

Nano aqua citrates as Biogenic Chemical Elements: Optimization of the *Macrolophus nubilus* h.-s. Trophicity in the Artificial Biotechnical System

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Abstract --- It was described the results of studies of the effect of the nano aqua citrates of germanium, selenium and zinc on the embryogenesis, postembryonic development, female fertility and vitality in the period of maturity and the reproduction of *Masrolophus nubilus* H.-S. It was experimentally proved the possibility of a full-value reproduction of local zoological cultures of such predatory as *Macrolophus nubilus* HS on artificial diet (with the addition of the above mentioned nano aqua citrates).

Index Terms--- nano aqua citrates selenium, germanium, zinc, embryogenesis, postembryonic development, female fertility, vitality, *Masrolophus nubilus* H.-S.

I. INTRODUCTION

Today the effective biological protection of the entomophagous populations for the reproduction in the industrial environments is highly in demand. For this purpose, it is conducted a search for the new approaches which could provide the most specific needs of the insect organisms. To solve this problem, we propose elements of a complex technology of enrichment diets by the high quality components which are able to positively influence on the organism of entomophages [1-6].

It should be noted that the intensive development of the nanotechnology leads to the appearance of the different nature of synthetic nanoparticles in the biosphere [7,8]. In this context, a lot of aspects of their environmental safety (especially metal nanoparticles), the impact on living and plant organisms are highly relevant. Furthermore, during the monitoring studies the important point belong to the examination of the toxicological properties of both types of the nanoparticles and their derivatives in the form of the ionic and molecular compounds obtained by reacting with the application as a pure reagents and components of biosphere [9].

Ones of the most promising and interesting derivatives of the nanoparticles are the citrate of the transition and biogenic metals which are obtained with the help of the modern nanotechnology [10-12] in aqueous solutions, that is allowed to give them name nano aqua citrates.

On the first phase the aqua complexes of the dispersible metals are prepared by the electric pulse ablation and at the second - the direct reaction of these highly active substances with lemon (or other organic) acids and as result of which they become as citrates (carboxylates).

This method of synthesizing metal citrates is considerably cheaper than the pure chemical one as well as it allows to obtain products on the level of the required purity and as aqueous solutions. Their concentrations vary widely depending upon the process parameters. Nanoparticles absent in the final product since they immediately react after receiving with pure food acids, in particular, with citric acid. The use of deionised water and ultrapure metals is a guarantee of their ecological and biological safety. Complex of the investigations are proved: their viricidal, fungicidal and ovotoxic action [13,14], their using in the forest sericulture [15]. They given hygienic evaluation and proved safe use of these materials for the further application as a source of micro and macro to enrich food products, including water [16].

It was experimentally shown [17-19] that nano aqua citrates are biologically active substances. When breeding beneficial insects they ensure prevention of the stressful conditions and diseases, contribute to the elimination of deficiency of biologically active substances, macro-and micronutrients. Nano aqua citrate of selenium, germanium and zinc are highly soluble in water and their ions associated with the citrate ions have a potential to be easily transported inside of the insect cells. In comparative comprehensive investigations it was found that the above mentioned nano aqua citrates are able to normalize the negative changes in the structure and function of the immune system, promote the growth of the total biomass of the population without breaking the usual functioning of the body, improve the humoral regulation by the coordination mechanism of vital processes of beneficial insects [19-21]. It is experimentally proved that the efficiency of the use of the nano aqua citrates in plant protection is determined, first of all, the real provision of basic life functions of living systems on the two levels of organization: organismal and population. In their application to explore a range of morphological, physiological, behavioral, genotypic and information biocenotic characteristics of individuals, populations of beneficial insects that ensures success in competition with other individuals and groups, resistance to environmental factors [19].

In the conditions of Ukraine *Macrolophus nubilus* H.-S. used to combat pests hothouse complex: *Tetranychus urticae* Koch., *Trialeurodes vaporariorum* Westw., *Myzodes persicae* Sulz. During a day the larva of *Macrolophus nubilus* H.-S. kills an average of 800 of larvae of *Trialeurodes vaporariorum* Westw., 30 of imago of *Myzodes persicae* Sulz., 300 of *Tetranychus urticae* Koch. at the different stades of the development. Optimal temperature for the ontogenesis of *Macrolophus nubilus* H.-S. is 19-23 °C, but during post-embryonic development it can develop in a wide range from 13 °C to 42 °C.

