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OPTIMIZATION OF BREEDING OF PREDATORY GREEN LACEWINGS IN ARTIFICIAL BIOTECHNOLOGY SYSTEM - THE WAY TO RATIONAL NATURE MANAGEMENT AND CONSERVATION OF BIOLOGICAL RESOURCES

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Abstract. The technological parameters of the diet for green lacewings are offered. Green lacewings cultivation is recommended on eggs, larvae and imago of host insects. First-age larvae of green lacewings are cultured on cryopreserved eggs of *Sitotroga cerealella* Oliv., which have been finely dispersed with a solution of iodine concentrate plus Se. In the following age, the larvae of green lacewings were bred on the phytophages *Hyperomyzus lactucae* Kalt. and *Aphis gossypii* Glov. at the ratios of 1:1, 1:2 and 1:4. Imago green lacewings fed with a water solution of nano aqua citrate of trace elements with biologically active components. With the modification of the artificial biotechnological system, there are changes in the qualitative and quantitative indices of feed that affect the ontogeny of green lacewings. The increase of imago productivity indices and increase of efficiency of green lacewings as biological agents for limiting the harmfulness of native phytophages are noticed by optimization of diet.

Key words: Green lacewings; Iodine concentrate; Selenium; Optimized diet; Fertility; Survival.

INTRODUCTION

The production of entomological products based on the green lacewings culture requires appropriate knowledge of the management of the technological process. There is a need for the creation and use of specialized green lacewings cultures adapted to changing technological conditions. Of the 2 000 described species of *Chrysopidae*, there are 70 species in Europe (Engel, M.S.et al.2007; Khramov, A. 2016). In agrocenoses of organic farming, a significant number of species from the family *Chrysopidae*, which are potential biological control agents, live (Porcel, M. et al. 2013). Of particular interest are species of the genus *Chrysopa*, that are predators, destroy aphids, leaflets, worms, mites and other small insects. Therefore, an appropriate assessment of entomophages according to the criteria for the effectiveness of limiting the harmfulness of phytophages in agrocenoses is relevant (Pappas, M.L.et al. 2011). The arsenal of effective entomophages is increasing; their function is enhanced in the integrated management of pests (Moroz, M.S. 2010; Moroz, M.S. 2015). With the use of modern insecticides, the current site belongs to the studies that demonstrate the potential of using predatory green lacewings to control the number of harmful phytophages (Bueno, A.F, Freitas, S. 2004; Mulligan, E.A.et al. 2010; Pathan, A.K.et al. 2010). Significant progress in the practice of biological control has been achieved in recent years (Jonsson, M.et al.2008). At the same time it should be noted that the effectiveness of entomophages depends on qualitative and quantitative indices of plant resources, population density of prey, biological potential of predators (Jacometti, M.et al. 2010). According to researchers (Canard, M.et al. 2007), the economically beneficial production and use of predatory green lacewings requires an in-depth study of taxonomy, biology and ecology of beneficial insects, which will reduce the cost of cultivation, marketing and will lead to commercial increase in the arsenal of effective entomophages.

MATERIALS AND METHODS

The research was conducted on the experimental basis of the National University of Life and Environmental Sciences of Ukraine. The reproduction efficiency of predatory green lacewings has been studied for seven generations. Experiments were carried out using laboratory cultures of *Chrysopa carnea* Steph., *Chrysopa septempunctata* McLachlan, *Chrysopa perla* L. and *Chrysopa sinica* Tj.

The larvae of the first age of predatory green lacewings were grown on the cryopreserved *Sitotroga cerealella* Oliv. eggs. Eggs of the host *Sitotroga cerealella* Oliv. were sprayed with a solution of iodine-concentrate plus Se. The larvae of the second age of predatory green lacewings were grown on larvae and imago of *Hyperomyzus lactucae* Kalt. and *Aphis gossypii* Glov. at the ratios of 1 : 1, 1 : 2, 1 : 4. Imagoes of predatory green lacewings were fed with an aqueous solution of nano aqua citrate of microelements with biologically active components for 120 hours.

