THE INFLUENCE OF THE ANTHROPOGENIC FACTOR ON THE BIODIVERSITY OF CODLING MOTH NATURAL ENEMIES

Katerina Nikolić[1], Ana Selamovska[2], Zoran Nikolić[1], Maja Babović Djordjević[1]

[1]University of Priština, Faculty of Agriculture, Kosovska Mitrovica - Lešak, Serbia
[2]Institute of Agriculture, University Ss. "Cyril and Methodius" in Skopje, Republic of Macedonia

Corresponding author: katerina_nikolic@yahoo.com

Abstract
The human role in bioecological examinations of codling moths is of crucial importance for the integral protection of pome fruit and the production of healthy and safe food. The codling moth (*Cydia pomonella* L.) is one of the most significant apple pests in terms of causing the diminished yield and poorer fruit quality in apples. As such, the codling moth requires daily monitoring by agricultural producers. The aim of this research was defined by the need for establishing the presence of codling moth natural enemies and the estimation of their codependence in apple plantations with various methods of protection. The examinations were carried out on the territory of Southern Serbia from 2005 to 2008. During the research, the standard entomological methods, such as pheromone traps, branch beating and placing bands around tree trunks, were used to track the presence, number and population dynamics of the codling moth and its natural enemies. The research results revealed the dominant role that the anthropogenic factor has in many segments of the integral apple protection and the production of high-quality apple fruit. Faunistic researches are inevitable for the correct determination of human actions, due to the clear composition of autochthonous natural enemies of the codling moth. The natural enemies of the codling moth whose presence was determined during the research belong to the following orders: Hymenoptera, Diptera, Dermaptera, Neuroptera, Coleoptera and Heteroptera. The analysis that has examined the human influence on the autochthonous natural enemies of the codling moth also contributes to the preservation of biodiversity and agrobiocenosis, as well as to the production of high-quality, safe food.

Keywords: Human influence, faunistic researches, *Cydia pomonella* L., integral protection, Southern Serbia.

Introduction

The attitude of man towards nature is important for the strategy of agricultural crop protection. People should pay attention not only to the battle against pests, but also on changing their attitude towards nature in terms of biodiversity preservation and enhancement of the role that useful entomofauna plays in agrobiocenosis. The more diverse and complex agrobiocenosis is, the more resilient it is, which leads to the more efficient mechanisms of natural pest control, better soil fertility and plant pollination. Only 1% of animals ate harmful. All others are useful or potentially useful (Čamprag, 2000). The existence of every insect or any other living organism is justified and purposeful; however, their increased or decreased number is due to people's actions. The apple is the most profitable kind of fruit and its production requires lots of human labour. The most prevailing plantations in Serbia are the traditional ones with outdated range of apple varieties. The leading apple variety is still idared, with a tendency to become less common (Keserović et al., 2013). Favourable natural climatic and edaphic conditipns, as well as human and scientific potentials in Serbia are far from being properly utilized. Provided that the modern technology of production is applied, the apple can bring the profit no other fruit variety can. (Veličković et al., 2009).
Intensification of fruit production leads to the emergence of great number of pests, which are most easily removed by using chemicals. However, long-term pesticide usage jeopardizes natural balance,

biodiversity and bioregulatory mechanisms. On the other hand, meteorological factors that are constantly changing in the direction of global warming have a specific influence on the development of apple production. Drought causes sressful reactions among fruit, which decreases their ability to resist pests. This makes apple irrigation mandatory and optimisation of irrigation deadlines and norms necessary (Milutinović et al., 2002) to.preserve pest resilience of fruit. By using monoculture fruit production, man creates specific conditions in the agrobiocenosis of orchards. The codling moth (*C. pomonella* L.) is the predominant type of insect detected respectively in monoculture apple plantations, mixed plantations, neglected orchards and wild apple trees. Fighting for its survival, this pest feeds on the fruit that man is also interested in (Almaši et al., 2004). Man's role in biological and ecological examinations of the codling moth is of vital importance for the integral protection of apple-like fruit and the production of healthy food. The codling moth requires monitoring on a daily basis by agricultural producers, as it is one of the most significant apple pests in terms of causing reduced apple fruit yield and diminished apple fruit quality. The aim of the examination is determined by the necessity to detect the presence of codling moth's natural enemies and estimate their interdependence in apple plantations with different protection approaches. Apple protection should be based on the integrated principles, making natural insect growth regulators of the codling moth a priority when it comes to the examination of codling moths' biology and ecology. Monitoring the biology and ecology of harmful and useful organisms enables the adequate protective reaction, with appropriate protective measures at the right time, leading to the most effective pest reduction, while preserving useful organisms and protecting the environment at the same time. The controlled usage of chemicals preserves the natural population of useful insects and enables them to act as bioregulators in fruit plantations (Nikolić et al., 2012).