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The aim of this work was in the evaluation of the effect of nano aqua citrates as the biogenic chemical elements on the ontogenesis of *Macrolophus nubilus* H.-S. at the optimizing trophicity in the artificial biotech system.

To achieve this goal the following tasks was solved:

- analyzing a possible correction of the individual immunity of *Masrolophus nubilus* H.-S. using nano aqua citrates of selenium, germanium and zinc obtained according to the nanotechnology;
- conducting a retrospective analysis of the environmental conditions and their overall effect on the life cycle of *Masrolophus nubilus* H.-S. when above mentioned nano aqua citrates were added to the diet.

II. MATERIALS AND METHODS

For the investigations it was taken the *Masrolophus nubilus* H.-S. from a local laboratory population that was grown by the conventional method [1,3]. In order to provide the genetic conservation of the laboratory culture the initial size of the starting population of *Masrolophus nubilus* H.-S. was within 2500 of the specimens. For the purpose of quarantine control of the population of *Masrolophus nubilus* H.-S. it was conducted the laboratory observation of life, behaviour, determining the extent of biological contamination. During the study of the biological indicators of the predator breeding it was used the technology described early [22]. Experienced insects were placed in a ventilation plate with moistened swab corrugated strips and tobacco leaves with a well defined main vein. Experiments were carried out in five and six replicates. They included the next diets: a) control (artificial diet according to the recipe of Castane and Zapata [22,23]); b) eggs of *Sitotroga cerealella* Oliv.; c) artificial diet according to the recipe Castane and Zapata with the addition of an aqueous solution of the nano aqua citrates of selenium, germanium and zinc at the concentrations of 0.0005, 0.001% and 0.0001%, respectively. The artificial diet was replaced with fresh daily, eggs of *Sitotroga cerealella* Oliv. added during replacement cotton swab every two days. Accounting for ovipositor predator deposited on the tobacco leaves was made through 24 hours. During the research the average daily temperature was in the range of 25 ± 1 °C, relative humidity of air - 70 ± 10 % and photoperiod - 16 hours.

III. RESULTS AND DISCUSSION

It is well known that an important element in breeding technology such entomophage as *Masrolophus nubilus* H.-S. is to optimize the trophism. For example, larvae and adults of this insect can feed on plant sap in the absence of herbivores. However, a full cycle of development is only possible if entomophages will feed animal food. If it is not enough, most of the larvae can die before reaching the age of the second step and the first larval age increases compared with the norm up to 168-192 hours. If the larvae can compensate for the lack of animal feed, feeding on plant sap, the female in his absence did not lay eggs [2]. The results of studying the effect of the biogenic chemical elements on the duration of the larval development of *Macrolophus nubilus* HS are shown in Fig. 1. According to the results, the best indexes of the first generation of larvae were in individuals who ate eggs of *Sitotroga cerealella* Oliv. Larval development in this case lasted for 446 hours or in 1.26 times faster than in the control

with the use of the artificial diet according to the formulation of Castane and Zapata. At the adding aqueous nano aqua citrates of zinc (0.0005%) , selenium (0.001%) and germanium (0.0001%) to the artificial diet the substantial changes in the rate of the development of the larvae were observed. In these embodiments the larvae have developed on 32, 45 and 34 hours faster, respectively, than in the control.

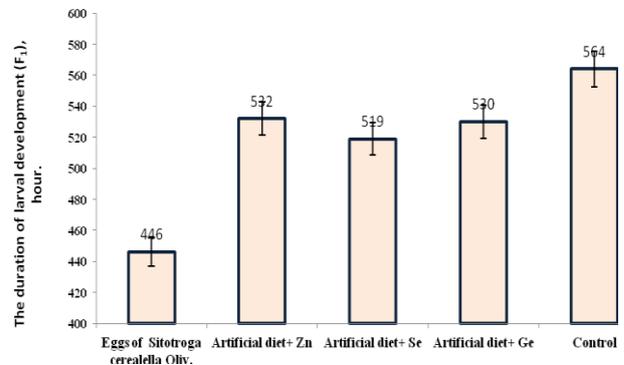


Fig. 1. Effect of technological parameters of nutrient diet enrichment by the chemical elements on the duration of larval development *Macrolophus nubilus* H.-S., (in period of 2011-2013 years, average values).

