STUDY OF *PROPYLEA QUATUORDECIMPUNCTATA* FEED CONSUMPTION DYNAMICS AT VARIOUS STAGES OF ONTOGENESIS IN REARING TECHNOLOGY

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Abstract. The development of rearing technologies for the agents of biological control of crop pests is an important and urgent task, the solution of which lies at the intersection of the engineering and the biological sciences. One of the promising agents for the biological control of aphids is lady beetle *Propylea quatuordecimpunctata*. In this study, the feed consumption rate of *Propylea quatuordecimpunctata* was investigated during the development of its rearing technology. Tests were carried out for larval and adult stages of the entomophage. Wheat aphid (*Schizaphis graminum*) at various stages of developmental was used to feed lady beetle. To determine the feed consumption by the beetle larvae the Florinsky tubes were used for the dynamics. The newly hatched larvae were placed in tubes one by one and covered with cotton gauze swabs. The wheat aphids were also placed in these containers. Every day, Propylea was moved to other containers, and the number of aphids was counted. There was determined the impact of the initial number of aphids upon the number of phytophages, destroyed by propylaea imago. The insects were kept together in cylindrical plexiglass containers 90 mm high and 75 mm in diameter. The bottom and the top of the containers were covered with a sieve cloth. The tests were repeated five times. The tests resulted in a correlation between the phytophage density and the number of pests, destroyed by the lady beetle. It was found that the density increasing led an increase of the destroyed aphids. The lowest indicator (5 individuals) was observed in the variant where the number of he applied pests was minimal (also 5 individuals). The highest indicator (34 individuals) was in the variant with the maximum initial number of aphids, which was 120.

Keywords: biological control, aphid, predator, rearing technology.

Introduction

The study of a possibility to use entomophages in the fight against the plant pests is becoming increasingly important in connection with the pollution of agrocenoses with chemicals, which has recently become global by their nature.

Entomophagous insects are capable to reduce significantly the number of pests, which helps obtain organic, ecologically pure products. One of the important agents of biological plant protection are beetles of *the Coccinellidae* family. They are quite effective in controlling the number of pests in agrocenoses [1-5]. In this regard, the issues of trophic specialization of individual species of the family and the ecology of invasions have been studied quite well [6].

Due to the high invasiveness of some species of coccinelids, researchers are increasingly paying attention to native species. For the territories of Ukraine and Latvia this species is *Propylea quatuordecimpunctata* (Linnaeus, 1758). As it is known, species of the genus *Propylea* are polyphagous, with a high preference for aphids and whiteflies [7- 9]. The authors note that their prey range is not very wide, but the species has been used as a biocontrol agent in the United States to control *Schizaphis graminum* [10].

The authors note that *P. quatuordecimpunctata* is commonly intraguild prey in guilds containing ladybirds such as *Harmonia axyridis* (Pallas, 1773) and *Coccinella septempunctata Linnaeus* 1758. The species is smaller in size and the authors express doubts about the species' potential for the biocontrol of the agrocenoses pests. However, the disadvantages of size are balanced by the high growth rate of individuals, high voracity, reproductive potential, and the ease with which this species can be grown in the laboratory [11]. Further research is required to accurately determine the biocontrol potential of *P. quatuordecimpunctata*.

The aim of these experiments was to study the efficiency of *P. quatuordecimpunctata* larvae and adults in destroying phytophages in order to optimize the technology of artificial breeding of the species.

Materials and methods

The investigations were conducted on a laboratory population of *Propylea quatuordecimpunctata* (Linnaeus, 1758), obtained from a natural environment and adapted to the technocoenosis conditions for six generations. The insect culture was kept under standard, species-optimal hydrothermal conditions in an industrial entomology laboratory (temperature 22-25 °C, air humidity 62-68%. Photoperiod: 16 hours day, 8 hours night). A laboratory population of *Schizaphis graminum* (Rondani, 1852) was used as a phytophagous food object, which was also kept in technocoenosis conditions, optimal for the species (temperature 22-25 °C, air humidity was 62-68%. Photoperiod: 16 hours day, 8 hours night).

The dynamics of food consumption of *P. quatuordecimpunctata* at the larval stage was determined using the Florinsky test tubes. The newly hatched predator larvae were placed into the test tubes, one at a time. The test tubes were covered with cotton-gauze swabs. The experiment was repeated ten times. As a source of food, a prey item – the common grain aphid (*Schizaphis graminum*) – was introduced into these containers. For this purpose aphids were shaken off the wheat sprouts onto a sheet of white paper and transferred one by one into test tubes, using a brush. As the predator larvae grew, the number of the introduced aphids was increased daily (Table 1). Every day the coccinellids were moved to other containers and the number of the remaining aphids was counted. Since the development of individuals of the same age lasts from two to three days, the number of the destroyed aphids was counted not only during the day but also, on average, during the development of the predator in each group. The number of aphids predated per day was calculated by dividing the sum of aphids predated on all days of the predator's development in a given instar by the number of days.