Material and methods

The examinations were carried out on the territory of Southern Serbia from 2005 to 2008. The chosen examination areas were located at Beli Potok, Donje Stopanje, Leskovac, Strojkovce (all four belonging to Jablanica District), Nis (Nisava District), Prokuplje (Toplica District), Vladicin Han and Prekodolce (parts of Pcinja District). The examination and monitoring were carried out in each examination area, on one fruit plantation (monoculture or mixed) with chemical protection. Nearby the examination areas, there were apple fruit trees in neglected plantations or in yards that were not chemically protected. The examination areas were located at different altitudes, which is relevant for comparison of developmental phases of the codling moth and its natural enemies. Meteorological data (air temperature and precipitation) were collected from weather stations in Leskovac, Nis and Vranje.

During the examination, the visual method was used as the basis for monitoring the growth of pests and their natural enemies in each examination area. The branch beating method was used for the collection of entomological material from randomly chosen fruit trees in orchards. Pheromone traps were used for monitoring the number and flight dynamics of the codling moth. Insect-hunting belts made from corrugated cardboard were set on branches and tree trunks in order to collect larvae and pupae of *C. pomonella* and its natural enemies. The gathered entomological material was carried to the laboratory where it was subjected to the taxidermy, labeling, determination and collecting. Human activity has been analyzed throughout the examination – particularly the influence of producers on entomofauna in the monitored agrobiocenoses.

Results and discussion

Southern Serbia has the humid continental climate with certain particularities. The valleys have a mild climate characteristic for the region of Zupa, whereas higher mountainous areas have the alpine and subalpine climate. Summer temperatures vary from moderate to very hot; winters are moderately cold, with spring and autumn in between. The districts of Jablanica, Pcinja, Nisava and Toplica are parts of Southern Serbia.

Agricultural production in Southern Serbia is fairly traditional, only partially influenced by new technologies, and with numerous small parts of heterogeneous arable land. The districts of Jablanica and Pcinja are the poorest areas in Serbia. The natural potential for the development of fruit production is satisfactory. However, the basic obstacle to the increase in fruit production is the anthropogenic factor (lack of manpower, unsatisfactory education of fruit producers, outdated types of plantations and an obsolete range of fruit varieties, an unfavorable age and educational structure of the workforce, poor traffic and hydro-technical infrastructure). A significant characteristic of the respective districts of Jablanica and Pcinja is well-preserved nature and rich biodiversity stemming from specific microclimatic conditions and geodiversity.

The examination period (2005-2008) was very dry and extremely hot. The year of 2007 was one of the hottest years ever recorded in Serbia. As a result of high temperatures, fruit plantations succumbed to the loss of freshness and premature fruit drop (in Prokuplje, Nis and Beli Potok). Fruit with decreased hardness and freshness is more likely to be attacked by codling moth caterpillars. Repeated mechanical apple fruit damage caused by hail was also recorded in 2006 and 2007 (in Prokuplje, Prekodolce and Leskovac). Mechanically damaged apple fruit is more prone to the attacks of codling moth caterpillars.

The examination results have shown that the anthropogenic factor has a dominant role in many segments of integral apple protection and production of high-quality apple fruit. The number of treatments carried out against *C. pomonella* in the examination areas between 2006 and 2008 varies from 2 (Leskovac in 2006/2007; Vladicin Han in 2008 and Prekodolce in 2007) to 12 (carried out in Beli Potok in 2008). The choice of chemicals is of crucial importance for efficient chemical protection. Keserović et al. (2013) pointed out that integral apple production cannot survive without the use of agrochemicals; it is, therefore, necessary to improve the efficiency of their application. Almaši et al. (2004) also discussed the possibility of controlled and selective use of chemicals. Thus, according to Nikolić et al. (2012), natural population of useful insects is preserved, alongside their undisturbed bioregulatory function in fruit plantations. According to Ognjanov et al. (2007), the concept itself of integral and biological apple production represents the unique and most important path fruit production should take in preparation for the integration into the European Union.

