

Breeding the predatory bug *Podisus maculiventris* Say to protect potatoes from *Leptinotarsa decemlineata* Say

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Abstract. The predator *Podisus maculiventris* Say is a representative of the order Hemiptera, family Pentatomidae. This insect is promising in the battle against the Colorado potato beetle *Leptinotarsa decemlineata* Say. For the successful use of *P. maculiventris* in the climatic conditions of the Russian Federation and other countries where this predator isn't found, it is necessary to develop methods of its artificial reproduction. The paper provides information on the selection of food based on the use of phytophagous insects and pests. Among the subjects *Galleria mellonella* L. caterpillars, *Tenebrio molitor* L. larvae and pupae, *Ephestia kuehniella* Zll. caterpillars, as well as *Zophobas morio* Fabr larvae were used. As a result of the experiment, *T. molitor* was recognized as the most effective insect prey in terms of biological and economic indicators. When using *Tenebrio molitor*, the imago yield of *P. maculiventris* amounted to 81.0-90.5%, which was the best indicator in comparison with other options.

1 Introduction

Leptinotarsa decemlineata Say is a dangerous potato pest on the territory of many countries, including the Russian Federation. The main method of dealing with the Colorado potato beetle is the use of chemicals. And although this is the most effective method, the consequences of the pesticide use are very serious (environmental pollution of soil and water bodies, the death of beneficial organisms: pollinating bees, entomophages, beneficial microorganisms, etc., accumulation in food products and negative impact on human health), therefore it is necessary to look for other ways to combat the pest. Among the alternative ways there is a biological plant protection using beneficial arthropods, which are predators.

Podisus maculiventris Say is a predator of many insect pests [1-3], including *Leptinotarsa decemlineata* Say.

P. maculiventris is an endemic species of North America: it is found from the southeastern part of Canada (Quebec) to the southeastern part of the United States of America (Florida). Inhabiting various biotopes, it plays a significant role in regulating the number of many pests of forest, garden and agricultural crops in North America [4]. *Podisus* attacks more than 75 species of the class *Insecta*, belonging to 41 families of eight orders [3]. It is rather gluttonous: the imago is able to destroy about 14 larvae of the

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younger Colorado potato beetle in one day (Ziskind, 1985). *P. maculiventris* is active throughout the year in warm regions on the southern part of the continent, in the northern and central regions - it develops in two generations per year, in the south - up to four generations [2, 5, 6]. The adults enter diapause and spend the winter in such shelters as forest litter, tree bark, tree stumps, and building cracks.

This predator does not inhabit the territory of the Russian Federation, therefore, in order to be able to use *P. maculiventris* against the Colorado potato beetle, it must be artificially cultivated in laboratory conditions.

The aim of the work was to select optimal physiological and economic parameters of insect prey species for breeding the predatory *P. maculiventris* under artificial conditions.

2 Materials and methods

In the selection and testing of natural food based on insect prey for cultivating *P. maculiventris*, larvae (I-II instars) served as material for the experiments. The experiments were carried out in Petri dishes in triplicate. Feeding was carried out in the following way: prey insects in the amount of four to five individuals (*Galleria mellonella* L. caterpillars, *Tenebrio molitor* L. larvae and pupae) and up to ten or twenty (*Ephestia kuehniella* Zll. caterpillars) were placed into a Petri dish with a bed of filter paper and a moistened cotton swab (a plastic film was placed under the swab). In addition, *Zophobas morio* Fabr larvae were used as food for *P. maculiventris*. One Petri dish contained up to 4 bugs. Feeding was carried out every other day.

Assessment of the quality of natural food was carried out according to the biological indicators of insect development: duration of development of larval stages to imago, survival rate, weight of bugs, fertility of females, and viability of eggs.

The survival rate was calculated using the following formula:

$$a / b * 100\% = c, \quad (1)$$

where

a – number of insects that survived the experiment;

b – number of insects initially participating in the experiment;

c – survival rate expressed as a percentage.

It is necessary to note the following points important for cultivation of *P. maculiventris*: optimal keeping conditions - temperature of 24-26 °C, relative humidity of 70-75%, duration of illumination - not less than 18 hours.

3 Results and discussion

When choosing the optimal feed for breeding entomophages, it is important to take into account not only the physiological needs of the species, but also the technological and economic aspects of breeding insect prey and/or hosts. The most accessible in this regard are *G. mellonella*, *T. molitor*, *E. kuehniella*, *Z. morio*. The listed species of insects satisfy the nutritional needs of entomophages and are quite easy to maintain when breeding them.

Selection of the host insect for breeding the Podisus under laboratory conditions is facilitated by the polyphagia of the predator, because the insect feeds on many types of prey, special attention is paid to the economy and manufacturability of growing forage insects. When breeding *Perillus*, the priority food based on insects is the one that enables you to obtain high-quality biomaterial that is capable of reproduction in a laboratory.

As a result of experiments on the selection and testing of natural food based on insect prey, the following data were obtained: when analyzing the effect of food on the weight of the imago Podisus, the following differences were revealed, reflected in Figure 1.

