

Influence of phytophagous behaviour on prey consumption by *Macrolophus pygmaeus*

D. Maselou¹, D. Perdikis² A. Fantinou¹

¹Laboratory of Ecology and Environmental Sciences, Agricultural University of Athens, Iera Odos 75, 118 55, Athens, Greece; ²Laboratory of Agricultural Zoology and Entomology, Agricultural University of Athens, Iera Odos 75, 118 55, Athens, Greece

Abstract: Omnivorous Heteroptera constitute an important component of predatory guilds with high potential for biological control. Understanding the relative effects of plant feeding on the suppression of prey by omnivores could be an important element for improving biological control strategies. In the current paper, the effects of different plant food sources on the predation rate of the omnivorous predator *Macrolophus pygmaeus* (Hemiptera: Miridae) were examined. In all the experiments, second instar nymphs of the aphid *Myzus persicae* (Homoptera: Aphididae) were used as prey at different densities. First, we evaluated the rate at which the predator preyed on *M. persicae* at various prey densities on pepper and eggplant leaves. Then, using eggplant flowers or pollen as additional food sources, we estimated predator efficiency for three different prey densities. The predation rate was not affected by the type of plant leaf used. However, the results showed that the predation rate of *M. pygmaeus* was significantly reduced when flowers or pollen were provided at high prey densities. The importance of these results in understanding the influence of phytophagy on predation rates of omnivorous predators is discussed.

Key words: *Macrolophus pygmaeus*, predator, phytophagy, pollen, flower

Introduction

Omnivory is the consumption of resources from more than one trophic level and is a frequent feeding strategy in terrestrial plant-inhabiting arthropod communities (Coll & Guershon, 2002). Most predators and parasitoids feed on plant-provided food (nectar, pollen) or engage in herbivory during at least part of their life cycle. Miridae (Heteroptera) are a family with very diverse feeding habits that include phytophagous, omnivorous and strictly predator species (Wheeler, 2001). Some predatory mirids are also considered to be the main natural enemies of several arthropod pests in managed and natural ecosystems (Perdikis *et al.*, 2011).

The omnivorous predator *Macrolophus pygmaeus* (Hemiptera: Miridae) is a major native natural enemy of several pests that seriously damage tomato and other vegetable crops and commonly colonize vegetable crops in both greenhouses and open fields in Mediterranean countries (Albajes & Alomar, 1999; Lykouressis *et al.*, 1999-2000). This predator can also successfully develop without prey and lays eggs when feeding on plants (Hansen *et al.*, 1999; Perdikis & Lykouressis 2000, 2002, 2004). Studies have also proved that *M. pygmaeus* nymphs can successfully reach adulthood when fed exclusively on bee pollen (Perdikis & Lykouressis, 2000) and on stamens cut from fully blooming flowers of the weed *Echallium elaterium* (Cucurbitaceae), without any other plant or prey material and with only a water source (moistened cotton) (Perdikis & Lykouressis, 2000). Perdikis & Lykouressis (2000) reported that when bee pollen pellets were added to a diet of eggplant leaves, the developmental period of *M. pygmaeus* was significantly shortened and completed within a period similar to when it was fed on eggplant leaves with the aphid prey *Myzus persicae*.

Furthermore, pollen supported the development and fecundity of *M. pygmaeus* (Maleki *et al.*, 2006). Plant feeding by mirid predators has been reported to be more intense in cases of prey shortage (Castañé *et al.*, 2011). It has also been proven that foraging on low-quality plant food sources resulted in increased prey consumption (Eubanks & Denno, 2000) and vice versa (Robinson *et al.*, 2008). The searching behaviour and feeding rate of a foraging predator can also be affected by the physical characteristics of plants, such as the density of trichomes on their leaf surfaces (De Clercq *et al.*, 2000). According to Perdikis *et al.* (1999), the predation rates of *M. pygmaeus* were affected by the host plant being higher in lower quality plant food (pepper in comparison to eggplant leaves), but only at the highest temperature tested (30°C).

