Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2020, 10(3), 24-27, doi: 10.15421/2020_128

RESEARCH ARTICLE *UDC: 632.634.791.937 (477.75)*

Biological, Trophological, Ecological and Control Features of Horse-Chestnut Leaf Miner (*Cameraria ohridella* Deschka & Dimic)

N. Lesovoy[1], V. Fedorenko[2], S. Vigera[3], P. Chumak[3], M. Kliuchevych[3], O. Strygun[2], S. Stoliar[3], M. Retman[4], L. Vagaliuk[1]

[1] *National University of Life and Environmental Sciences of Ukraine, Heroev Oborony Str., 13, Kyiv, 03041, Ukraine*

[2] *Institute of Plant of Protection of NAAS Vasylkivska Str., 33, Kyiv, 03022, Ukraine*

[3] *Zhytomyr National Agroecological University, 7, Staryi Blvd., Zhytomyr, 10008, Ukraine*

[4] *Institute of Water Problems and Land Reclamation NAAS Vasylkivska Str., 37, Kyiv, 03022, Ukraine*

**Corresponding author E-mail: kluchevichm@ukr.net*

Received: 17.06.2020. Accepted: 17.07.2020

The horse-chestnut leaf miner (*Cameraria orhidella* Deschka & Dimic) is now one of the most dangerous "invasive alien" pests of plantations of bitter chestnut (*Aesculus hippocastanum* L.) in Ukraine. The factors of absence of natural enemies, the presence of a sufficient amount of fodder base, favorable conditions for reproduction and development have led to the fact that (17 years after the first appearance of this moth) this pest occurs almost throughout Ukraine. It was noted, that *Cameraria ohridella* first appeared in Kyiv, Ukraine, in 2003. Biological, trophological, and ecological features of *Cameraria ohridella* in the conditions of the urban phytocenoses in Kyiv (botanical gardens and parks) during 2001–2019 were studied. It was investigated that 77,2–86,2% of total number of mines were found on the lower tier leaves of the chestnut trees. It was established that *Cameraria ohridella* develop three generations under conditions of the research zone. The fourth generation is possible, but under unfavorable weather conditions in Kiev, most puppae die. The research was carried out in 2008–2019 and it has been determined that increased resistance to *Cameraria ohridella* have following species: *Aesculus* × *Carnea* Hayne, A. *octandra Marsh.*, A. *pavia* L., and *A. parviflora* Walt. It was shown, that in the presence of chestnuts that are damaged by *Cameraria ohridella* in phytocenoses, it is advisable to treat them with injection of the Imunocomplexon-CH composite into the trunk, which is undergoing the trials stage now. The drug is effective for not less than 3–4 years (efficiency level – 90–100%), which is due to immunization and stimulation of the plant development.

Keywords: Horse-chestnut leaf miner; Chestnut; Immunisation; Monitoring; Phenology; Urban phytocenosis

Introduction

Recent researches indicate that at the present stage it is necessary to improve the principles of formation and functioning of urban and rural phytocenoses, taking into account systemic and environmental protection approaches that will significantly improve their sustainable and efficient development. That is why in recent years, scientists have begun to justify the patterns of sustainable development of urban phytocenoses, which are based on increased resistance to biotic and abiotic factors and aesthetic satisfaction of the population (Vyhera, 2009; Trybel et al., 2008; Akymov et al., 2006). Despite this argument, species of plants are grown in urban phytocenoses in a number of settlements, for example, specific aboriginal and introduced species with corresponding symbols, but harmful organisms significantly damage them. This leads to a decrease in the aesthetic appearance of plants, inhibition of growth and development or even death.

Varieties of chestnuts are the most common plants grown for phytodesign compositions in recent years. Data from various researchers indicate that a significant number of species of harmful biota, especially pathogens and insect phytophages (Vyhera, 2015; Trybel et al., 2008), damage these plants.

The most harmful species that damage chestnuts (*Aesculus hippocastanum* L.) during the growing season are the following groups or species of arthropods (Artropodae): soil living *phytophagous* insects – chafer larvae, click beetles, head-stander beetles, turnip moths caterpillars; sucking insects – red mites, spider mite; Horse-chestnut leaf miner and others.

Recently, Horse-chestnut leaf miner (*Cameraria ohridella* Deschka & Dimic) has become especially harmful among this group of harmful biota. It migrated to the territory of Ukraine in the late XX – early XXI century. This species immediately became extremely dangerous, since it significantly damages the leaves, which consequently affects the aesthetic appearance of chestnut trees. In the conditions of the Northern Forest Steppe (Kyiv), the *Cameraria ohridella* has not been studied sufficiently, especially from the standpoint of environmental control, since the chemical method of protection in human settlements is prohibited (Hryhoriuk et al., 2011).

