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Harmfulness of the viburnum leaf beetle (*Pyrrhalta viburni Payk.*) on plants of the *Viburnum* L. genus and elements of its control technology for strategies in breeding work in the system of fruit and decorative gardening

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Abstract. The studies were conducted in various ecological points of Ukraine (western and northern part of the Forest-Steppe, Southern Polissia) to examine the bioecological features of *Pyrrhalta viburni* Paykull and develop measures to reduce its harmfulness in the system of fruit and decorative gardening. The purpose of the study was to examine the bioecological features of the viburnum leaf beetle on plants of the *Viburnum* L. genus and elements of its control technology (selection of species, varietal composition, seasonal pruning, mechanised trunk, or inter-bush loosening of the soil, application of mineral fertilisers, use of paraffin oil and Actofit biological product) for strategies in breeding work. The study was based on the use of the method of conducting a qualification examination, visual methods (route and detailed), the method of accounting and describing pests, determining the degree and score of infestation, and the percentage of damaged plants. As a result, species

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of the *Viburnum* L. genus are differentiated by susceptibility to viburnum leaf beetle into: susceptible – *V. opulus*, *V. sargentii*, moderately or poorly receptive – *V. lantana*, and immune or resistant – *V. sieboldii*, and in the garden conditions on moderately or poorly susceptible – *V. opulus*and *V. sargentii* and resistant – *V. sieboldii* and *V. lantana*. The most effective measure of mechanical control of the viburnum leaf eater, in particular, in the collection, hybrid, breeding, and queen nurseries, is pruning individual branches with pest eggs laid on them during November-March. It is identified that the appropriate measure is the formation of biological barriers in the breeding nurseries of Viburnum, represented by other viburnum species (Siebold's viburnum, Viburnum lantana), which are less susceptible to the viburnum leaf beetle than the plants of Viburnum opulus or Viburnum sargentii, which will allow preserving valuable genotypes of the above-mentioned viburnum species from damage by the pest at an early stage and prevent the use of environmentally dangerous chemical pesticides. The results of the study expand information about the *Pyrrhalta viburni* Payk. species and can be used in the ecology of insect pests, the developed measures will allow controlling the populations of viburnum leaf beetle in the system of fruit and decorative gardening at an early stage

Keywords: viburnum leaf beetle; bioecological features; plant species of the *Viburnum* L. genus; pest infestation and damage to plants; control measures

INTRODUCTION

Pests-parasites of higher plants, developing on the surface or inside living tissues, use nutrients for their growth and development and often lead to serious changes in the host or their partial or complete death. Therefore, it is necessary to consider the bioecological features of pests to further control them. Among the plants that are not widely distributed in the culture, many species of the *Viburnum L.* genus are gaining popularity in both fruit and decorative gardening. The list of these species includes Viburnum opulus, Viburnum lantana, Viburnum sargentii, Viburnum prunifolium, Viburnum dentatum, Viburnum Roseum, Viburnum rhytidophyllum, etc. (Moskalets *et al*, 2019; Moskalets *et al.*, 2020).

One of the most dangerous insect pests of the above-mentioned genus is the viburnum leaf eater (*Pyrrhalta viburni* Paykull). Klimassewski *et al.* (2020) in their study note that autochthonous populations of the viburnum leaf beetle are common in Eurasia, including Ukraine, allochton infestations were observed in North America (Canada, USA). Both larvae and imagoes often destroy a substantial part of the leaf apparatus of viburnum, which negatively affects the condition of plants. The pest does not immediately destroy the host plants, but in case of repeated defoliation, death is noted in the second or subsequent years.

The Harmfulness of the viburnum leaf eater (*Pyrrhaltaviburni* Paykull) was investigated by American researchers (Weston & Desurmont, 2020), who note that this pest parasitises plants of many species *V. trilobum* Marshall, *V. opulus* L., *V. sargentii* Koehne, *V. rafinesquianum* Schultes, *V. recognitum* Fernald and *V. dentatum* L.

As noted by (Liesch, 2021), substantial damage to viburnum plants (leaves, fruits) can cause them to weaken or even die. New populations of *Pyrrhalta viburni* have a negative impact on both plants in nurseries and wild forms of viburnum and their associated fauna, which forms close biocenotic relationships with plants.