For incubation, eggs of predatory green lacewings were placed in a thermostat for 24 hours. The incubation temperature is 24-25^{0}C and relative humidity - 80%. The eggs of the predatory green lacewings were packed into veneer insulators 24 hours before the larvae were reborn. The predatory green lacewings were bred individually in a facet insulator.

Imago predatory green lacewings were fed with an aqueous solution of nano aqua citrate of microelements – 1.11 mg / dm^3 with biologically active components – 65 mg / dm^3 for 120 hours. Predatory green lacewings of control variants were grown on eggs of the host *Sitotroga cerealella* Oliv. To enhance reproductive capacity, imago predatory green lacewings were fed carbohydrate protein feed. Sucrose and honey were used as carbohydrates and the autolysate of beer yeast was used as the protein.

Predatory green lacewings larvae were grown in isolated cells at an optimum temperature of 25 ^{0}C, a light day duration of 18 hours, and a relative humidity of 70-80%.

Reproductive potential ($\mathbf{R}_\pi$) was determined by the formula:

$R_\pi = (\Sigma_\rho \times \delta)\, \nu$,

where Σ_ρ –is the sex ratio, δ –the number of offspring, ν –number of generations.

The reliability of the differences between the results obtained in the experiment and control was determined by calculating the student's criterion (coefficient of reliability difference). The processed varied statistical results had a reliability value of P = 0.95; P_2 = 0.99 and P_3 = 0.999.

RESULTS AND DISCUSSION

The results of the experiments on the influence of technological parameters on the survivalability of the predator larvae of green lacewings are presented in Table 1. According to the results of the research, the positive effect of using the experimental diet in optimal concentrations leads to an increase in the survival rate of the larvae of *Chrysopa carnea* Steph., *Chrysopa septempunctata* McLachlan., *Chrysopa perla* L.and *Chrysopa sinica*Tj.

The best survivalability rates are provided by the cultivation of the first age larvae of green lacewings on cryopreserved eggs of *Sitotroga cerealella* Oliv. treated with a finely dispersed iodine-concentrate plus Se, as well as by the cultivation of the second age entomophages on *Hyperomyzus lactucae* Kalt. and *Aphis gossypii* Glov. in a ratio of 1:2.

In particular, the feeding of green lacewings larvae of the first age with iodine concentrates plus Se containing: iodine – 0.8 mg/dm^3, selenium – 0.0005 mg/dm^3, provided the best survivalability rates, respectively, *Chrysopa carnea* Steph. – 83%, *Chrysopa septempunctata* McLachlan. – 88%, *Chrysopa perla* L. – 85% and *Chrysopa sinica* Tj. – 87%, which is, in percentage terms, greater for: *Chrysopa carnea* Steph. – 16%, *Chrysopa septempunctata* McLachlan. – 14%, *Chrysopa perla* L. – 14% and *Chrysopa sinica* Tj. – 11%, compared with the control variant.

The best survival rates of predatory green lacewings were while feeding with larvae and imago of *Hyperomyzus lactucae* Kalt. and *Aphis gossypii* Glov at a ratio of 1:2, respectively, *Chrysopa carnea* Steph. – 86%, *Chrysopa septempunctata* McLachlan. – 89%, *Chrysopa perla* L. – 86% and *Chrysopa sinica* Tj. – 89%, which is higher in a percentage than: *Chrysopa carnea* Steph. – 19%, *Chrysopa septempunctata* McLachlan. – 15%, *Chrysopa perla* L. – 15% and *Chrysopa sinica* Tj. – 13%.

The results of the impact of the technological parameters on the fertility of the female predators of green lacewings are presented in Table 2. According to the results of the research, the positive effect of feeding the imagoes of green lacewings with the aqueous solution of the nano aqua citrate of microelements with the biologically active components in an optimal ratio leads to the increase in the proportion of fertilized eggs of *Chrysopa carnea* Steph., *Chrysopa septempunctata* McLachlan., *Chrysopa perla* L. and *Chrysopa sinica* Tj.

