

Intraguild predation among different larval instars of *metasyrphus corollae* (f.) (diptera: syrphidae) and *exochomus nigromaculatus* (goeze) (coleoptera: coccinellidae)

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ABSTRACT

The interspecific interactions between different larval instars of two aphidophagous predator species, *M. corollae* and *E. nigromaculatus* were examined under laboratory conditions. Intraguild predation (IGP) between predators was studied in various larval densities of the predator and in the presence or absence of extraguild prey aphids after 24 hours. There was a highly significant difference of IGP at the different densities in the presence or absence of aphids between the 1st instar larvae of *M. corollae* by the 2nd instar larvae of *E. nigromaculatus* and when the 1st instar larvae of *M. corollae* was confined with the 3rd instar larvae of *E. nigromaculatus*. The highest IGP percentage by the 4th instar larvae of *E. nigromaculatus* against the 1st instar larvae of *M. corollae* was observed at the fifth level of density in the presence or absence of aphids. IGP on the 2nd instar larvae of *M. corollae* by the 2nd instar larvae of *E. nigromaculatus* differed significantly at the various densities in the absence of aphids, but no significant difference was found on IGP between them in the presence of aphids. The predation by the 3rd instar larvae of *E. nigromaculatus* against the 2nd instar larvae of *M. corollae* rose at both fourth and fifth levels of density in the presence of aphids. Meanwhile, in the absence of aphids, the highest level of IGP was obtained at the fourth level of density. IGP rate by the 4th instar larvae of *E. nigromaculatus* against the 2nd instar larvae of *M. corollae* differed significantly at the different densities in the presence or absence of aphids.

The influences of larval density and prey presence or absence on the incidence of intraguild predation among the two predator species were considered and the outcome of predatory interference between them is discussed.

INTRODUCTION

The predators feeding on aphids make up the aphidophagous predator guild. The predation among various life stages may take place between different species within a guild (Intraguild). Ladybeetles (Coleoptera: Coccinellidae) are very voracious and abundant in terms of numbers of species and individuals and are an important component of these guilds. It is suggested that intraguild predation is important in structuring these guilds (Yasuda and Shinya, 1997). It has a strong impact on the population dynamics of many beneficial and pest insect species. Strong effects on aphid

populations were observed when ever high levels of syrphid oviposition occur early and large numbers of larvae hatched before aphid populations achieved high growth rates (Tenhumberg and Poehling, 1995).

Intraguild predation (IGP) represents an extreme form of competition between species (Polis *et al.*, 1989). When an insect predator from a specific trophic level attacks another entomophagous arthropod from the same trophic level, and both species eat the same prey or fight each other, we can define this interaction as intraguild predation (Polis and Holt, 1992). In general, IGP is defined as the killing and eating of species that use similar, often limited, resources and thus are potential competitors (Polis *et al.*, 1989; Rosenheim, 2005).

Studies on intraguild predation have increased, especially with respect to the analysis of failures in biological control programs (Rosenheim *et al.*, 1995; Rosenheim, 2005). Direct and indirect interactions between predators are one of the most recently identified factors that determine the abundance and densities of predators (Janssen *et al.*, 1998). In many cases, intraguild predation was found to reduce the efficacy of biological control due to heterospecific competition between predator species. The likelihood of IGP increases if the predators belong to the same guild and share the same foraging habitat (Rosenheim *et al.*, 1995; Losey and Denno, 1999). Other factors that affect the occurrence of intraguild predation are relative body size, prey specificity, and mobility of predators, as well as the availability of extraguild prey (Sengonca and Frings, 1985; Polis *et al.*, 1989; Lucas *et al.*, 1998). Intraguild predation is particularly common when generalist predators belong to the guild (Lucas *et al.*, 1998). This is especially true for aphid antagonist guilds, which are rich in species of both generalist and specialist predators.

In this study, we investigated IGP between different larval instars of two aphidophagous predators, *M. corollae* and *E. nigromaculatus*. Interactions between predators were studied in various larval densities and in the presence or absence of the green aphid, *Myzus persicae* (Sulzer) as extraguild prey under laboratory conditions to determine the influence of predator larval density and prey presence or absence on the incidence of intraguild predation between them.