Based on the monitoring, it is possible to determine to a certain extent the locations of the viburnum leaf beetle, as noted by (Robinson & Simisky, 2022), who are specialists of the Centre for Agriculture, Food and the Environment (USA) and provide advice for production, as the employees of the University of New Hampshire hotline do (Ask UNH Extension, 2019). According to monitoring studies by experts from the Department of Entomology at Michigan State University (Donne & Smitley, 2020), the appearance or disappearance of the viburnum leaf beetle is dynamic, which often weakens the vigilance of gardeners. This is also noted by (Brewer, 2018) of Cornell University's Department of Horticulture and (Williamson, 2021) Clemson University's HGIC horticultural extension agent (USA).

A delay in the identification of the pest, as noted by (Connolly, 2021), contributes to its spread in both fruit and decorative viburnum plantings. As noted (Kraus *et al.,* 2022), in 48 US states, the viburnum leaf beetle can damage viburnum plants, although until recently the pest was localised only in two states near Canada. In Europe, there are a number of facts of concern for researchers about the growth of harmful viburnum leafhoppers. In France, researchers (MNHN & OFB, 2023) have been conducting thorough studies related to the vital activity of the viburnum leaf beetle since 2003.

Members of the British Royal Horticultural Society (Royal Society, 2023) reported that regular studies allow forming the dynamics of the pest over the years, in particular, in 2010, the viburnum leaf beetle was a type of garden pest in the leading positions. German researchers (Rheinheimer & Hassler, 2018) note that although the viburnum leaf beetle is absent in the Balkan Peninsula, this is not a reason to stop monitoring its detection.

The horticultural expert (Crossley, 2023) notes that the earlier the pest is detected, the easier it is to eliminate it, so it is important to monitor the damage and the pests themselves, in particular, to expand information about its biological features due to global climate change. Holly Crossley reports that a retrospective analysis of long-term data on the viburnum leaf beetle

shows that beetles and larvae of this species feed only on viburnum. This makes it easier to monitor its populations. It was recently identified that the above-mentioned pest in the shade is less parasitic on viburnum plants.

Weather and climatic factors play an important role in fluctuations in the number of viburnum leaf beetles. As noted by (Bradley, 2020), an employee of CBC News, elevated air temperatures in winter contribute to better wintering of the viburnum leaf beetle, and, consequently, an increase in the manifestations of parasitism of insect pests in gardens. According to the researcher (Maier, 2019), the expansion of the range of the viburnum leaf beetle is inevitable. Therefore, systematic monitoring of the manifestation of any unfavourable biotic factors in the future reduces problems and provides ways to solve them.

An increase in the area under viburnum plants, in the absence of timely control measures, can lead to an expansion of the range of viburnum leaf beetle not only in Ukraine but also abroad, in particular, as a harmful invasive species, which is often stated in scientific publications by entomologists in North America (Omand, 2016). In connection with the above, the study of bioecological features of the viburnum leaf beetle and the development of measures for its control in the system of fruit and decorative gardening is relevant.

The purpose of the study was to examine the bioecological features of the viburnum leaf beetle on plants of the *Viburnum L.* genus and develop measures to reduce its harmfulness.

MATERIALS AND METHODS

Records for damage to viburnum plants by viburnum leaf beetle were conducted in breeding nurseries of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine (northern Forest-Steppe, Fastovsky district of the Kyiv region) during 2018-2021 and separate strongholds for environmental testing of viburnum source material (Western Forest-Steppe, in particular, Zhovkivsky, Zolochivsky districts of the Lviv region and the southern part of Polissia, in particular, Nosivsky and Nizhinsky districts of the Chernihiv region) during 2020-2021. Varieties of Viburnum opulus were involved in the study of the degree of plant damage: Uliana, Ania, Velykoplidna, Yaroslavna, and sterile varieties Roseum, Viburnum sargentii – Onondaga, Viburnum sieboldii Seneca, and Viburnum lantana – Vidrodzhennia and Aureum. Observations and records were conducted during April-September, according to the methodology of qualification examination of varieties of forest plant species (Methodology of qualification examination..., 2016).

The study used visual methods based on direct examination and counting of the viburnum leaf beetle and the organs of viburnum plants damaged by them, examining 5 viburnum trees or bushes along the diagonal of the quarter. According to the technique of execution, they alternated with route or detailed ones, depending on the scale of damaged plants. Route surveys were mainly used to visually detect the population of plants with imagoes and pest larvae, while the area of surveys was not less than 10% of the total area of visual surveys. During detailed accounting, the number (density) of the pest and the degree of damage to plants by it, the feasibility and methods of certain protection measures were determined. The degree of colonisation (damage) of plants by viburnum leaf beetle was determined on a special scale according to the "Methodology of qualification examination"(2016) (Table 1).