The best fertility indexes for green lacewings are provided with feeding of the imagoes for 120 hours after their exit from the cocoons with a water solution of the nano aqua citrate of microelements – 1.11 mg /dm^3 with biologically active components - 65 mg/dm^3. In particular, the feeding for 120 hours of green lacewings imagoes provided the best fertility rates for females, which led to an increase in the proportion of fertilized eggs that develop in live larvae, respectively, *Chrysopa carnea* Steph. – 93%, *Chrysopa septempunctata* McLachlan. – 95%, *Chrysopa perla* L. - 94% and *Chrysopa sinica* Tj. – 95% that is in percentage terms more on *Chrysopacarnea* Steph. – 14%, *Chrysopa septempunctata* McLachlan. – 14%, *Chrysopa perla* L. – 11% and *Chrysopa sinica* Tj. – 10%.

Table 1. *Influence of technological parameters on the survivalability of predator larvae of green lacewings*

Indexes	Green lacewings			
	Ch.carnea	*Ch. septempunctata*	*Ch. perla*	*Ch.sinica*
	Survivalability of larvae,%	Survivalability of larvae,%	Survivalability of larvae,%	Survivalability of larvae,%
Concentration of dietary iodine concentrate plus Se for larvae of green lacewings of the first age, mg/ dm^3				
I 0.4 + Se 0.00025	77	82	77	83
I 0.8 + Se 0.0005	83	88	85	87
I 1.6 + Se 0.001	79	85	81	84
Correlation of the host-insects *Hyperomyzus lactucae* and *Aphis gossypii* for the breeding of green lacewings larvae in subsequent generations				
1:1	82	83	79	80
1:2	86	89	86	89
1:4	80	82	77	81
Control	67	74	71	76

For example, introducing into the diet for imago in an optimal ratio of nano aqua citrate of microelements – 1.11 mg / dm^3, with biologically active components – 65 mg / dm^3 provided the best results for increasing the proportion of fertilized eggs, respectively, *Chrysopa carnea* Steph.– 94%, *Chrysopa septempunctata* McLachlan. – 97%, *Chrysopa perla* L. – 95% and *Chrysopa sinica* Tj. – 97%, which is, in percentage terms, more by: *Chrysopa carnea* Steph. – 15%, *Chrysopa septempunctata* McLachlan. – 16%, *Chrysopa perla* L. – 12%, and *Chrysopa sinica* Tj. – 12%.

Table 2. *Influence of technological parameters of nutrition on the fertility of females of predatory green lacewings*

Indexes	Green lacewings			
	Ch.carnea	*Ch. septempunctata*	*Ch. perla*	*Ch.sinica*
	Fertility,%	Fertility,%	Fertility,%	Fertility,%
The hours of feeding of the imago green lacewings after exit from cocoons, hours				
72	90	89	90	88
120	93	95	94	95
144	91	92	93	90
Concentration of nano aqua citrate microelements with biologically active components to dietary supplement for green lacewings imago, mg / dm^3				
0,55 + 35	92	93	91	95
1,11 + 65	94	97	95	97
2,2 + 100	95	96	94	97
Control	79	81	83	85

Figure 1 shows the influence of the technological parameters of the nutrition of predatory *Chrysopidae* to the larval yield of the first and third age of the second generation.

From the experimental presented data, it is obvious that the breeding of predatory green lacewings experimental variants increases the yield of larvae of the first and third age of the second generation. Thus, in experimental variants the yield of larvae of the first and third age of the second generation was on average for *Chrysopa carnea* Steph. – 90% and 73%, *Chrysopa septempunctata* McLachlan. – 88% and 68%, *Chrysopa perla* L. – 92% and 79%, and *Chrysopa sinica* Tj. – 95% and 81%, respectively 21% and 13%, 20% and 9%, 22% and 18%, and 26% and 22% respectively, compared to the control variant.