Although pollnivory can support the efficient development and/or reproduction of *M. pygmaeus* (Perdikis & Lykouressis, 2000), the influence of plant-provided foods on the rate at which this predator consumes its prey has not been explored. These data are essential for estimating the efficacy of omnivorous predators as biological control agents and would help to further our knowledge of the predator's behaviour. To investigate this issue, we exposed *Myzus persicae*, as prey, to the predator and investigated whether its impact was influenced by plant species and/or the presence of plant-provided food. We addressed two specific questions: 1) Did plant species have any effect on the predation rate? 2) Did the presence of an alternative food source, such as plant pollen or flowers, influence the results obtained? First, we tested the response of *M. pygmaeus* to prey density on the leaves of two plant species. Then, we used three different prey densities, simulating conditions of limited to high prey availability, in a plant species to test the influence of plant-provided food on prey consumption by the predator.

Material and methods

The experiments took place in plastic Petri dishes (Ø 9cm, 1.5cm height) with a mesh-covered hole in the lid (Ø 3cm) to reduce the accumulation of humidity. A leaf from one of either plant: sweet pepper (cv. Vidi) or eggplant (cv. Bonika F1), was placed on its abaxial surface on top of a layer of cotton wool moistened with water. 5th instar nymphs of *M. pygmaeus* were used in all the experiments. These were obtained from 1st or 2nd instar nymphs that were transferred from potted caged egg or pepper plants together with eggs of *Ephestia kuehniella* that were kept in wooden framed rearing cages at 25°C, 65 ± 5% RH and with 16 hours of light per day. To exclude the effects of variable hunger levels, all the predators were caged on plants that were clean of prey and kept under the same conditions for 24 h prior to their use in the experiments. Each caged plant species was covered with a plastic cylindrical cage (Ø 11cm, height 30cm) with two rectangular openings (9 x 9cm), covered with fine muslin to allow ventilation.

In the first experiment, one 5th instar *M. pygmaeus* nymph was introduced into each dish, with aphids at different densities, and its predation rate was recorded after a period of 24h. 2nd instar *M. persicae* nymphs were used as prey in all the experiments and gently placed and evenly distributed on each leaf. The prey densities used were: 2, 4, 8, 16, 20, 24 and 32 prey items per dish and 10 replicates were made at each prey density level used.

In a second experiment, one flower at full bloom or a significant amount of pollen was introduced into each dish in addition to the leaf with the aphids. These flowers and the pollen were collected from mature plants grown as previously described. In these treatments, the same methodology was used as described in the experiment in which predation rates were recorded on different leaves; the prey densities selected were: 4, 12 and 24 aphids per leaf. These prey densities were selected based on results from a previous study which had shown

that predator saturation occurred at a prey density of almost 24 items when 2nd instar *M. persicae* nymphs were used as prey (Fantinou *et al.*, 2008).

Data on the predation rate were analyzed using a 2 way-ANOVA with the plant species (eggplant vs. pepper) and prey density as factors. Analyses were conducted using log-transformed data. Comparisons among means were performed using the Tukey-Kramer HSD. Analyses were conducted with the JMP statistical package (v. 8 SAS Institute, 2008).

Results and discussion

On both plants the rate of prey consumption by the predator increased as prey density increased (Figure 1). However, aphid mortality eventually declined due to predation, with this starting when prey density was greater than 20 items per leaf. Although the same general pattern of prey consumption was recorded, the predation rate seemed to level off earlier on pepper plants than on eggplants, but no significant differences were found ($F = 1.1558$; $P = 0.2841$). The predation rate was, however, significantly affected by prey density ($F = 130.368$; $P < 0.0001$). According to Perdakis *et al.* (1999), the predator may be able to locate and consume its prey more easily on pepper plants because their leaves are less hairy than those of egg-plants.