Table 1. *Scale for assessing the degree and points of infestation (damage) of viburnum plants*

Populating the leaf surface, %	Degree of population	Population point
0	0	0
<5	very weak	1
5-25	weak	2-3
26-50	medium	4-5
51-75	strong	6-7
>75	very strong	8-9

Source: *(Methodology of qualification examination..., 2016)*

The population of plants with viburnum leaf beetle was determined by the formula:

$$P = 100 \times \frac{n}{N}, \quad (1)$$

where *P* –population of plants, %; *n* – number of inhabited plants or leaves, pcs.; *N* – total number of plants (leaves) registered, pcs.

The coefficient of plant damage was determined by the formula:

$$K = (\mathrm{A} \times \mathrm{B}) \div 100, \quad (2)$$

where *K* – plant damage coefficient; *A* – percentage of damaged plants; *B* – average damage score.

Detailed records were conducted with a frequency of 10 days. Additionally, the pest population was recorded

using glue traps (catching belts). Traps were examined and captured beetles and larvae were counted daily or once every 3-5 days, removing insects from the adhesive surface with tweezers. The intensity of larval damage to plants was determined on a four-point scale: 0 – plants were not damaged; 1 – slightly damaged, about 25% was lost; 2 – medium, 26-50%; 3 – strongly, 51-75% of the leaf surface was lost. The results of accounting during the growing season were recorded in the study log. Damage from viburnum leaf beetle larvae was determined from special literature sources (Puzrina, 2020).

Pruning was conducted to control the pest in breeding nurseries (in 2018-2019 forming + regulating, in 2019-2021 – regulating + rejuvenating + sanitary pruning) during February-March (main – cutting or thinning of branches and additional – shortening of branches) and August-September (less often October); three-time trunk and inter-bush tillage during the growing season (or tillage at the stem strip of soil, which was 1.5-2 times wider than the crown of viburnum plants); application of nitrogen and phosphorus-potassium fertilisers (on average 3-5 kg/m^2 on a specially prepared area in the forest belt, paraffin oil was applied (before the vegetative buds opened) and treated with a 0.4% solution of Actofit biologics three times (in the daytime during the growing season of viburnum at an air temperature not lower than +18°C and not higher than +28°C every 14 days, with a norm of 4 ml/L of water + 0.1-0.2 ml/L of liquid soap). Mathematical data processing was performed using Statistica-6.0 and Microsoft Excel computer programmes.

RESULTS

Viburnum leaf eater *Pyrrhalta viburni* Paykull, 1799, synonym – *Galeruca viburni* (Payk.) belongs to the genus Pyrrhalta, tribe Galerucini, subfamily Galerucini (*Galerucinae*), leaf-eating families (*Chrysomelidae*), a number of Coleoptera or beetles (*Coleoptera*) of the Insect class (*Insecta*). The range of the viburnum leaf eater is West-Palearctic, except for the extreme southern and northern territories. These are insects with complete metamorphosis that go through the egg, larva, pupa, and imago stages in their life cycle. Imagoes of the pest were often identified on the leaves of viburnum in late June, until the onset of autumn frosts. Notably, imagoes, in addition to leaves, damage the fruits of Viburnum plants during the filling phase. Fruits damaged in this way often change shape or rot and fall off. Larvae are able to strongly skeletonise leaves, even before they bloom, in particular, at the top of branches. The larvae have been identified to make irregular round or elliptical holes that sometimes cross the thin veins of the leaf. Initially, small larvae feed on the lower surface of the leaf blade between its veins, eating the soft parenchyma (Fig. 1).

Figure 1. *Damaged viburnum leaf by viburnum leaf beetle larvae*
Source: *photographed by the authors*

Larvae of the first instar are light yellow, the second – also yellowish with black spots (up to 0.7 cm), the third instar – darker and in the second decade of June reach about 1 cm in length (Fig. 2).

