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Complex of Aphidophagous Predators of Mealy Plum Aphid *Hyalopterus pruni* Geoffr. and Their Efficiency in Pest Control †

Igor Shevchuk [1,*] and Olga Shevchuk [2]

[1] Sector of Plant Protection, Institute of Horticulture of National Academy of Agrarian Sciences of Ukraine, Sadova Str., 23, 03027 Novosilky, Kyiv, Ukraine
[2] Laboratory of Phytopathology, Institute of Plant Protection of National Academy of Agrarian Sciences of Ukraine, Vasylkivska st., 33, 03022 City, Kyiv, Ukraine; shevchukolv@gmail.com
* Correspondence: shevig@ukr.net
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Abstract: Aphids are the dominant pests in the complex of harmful fauna of stone fruits in Ukraine; in addition to fruit-damaging species. In plum orchards mealy plum aphid *Hyalopterus pruni* Geoffr. (Hemiptera: Aphidinae) cause serious economic damage. Insect predators have an important role in the regulation of agricultural pests. Our goal was to determine the role of predation in the dynamics of mealy plum aphid population. Investigations were carried out in period of mass development of mealy plum aphid in the experimental plum orchard garden of the Institute of Horticulture of Ukrainian Academy of Agrarian Sciences of Ukraine. For this purpose, model trees were selected and isolators were installed on 4 branches of each tree with aphid-infested leaves. Different species of entomophagous were placed in isolators and assessments were performed on daily basis. According to our observations, *Adalia bipunctata* L., *A. decempunctata* L., *Syrphus ribesii* L., *S. balteatus* Deg, *Chrysopa perla* L., *Ch. carnea* Steph. dominate among aphidophagous predators. *Coccinella septempunctata* L., *Calvia quatuordecimguttata* L., *Propylaea quatuordecimpunctata* L. were less common. *Syrphus* and *Chrysopa* larvae have the highest predation activity. The influence of weather conditions on the efficiency of aphidophagous predators was analyzed. Optimal conditions for *A. bipunctata, A. decempunctata, S. ribesii, S. balteatus, Ch. perla, Ch. carnea* during June-July were as follows: mean daily temperature −17–20 °C, precipitation 0.1–1.5 mm and relative air humidity 57–67%. The threshold ratios of dominant aphidophagous predators to aphids were determined. High predation activity of *Syrphus* and *Chrysopa* larvae and coccinellids indicates that the ratio of entomophages to aphids must be taken into account when making decision about control measures

Keywords: plum; mealy plum aphid; entomophages; predation activity; threshold ratio

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1. Introduction

Mealy plum aphid *Hyalopterus pruni* Geoffr. is an important pest of stone fruits [1]. In Ukraine it is one of the dominated species in plum orchards. It reproduces en masse, both in nurseries and in young and fruitful orchards. They concentrate on the leaves, fruits and shoots, sucking their juice, which causes severe deformation, oppression, weakening of fruit trees. Harmfulness of aphids is also manifested in reduced yields and frost resistance of plantations. This pest can cause death of trees [2,3].

An important role in the regulation of aphid numbers is played by aphidophages. Ladybugs against aphids are used around the world [4,5]. Also, one of the main regulators of aphid population density is considered to be the syrphid larvae [6]. A promising way to develop a biological method is to study their efficiency.

Understanding the relationship in the plant-aphid-predator (parasite) system is necessary to improve the integrated pest management program for fruit crops [7].

The goal of this study was to determine the species composition, daily amount of forage resources eaten by natural aphid entomophages and establish criteria for their efficiency.

2. Materials and Methods

The trophic activity of natural regulators (both in the imaginal and larval stages) of leaf aphids was studied in the experimental garden of the Institute of Horticulture of National Academy of Agrarian Sciences of Ukraine. Determination of the amount of aphids eaten by entomophages was carried out in July (the period of mass development of mealy plum aphid). For this purpose, 5 model plum trees for each entomophage were selected. Isolators were installed on 4 branches of each tree, on which aphid-infested leaves were found and different species of entomophages were placed into them: *Adalia bipunctata*, *Adalia decempunctata* (both imago and larvae), *Syrphus* larvae, *Chrysopa* larvae. The ratio entomophage:aphid was 1:100. To ensure such ratio 4–5 specimens of entomophage was placed in each isolator depending on aphid density. Isolators were made of film and nylon mesh with small holes. Before placing of entomophages, aphids were precounted. The ratio entomophage:aphid was 1:100. To ensure such ratio 4–5 specimens of entomophage was placed in each isolator depending on aphid density. After counting the aphids and placing the entomophages, the isolators were tied tightly. Assesments were performed on daily basis.

The efficiency of entomophages was determined by the formula:

$$E = 100 \cdot \frac{K_0 - K_1}{K_0}$$

K_0—the initial number of aphids;

K_1—the number of aphids after entomophages feeding.

Experimental data were analyzed by one-way ANOVA followed by Duncan's multiple range test ($p = 0.05$).