One of the important indicators that determines the quality of the industrial population of entomophages is the life expectancy of adults. The increase in the life expectancy of adults is one of the methods for the optimization of culture of the entomophages, that is the prerequisite for the next step - the exposure of the individuals in a highly sustainable agrobiocenoses. It was found that the life expectancy of the first generation of adults of *Macrolophus nubilus* H.-S. varied depending on the nutrient diet enrichment by the chemical elements. Using artificial nutrition which is included the preparations of the nano aqua citrates with Ge, Se and Zn it is possible to cause increasing the life expectancy of the adults compared with the control on 46,62, 31.18 and 29,45 hours, respectively. It should be noted that the use of nano aqua citrates of Ge, Se and Zn as the additional components in the composition of the artificial diet gave possibility to increase the life expectancy of the *Macrolophus nubilus* H.-S. imago even in the comparison with food from the eggs of *Sitotroga cerealella* Oliv. on 13,17, 14.9 and 30, 34 hours, respectively (Fig. 2).

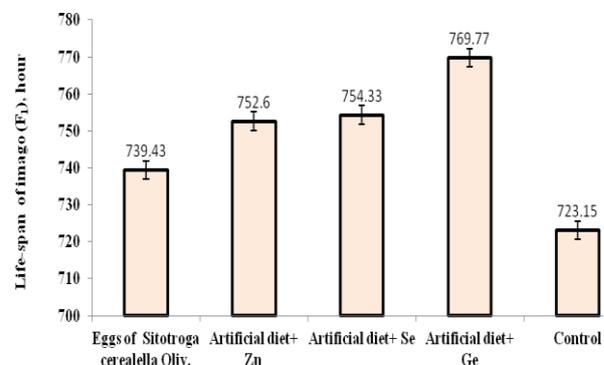


Fig. 2. Effect of the technological parameters of the nutrient diet enrichment by the chemical elements on the life expectancy of the first generation of adults *Macrolophus nubilus* H.-S. (during 2011-2013 years, average values).

An important indicator of the genetically caused entomophages is vitality that characterizes the ability of the species to survive on the appropriate stages of the development. In a broader sense the viability includes the anatomical and morphological as well as the physiological, biochemical, genetic states and the rules of functioning of reflex behavioural norms responses to the changes of environment. Previous studies have revealed that at the optimal action of the stress factors of abiotic and biotic nature in an entomological cultures of the beneficial insects is formed the core of adaptive micro populations in subsequent generations which forms the artificial and ecologically isolated groups with the given stable properties [20]. It has been established that in the context of the pessimistic and optimal trophy factors artificial populations had morphological differences. Created on the basis of adaptive micro populations the laboratory cultures were different from the original ones in respect of the adaptive, physiological and ethological properties [17,20,21]. The results of studying the effect of a diet enriched by the biogenic chemical elements on the viability of the first generation of *Macrolophus nubilis* H.-S. is shown in Fig. 3.

The analysis determined that the highest index and relatively close in the magnitudes of the *Macrolophus nubilis* H.-S. viability in the test cases where the larvae and adults feed on natural breeding and fattening (eggs of *Sitotroga cerealella* Oliv.) was on the level of 82% and on artificial diet supplemented with nano aqua citrate of Se (0,001%) - 84%. With the respect to the experimental embodiments, where the feed was supplemented with the artificial diet of the nano aqua citrates of Ge, and Zn, the entomophage species viability was 79% and 80%, or 3% and 4% higher compared with a control option.

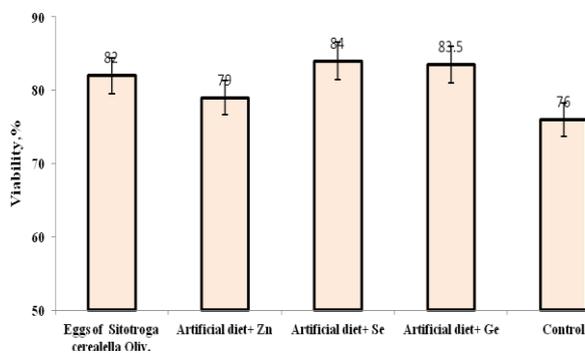


Fig. 3. Effect of technological parameters of nutrient diet enrichment by the chemical elements on the viability of the first generation of *Macrolophus nubilis* H.-S. (2011-2013 years, average values).