The results of research on the influence of technological parameters of the supply of predatory green lacewings to the yield of the first and second generation imago are presented in Figure 2. From the experimental presented data, it is evident that the percentage of the imago of the first (F_1) and the second (F_2) generation of experimental variants was for *Chrysopa carnea* Steph.– 62% and 65%, *Chrysopa septempunctata* McLachlan.

– 60% and 62%, *Chrysopa perla* L. – 64% and 63% and *Chrysopa sinica* Tj. – 65% and 61%, respectively 11% and 13%, 11 % and 11%, 16% and 16% and 16% and 13%, respectively, compared with the control variant.

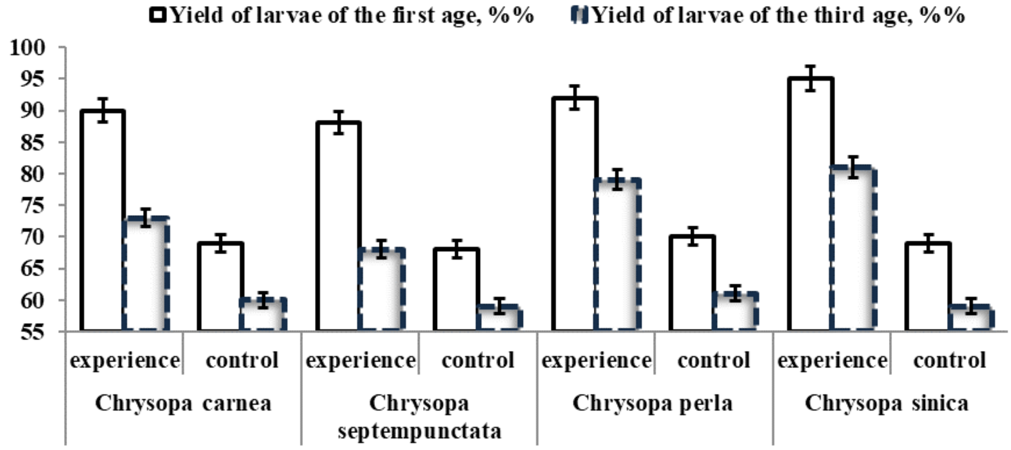

Figure 1. *Effect of technological parameters of feeding of predatory green lacewings on the yield of larvae of the first and third age of the second generation (2012-2018 years, average values)*

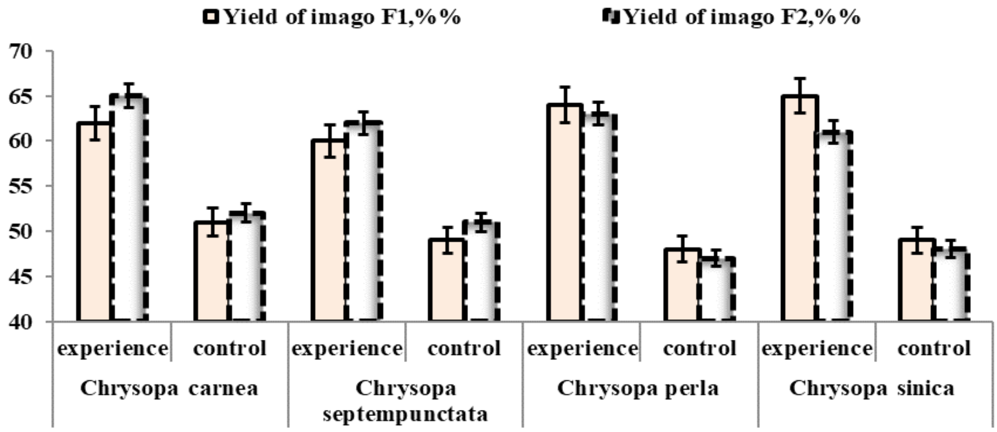

Figure 2. *Influence of technological parameters of nutrition of predatory Chrysopidae on the yield of the imago of the first and second generation (2012-2018 years, average values)*