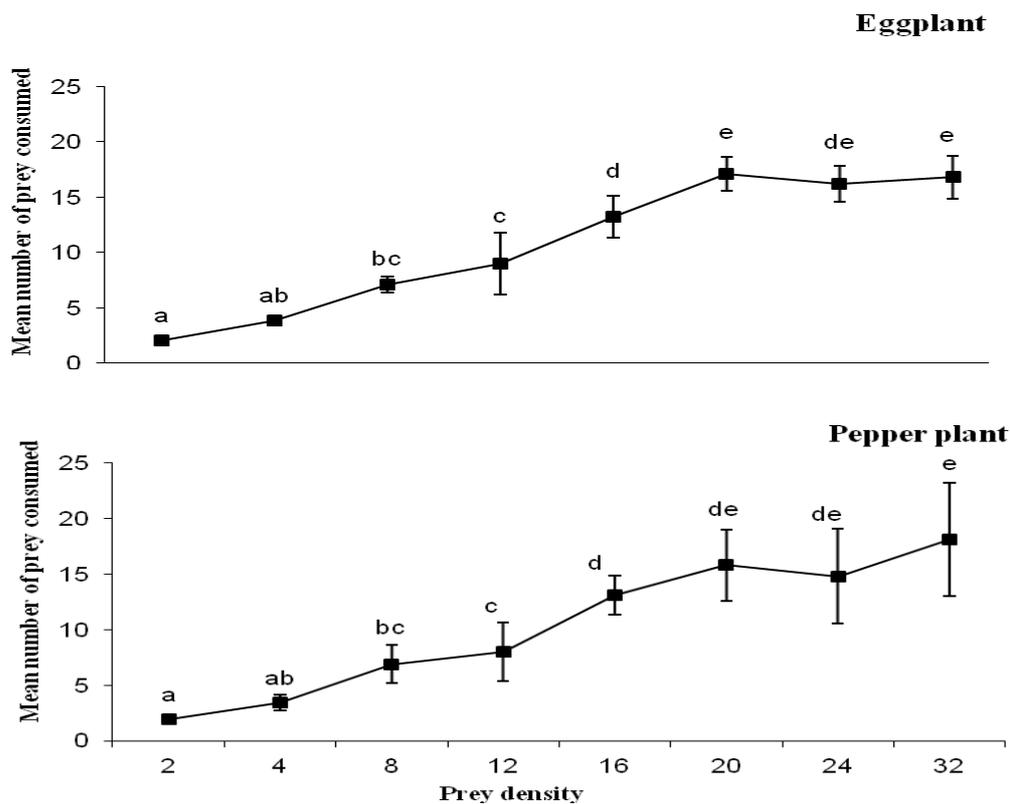


Figure 1: Predation rate of *Macrolophus pygmaeus* on 2nd instar nymphs of *Myzus persicae* on either an eggplant or pepper plant leaf.

Many arthropod predators may rely on plant-provided alternative food sources such as pollen or nectar, the availability of which is unlikely to be influenced by predator consumption (Eubanks & Denno, 2000). According to the results presented here, *M. pygmaeus* did not reject aphids in favour of pollen or flowers when they were present. However, we found that the predation rate was significantly affected when the predator was offered an eggplant flower or pollen in addition to the prey at the highest prey density ($F = 9.9938$, $P = 0.0001$). The pollen and flowers had no effect on prey consumption at prey densities of 4 and 12, but, at the prey density of 24 aphids, significantly fewer prey items were consumed in the presence of either pollen or flowers (Table 1). The reduced predation rates of *M. pygmaeus* observed in the presence of an alternative food source would therefore seem to indicate pollen or flower utilization by the predator. This result suggests that flowers and aphids are partially substitutable in the *M. pygmaeus* diet. However, this behaviour only occurred at high prey densities, perhaps indicating that there may be a limit beyond which prey consumption can be replaced by feeding on plant material. It has been reported though that when prey density drops below a certain threshold, optimally foraging predators aiming to reach satiation may switch to alternative food, either by including this food in their diets or by moving to the alternative food source (van Baalen *et al.*, 2001). Although the reduced prey consumption observed when a flower was added to the experimental arena was only recorded in a period of 24h, this may be attributed to the spatial complexity that may reduce the time available for prey searching and feeding by the foraging predator (Hoddle, 2003).

Table 1. Predation rate of *Macrolophus pygmaeus* on 2nd instar nymphs of *Myzus persicae* with eggplant leaf or leaf supplemented with flower or pollen.

Prey density offered	Predation rate (Mean± SE)					
	Eggplant leaf		Eggplant leaf & flower		Eggplant leaf & pollen	
4	3.80 ± 0.42	Aa	3.40 ± 0.84	Aa	3.80 ± 0.42	Aa
12	9.00 ± 2.78	Ab	8.10 ± 2.85	Ab	8.10 ± 2.56	Ab
24	16.20 ± 1.61	Ac	9.80 ± 2.62	Bb	11.30 ± 3.92	Bb

Means within the same column followed by the same lower case letter and in the same row by the same upper case letter are not significantly different (Tukey–Kramer HSD test, $\alpha = 0.05$).

The results of the present study revealed that the predatory efficiency of *M. pygmaeus* declined in the presence of alternative plant resources. It has been reported that this predator can survive and reproduce at different rates depending on the plant substrate available and without feeding on prey (Perdikis & Lykouressis, 2004). The relative importance of alternative food recourses on the ability of the predator to control herbivore pests should therefore be explored further.