As a result of the optimization of the nutrition on the basis of the artificial diet with the addition of the nano aqua citrates the local population of *Macrolophus nubilis* H.-S. was in a relatively better conditions to maintain its existence in a changing environment as it is evidenced qualitative increase in the changes of the structure and functions of the body, conditions of existence which are in coincidence with the trophic needs of entomophage. At the nutrition of *Macrolophus nubilis* H.-S. on the basis of the proposed food it was found that the best performance for the eggs laid by females of the second generation were observed in the experimental variants where the eggs of *Sitotroga cerealella* Oliv. was used as feed (105%) as well as at the application

of the artificial diet with nutrient chemical nano aqua citrates of Ge (85%), Se (80%) and Zn (69%), that in comparison with the control variant was higher on 56.72%; 26.87%; 19.40% and 2.99%, respectively (Fig. 4).

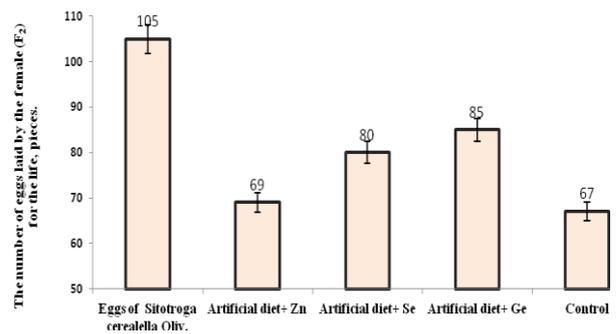


Fig. 4. Effect of technological parameters of the nutrient diet enrichment by the chemical elements in the form nano aqua citrates on the productivity of females of the second generation *Macrolophus nubilis* H.-S. (2011-2013 years, average values).

Enriching nutrient diet by the chemical elements had an impact on the embryogenesis of the second generation of *Macrolophus nubilis* H.-S. In the experiments it was stated a decrease in the time of the embryo development of the second generation of entomophage (Fig. 5). So, in a population where the parental generation of *Macrolophus nubilis* H.-S. was nursed by the eggs of *Sitotroga cerealella* Oliv. the embryogenesis in F₂ was shortened compared to the control at 31.28%, while in case of the artificial diet supplemented with the biogenic chemical elements in the form of the nano aqua citrates of Zn, Se and Ge only on 10,59% 20.20% and 23,40%, respectively.

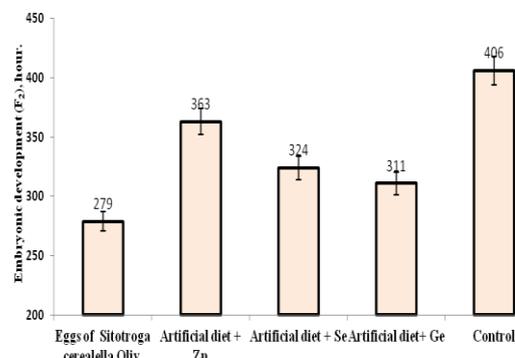


Fig. 5. Effect of the technological parameters of the nutrient diet enrichment by the chemical elements in the form nano aqua citrates on the embryonic development of the second generation of *Macrolophus nubilis* H.-S. (2011-2013 years, average values).

IV. CONCLUSION

Thus, based on the investigations conducted during 2011-2013 it was stated that the duration of the embryonic and post-embryonic development, the fecundity and the viability in the adulthood as well as the reproduction of *Masrolophus nubilis* H.-S. in the local zoological cultures varies depending on a trophic factor.

In the case of the optimization of the trophicity by the using biogenic chemical elements on the basis of the nano aqua citrates with selenium, germanium and zinc it was

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shown their positive influence on the ontogeny of *Masrolophus nubilus* H.-S.

The artificial diet with the addition of the nano aqua citrates of selenium, germanium and zinc ensures the full ontogenesis for the growing native zoological culture of *Masrolophus nubilus* H.-S.

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