MATERIALS AND METHODS

Laboratory cultures were started with *E. nigromaculatus* and *M. corollae* which were collected from different plants infested with aphids at the experimental farm of Faculty of Agriculture, Mansoura University for the two predator species. Continuous laboratory cultures were established. Green peach aphids, *M. persicae* were offered to predators during their development except the adult stage of *M. corollae*.

The larvae in different instars of both predator species were combined to evaluate the interspecific interactions between them through six separated combinations. The 1st instar larvae of *M. corollae* was combined with the 2nd, 3rd and 4th instar larvae of *E. nigromaculatus*, and the 2nd instar

larvae of the first predator with the 2nd, 3rd and 4th instar larvae of the second one.

Different predator densities were tested in each combination, one, two, three, four and five larvae. To test the effect of extraguild prey availability, two treatments were examined for each combination. The first treatment was provided with sufficient number of aphids, *M. persicae* in surplus to predator consumption. While, the second did not receive any preys. Five replicates were observed for each combination for every treatment. After 24 hours, the number of preyed larvae was determined by counting the number of remaining and left over larvae to investigate IGP in the presence or absence of aphids. The experiment was conducted by using rearing unit (11x9x4.5 cm) under laboratory conditions at 28.0 ± 2.0 °C, 75.0 ± 5 % RH and photoperiod of 14L: 10D.

Data analysis:

The outcome IGP between larvae in different instars of both predator species, the effect of larval predator density and larval instars on IGP percentages in the presence or absence of aphids were subjected for one way analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test (Costat Software, 2004).

RESULTS AND DISCUSSION

After 24 hours, IGP on the 1st instar larvae of *M. corollae* by the 2nd instar larvae of *E. nigromaculatus* was determined. In the presence of aphids, at the first two levels of density, there was no predation by *E. nigromaculatus* against *M. corollae*. The highest IGP rate (44%) (2.2 ± 0.2) was obtained by *E. nigromaculatus* against *M. corollae* at the fifth level of density (5 larvae from *E. nigromaculatus* x 5 larvae from *M. corollae*) (Table 1). In the absence of aphids, IGP ranged from (50%) (1.0 ± 0.3) at the second level of density to (68%) (3.4 ± 0.24) at the fifth level. There was a highly significant difference of IGP at the different densities in the presence or absence of aphids (ANOVA, $F = 31.9$; $df = 4$; $P = 0.000$ in the presence of aphids and $F = 18.5$; $df = 4$; $P = 0.000$ in the absence of aphids).

When the 1st instar larvae of *M. corollae* was confined with the 3rd instar larvae of *E. nigromaculatus* in the presence of aphids, the highest IGP rate (56%) (2.8 ± 0.4) was achieved by *E. nigromaculatus* against *M. corollae* at the fifth level of density. Meanwhile, IGP was (80%) (4.0 ± 0.3) at the same level of density in the absence of aphids (Table 2). A highly significant difference of IGP was obtained at all different densities in the presence or absence of aphids, (ANOVA, $F = 17.06$; $df = 4$; $P = 0.000$ in the presence of aphids and $F = 23.35$; $df = 4$; $P = 0.000$ in the absence of aphids).

The highest IGP percentage by the 4th instar larvae of *E. nigromaculatus* against the 1st instar larvae of *M. corollae* was reported at the fifth level of density in the presence or absence of aphids. It was (64%) (3.2 ± 0.4) (Table 3) (ANOVA, $F = 14.7$; $df = 4$; $P = 0.000$) and (88%) (4.4 ± 0.4) (Table 3) (ANOVA, $F = 23.3$; $df = 4$; $P = 0.000$), respectively.

Table 1. Mean numbers of preyed larvae \pm SEM and IGP percentage between the 1st instar larvae of *M. corollae* and the 2nd instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae \pm SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.0 \pm 0.0c (0.0%)	-	0.6 \pm 0.24c (60.0%)	-
2	0.0 \pm 0.0c (0.0%)	-	1.0 \pm 0.3c (50.0%)	-
3	0.8 \pm 0.2b (26.66%)	-	1.6 \pm 0.24bc (53.33%)	-
4	1.4 \pm 0.24b (35.0%)	-	2.4 \pm 0.24ab (60.0%)	-
5	2.2 \pm 0.2a (44.0%)	-	3.4 \pm 0.24a (68.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