3. Results

According to our observations, *Adalia bipunctata* L., *A. decempunctata* L., *Syrphus ribesii* L., *S. balteatus* Deg, *Chrysopa perla* L., *Ch. carnea* Steph. dominate among aphidophagous predators of mealy plum aphid. *Coccinella septempunctata* L., *Calvia quatuordecimguttata* L., *Propylaea quatuordecimpunctata* L. were less common. So, in further experiments *A. bipunctata*, *A. decempunctata*, *Syrphus* larvae and *Chrysopa* larvae were used.

In all years *Syrphus* and *Chrysopa* larvae have the highest predation activity—in average 73.7% and 71.2% respectively. *A. bipunctata* and *A. decempunctata* were less effective (Table 1).

Table 1. Efficiency of entomophages against mealy plum aphid, %.

Entomophages	2017	2018	2019	2020	Mean
Adalia bipunctata	75.5b [1]	65.1b	54.5ab	74.6b	67.4
Adalia decempunctata	63.8a	47.4a	65.2b	52.0a	57.1
Syrphus larvae	87.2c	70.8b	49.1a	87.8c	73,7
Chrysopa larvae	88.4c	81.2c	59.6b	55.5a	71,2

[1] Within each column, means followed by the same letter do not differ at $p = 0.05$.

It is necessary to say more on the dependence of the efficiency of useful fauna on weather conditions. Optimal for the activity of *Syrphus* larvae (efficiency of 87.2–87.8%),

were average daily temperatures 17.6–19.9 °C, maximum 22.6–25.4 °C, minimum humidity 42.6–48% and average 57.9–67.8%. With decreasing temperature and increasing humidity, compared with the above values, their efficiency decreased to 49.1%.

The efficiency of *Chrysopa* larvae is influenced by the minimum temperature of 11.2–12.9 °C and the average daily temperature of 17.6–19.0 °C, precipitation of 0.1–1.0 mm and average humidity of 57.9–74.9%. Under such conditions, their efficiency was 81.2–88.4%. At elevated temperature, humidity and increased precipitation, the efficiency of *Chrysopa* larvae decreased to 55.5–59.6%.

Average daily air temperature 17.6–19.9 °C, maximum 22.6–25.4 °C, minimum 11.2–14.1 °C and minimum humidity 42.6–48% favored feeding of *A. bipunctata.* Under such conditions, their efficiency was 74.6–75.5%. Cool weather reduced the efficiency of beetles to 54.5–65.1%.

Moderate temperatures—average daily up to 17.6 °C, maximum up to 22.6 °C, minimum up to 11.8 °C, precipitation 0.1–1.5 mm and average air humidity up to 69% stimulate the activity of *A. decempunctata*. Its efficiency was 63.8–65.2%. High humidity and air temperature have a negative effect on the life of beetles, resulting in reduced efficiency to 47.4–52.0%.

The final stage was to determine the threshold ratio of entomophagous to mealy plum aphid. Since different insects (imago or their larvae) kill different numbers of aphids, the thresholds has been determined for each of them. The thresholds ratio of plum aphids is the presence of *A. bipunctata* was 25–40, *A.decempunctata*—20–30, *Syrphus* larvae—30–50 and *Chrysopa* larvae—10–30.

4. Discussion

Many species of aphidophagous ladybirds are important predators in biological pest control. *A. bipunctata* have high predation rate. In greenhouse experiments it completely eradicated the green peach aphid population in sweet pepper within 2 days following release and predation per adult female was 122.7 aphids per 24 h [8]. For mealy plum aphid we found the rate 1:25–40 as threshold.

Our investigations showed that under favorable weather conditions aphidophages can reduce the population of mealy plum aphid by 74–88%. The best results were obtained for *Syrphus* and *Chrysopa* larvae. Average daily air temperature 17.6–19.9 °C, with maximum of 22.6–25.4 °C and minimum 11.2–14.1 °C, precipitation 0.1–1.5 mm and average air humidity 57.9–67.8% were optimal for the feeding of *A. bipunctata*, *A. decempunctata, Syrphus* larvae and *Chrysopa* larvae.

Cool weather reduced the efficiency of *A. bipunctata*. Jalali et al. [9] showed that the lower developmental threshold for this insect is 9–11 °C. And the best temperature for its rearing is around 23 °C [9,10].

Feeding potential of *S. balteatus* varies from 202 to 986 in dependence of aphid species [11]. It can control development of *Aphis pomi* population when maintained at ratio from 1:50 for the initial infestation level to 1:200 at later period of infestation [12].

Chrysopa carnea plays the important role as an aphidophage on many crops. Releases of its early second stage larvae at the predator/prey ratios of 1:5, 1:10, 1:20 and 1:40 successfully controlled *Myzus persicae* on sugar beet [13]. A ratio of 1 adult *C. carnea* per 5–30 aphids is recommended in geenhouses [14]. Our investigation showed that at ratio 1:10–30 *Chrysopa* larvae can efficiently control mealy plum aphid. This ratio was the lowest among four investigated entomophages.

5. Conclusions

In plum orchards *A. bipunctata*, *A. decempunctata*, *S.ribesii, S. balteatus*, *Ch. perla*, *Ch. carnea* dominate among entomophages of mealy plum aphid. High predation activity of *Syrphus* and *Chrysopa* larvae and coccinellides indicates that the ratio of entomophagous to aphids must be taken into account when making decision about control measures.

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