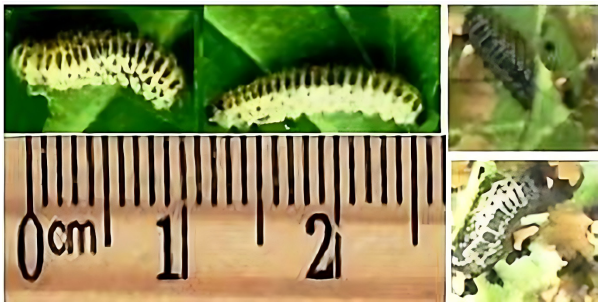

Figure 2. *Image of Pyrrhalta viburni Payk larvae*
Source: *photographed by the authors*

At the end of May or in the first or second decade of June, populations of viburnum leaf beetle larvae can be observed on viburnum plants. In particular, a high number of larvae was noted on fruit and decorative varieties of the viburnum plant (Moskalets *et al.*, 2023). Larvae develop for about four to five weeks. Further, their migration by stems to the soil surface can be observed, where the pupation stage takes place. The pupal stage usually lasts from two to three weeks and ends with the release of an adult beetle from the soil (Murray *et al.*, 2016).

In the first decade of July, there was an increase in the number of greyish-brown beetles, which was marked by the appearance of substantial mines on the leaves of viburnum. Imagoes of the above-mentioned pest, and larvae, gnaw holes in the leaves but have slower life activity than larvae (Fig. 3).

Figure 3. *Adult viburnum leaf eater*
Source: *photographed by the authors*

The second stage of the numerous appearance of the leaf-eating imagoes in the conditions of the Northern Forest-Steppe was noted in the third decade of June, the southern part of Polissia – in the first decade of July. The manifestation of imagoes' vital activity was noted by the end of the third decade of September (in certain years, 2018 and 2020, beetles of the above-mentioned pest were noted in the first decade of October). Both imagoes and larvae of the above-mentioned pest feed both singly and in groups, gnawing holes in the leaves of Viburnum creating a web (or skeletonised) pattern, causing substantial damage to viburnum trees (bushes) every spring. In late August-early September, female pests lay dirty-dark-yellow eggs in small groups (an average of 17 pcs.) on the apical branches of the current year. Then the eggs are covered with a cap of chewed bark and excrement, bonded with special cement, which they make. In autumn or winter, egg-laying sites can easily be identified on annual increments, along their lower side. According to Gyeltshen (Gyeltshen, 2022), the female viburnum leaf beetle lays about 100 eggs during its development cycle. It is noted that in some years (2018, 2021), drying of annual shoots was noted, where females of the viburnum leaf beetle gnawed out holes for laying eggs.

Thus, in the spring, larvae cause substantial damage to viburnum plants, and imagoes – in July-August. Damaged leaves often turn yellow, then half-eaten leaf particles near the vein turn brown with shrunken edges, while in wet weather, eaten leaves with pest excrement have an unpleasant smell. Frequent drying of the apical branches of Viburnum plants of the current year was also noted.

Strong colonisation of plants with viburnum leaf beetle leads to the loss of chlorophyll by the leaves and a decrease in the mass of a unit of surface. Plants of various types of Viburnum that were previously placed on a specially prepared plot in the forest belt during 2018-2021 were 5-9 times more populated by pest populations and suffered from it than in the conditions of a breeding garden, where viburnum plants had proper care (pruning, fertilising with mineral fertilisers, with stem or inter-bush loosening of the soil). Among the examined species of Viburnum in the forest belt, the most populated were *Viburnum opulus* L. (55-87%), *V. sargentii* Koeh. (75-90%), and *V. opulus* 'Roseum' (85-100%) plants. Notably, under the above conditions, the population (damage) of plants of the *V. lantana* L. species was at the level of 7-22%, and *V. sieboldii* Miq. – practically no viburnum leaf beetle. In the conditions of agrocenosis, the average annual population of plant *Viburnum opulus* L. and *V. sargentii* Koeh. species was at the level of 10% or lower. At the level of 35% was the population of plants *V. opulus* 'Roseum', in 2021 – at a level of more than 45%. The plants of the species *V. lantana* L. (with the exception of the collection nursery, where the population was 2-3%) and *V. sieboldii* Miq. on average, imagoes and pest larvae were practically not damaged (Fig. 4).