The objective of the research is to study biological, trophological, ecological and environmental control features of the *Cameraria ohridella* in conditions of the urban phytocenoses of Kyiv.

Materials and Methods

Researches were conducted during 2001–2019 in botanical gardens and parks of Kyiv according to the following mole locality position: Botanical garden named after Phomin (Kyiv) – 50.442597 NL.; 30.502008 EL; 108,3 m above sea level (ASL); botanical garden of National University of Life and Environmental Sciences of Ukraine (Kyiv) – 50.383053 NL; 30.503463 EL; 194,48 m (ASL); Zhytomyr: – Staryi Avenue – 50.248490 NL; 28.667253 EL; 193,26 m. (ASL).

Monitoring of the development of chestnuts and the appearance and reproduction of *Cameraria ohridella*, the features of damage to the leaves were carried out according to generally accepted methods (Vyhera et al., 2017; Sykalo et al., 2017; Chumak, 1992).

The intensity of leaf damage of chestnuts by *Cameraria ohridella* was measured on a scale (Table 1) (Kolisnichenko, 2004).

Table 1. Scale of damage assessment of horse chestnut leaves damaged by *Cameraria ohridella.*

Mark	Leaf damage degree	Leaf area covered with mines, %
1	Missing or barely noticeable	<3
2–3	Faint	3–5
4–5	Medium	6–25
6–7	Intense	26–50
8–9	Very intense	51–75

Results

It has been found that *Cameraria orhidella* was first noticed in Kyiv (Ukraine) in 2003 (Figure 1). Since 2006, this species has stably damaged almost all plants of the horse chestnut, but with varying degrees of damage.

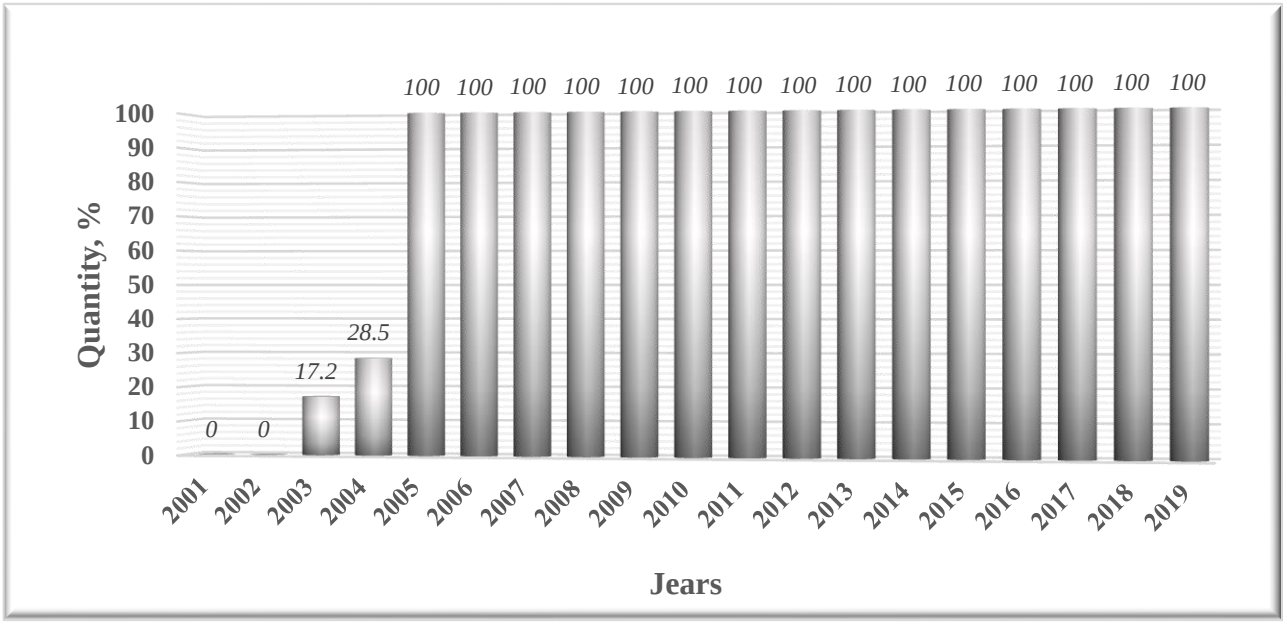

Figure 1. Damage dynamics to horse chestnut by *Cameraria ohridella* in the A. V. Fomin Botanical Garden, 2001– 2019.