The total number of aphids predated by a particular predator instar was calculated as the sum of the predated individuals for each day of that instar. The change in the age of the predator larvae was determined by the shedding of the cuticle during the molting period.

Table 1

Scheme of the experiment to determine gluttony of *P. quatuordecimpunctata*

Age of *P. quatuordecimpunctata* larvae	**I**		**II**		**III**		**IV**		
Duration of development of *P. quatuordecimpunctata* larvae (days)	1	2	3	4	5	6	7	8	9
Number of aphids placed in the test tubes with entomophage larvae, pcs.	20	20	25	35	40	50	60	60	60

Experiments with *P. quatuordecimpunctata* imagos were carried out at a temperature of +19-21 °C, the air humidity was 62-68%. Photoperiod: 16 hours day, 8 hours night. During the research the influence of the initial number (planting density) of aphids upon the efficiency of their destruction by the adult propylaea was determined. The insects were kept in cylindrical containers, 90 mm high and 75 mm in diameter, made of organic glass. The bottom and top of the containers were covered with sieve fabric (Fig. 1).

Fig. 1. **Container for keeping *Propylea quatuordecimpunctata* at the imago stage**

Aphids were shaken off the wheat shoots onto a white paper. Using a brush, the required number of insects were transferred into containers. After this, one imago *P. quatuordecimpunctata* was placed there, which had previously been kept without food for 12 hours. After 24 hours the predators were removed from the containers and the number of unharmed aphids was counted. The experiments were repeated ten times. In the variants the initial number of aphids was 10, 15, 30, 60 and 120 individuals. In total, 5 series of the experiments, described above, were carried out with the imago and larvae.

Results and discussion

P. quatuordecimpunctata is a local and widespread species in Ukraine and Latvia. The species is polymorphic with the background colours ranging from cream to yellow and light orange. The development of larvae of this species at a temperature of +20- 24 °C and a relative air humidity of 80-85% lasts, on average, 8-10 days, depending on the peculiarities of the predator population and food [11]. In our studies this period was 9 days. Larvae of the first, second and third instars developed for two days, and larvae of the fourth instar – for three days (Table 2).

As a result of the conducted research, it was established that in the first day the first-age larvae eat a smaller amount of phytophage than the older larvae. On the last day of the larval development when the insect is preparing to pupate and has already stopped feeding, the food consumption also decreases. The indicators in these variants did not differ significantly – 12.2 and 12.6 individuals per larva (Fig. 2). Starting from the first age, the number of the destroyed aphids increased daily and reached a maximum in IV age larvae on the 8th day of development. At this age each larva consumed an average of about 46 aphids per day.

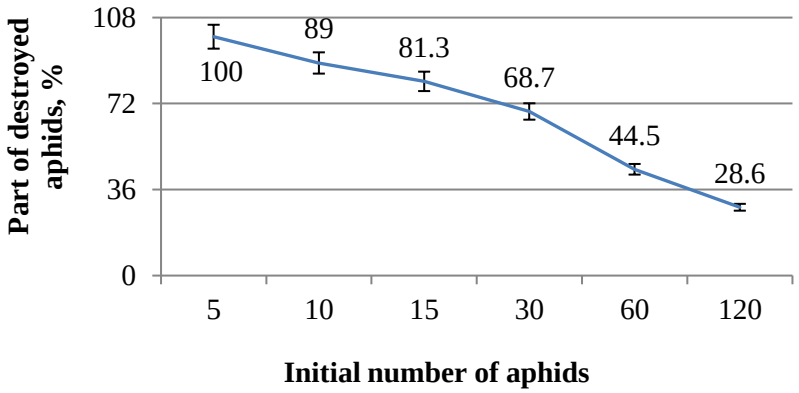

Fig. 2. **Number of aphids destroyed by the larva of *Propylea quatuordecimpunctata* depending on the development period of the predator**

The average number of aphids destroyed by the predator per day was highest in the III and IV ages. These figures were 30.5 and 32.0 individuals, respectively. On the whole, in the experiment the overall average intensity of the food consumption by the larvae of *Propylea quadrata* was 26.2 pieces per day. The average voracity by age was 25.5 aphids per day. The average number of aphids destroyed by predators per day at age II differs slightly from this value for the whole experiment and is 24.6 pieces (Table 2).

Table 2

Number of aphids, destroyed by *Propylea quatuordecimpunctata* l arvae during their development

Age of *P. quatuordecimpunctata*	Duration of development of *P. quatuordecimpunctata* larvae, days	Average number of aphids, destroyed by the predator larvae, per day pcs	Total number of aphids, destroyed by the predator per age, pcs
I	1	14.9 ± 3.8	29.8
	2		
II	3	24.6 ± 3.4	49.2
	4		
III	5	30.5 ± 4.3	61.0
	6		
IV	7	32.0 ± 14.7	96.4
	8		
	9		
Average	–	25.5 ± 6.7	236

It should be noted that the total number of aphids, eaten by the predator larvae during the entire development period of 1 individual phytophage, was 96 phytophages. This indicates a fairly high efficiency of this species as a biomethod agent. It is known that the imago of Coccinella septempunctata ate on average 87.5-91.0 individuals of cereal aphid per day under laboratory experimental conditions, and the last instar larva of this species ate 60-76.3 individuals [12].

