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Interspecific interactions modulate the consumption rate of ladybird beetle

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ABSTRACT

Organisms living within an ecological community interact directly or indirectly at inter or intraspecific levels for food, habitat as well as reproduction. Henceforth, a laboratory study was designed to assess the interspecific interaction between the parthenium beetles and the ladybird beetles. It was hypothesized that the interspecific interaction between these two beetles belonging to different ecological niche would not affect the consumption of ladybird beetle. However, it was found that the prey consumption rate of *M. sexmaculatus* was significantly affected by the physical presence of *Z. bicolorata*.

Key words : *Interspecific interaction, Consumption rate, Z. bicolorata, M. sexmaculatus.*

Introduction

Plants interact with numerous organisms, in which the insects are the most important visitors that show different kinds of interactions which may be positive or negative. Under the positive insect-plant interactions, insects play an essential role in the protection, fertilization or dispersal of plants, while plants may provide food or a nesting source for insects. Thus, plants interact directly or indirectly with insect species belonging to various communities such as pollinators, phytophagous, predators and parasitoid insects. Among these, the foremost interaction of plants occurs with phytophagous insects (Thompson, 2005).

Phytophagous insects alter the phenotype of their host (Dicke and Baldwin, 2010), which in turn affects the interaction of the host plant with the other insect visitors (Ohgushi, 2008). These interactions may involve individuals of different trophic levels, known as inter-trophic interactions (Ohgushi, 2005). There are many interspecific interactions between the different insect communities participating in such inter-trophic interactions during their foraging behavior. In which, ladybirds (Coleoptera: Coccinellidae) are good friends of humans as they feed on pests such as aphids and scale insects, hence known as a biocontrol agent.

In nature, ladybird beetles interact with various insect species while foraging on different plant species for aphids. Out of all the coccinellid predators, it has been noticed that *Menochilus sexmaculatus* (Fabricius) is the dominant species of ladybirds which visits about 11 different host plant species for the aphids (Kumar *et al*., 2017). Amongst them, *P. hysterophorus* is an invasive and noxious weed which is commonly called as carrot grass and is infested by various aphid species like *Aphis craccivora* (Koch), *Aphis gossypii* (Glover) and *Aphis fabae* (Scopoli). Consequently, the coccinellid predator, *Menochilus sexmaculatus* also visit the weed for their food (Kumar *et al.,* 2017). On the other hand, *Zygogramma bicolorata* Pallister is a host-specific biocontrol agent for the weed *P. hysterophorus.* Thus, *M. sexmaculatus*

and *Z. bicolorata* naturally engage in a heterospecific relationship while foraging for their food.

During foraging, ladybirds release some volatile hydrocarbon tracks by their footprints to avoid areas they have already explored. Numerous studies on semiochemical tracks of both larvae and adults of ladybird beetles have been performed at the conspecific level (Mishra *et al.,* 2012a; Martini *et al.,* 2013). However, there is a lack of information regarding the effect of heterospecific tracks on the predatory attributes of ladybird beetles. Thus, the present study is an attempt to answer whether the physical presence of *Z. bicolorata* on *P. hysterophorus* would influence the foraging behavior of coccinellid beetles. For this, the consumption rate of larvae and adults of *M. sexmaculatus* was assessed in the physical presence of 3rd instar larvae and adults of *Z. bicolorata.* So, we hypothesized that due to differential feeding habits and dissimilar ecological niches, the physical presence of *Z. bicolorata* would not affect the predation rate of *M. sexmaculatus*.

Materials and Methods

To achieve the goal, adult males and females of *Z. bicolorata* and *M. sexmaculatus* were collected from the agricultural areas near Indira Gandhi National Tribal University, Amarkantak, (22° 40′ N, 81° 45′ E), India and paired randomly in plastic Petri dishes (height 13.7±1.0 mm and diameter 91.5±1.0 mm) under constant abiotic laboratory conditions (24.5±2 ^{0}C, RH 65±5% with 14L: 10D h) in a BOD incubator (Remi CHM-16 Plus). The adults of *M. sexmaculatus* were reared on a daily-replenished supply of aphid, *Aphis craccivora*, which were collected from *P. hysterophorus* grown in the agricultural fields and the parthenium beetles were fed with fresh *P. hysterophorus* leaves. Eggs laid by the females were collected every 24 h and observed for hatching. After hatching, larvae were reared individually under similar abiotic conditions and food as their respective parents. 4th instar larvae of *Z. bicolorata* were kept in 500 ml glass beakers containing moist sand for the pupation. After 10-11 days, the adult *Z. bicolorata* emerged from beakers were kept individually in fresh Petri dishes. Adults and larvae of both species were used for further experimentation.