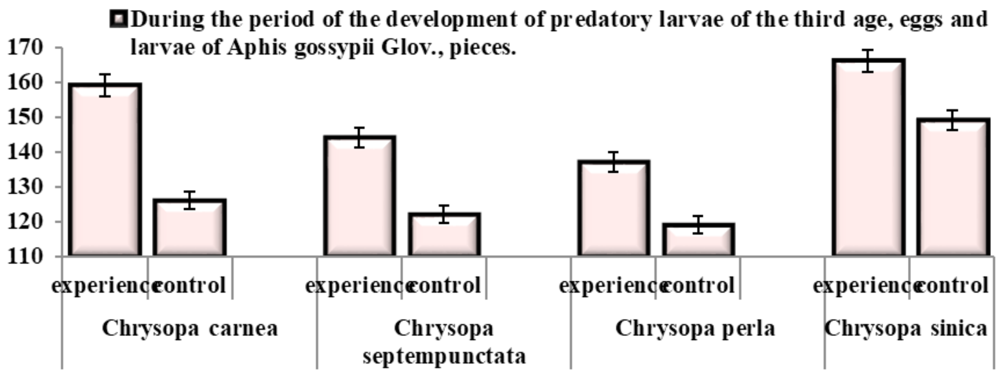

Figure 3. *Influence of technological parameters of nutrition on the gluttony of third age larvae of predatory green lacewings (2013-2018 years, average values)*

The figure 3 shows the effects of technological parameters on the covetousness of larvae of the third age of predatory green lacewings in eggs and larvae of the host-insect *Aphis gossypii* Glov. According to the results obtained in experimental variants, the number of destroyed eggs and larvae of the host insect *Aphis gossypii* Glov. increased during the development period of the third age larvae of green lacewings. In experimental variants, there was observed an increase in the level of covetousness of larvae of the third age of predatory green lacewings. Thus, during the development of the larva of the third age, predatory green lacewings destroyed a significant number of eggs and larvae of the host insect *Aphis gossypii* Glov., namely: *Chrysopa carnea* Steph. – 159 pieces, *Chrysopa septempunctata* McLachlan. – 144 pieces, *Chrysopa perla* L. – 137 pieces and *Chrysopa sinica* Tj. – 166 pieces, which is respectively on 20.75%, 15.28%, 13.14% and 10.24% more compared with the control version.

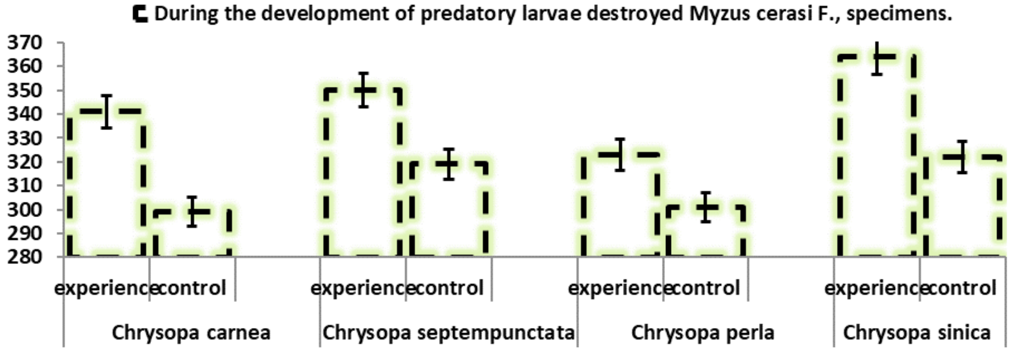

Figure 4. *Influence of technological parameters of nutrition on the gluttony of predatory larvae of green lacewings in relation to the host insect Myzus cerasi* F. *(2013-2018 years, average values)*

The results of the experiments on the influence of technological parameters of the nutrition on the gluttony of predatory green lacewings against the host insect *Myzus cerasi* F. are shown in Figure 4. In experimental variants, the average amount of *Myzus cerasi* F. destroyed during the period of the development of the predator larvae of green lacewings was: *Chrysopa carnea* Steph. – 341 specimens, *Chrysopa septempunctata* McLachlan. – 350 specimens, *Chrysopa perla*L.– 323 specimens and *Chrysopa sinica*– 364 specimens, which is 12.32%, 8.86%, 6.81% and 11.54% respectively, compared with the control variant.