Faunistic research is inevitable for the correct conceptualization of human activity, due to a clear and easily visible species composition of *codling moths' autochthonous natural enemies. Lazarevska et al.* (2005) claim that the species composition of natural enemies depends on natural geographical and microclimatic conditions. Lacey and Unruh (2005) emphasize the key role that natural enemies of the codling moth play in the integral protection system against *C. pomonella*. Monteiro et al. (2008) point out to numerous predators and pests that have insufficient control over the codling moth in commercial plantations.

The research carried out on the territory of Southern Serbia determined the presence of the following natural enemies of the codling moth: Hymenoptera, Diptera, Dermaptera, Neuroptera, Coleoptera and Heteroptera.

Trichomma enecator Rossi. (Hymenoptera: Ichneumonidae)
Pristomerus vulnerator Panz. (Hymenoptera: Ichneumonidae)
Ascogaster quadridentata Wesm. (Hymenoptera: Braconidae, Cheloninae)
Chelonus annulipes Wesm. (Hymenoptera: Braconidae, Cheloninae)
Itoplectis maculator F. (Hymenoptera: Ichneumonidae, Pimplinae)
Itoplectis alternans Grav. (Hymenoptera: Ichneumonidae, Pimplinae)
Phaeogenes invisor Thumb. (Hymenoptera: Ichneumonidae)
Agathis laticarpa Telenga (Hymenoptera: Braconidae, Agathinae)
***Apanteles* sp.** (Hymenoptera: Braconidae)
Campoletis chloridae Uchida (Hymenoptera: Ichneumonidae)
Scambus nigricans Thoms (Hymenoptera: Ichneumonidae)
Temelucha discoidales Szépligeti (Hymenoptera: Ichneumonidae)

Bracon sphaerocephalus Szepl. (Hymenoptera: Braconidae)
Eulophus pennicornis Ness. (Hymenoptera: Eulophidae, Eulophinae)
Torymus bedeguaris L. (Hymenoptera: Torymidae, Toryminae)
Perilampus intermedius Boucek (Hymenoptera: Perilampidae, Perilampinae)
Dibrachys affinis Masi (Hymenoptera: Pteromalidae, Pteromalinae)
Habrocytus chrysosus Walkien. (Hymenoptera: Pteromalidae)
***Trichogramma* sp.** (Hymenoptera: Trichogrammatidae) (сл. 1.)

Actia pilipennis Fall. (Diptera: Tachinidae)

Forficula auricularia L. (Dermaptera: Forficulidae)
Forficula smyrnensis (Dermaptera: Forficulidae)

Chrysopa carnea Steph. (Neuroptera: Chrysopidae)
Chrysopa perla L. (Neuroptera: Chrysopidae) (сл. 2.)
Dichochrysa ventralis Curtis (Neuroptera: Chrysopidae)

Coccinella septempunctata L. (Coleoptera: Coccinellidae)
Coccinula quatuordecimpustulata L. (Coleoptera: Coccinellidae)
Adalia bipunctata f. Tybica (Coleoptera: Coccinellidae)
Adalia bipunctata f. Sexpustulata (Coleoptera: Coccinellidae)
Adalia decempunctata L. (Coleoptera: Coccinellidae)
Chilocorus renipustulatus (Scriba) (Coleoptera: Coccinellidae)
Hippodamia variegata Goeze (Coleoptera: Coccinellidae)
Oenopia conglobata L. (Coleoptera: Coccinellidae)
Platynaspis luteorubra Goeze. (Coleoptera: Coccinellidae)
Propylea quatourdecimpunctata L. (Coleoptera: Coccinellidae)
Psyllobora vigintiduopunctata L. (Coleoptera: Coccinellidae)
Scymnus frontalis Fabr. (Coleoptera: Coccinellidae)
Deraeocoris ruber L. (Heteroptera: Miridae)

The research shows that the parasites of the codling moth (*C. pomonella*) have been present in very small numbers during all the years of the research and in all the research facilities. The prevalence of the parasite species is greater in the chemically protected plantations in comparison to those plantations that are not chemically protected. This leads to the conclusion that chemical protection does not have an important influence on faunistic composition of the parasites of the codling moth (Nikolić, 2015).