The experiments at the imago stage showed that with an increase in the density of phytophages, the number of pests, destroyed by adult propylaea, also increased. The lowest rate (8.9 individuals) was observed in the first variant where the number of the introduced pests was minimal (10 individuals). The highest indicator (34.3 individuals) was noted in the sixth variant with the maximum initial number of aphids amounting to 120 individuals (Table 3).

Table 3

Dependence of the number of aphids destroyed by *P. quatuordecimpunctata* adults upon the density of the phytophage

No.	Initial number of aphids, pcs	Number of destroyed aphids, pcs.
1	10	8.9 ± 1.8
2	15	12.2 ± 2.6
3	30	20.6 ± 4.8
4	60	26.7 ± 3.8
5	120	34.3 ± 8.0

However, it is necessary to note the decrease in the efficiency of aphid consumption depending on the density of its planting. With a minimum number of aphids, almost complete destruction of all the individuals was observed. Subsequently, with an increase in the density of the phytophage, the proportion of the destroyed aphids decreases in relation to their initial number (Fig. 3). When planting 120 individuals, it was only 28.6%. At a density of 10 and 15 aphids, the proportion of destroyed insects is quite high and exceeds 80%. This indicates that eating less than 12 aphids per day does not fully satisfy the needs of the predators' body for physiological processes. A fairly high rate is also observed with the initial number of 30 individuals of aphids. About 20 pieces were destroyed, which is 67%. With an initial number of aphids of 60 and 120 aphids, less than 50% of the phytophages were destroyed, which indicates saturation of the imago at a phytophage density of more than 20 individuals per entomophage.

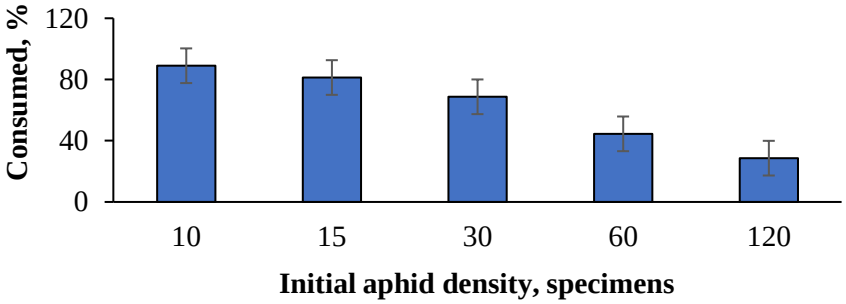

Fig. 3. **Dependence of the feeding intensity of the imago predator upon the initial density of prey**

So we have shown that an increase in the prey density does not significantly affect the feeding intensity of predators. The results, obtained by us, may be used in planning the release density of *P. quatuordecimpunctata* in the biological control programs for aphids, as well as for optimizing the technological process of cultivating the species in technocenosis conditions. In literature there is demonstrated positive experience of *P. quatuordecimpunctata* in controlling aphids in a corn field. The authors have shown that the maximum population density of aphids was associated with the maximum population density of coccinellids [13]. In our opinion, the use of native species for artificial reproduction with subsequent release into nature has a number of advantages, associated with the absence of pollution of biocenoses by alien species and, consequently, the preservation of their biodiversity, which is noted in a number of research works [14].

Conclusions

1. A study of the feeding intensity of *Propylea quatuordecimpunctata* larvae showed that already from the second instar the larvae are quite effective in controlling the pest. Each predator of this age eats an average of 49 prey per day. In addition, during this entire period the larva can destroy up to 206 victims. This indicates a need to release individuals into the wild at this age.
2. The lowest consumption of aphids was observed during the first and last days of the predator's development.
3. The study of an adult predator need for food showed that the optimal number of victims is 30 aphids per beetle.
4. Eating less than 12 aphids per day does not fully satisfy the need of the predators' body for physiological processes to occur.
5. It has been shown that during laboratory breeding of *P. quatuordecimpunctata*, the imago saturation occurs at a phytophage density of 10 to 30 individuals per entomophage a day. The obtained data may be used to optimize the breeding of this species in the conditions of technocenosis.

Author contributions

Conceptualization, V.B.; methodology, T.M., V.B.; software, A.Z.; validation, A.A., A.R; formal analysis, V.B and J.O..; investigation, V.B., S.I., V.N., J.O.; data curation, A.A., V.B. an T.M.; writing – original draft preparation, V.B.; writing – review and editing, A.A., A.R.; visualization, V.B., T.M.; project administration, A.R.; funding acquisition, V.B. All authors have read and agreed to the published version of the manuscript.

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