the beginning of the tests, second to fourth instars larvae and adults were starved for 24h then, they were weighed on a 10^{-4} mg Mettler AM 50 analytical balance. First instars larvae were not starved they were also weighed before the experiments. One-weighed individuals of one species of ladybirds was placed with a weighed individual of the other species in a 2L transparent plastic box that contains also a potted broad bean without aphid. Twenty-four hours later, the box was checked to determine which species survived if any. There were 15 replicates for each combination.

The natural mortality of each developmental instar of the two species was used as a control. A single individual of each instar was kept for 24h in a 2L transparent plastic box with a broad bean without aphid. There were 3 replicates for each instar.

All trials were performed at 20 ± 1 ºC, 75 ± 5% of RH and a photoperiod of 16L:8D, under fluorescent lamps (Philips ref.: TDL 23W/54 and TDL 18W/54).

A symmetry index was adapted from LUCAS et al. (1998) and expresses the number of replicates in which a given predator was eaten over the total numbers of replicates in which there was IGP for a particular combination of predator.

Statistical analysis

The symmetry indices for each combination were compared to a theoretical index of 50% corresponding to a symmetric interaction, using a Chi-square test (χ^2, $P < 0.05$) (SPSS PRODUCTION FACILITY 2001).

RESULTS

Among all significantly asymmetric combinations, *H. axyridis* was IG predator in 16 times and *C. undecimpunctata* only in 3 combinations. IGP were not significantly asymmetric in 19 combinations and symmetric in one of them. Absence of IGP was observed 6 times. Among all combinations with *H. axyridis* adults except on pupas and adult, the IGP was significantly asymmetric. On the other hand, in all combinations of *C. undecimpunctata* adults, significantly asymmetric IGP only occurred on eggs. IGP between adults did not occurred significantly asymmetric IGP, on pupae, exclusively occurred in the presence of the fourth larval stage of *H. axyridis*. Larvae of both species attacked heterospecific. In general, predation rate of immature stages of *H. axyridis* is higher (Fig. 1).

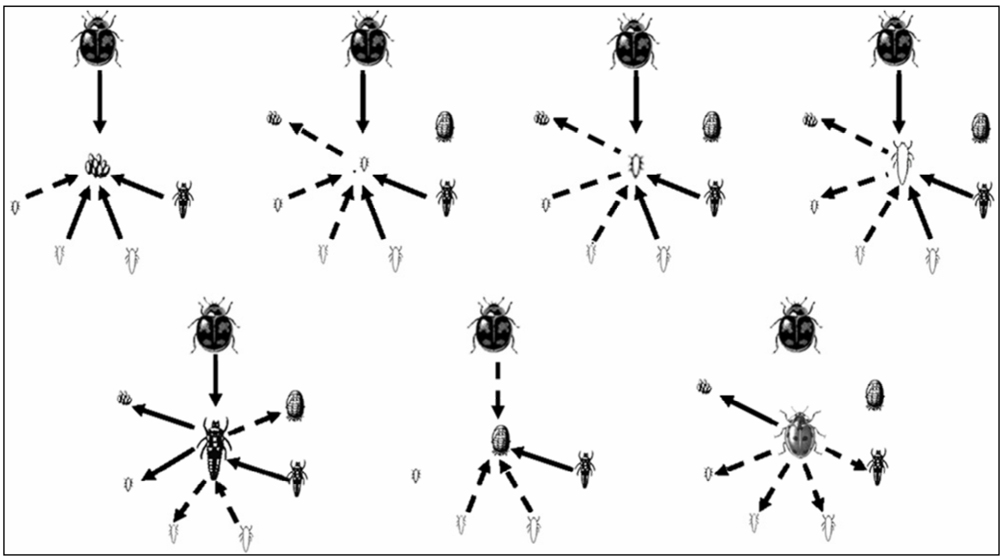

Fig. 1. Representation of the intraguild predation (IGP), between various developmental stages of H. axyridis and C. undecimpunctata. Legend: Close arrow - significant asymmetry IGP; Dashed arrow - not significantly asymmetric IGP; Dashed line- symmetric IGP; Lack of arrows and lines- absence of IGP; C. undecimpunctata: in central position (χ^2, df=1, $P < 0.05$).

DISCUSSION

We characterized, under controlled conditions, the direction and symmetry of IGP between *H. axyridis* and *C. undecimpunctata*. Among all combinations tested, 19 of them were found to be significantly asymmetrical, with a 16 combinations having *H. axyridis* as the IG predator and only in 3 of them *C. undecimpunctata* was the IG predator. Those results are according with our previously prediction in which *H. axyridis* would be the aggressor (IG predator) and *C. undecimpunctata* the victim (IG prey) in most of the combinations among their developmental stages.

Eggs were the most vulnerable developmental stage. We think that ease capture, in consequence of immobility, is the main reason for their vulnerability. It seems, however, that pupae's immobility do not confers any disadvantaged in this biotic relation because they were almost invulnerable to IGP, the biggest body size, can contribute to its lower vulnerability.

Concerning the combinations between the larval stages, the differences size of IG predator and IG prey could determine the direction and symmetry.

In all combinations with adults versus either larval stages or eggs, adults took advantage, mainly *H. axyridis*. However IGP between adults did not occurs.

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