The experiment was divided into four setups. In the first setup, a male of *M. sexmaculatus* was kept in four experimental combinations along with a) two adults, b) five adults, c) two 3rd instar and d) five 3rd instar larvae of *Z. bicolorata*. All these experimental setups were kept in plastic Petri dishes along with the 15 mg of aphids on *P. hysterophorus* leaves and then placed in a BOD incubator for 24 h. Thereafter, the aphids that remained in Petri dishes were weighed with the help of a digital weighing balance (Aczet digital weighing balance). Based on the recorded data, the prey consumption rate was calculated with the help of the following formula (Patel *et al.,* 2019).

$$\text{Consumption rate} = \frac{\text{Prey biomass consumed (mg)}}{\text{Feeding duration (days)}}$$

A similar experiment was conducted for the remaining three experimental setups for female, 2nd instar, and 4th instar of *M. sexmaculatus* (Figure 1). Each experimental treatment was performed in 10 replicates. However, in control setups, adult males/ adult females/2nd instars/4th instars of *M. sexmaculatus* were individually allowed to feed on 15 mg aphids that were not exposed to 3rd instar larvae and adults of *Z. bicolorata* and calculated the consumption rate.

All the consumption rate data were tested for normality by applying Kolmogorov-Smirnov's test, which revealed that there was a normal distribution. The heterogeneity of data variance was checked with the help of Bartlett's test, which revealed that there were homogenous variances. Consumption rates were subjected to one-way ANOVA which was followed by Tukey's post hoc honest test of significance at a 5 % level. All statistical analyses were performed using MINITAB-16 as statistical software (Minitab Inc., State College, Pennsylvania, USA).

Results and Discussion

Results showed that the prey consumption rate of adult males (F= 18.85; df = 39,1; P= 0.000; Figure 2: a) and females (F = 4.23; df = 39,1; P= 0.012; Figure 2: b) of *M. sexmaculatus* were significantly affected by the physical presence of larvae and adults of *Z. bicolorata*. However, values of comparison of mean showed that the consumption rate of the male and female of *M. sexmaculatus* in the physical presence of two 3rd instar larvae of *Z. bicolorata* was significantly decreased. Furthermore, the statistical analysis also affirmed that the consumption rate of 2nd instar (F= 4.20; df = 39,1; P= 0.012; Figure 2:c) and 4th instar (F= 18.45; df= 39, 1; P= 0.000; Figure 2:d) of *M.*

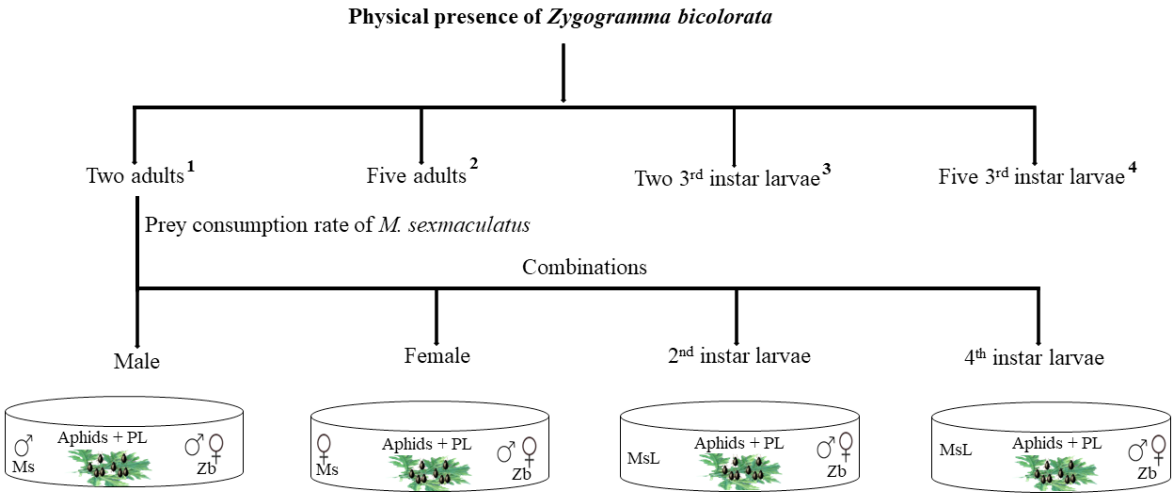

Fig. 1. Experimental setup

Abbreviations- Ms: *M. sexmaculatus*; Zb: *Z. bicolorata*; MsL: *M. sexmaculatus* larvae; PL: *P. hysterophorus* leaf. In 2, 3 and 4- similar experimental treatments were given as 1.

sexmaculatus were significantly influenced by the physical presence of larvae and adults of *Z. bicolorata*. Additionally, the value of consumption rate of 4th instar of *M. sexmaculatus* significantly decreased in the physical presence of 5 adults of *Z. bicolorata*.