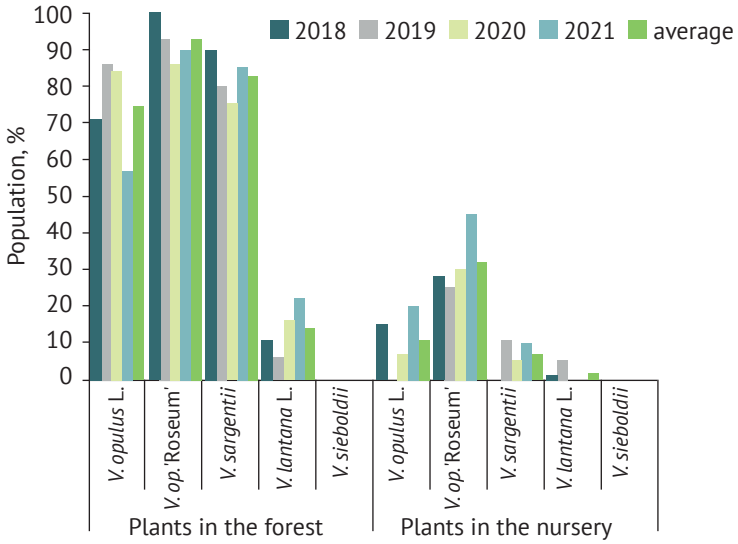

Figure 4. *Population of plants with viburnum leaf beetle depending on the place of cultivation of Viburnum plants by the year*
Source: *compiled by the authors*

The above gives grounds to popularise the above-mentioned types of Viburnum in the horticultural system, both for landscaping and for the formation of protective barriers against the viburnum leaf beetle. According to Figure 4, it can be stated that the stable population of Viburnum plants of individual species at the level of more than 60%, which is a cause for concern since the annual trend towards an increase in viburnum leaf beetle populations will pose a threat to plants in culture. Therefore, minimal damage to plants affects their condition, determines their resistance to drought and frost, suitability for reproduction by green or lignified seedlings, etc. Annual accounting of viburnum plants by pest population and assessment by damage score allowed for calculating the coefficient of damaged plants (Table 2).

Table 2. *Coefficient of damage to plants of the Viburnum L. genus by viburnum leaf eater (compiled by the authors)*

Place of plant growth	Species name	Year				Average by year
		2018	2019	2020	2021	
Plants in the forest belt	*V. opulus* L.	5	7.7	7.6	3.4	5.2
	V. opulus 'Roseum'	9	8.4	7.7	8.1	8.3
	V. sargentii Koehne	8.1	7.2	5.3	7.7	7.4
	V. lantana L.	0.3	0.1	0.5	0.7	0.4
	V. sieboldii Miq.	0	0	0	0	0
Plants in the collection nursery	*V. opulus* L.	0.5	0	0.1	0.6	0.3
	V. op. 'Roseum'	1.1	0.8	1.2	2.3	1.3
	V. sargentii Koehne	0	0.3	0.1	0.3	0.1
	V. lantana L.	0	0.1	0	0	0
	V. sieboldii Miq.	0	0	0	0	0

Source: *compiled by the authors*

According to Table 2, on average, the highest coefficient of plant damage in the forest belt was observed in the *V. opulus* 'Roseum' (8.3), *V. sargentii* Koeh. (7.4), and *V. opulus* L. (5.4) species. Under the conditions of culturocenoses, the indicators of the plant damage coefficient for almost all species did not exceed one. Based on the data in Table 2, it was possible to determine the average damage score and the degree of pest infestation (Table 3).

Table 3. *Average damage score of plants of the Viburnum L. genus viburnum leaf eater (compiled by the authors)*

Place of plant growth	Species name	Year				Average by year	Degree of population
		2018	2019	2020	2021		
Plants in the forest belt	*V. opulus* L.	7	9	9	6	7.8	very strong
	V. op. 'Roseum'	9	9	9	9	9.0	very strong
	V. sargentii Koehne	9	9	7	9	8.5	very strong
	V. lantana L.	3	2	3	3	2.8	weak
	V. sieboldii Miq.	0	0	0	0	0.0	0
Plants in the collection nursery	*V. opulus* L.	3	0	2	3	2.0	weak
	V. op. 'Roseum'	4	3	4	5	4.0	medium
	V. sargentii Koehne	0	3	2	3	2.0	weak
	V. lantana L.	1	2	0	0	0.8	very weak
	V. sieboldii Miq.	0	0	0	0	0.0	0

Source: *compiled by the authors*

According to Table 3, the average damage score for almost all the examined varieties of the *V. opulus* L. species (Uliana, Ania, Velykoplidna, Yaroslavna) was at the level of 7.8 and sterile Roseum and *V. sargentii* Koeh. species – 9 and 8.5, respectively, which indicates a very strong degree of pest infestation. In the conditions of garden breeding, the species *V. opulus* L. and *V. lantana* L. had an average damage score of 2 and 2.8, respectively,

i.e. a weak degree of infestation. Average damage score and degree of infestation of plants of the *V. sieboldii* Miq. species were zero, which could be checked when growing plants of this species at different ecological points (Fig. 5).