Table 2. Mean numbers of preyed larvae \pm SEM and IGP percentage between the 1st instar larvae of *M. corollae* and the 3rd instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae \pm SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.0 \pm 0.0d (0.0%)	-	0.6 \pm 0.24d (60.0%)	-
2	0.6 \pm 0.24cd (30.0%)	-	1.2 \pm 0.2cd (60.0%)	-
3	1.4 \pm 0.24bc (46.66%)	-	2.0 \pm 0.3bc (66.66%)	-
4	2.0 \pm 0.3ab (50.0%)	-	3.0 \pm 0.3ab (75.0%)	-
5	2.8 \pm 0.4a (56.0%)	-	4.0 \pm 0.3a (80.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

Table 3. Mean numbers of preyed larvae ± SEM and IGP percentage between the 1st instar larvae of *M. corollae* and the 4th instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae ±SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.4±0.24c (40.0%)	-	0.8±0.2d (80.0%)	-
2	1.0±0.3c (50.0%)	-	1.4±0.24cd (70.0%)	-
3	1.6±0.24bc (53.33%)	-	2.2±0.4bc (73.33%)	-
4	2.4±0.24ab (60.0%)	-	3.4±0.24ab (85.0%)	-
5	3.2±0.4a (64.0%)	-	4.4±0.4a (88.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

IGP on the 2nd instar larvae of *M. corollae* by the 2nd instar larvae of *E. nigromaculatus* differed significantly at the different densities in the absence of aphids after 24h (ANOVA, F= 8.2; df= 4; P= 0.0004), but no significant different was found on IGP between them in the presence of aphids (ANOVA, F= 2.6; df= 4; P= 0.071) (Table 4).

Table 4. Mean numbers of preyed larvae ± SEM and IGP percentage between the 2nd instar larvae of *M. corollae* and the 2nd instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae ±SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.0±0.0a (0.0%)	-	0.0±0.0 c (0.0%)	-
2	0.0±0.0a (0.0%)	-	0.4±0.24bc (20.0%)	-
3	0.4±0.24a (13.33%)	-	0.8±0.2abc (26.66%)	-
4	0.6±0.24a (15.0%)	-	1.2±0.2ab (30.0%)	-
5	0.6±0.24a (12.0%)	-	1.4±0.24a (28.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

In the first two levels of density, there was no predation by the 3rd instar larvae of *E. nigromaculatus* against the 2nd instar larvae of *M. corollae*. Meanwhile, the predation by *E. nigromaculatus* rose at both fourth and fifth levels of density. It was (20%) (0.8±0.2) and (20%) (1.0±0.3), respectively (ANOVA, F= 5.2; df= 4; P= 0.049) in the presence of aphids (Table 5). In the absence of aphids, the highest level of IGP after 24 h. by *E. nigromaculatus* against *M. corollae* was obtained at the fourth level of density (45%) (1.8 ± 0.2). Meanwhile, the lowest level of IGP was achieved at the second level of density (30%) (0.6±0.24) (ANOVA, F= 15; df= 4; P= 0.000) (Table 5).

Table 5. Mean numbers of preyed larvae ±SEM and IGP percentage between the 2nd instar larvae of *M. corollae* and the 3rd instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae ±SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.0±0.0b (0.0%)	-	0.4± 0.24c (40.0%)	-
2	0.0±0.0b (0.0%)	-	0.6±0.24c (30.0%)	-
3	0.4±0.24ab (13.33%)	-	1.0±0.00bc (33.33%)	-
4	0.8±0.2ab (20.0%)	-	1.8±0.2ab (45.0%)	-
5	1.0±0.3a (20.0%)	-	2.2±0.2a (44.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

IGP rate by the 4th instar larvae of *E. nigromaculatus* against the 2nd instar larvae of *M. corollae* differed significantly at the different densities in the presence or absence of aphids, (ANOVA, F= 10.18; df= 4; P= 0.0001 in the presence of aphids and F= 14.65; df= 4; P= 0.000 in the absence of aphids). After 24 h. IGP ranged from (0%) at the first level of density to (35%) (1.4 ± 0.24) at the fourth level in the presence of aphids (Table 6). Meanwhile, the highest level of IGP after 24 h. by *E. nigromaculatus* against *M. corollae* was obtained at the fifth level of density (64%) (3.2 ± 0.4). While, the lowest level of IGP was achieved at the first level of density (40%) (0.4 ± 0.24) in the absence of aphids (Table 6).