Many years of research have shown that *Cameraria ohridella* is wintering in the stage of a chrysalis in fallen leaves. When analyzing the fallen leaves in the laboratory, it was found that in each leaf, on average, there were 1–2 chrysalises. At the same time, the survival rate for these chrysalises until the butterfly stage was almost 40%.

The beginning of the butterflies emerge was observed at the end of April-early May. It was noted that in shady and windy places, the emerge took place ten to twenty days later. That is why, in our opinion, there was observed a long, stretched in time, emerge of the butterflies (Figure 2).

If the first butterfly specimens we noticed about ten days before chestnut flowering, then their massive emerge happened during the flowering. We have investigated that the males emerge first, and after 5–10 days there is a mass emerge of females, which is explained by the difference in the boundary (biological zero) of the pupae development, which is lower in males than in females.

The vast majority of butterflies after the emerge concentrate on the trunks on the shaded side of the tree and the side branches for 7–10 days, which allows to detect the first and mass emerges of the butterflies and the duration of their flight.

When leaving the winter shelter, the adults are located predominantly on the southern side of the trunk, which can be used for monitoring, and subsequently for adjusting the number of *Cameraria ohridella*. After pairing, the females lay eggs on the leaf top, usually closely to the lateral veins, and rarely near the central vein. Embryogenic development of eggs, is 7–14 days, depending on the temperature.

After the revival, the caterpillar of the first age penetrates the cuticle and gets into the epidermis layer of the leaf cells, where it feeds on the juices through the first stages of development, and after lentilation at the fourth stage, as the oral device changes to gnawing, the insect feeds on the tissues of the parenchyma, significantly expanding the size of the mine. 77.2–86.2% mines were noted on the lower tier leaves of chestnut trees (Table 2).

Table 2. Leaf damage of different tiers of horse chestnut by *Cameraria ohridella* in the A. V. Fomin Botanical Garden (2011–2019).

Year	Damaged leaves at different tiers, %		
	lower	middle	upper
2011	83,3	15,8	0,9
2012	82,9	14,5	2,6
2013	77,2	18,6	4,2
2014	86,2	8,7	5,1
2015	80,7	17,4	1,9
2016	83,5	16,6	4,7
2017	80,5	16,0	4,7
2018	81,3	17.1	4,8
2019	85,7	17,9	5,1

The caterpillar at the sixth age, and later at the pre-moth stage, does not eat, but prepares a thin web crib, and chrysalis is formed. Caterpillar development lasts 25–26 days; of which the development of the first stage – 1–3 days, the second – 3–5, the third – 4–6, the fourth – 5–7, the fifth – 10–12, the sixth – 1–3 days. The pupae development of later stages is about 7–10 days, and the whole development cycle in optimal conditions is close to 40 – 57 days.

We have found that three generations of *Cameraria ohridella* can develop in the conditions of the research zone (Table 3). The fourth generation is possible, but in the unfavorable weather conditions in Kiev, most pupae die.

Generation	Terms of mass occurrence, duration															Wintering stage
	V			VI			VII			VIII			IX			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
	(0)	(0)														
I	+	+	+													
	●	●	●	●												
		–	–	–	–	–	–									
				0	0	0	0	0								
					+	+	+	+								Pupa in fallen leaves
					●	●	●	●								
II					–	–	–	–	–	–						
							0	0	0	0	0					
								+	+	+	+					
								●	●	●	●	●				
III									–	–	–	–	–	–	–	
											0	0	0	(0)	(0)	

Symbols: + adults; ● egg; __ – larvae; 0 – pupae; (0) – wintering stage.

Table 3. The phenology of *Cameraria ohridella* development (Kyiv, 2008–2019).

In recent years, the organizational-technological methodology of plant protection focuses on the preventive protection of plants, which ensures stable formation and functioning of phytocenoses or the growth and development of specific plant varieties by organizing the biased use of processes, techniques and technological materials against predictably dangerous biotic and abiotic factors. There is no doubt that the basis of such an effective plant protection is the well-founded selection of a variety of cultivated plants with an increased resistance to biotic and abiotic factors in the specific zonal conditions of urban phytocenoses.