The above results allowed ranking species by susceptibility to viburnum leaf beetle depending on the growing conditions. Under conditions of non-interference with plant care (in a specially prepared place in a forest belt), various viburnum species were ranked as susceptible – *V. opulus*, *V. sargentii*, moderately or poorly receptive – *V. lantana*, and immune or resistant – *V. sieboldii*. Under the conditions of proper plant care, viburnum species were differentiated into moderately or poorly susceptible ones. – *V. opulus*and *V. sargentii*, and resistant – *V. sieboldii*and *V. lantana*.

Differentiation of viburnum species by susceptibility allows identifying and suggesting viburnum species that are not very susceptible or resistant to damage by the viburnum leaf beetle for the horticultural system as a measure to control its populations in culturocenoses. Due to the high degree of population and damage to plant species *V. opulus*, *V. sargentii*etc. in various ecological points in the early spring period (before budding), paraffin oil treatment was used, which does not have a phytotoxic effect on the plant and at the rate of consumption of a working solution of 200-250 l/ha and an oil concentration of 820 g/L forms a thin coating that effectively blocks the entry of air into the eggs and the hatching of leaf beetle larvae from them, which then suffocate. Therefore, the control of wintering stages of viburnum leaf beetle when using paraffin oil and during the growing season of plants by applying 0.4% solution of Actofit biological product (dose 4 ml/L + 0.1-0.2 ml/L of liquid soap) provided almost reliable control of viburnum leaf beetle populations both in the southern Polissia and in the Northern and Western Forest-Steppe of Ukraine (Fig. 5).

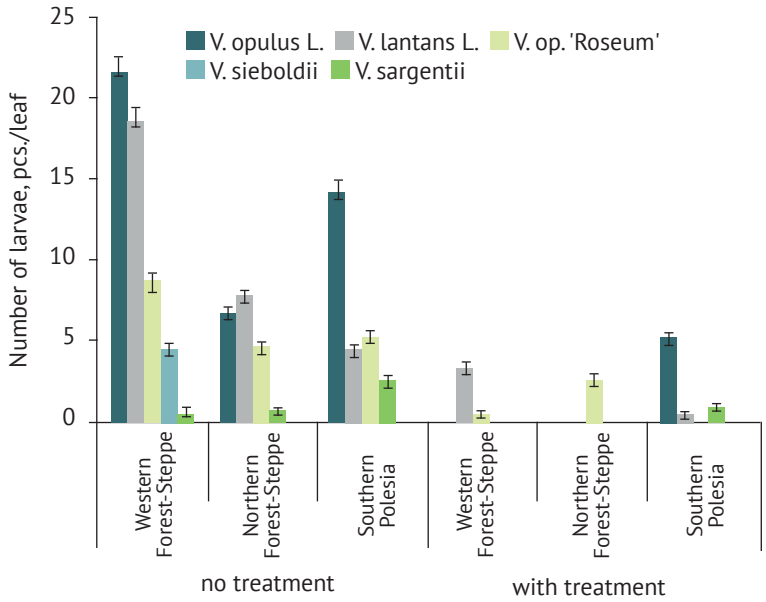

Figure 5. *The number of viburnum leaf beetle larvae, depending on physical and geographical conditions and the method of their control (treatment with paraffin oil and application of Actofit biological product), is average for 2020-2021 (compiled by the authors)*

Thus, the conducted studies allowed identifying the bioecological features of the viburnum leaf beetle regarding the choice of feed base from the list of different types of viburnum, the number depending on economic activity and growing conditions; ranking plant species by susceptibility to the pest and testing measures to reduce its harmfulness.

DISCUSSION

Leaf beetles are characterised by the attachment to forage plants and ecological niches, among which many biological forms that are visual objects for identifying the manifestations of parasitism are present (Gyeltshen, 2022). Until recently, this viburnum leaf beetle was widespread in Europe, since the late 1890s, individual specimens have been observed in North America, and already in 1924 entomologists recorded these beetles in Canada. Harmful infestations of the viburnum leaf beetle were recorded in North America in 1947, 1970, and 1994 (including the states of New York, Connecticut, New Hampshire, Massachusetts, Vermont, and Pennsylvania) and are occurring still (Smith & Hatch, 2017). As Chris Maier (Maier, 2019) notes, susceptible viburnum species were already at risk of substantial damage as of 2016, in particular, the territories of new locations for viburnum leaf beetles (Ohio, Michigan, Wisconsin, and Illinois).