Results indicated that percentage of IGP on *M. corollae* larvae was increased particularly in the absence of extraguild prey. It was higher than percentage of *M. corollae* preyed larvae by *E. nigromaculatus* larvae in the presence of aphids. Yasuda and Shinya (1997) noted that prey abundance influenced the frequency of intraguild predation. The incidence of intraguild predation by aphidophagous ladybird larvae is affected by the relative

abundance of prey to larvae. The presence of aphids as extraguild prey significantly reduced the frequency of IGP, the total number of IGP events decreased by half in the presence of aphids (Hindayana *et al.* 2001). In the presence of aphids, IGP most likely was reduced because of the dilution effect, which increases the chances of survival for the competing predators (Taylor, 1984; Turchin and Kareiva, 1989; Lucas *et al.*, 1998). This estimation is incompatible with (Lucas *et al.*, 1998). The presence of extraguild prey could either increase or decrease the probability of IGP or could have no effect. Nutritional benefits gained by cannibalism and intraguild predation may increase population stability resilience, and decrease the probability of extinction (Schausberger and Croft, 2000).

It shown that higher percentages of IGP was observed on the 1st instar larvae of *M. corollae* compared with percentages of the 2nd instar larvae preyed by *E. nigromaculatus* larvae in the presence or absence of aphids. This findings are complete agreement with Hindayana *et al.* (2001) who mentioned that first instar larvae of *Episyrphus balteatus* de Geer (Diptera: Syrphidae) did not show defense or counterattack behavior in confrontations with other aphidophagous predators, L₂ and L₃ *E. balteatus* used oral secretions (slime) to defend themselves against the opponent or to attack it. Slime is used by syrphid larvae as a sticky salivary glue to capture prey and as a defensive secretion (Eisner, 1971). Defense mechanisms were less pronounced in sessile stages like eggs, L₁, and pupae. These developmental stages have few possibilities to defend themselves against a predator's attack (New, 1991). Eggs and younger larvae are more vulnerable to cannibalism by older larvae than vice versa (Agarwala and Dixon, 1992). Similarly, in intraguild predation, a small species is more likely to be the intraguild prey of a large species (Sengonca and Frings, 1985; Lucas *et al.*, 1998; Phoofole and Obrycki, 1998; Hindayana *et al.*, 2001).

In all combinations, IGP was by *E. nigromaculatus* larvae (IG predator) against larvae of *M. corollae* (IG prey) but not the reverse. Similar results were reported by Hindayana *et al.* (2001) who reported that counterattacks by *E. balteatus* were seldom observed, in those cases where *E. balteatus* larvae behaved as IG predator, a large proportion of *C. septempunctata* larvae survived an aggression, i.e., were not consumed by *E. balteatus*.

IGP rates indicated that *E. nigromaculatus* larvae in its four instars are the most voracious and aggressive in all experiment combinations. The relative size of predators in interspecific interactions determined the outcome of the interaction, with larger individuals behaving as IG predators and smaller individuals becoming IG prey (Sengonca and Frings, 1985; Polis *et al.*, 1989; Lucas *et al.*, 1998; Snyder and Wise, 1999). Large individuals are able to fight longer than small individuals because of proportionally larger energy reserves (Peters, 1983; Griffiths, 1991). In addition, they have larger mandibles (Griffiths, 1992). So, they could usually overcome the adversary.

In general, the outcome of intraguild predation depends on the relative size and/or developmental stage of the prey and predator, the availability of extraguild prey and the behavior of both IG predator and IG prey in each other interactions. Results here demonstrated that IGP were

strongly density dependent and may contribute to population regulation of certain predators.

Table 6. Mean numbers of preyed larvae \pm SEM and IGP percentage between the 2nd instar larvae of *M. corollae* and the 4th instar larvae of *E. nigromaculatus* confined together at different predator densities with the presence or absence of extraguild prey aphids, *M. percicae* under laboratory conditions after 24h.