Acknowledgements

This project was co-funded by the European Union - European Social Fund (ESF) & National Sources, within the framework of the “HRAKLEITOS II” programme of the “Operational Programme for Education and Life Long Learning” of the Hellenic Ministry of Education, Life Long Learning and religious affairs.

References

- Albajes, R. & Alomar, O. 1999: Current and potential use of polyphagous predators. In: Integrated Pest and Disease Management in Greenhouse Crops, eds. Albajes, Gullino, van Lenteren and Elad: 265-275.
- Castañé, C., Arnó, J., Gabarra, R. & Alomar, O. 2011: Plant damage to vegetable crops by zoophytophagous mirid predators. *Biol. Control* 59: 22-29.
- Coll, M & Guershon, M. 2002: Omnivory in terrestrial arthropods: mixing plant and prey diets. *Ann. Rev. Entomol.* 47: 267-297.
- De Clercq, P., Mohaghegh, J. & Tirry, L. 2000: Effect of host plant on the functional response of the predator *Podisus nigrispinus* (Heteroptera: Pentatomidae). *Biol. Control* 18: 65-70.
- Eubanks, M. D & Denno, R. F. 2000: Host plants mediate omnivore-herbivore interactions and influence prey suppression. *Ecology* 81: 936-947.
- Fantinou, A., Perdikis, D., Maselou, D. & Labropoulos, P. 2008: Prey killing without consumption: does predator show adaptive foraging behavior *Biol. Control* 47: 187-193.
- Hansen, D. L., Brødsgaard, H. F. & Enkegaard, A. 1999: Life table characteristics of *Macrolophus caliginosus* preying upon *Tetranychus urticae*. *Entomologia Experimentalis et Applicata* 93: 269-275.
- Hoddle, M. S., 2003: The effect of prey species and environmental complexity on the functional response of *Franklinothrips orizabensis*: a test of the fractal foraging model. *Ecol. Entomol.* 28, 309-318.
- Lykouressis, D. P., Perdikis, D. Ch. & Chalkia, Ch. A. 1999-2000: The effects of natural enemies on aphid populations on processing tomato. *Entomol. Hellenica* 13: 35-42.
- Maleki, F., Ashouri, A., Mohaghegh, J. & Bandani, A. 2006: Effects of some diets on *Macrolophus pygmaeus* Rambur (Hemiptera: Miridae) fitness under laboratory conditions. *Commun. Appl. Biol. Sci. Ghent University* 71: 393-397.
- Perdikis, D. Ch., Lykouressis, D. P. & Economou, L. P. 1999: The influence of temperature, photoperiod and plant type on the predation rate of *Macrolophus pygmaeus* on *Myzus persicae*. *BioControl* 44: 281-289.
- Perdikis D. & Lykouressis, D. 2000: Effects of various items, host plant and temperature on the development and survival of *Macrolophus pygmaeus* (Rambur) (Hemiptera: Miridae). *Biol. Control* 17: 55-60.
- Perdikis, D. Ch. & Lykouressis, D. P. 2002: Life table and biological characteristics of *Macrolophus pygmaeus* when feeding on *Myzus persicae* and *Trialeurodes vaporariorum*. *Entomol. Exp. Appl.* 102: 261-272.
- Perdikis, D. & Lykouressis, D. 2004: *Macrolophus pygmaeus* (Hemiptera: Miridae) population parameters and biological characteristics when feeding on eggplant and tomato without prey. *J. Econ. Entomol.* 97: 1291-1298.
- Perdikis, D., Fantinou, A. & Lykouressis, D. 2011: Enhancing pest control in annual crops by conservation of predatory Heteroptera. *Biol. Control* 59: 13-21.
- Robinson, K. A., Jonsson, M., Wratten, S. D., Wade, M. R. & Buckley, H. L., 2008: Implications of floral resources for predation by an omnivorous lacewing. *Bas. Appl. Ecol.* 9: 172-181.
- SAS Institute 2008: JMP version 8. Cary (NC). SAS Institute Inc.
- Van Baalen, M., Kivan, V., Van Rijn, P. C. J. & Sabelis, M. W. 2001: Alternative food, switching predators and the persistence of predator prey systems. *The Am. Nat.* 157: 513-524.
- Wheeler, A. G. Jr. 2001: Biology of plant bugs (Hemiptera. Miridae): Pest predators opportunists. Cornell University Press, Ithaca, N.Y.