The figure 5 shows the results of studies on the influence of technological parameters of nutrition on the efficiency of the use of predatory green lacewings as biological agents for limiting the harm of *Brevicoryne brassicae* L. and *Myzodes persice* Sulz. Experimental results show that green lacewings are typical polyphages, which feeds on eggs and larvae of aboriginal phytophages, limiting their potential harm.

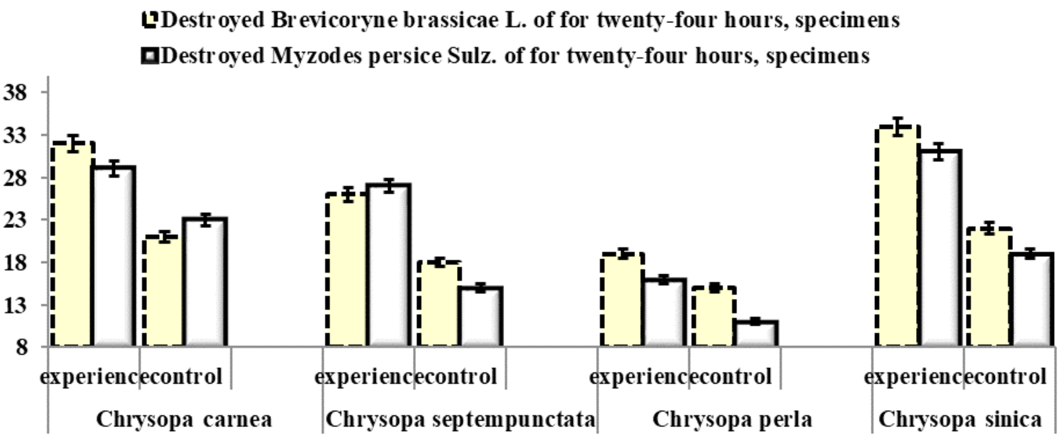

Figure 5. *Influence of technological parameters of nutrition on efficiency of use of green lacewings as biological agents for limiting the harm of Brevicoryne brassicae* L. *and Myzodes persice* Sulz. *(2014-2018 years, average values)*

It has been experimentally proved that the cultivation of predatory green lacewings experimental variants provides the best indicators for the elimination of harmful phytophages per day. Thus, for example, in experimental variants, the average number of dead specimens of aboriginal phytophages, *Brevicoryne brassicae* L. and *Myzodes persice* Sulz. was, per day: *Chrysopacarnea* Steph.– 32 and 29 specimens, *Chrysopa septempunctata* McLachlan – 26 and 27 specimens, *Chrysopa perla* L. – 19 and 16 specimens and *Chrysopa sinica* Tj.– 34 and 31 specimens, which is, respectively, by 34.38 and 20.69%, 30.77 and 44.44%, 21.05 and 31.25%, and 35.29 and 38.71%, more compared to the control variant.

Optimizing the cultivation of predatory green lacewings has improved the development, increased the performance of the imago, increasing the effectiveness of their use as biological agents to limit the harmfulness of aboriginal phytophages.

As an example of the study, it can be argued that the production of a quality biological product based on green lacewings requires appropriate knowledge of the management of the technological process. The strategy of creating and using for this purpose green lacewings cultures, specifically adapted to changing agrocenoses conditions, is undoubtedly. Artificially created green lacewings cultures should have stable values of quality indicators and tolerance to adverse environmental factors.

CONCLUSIONS

The production of quality biological products based on green lacewings is possible due to the improvement of the methods of control of the technological process.

The proposed technological parameters for optimizing the diet for predatory green lacewings are consistent with the criteria of effectiveness, the strategy for the conservation of biodiversity, and meet the priorities for conservation, restoration and improvement of natural ecosystems.

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