There are certain agrotechnical measures applied by man that have an influence on the increased resilience of the apple fruit against the codling moth, which results in the apple fruit that is stronger and less susceptible to the attacks of codling moth caterpillars. These are preventive measures aiming to solve the problem of wormy apples caused by the codling moth in a long run. Thus, the choice of the spot intended for apple growing is a very significant factor. In Beli Potok, the apple plantation is nearby the artificial reservoir that is part of Porecje – Vucje Ltd. Irrigation was carried out on several occasions during all the research years, which led to apple production of greater quality with minimal damage (3-5%).

Land cultivation in autumn is very important as a measure for destruction of codling moth caterpillars that hide in fallen fruit or in the land nearby. Pruning is important for fertility regulation, aeration and an increased exposure of a tree crown to sunlight; thus, leading to more regular formation of apple fruit. Apples that do not touch each other excessively have better form; they are more easily chemically protected and less susceptible to the attacks of codling moth caterpillars. Potassium fertilization increases plant resilience and hardens the apple skin; thus, making it more

difficult for codling moth caterpillars to bite through the apple skin and make tunnels inside an apple. Small portions of land nearby apple plantations that are left without agrotechmical and chemical measures (refugia) should enable the development of codling moths' natural enemies. According to Thalji (2010), abandoned orchards and individual trees in yards have entomofauna that differs from the one found in plantations that are well taken care of; therefore, they have a significant place in preserving useful entomofauna and retaining biodiversity of natural ecosystems. The examination of apple sensibility and susceptibility to the codling moth, as well as the creation of apple varieties that are more resilient against C. pomonella should become more common. Apples that are more resilient to the attacks of the codling moth are those that have the thick and hairy apple skin, hard apple flesh and the solid core. Kišpatic and Maceljski (1989) state that fruit resilience also depends on fruit juice content. The examinations of Tadić (1957) and Injac et al. (1992) show that the Jonathan apple variety is more resilient to C. pomonella in comparison to the Golden Delicious variety. Postolovski and Lazarevska (2014) indicate that the codling moth attack is weaker in short and thick plantations, among apple varieties with smooth bark, as caterpillars find it hard to pupate. The performed analysis of the influence man has on autochthonous natural enemies of the codling moth on the territory of Southern Serbia contributes to biodiversity preservation of fruit agrobiocenosis and to the production of high-quality and healthy food.



Picture 1. *C. pomonella* eggs attacked by the parasite *Trichogramma* sp.



Picture 2. *C. pomonella* and *Chrysopa* sp. larvae in an apple

Conclusions

The codling moth is a pest that appears every year in all fruit plantations and causes significant damage. An inevitable task for every producer is to determine the presence of codling moths' natural enemies and their interdependency in plantations with different protection approaches. Thus, apple protection would be based on integral principles and natural regulators of the codling moth would be given the primary place in examination of their biology and ecology.

The anthropogenic factor has a dominant place in many segments of integral apple protection. Faunistic research is a necessity in appropriate conceptualization of man's work due to the transparent composition of autochthonous natural enemies of the codling moth. The registered species of codling moths' natural enemies on the territory of Southern Serbia in the period from 2005 to 2008 are as follows: Hymenoptera, Diptera, Dermaptera, Neuroptera, Coleoptera and Heteroptera. The parasites of C. pomonella were present in very small numbers in all the research facilities and in all the research years. Chemical protection did not have any significant influence on the faunistic composition of the parasites that attack the codling moth.

The performed analysis of the influence man has on autochthonous natural enemies of the codling moth enables biodiversity preservation of codling moths' natural enemies. The manner in which agrotechnical measures are applied in fruit plantations influences the quality of entomofauna, helps agrobiocenosis preservation and production of high-quality and healthy food.

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