An analysis of literary sources has shown (Sykalo et al., 2017; Trybel et al., 2008; Chumak, 1992) that such varieties of chestnut trees grow under the conditions of Ukraine: Horse chestnut – *Aesculus hippocastanum* L. (Hippocastanum vulgare Gaerth, *Aesculus castanea Gilib*, *Hippocastanum Car*); red buckeye or firecracker plant – *Aesculus pavia* L. (*Pavia rubra* Lam., *Pavia Mickanxii Spach.*); yellow buckeye – *Aesculus soctandra Marsh*. (*Aesculus lutea Wang.*, *Aesculus flava Ait.*, *Pavia lutea Poir*, *Pavia flava* Moench); *bottlebrush buckeye* (*Aesculus parviflora* Walt.) (*Aesculus macrostachya* Mick, *Pavia alba* Poir., *Pavia macrostachya* Lois., *Macrostachya discolor* Spach.); *dwarf buckeye* (*Aesculus neglecta* Lindl.), (*Pavia eglecta* Spach.); red-and-yellow buckeye (*Aesculus discolor Purch.*, Ae. *versicolor Wender*); California buckeye (*Aesculus californica* (Spach.) Nutt.); red horse chestnut (*Aesculus carnea Hayne*, *Aesculus intermedia* Andre., Pavia carnea spach., *Aesculus rubicund* Lois.); hybrid buckeye (*Aesculus hibrida* DC.), (*Aesculus versicolor* Wend., Pavia hybrid DC., Pavia versicolor Spach.).

According to our studies conducted during 2008–2019, the increased resistance to *Cameraria ohridella* have: *Aesculus* × *carnea Hayne*, A. *octandra Marsh.*, A. *pavia* L., and *A. parviflora* Walt.

Regulation of the number of *Cameraria ohridella* using biological agents. Monitoring of chestnut varieties has shown that among them, the dominant species is *Aesculus hippocastanum* L., not only in Kiev, but also in Ukraine. At the same time, it was found that this species is most severely damaged by *Cameraria ohridella*, against which there are nearly no effective plant protection products. That is why the research conducted during 2010–2019 in the A. V. Fomin Botanical Garden was aimed for developing an effective biological preparation against this dangerous phytophagus.

For chestnut trees damaged by *Cameraria ohridella* that are present in the urban phytocenoses, it is practical to treat them with injection into the trunk of the composite preparation Immunocomplexon-Ch, which was developed on the base of. A.V. Fomin Botanical Garden under supervision of Senior Researcher P. Chumak. The effectiveness of the drug lasts for 3–4 years, which is due to immunization and stimulation of plant development. At the present stage, industrial tests of Immunocomplexon-Ch are successfully carried out in the A. V. Fomin Botanical Garden (Kyiv), National University of Life and Environmental Sciences of Ukraine (Kyiv), and Zhytomyr National Agroecological University, etc.

After receiving the patent and registration of the drug in the State Committee of the Ministry of Ecology of Ukraine, it will be possible to implement the preparation in all cities of Ukraine. All information mentioned above shows that scientifically the problem of protecting chestnuts from the *Cameraria ohridella* can be solved.

Discussion

A number of scientists believe (Zerova et al., 2008; Zerova et al., 2007) that the average annual spread of *Camerraria ohridella* in Europe is about 100 km per season, but suggest (Trybel et al., 2008) that there has been the probability of their increase in recent years. There are two opinions about ways to settle the horse-chestnut leaf miner. Thus, Heitland and Metzger (1997) believe that the main ones are vehicles, because the centers of mass reproduction of phytophagous occur in regions that are far from the primary foci, and mainly along highways. Aerogenic method of insect migration is also quite common. In the evening, butterflies rise en masse with ascending air currents to a height of 100 m and are transported over considerable distances (up to 500 km or more) (Tribel, 1989; Scherbinovskiy, 1952; Melnichenko, 1936; Pyatnitskiy, 1936).

According to the literature (Trybel et al., 2008) the main forage plant *Cameraria orhidella* is *Aesculus hippocastanum*, but in entomological practice there are cases when oligophages become polyphagous during outbreaks of mass reproduction, and monophages-oligophages, so it is theoretically possible to expand the range of forage plants of the horse-chestnut leaf miner with systematic mass reproduction in new places.

According to Ukrainian researchers (Zerova et al., 2008; Zerova et al., 2007; Akymov et al., 2006) 3–4 generations of *Cameraria orhidella* develop in Ukraine, but the fourth generation develops only to the caterpillar L2–L4, which dies in winter.

Conclusion

In developing the concept of formation and functioning of stable urban phytocenoses with increased resistance to biotic and abiotic factors, it is necessary to take into account the features of the damage by harmful organisms of the infrequent ethnical and introduced species of plants. Creation of stable urban phytocenoses with high resistance to biotic and abiotic factors has an important environmental and economic value. Increased resistance to moths have red horse chestnut (*Aesculus* × *carnea* Hayne), red buckeye (A. *pavia* L.), and bottlebrush buckeye (*A. parviflora* Walt.). The theoretical framework for the urban phytocenoses protection should be grounded on natural plant protection systems based on the use of environmental protection methods with a lesser use of pesticides. A new type of biological preparation - Immunocomplexon-Ch is effective in controlling the number of *Cameraria ohridella* (biological efficiency at 90–100%) and duration of its action when introded into the chestnut trunks is not less than 3–4 years.