The results indicate that the physical presence of *Z. bicolorata* significantly affects the prey consumption rate of *M. sexmaculatus*. It may be due to a fact that parthenium beetles are dietary specialists, as they are host-specific towards *P. hysterophorus*, whereas aphids consume multiple hosts. In view of this, the physiological efficiency hypothesis predicts that specialist feeders will be superior over the gen-

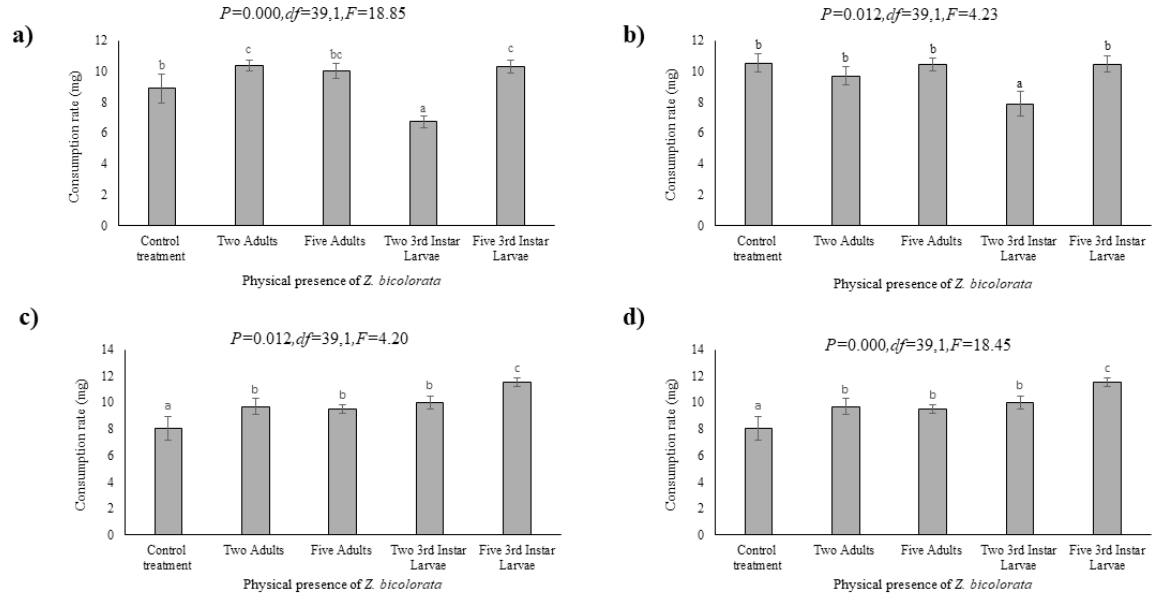

Fig. 2. Effect of physical presence of *Z. bicolorata* on prey consumption rate of a) male *M. sexmaculatus*; b) female *M. sexmaculatus*; c) 2nd instar larvae of *M. sexmaculatus*; d) 4th instar larvae of *M. sexmaculatus*

eralists on a shared host as they are physiologically adapted to that host (Singer, 2001). So, the parthenium beetles being specially adapted to the weed will be superior over aphids which are generalized feeders. Thus, the predation of ladybird beetles may also be significantly affected by the physical presence of *Z. bicolorata*.

Further results show that the consumption rate of adults of *M. sexmaculatus* comparatively decreased in the physical presence of two 3rd instar larvae of *Z. bicolorata* than the other experimental conditions. This might be because of minimum intraspecific competition compared to interspecific competition within and between the species respectively, as a result of which larvae of the parthenium beetle may have been entangled more in heterospecific rather than the conspecific interaction. Hence, the interference is maximum as compared with the other treatments.

On the other side, in the case of the 2nd instar and 4th instar of *M. sexmaculatus,* interspecific competition also shows a significant effect on the consumption rate. In fact, in the case of 2nd instar larvae, the consumption rate significantly increased in all the experimental treatments. This significant increase may have happened because of their vulnerability compared to the parthenium beetle. However, in the case of the 4th instar, persuasion of consumption rate was not like the 2nd instar as they are voracious feeders and thus are larger in size than the 2nd instar (Kumar *et al*., 2014).

In conclusion, the heterospecific interaction between the ladybird and parthenium beetle affects the prey consumption rate of the ladybird, *M. sexmaculatus*. Such behavior modulates their consumption rate but may protect them from natural enemies (Patel *et al.,* 2019). Overall, it can also be concluded from the present study that the ladybird beetle, *M. sexmaculatus,* is engaging in an interspecific interaction with the different stages of the parthenium beetle, *Z. bicolorata.* However, future studies could be targeted towards the developmental and reproductive attributes of the ladybird beetle in the physical presence as well as semiochemical footprints of *Z. bicolorata*.

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Conflict of Interest

It is certified that all the authors have contributed significantly, agree with the manuscript's content, and have no conflicts of interest.

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