Currently, the pest is widespread in the eastern part of the United States, in particular, in British Columbia

and parts of Washington, and is also localised, especially in western North America, according to Todd Murray (Murray*et et al.*, 2016) in recent years, the likelihood of pest coverage in the Pacific Northwest has increased. As noted above, the range of the viburnum leaf eater in Europe has been known for a long time, there are territories where the pest has been recorded for the first time in recent years (Mirza*et et al.*, 2021).

Entomologist Desurmont G. (Desurmont *et al.*, 2020; Weston & Desurmont, 2020) notes that the viburnum leaf beetle is one of the most dangerous pests of the viburnum garden. The researchers showed that in addition to Viburnum opulus, other species of the *Viburnum* L. genus were also susceptible to imagoes and larvae of the aforementioned pest (in particular, *Viburnum opulus* L., *V. lantana* L. etc.), which are very popular in the system of decorative gardening.

In the presented study, in addition to various species, preference for examining susceptibility was given to varieties of Viburnum opulus. (Desurmont *et al.*, 2019) report that regardless of viburnum varieties, the survival rate of viburnum leaf beetle eggs increases in association with ticks of the *Trichoribatestrimaculatu*s (Ceratosetidae) species as an example of commensalism.

As noted by (Liesch, 2021), in years of high abundance of viburnum leaf beetle, the use of *Viburnum zobata*, *Viburnum opulus*, and *Viburnum opulus* var. *americanum*) in gardening is not advisable since the plants of these species suffer from the above-mentioned phytophage, while *Viburnumplicatum* F. *tomentosum*, *Viburnum* x *juddii*, or *Viburnum carlesii* should be planted. Although, as evidenced by Desurmont & Weston (2014), stage 3 larvae from the optimal *Viburnum dentatum* host plant can migrate to suboptimal host plants (*V. lentago*, *V. carlesii,* and *V. sieboldii*).

Dr. Paul Weston (Weston, 2018), a woody plant entomologist at Cornell University, also investigated the susceptibility to damage of viburnum plants by the viburnum leaf beetle. As a result, different viburnum species were differentiated into susceptible (*V. dentatum*, *V. nudum*, *V. opulus*, *V. trilobum*, *V. propinquum*, *V. rafinesquianum*), moderately susceptible (*V. acerifolium*, *V. lantana*, *V. rufidulum*, *V. sargentii*, *V. wrightii*), and resistant (*V. bodnantense*, *V. carlesii*, *V. davidii*, *V.* x *juddii*, *V. plicatum*, *V. plicatum* var. *tomentosum*, *V. rhytidophyllum*, *V. setigerum*, *V. sieboldii*). From the data of the presented study, parallels can also be drawn, in particular, regarding the level of susceptibility to viburnum leaf beetle of plants of such species as *V. opulus*, *V. lantana*, *V. sargentii*, and *V. sieboldii*.

Weston (2018) also notes that to reduce the number of viburnum leaf beetle populations, pruning viburnum bushes or trees, in particular, removing egg-infested twigs is recommended, which in researcher's opinion is one of the most effective measures after growing resistant varieties and applying insecticidal soap or garden oil.

(Humphreys & Ruxton, 2019) note that leaf-eating pest larvae are more likely to fall from herbaceous plants than from woody plants before pupation or for protection from predatory insects. This is also evidenced by the data of (Konstantinov *et al.*, 2018). Therewith, according to (Matsubara & Sugiura, 2021) and (Shinohara & Takami, 2020), plant architectonics is important.

Many papers have been devoted to measures to control the viburnum leaf beetle, and as noted (Giesmann, 2017), all of them have their feasibility depending on the area of use of viburnum plants. The expediency of using fertilisers in the garden to improve the growth and development of plants and, ultimately, increase soil fertility is confirmed by (Wyckhuys *et al.*, 2017), which substantially affects the reduction of parasitism on the part of insect pests.

Imagoes and larvae of the viburnum leaf beetle are destroyed with contact insecticides (Actellic, Fundazol, etc.), if necessary, although beetles that are more mobile than larvae are more difficult to control. Therefore, to achieve the best results, insecticides are used when the larvae are in the first or second stage of development (Zverev*aet et al.*, 2017). Most garden crops are attacked by several insect pests. As broad-spectrum chemical control options become increasingly limited, there is a need to develop new control methods. Researchers consider it appropriate to use biological protective equipment in the control of leaf-eating pests (Liao *et al.*, 2021).