References

Akymov, Y. A., Zerova, M. D. & Narolskyi, N. B. (2006). Byolohyia kashtanovoi mynyruiushchei moly – Cameraria ohridella Geschka&Dimić (Lepidoptera: Gracillariidae) v Ukrayne. Vesnyk zoolohy, 40(4), 321–332. (in Ukrainian).

Chumak, P. Ya. (1992). Biotsenotychne obgruntuvannia preventyvnoi systemy biolohichnoho zakhystu roslyn-introdutsentiv vid shkidnykiv. Okhorona, vyvchennia i zbahachennia roslynnoho svitu. Kyiv : Lybid.

Heitland, W. & Metzger, J. Die (1997). Kastanienminiermotte Cameraria orhidella Deschka & Dimic (Le pi doptera: Gracillariidae) in Bayern. LWF Aktueli.

Hryhoriuk, I. P., Demchuk, T. L. & Kolomiiets, Yu. V. (2011). Naukovo-praktychni zasady zberezhennia i vidnovlennia roslyn hirkokashtana zvychainoho (Aesculus hippocastanum L.) u miskykh urbanizovanykh umovakh: mat. KhIII zizdu Ukrainskoho Botanichnoho tovarystva (Lviv, 19–23 veresnia 2011 r.). (in Ukrainian).

Kolisnichenko, O. M. (2004). Sezonni biorytmy ta zymostiikist derevnykh roslyn. Kyiv : Fitosotsiotsentr.

Melnichenko, A. N. (1936). Zakonomernosti massovogo pereleta lugovogo motyilka i problemyi postroeniya ego zaletov. Zaschita rasteniy, 7(1), 56–59. (in Russian).

Pyatnitskiy, G. K. (1936). K voprosam ekologii i teorii massovyih razmnozheniy lugovogo motyilka. Leningrad : TsUGEMS. (in Russian).

Scherbinovskiy, N. S. (1952). Pustyinnaya sarancha shistotserka. Moskva : Gosselhozizdat. (in Russian).

Sykalo, O. O., Chumak, P. Ya., Vyhera & S. M., Sylchuk, O. I. (2017). Osnovy zakhystu rozsadnykiv ta tsenoziv dekoratyvnykh roslyn. Kyiv : TsP"Interservis". (in Ukrainian).

Tribel, S. A. (1989). Lugovoy motyilek. Moskva : VO Agropromizdat. (in Russian).

Trybel, O. S., Hamanova, O. M. & Svientoslavski, Ya. S. (2008). Kashtanova minuiucha mil. Kyiv : Kolobih. (in Ukrainian).

Vyhera, S. M. (2009). Fitontsydolohiia z osnovamy vyroshchuvannia ta zastosuvannia fitontsydno-likarskykh roslyn: navchalnyi posibnyk. Kyiv : Ruta. (in Ukrainian).

Vyhera, S. M. (2015). Pryrodookhoronnyi kontrol kulturnykh fitotsenoziv. Kyiv : TsP "Komprynt". (in Ukrainian).

Vyhera, S. M., Chumak, P. Ia., Kovalchuk, V. P. & Sylchuk, O. I. (207). Efektyvnyi sposib monitorynhu moli kashtanovoi minuiuchoi pershoho pokolinnia. Patent na korysnu model № 121 584. Zareiestrovano v Derzhavnomu reiestri patentiv Ukrainy na korysni modeli 11.12. 2017. (in Ukrainian).

Zerova, M. D., Nykytchenko, H. N. & Narolkyi, N. B. (2008). Kashtanovaia mynyruiushchaia mol v Ukrayne. Kyiv. (in Ukrainian).

Zerova, M. D., Svyrydov, S. V. & Narolskyi, M. B. (2007). Kashtanova minuiucha mil. Kyiv. (in Ukrainian).

Citation:

Lesovoy, N., Fedorenko, V., Vigera, S., Chumak, P., Kliuchevych, M., Stoliar, S., Retman, M. (2020). Biological, Trophological, Ecological and Control Features of Horse-Chestnut Leaf Miner (*Cameraria ohridella* Deschka & Dimic.). *Ukrainian Journal of Ecology, 10*(3), 24-27.