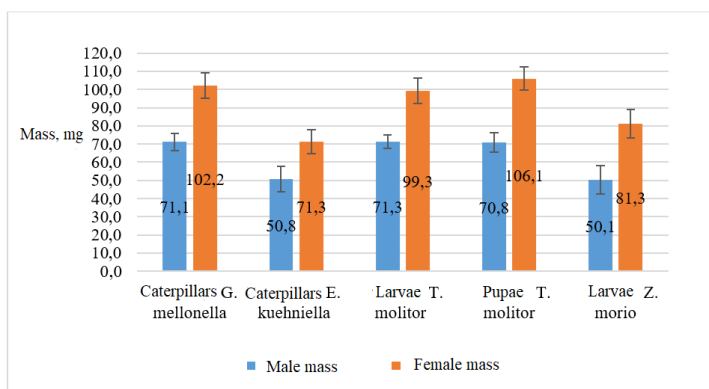


Fig. 1. Body mass parameters of *P. maculiventris* males and females depending on the type of food

The smallest mass of an imago of a predator was recorded when feeding it on ephestia larvae (males - 50.8 mg, females - 71.3 mg), the maximum mass - when feeding it on wax moth larvae (males - 71.1 mg, females - 102.2 mg), on larvae and pupae of a large flour beetle (males - 71.3 mg, females - 99.3 mg and males - 70.8 mg, females - 106.1 mg, respectively). When feeding Podisus on larvae of zophobas, a decrease in the mass of insects is noted, the yield of adults decreases, however, the number of eggs laid by one female for the entire period of life amounts to 346.9, which is the best indicator in comparison with other feeds.

Table 1 presents data on imago yield, duration of the larval stage, duration of generation, number of eggs from one *P. maculiventris* female, depending on the type of food.

Table 1. Influence of food (prey insects) on biological parameters of the predatory bug *P. maculiventris*

Development indicators		Type of food (prey insect)				
		<i>G. mellonella</i> (caterpillars)	<i>E. kuehniella</i> (caterpillars)	<i>T. molitor</i>		<i>Z. morio</i> Larvae
				Larvae	Pupae	
Duration of larval stage development, on average, days		18.0±0.7 ^{a*}	19.1±0.6 ^b	17.0±0.5 ^c	18.2±0.5 ^a	19.0±0.5 ^b
Lifespan of adults, days		33.1±0.6 ^a	32.8±0.6 ^a	32.7±0.9 ^a	34.2±0.6 ^b	38.9±0.1.6 ^c
Generation duration, days		51.1±0.7 ^a	51.8±0.1.1 ^a	49.7±0.9 ^c	52.4±0.9 ^b	57.9±2.0 ^d
Average weight on fledging day, mg:	Males	71.1±7.0 ^a	50.8±8.8 ^b	71.3±5.0 ^a	70.8±6.7 ^a	50.1±10.6 ^b
	Females	102.2±11.3 ^a	71.3±8.9 ^b	99.3±11.6 ^a	106.1±11.7 ^a	81.3±11.4 ^b
Imago yield, %		85.7	61.9	81.0	90.5	71.4
Number of eggs for the entire period of life, pcs.		215.7±13.4 ^a	147.9±40.8 ^b	210.1±36.1 ^a	291.3±46.4 ^c	338.9±25.4 ^d

* Note: there are no statistically significant differences according to Duncan's criterion at a 95% probability level between the options marked with the same letter indices, when compared within the lines.

When larvae of the predatory bug *P. maculiventris* are fed on caterpillars *G. mellonella* and pupae of *T. molitor*, the best indicators of imago yield and predator development are noted. The lifespan of imago in the first case (feeding on *G. mellonella* caterpillars) is 33.1 days, in the second case (feeding on *T. molitor* pupae) - 34.2 days. The number of eggs during the period of a female's life when fed on *G. mellonella* caterpillars was 215.7, when fed on *T. molitor* pupae - 291.7, when fed on *Z. morio* larvae - 338.9; however, the yield of adults decreases in comparison with the options where wax moth and pupae of the flour beetle are used and is 71.4 against 85.7 and 90.5%, respectively.

Feeding *P. maculiventris* on *E. kuehniella* caterpillars was ineffective. Duration of the larval stage development when feeding on *E. kuehniella* is 19.1 days, while the lifespan of an imago is 32.8 days.

When *T. molitor* larvae are used as natural food, the larval stage development is completed in 17.1 days, which is the best indicator in comparison with other options. The lifespan of an imago is about 33 days.

The imago yield is quite high for any species of the proposed prey insects (the lowest rate of imago yield was observed when feeding on *E. kuehniella* larvae - 61.9%).

In terms of technological and economic indicators, among the considered available options for year-round breeding, the most favorable food for growing Podisus is the culture of large *T. molitor*. *T. molitor* larvae, due to the absence of cobwebs (in contrast to *G. mellonella* and *E. kuehniella* caterpillars), are easily separated from the spent food substrate, which determines their manufacturability. In addition, breeding Podisus on a beeswax moth would increase the prime cost of the predator due to expensive ingredients (honey, wax, glycerin, milk powder, etc.) for breeding *G. mellonella*.

Thus, when developing a technology for breeding the bug *P. maculiventris*, it is most expedient to use *T. molitor* larvae and pupae as natural food, and it is also possible to use *Z. morio* larvae. It should be noted that, on basis of the results obtained, the development of methods for combined feeding of a predator may turn out to be promising, where the disadvantages of some prey insects will be compensated for by the advantages of others according to certain indicators and vice versa, for example, feeding on *Z. morio* larvae gives high rates of female fertility, etc.

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