Density	Mean numbers of preyed larvae \pm SEM and IGP %			
	With aphids		Without aphids	
	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>	By <i>E. nigromaculatus</i> against <i>M. corollae</i>	By <i>M. corollae</i> against <i>E. nigromaculatus</i>
1	0.0 \pm 0.0b (0.0%)	-	0.4 \pm 0.24d (40.0%)	-
2	0.4 \pm 0.24b (20.0%)	-	1.0 \pm 0.00cd (50.0%)	-
3	0.8 \pm 0.2ab (26.66%)	-	1.6 \pm 0.24bc (53.55%)	-
4	1.4 \pm 0.24a (35.0%)	-	2.2 \pm 0.4ab (55.0%)	-
5	1.6 \pm 0.24a (32.0%)	-	3.2 \pm 0.4a (64.0%)	-

^a Means followed by the same letter in a column of different densities are not significantly different at the 1% level of probability (Duncan's Multiple Range Test).

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الإفتراس بين الأعمار اليرقية المختلفة لكل من *Metasyrphus corollae* ،
Exochomus nigromaculatus تحت الظروف المعملية
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تم دراسة إفتراس يرقات العمر الثاني ، الثالث و الرابع لأبو العيد *E. nigromaculatus* على يرقات كل من العمر الأول و الثاني من ذبابة السيرفس *M. corollae* في الكثافات المختلفة لكلا المفترسين و في حالتى وجود أو عدم وجود فريسة من الخوخ الأخضر تحت الظروف المعملية. أوضحت النتائج بعد ٢٤ ساعة أن هناك فرقاً معنوياً بين كثافة الأعمار اليرقية للمفترسين وبين نسبة إفتراس اليرقات IGP وذلك في وجود أو عدم وجود المن. أشارت النتائج إلى وجود فروق عالية المعنوية بين كثافة الأعمار اليرقية للمفترسين وبين نسبة إفتراس اليرقات IGP في وجود أو عدم وجود المن عند تواجد يرقات العمر الأول لذبابة السيرفس مع يرقات العمر الثاني لأبو العيد. كذلك عند تواجد يرقات العمر الأول لذبابة السيرفس مع يرقات العمر الثالث لأبو العيد. كما بينت النتائج أن أعلى معدل إفتراس IGP ليرقات العمر الأول من ذبابة السيرفس بواسطة يرقات العمر الرابع لأبو العيد كان عند تواجد خمس يرقات من النوعين معاً وذلك في وجود أو عدم وجود المن. أما عند تواجد يرقات العمر الثاني لذبابة السيرفس مع يرقات العمر الثاني لأبو العيد ، أوضحت النتائج وجود فروق معنوية بين كثافة الأعمار اليرقية للمفترسين وبين نسبة إفتراس اليرقات IGP وذلك في عدم وجود المن. أما في تواجد المن أظهرت النتائج عدم وجود فروق معنوية بينهم . أما عند تواجد يرقات العمر الثاني لذبابة السيرفس مع يرقات العمر الثالث لأبو العيد ارتفعت نسبة إفتراس IGP ليرقات العمر الثاني من ذبابة السيرفس بواسطة يرقات العمر الثالث لأبو العيد في كلا من الكثافتين الرابعة والخامسة لليرقات وذلك في وجود المن، بينما كان أعلى معدل إفتراس IGP ليرقات العمر الثاني من ذبابة السيرفس بواسطة يرقات العمر الثالث لأبو العيد في عدم وجود المن عند تواجد أربع يرقات من النوعين معاً. كما أظهرت النتائج وجود فروق معنوية في معدل إفتراس IGP ليرقات العمر الرابع لأبو العيد ليرقات العمر الثاني من ذبابة السيرفس بين مختلف كثافات الأعمار اليرقية للمفترسين في وجود أو عدم وجود المن. ومن هذه الدراسة يمكن أن نستنتج أن الإفتراس بين الأنواع يعتبر من العوامل المتوقعة على الكثافة حيث يؤثر كل مفترس على الآخر تأثيراً سلبياً مما يؤثر على مستوى المكافحة الحيوية المطلوب . أيضاً إتضح من الدراسة أن تواجد الفريسة الطبيعية، حجم أو طور النمو إلى جانب سلوك المفترسات تؤثر على نتائج الإفتراس بين الأنواع المختلفة.

قام بتحكيم البحث

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