In particular, (Baroffio *et al.*, 2018) suggest using extracts from plants with phytoncidal properties in pest control (in particular, infusions of onions, garlic, chamomile leaves, tobacco, potato stalks, tomatoes, or bitter pepper fruits). An effective biological measure is the luring of certain species of ticks or birds, which will be able to reduce the population of leaf-eating pests. Thus, as noted by (Heimpel & Mills, 2017), biological control or reasonable selection and subsequent introduction of a specialised insect predator (in particular, spined soldier bug (*Podisus maculivenrtis*) against the pest, which effectively reduces their populations to less harmful levels.

As the researchers (Xiu*et et al.*, 2019) and (Wyckhuys *et al.*, 2018; 2019) state, predatory bugs can control the number of leaf-eating pests. Individual researchers (Silchuk*et et al.,* 2015) also suggest the use of bacterial preparations, in particular, Actofit, the effectiveness of which against viburnum leaf beetle larvae exceeds 80%. In particular, in the studies of the above-mentioned authors, the coefficient of damage to plants of the *Viburnum L.* genus from viburnum leaf beetle was 3 times smaller, and in this study for the individual species – more than 7-8 times.

Summarising the above, it can be concluded that problems with pests in the garden or field arise against the background of complete or partial failure to consider practical experience, which leads to a reduction

in certain plant species, an increase in the level of application of an intensive chemical protection system, or redevelopment of the production process, which generally entails negative consequences in both economic and environmental aspects. In this regard, in the system of fruit and decorative gardening with the expansion, introduction of new species, varieties of viburnum, elements of their cultivation technologies, etc., the priority is a comprehensive analysis of abiotic, biotic (including biocontrol of native and invasive pests), and anthropic environmental factors in combination with scientific-practical long-term experience.

CONCLUSIONS

Viburnum leaf beetle is the most dangerous pest for the plants of the *Viburnum* L. genus; studies have shown that it is very damaging to plants of Viburnum opulus, Viburnum Roseum, Viburnum sargentii, etc. Without proper care, viburnum plants sometimes suffer from mass populations of the viburnum leaf beetle. It is noted that imagoes of the viburnum leaf beetle were identified on the leaves of viburnum at the end of June, until the onset of autumn frosts. Therewith, beetles, in addition to leaves, damage the fruits of viburnum plants during the filling phase, which often change shape or rot and fall off. Larvae of the pest are able to strongly skeletonise the leaves, even before they bloom, in particular, at the top of the branches of viburnum plants.

Viburnum leaf beetle substantially damages the leaves of Viburnum opulus and Viburnum Roseum, which weakens the growth and development of plants, reduces decorative properties, and leads to the drying of annual branches. It is noted that damaged viburnum bushes or trees form a second leaf shoot after a short time, but their development is suspended by unsuitable conditions for growth in August-September.

Plants of the Viburnum opulus varieties have a low natural resistance to viburnum leaf beetle, but proper care of plantings (pruning, feeding with nitrogen and phosphorus-potassium mineral fertilisers, three-time trunk or inter-bush tillage, applying paraffin oil to the blooming of vegetative buds, and three-time use of Actofit biological product for vegetative plants) substantially reduces the number of its populations and reduces the susceptibility of plants to this pest.

For the system of fruit and decorative gardening, the following species of viburnum are recommended as a measure to control viburnum leaf beetles' populations in culturocenoses – *V. sieboldii, V. lantana* as they are poorly susceptible or resistant to damage by these pests.

A promising area of further research is the involvement of immune or low-susceptible species and varieties of the *Viburnum* L. genus in the breeding and production processes in the system of fruit and decorative gardening, which will correct the population characteristics or make it impossible for the viburnum leaf beetle to appear.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Шкодочинність калинового листоїду (*Pyrrhalta viburni Payk.*) на рослинах роду *Viburnum* L. та елементи технології його контролю для стратегій у селекційній роботі в системі плодового і декоративного садівництва

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Анотація. Представленні дослідження проведені врізних екологічних точках України (західна і північна частина Лісостепу, Південне Полісся) з вивчення біоекологічних особливостей *Pyrrhalta viburni* Paykull і розробки заходів щодо зменшення його шкодочинності в системі плодового і декоративного садівництва. Мета роботи передбачала вивчення біоекологічних особливостей калинового листоїду на рослинах роду *Viburnum* L. та елементи технології його контролю (підбір видового, сортового складу, сезонні обрізки, механізовані пристовбурові чи міжкущові рихлення ґрунту, внесення мінеральних добрив, застосування парафінової олії і біопрепарату Актофіт) для стратегій в селекційній роботі. Дослідження базувалися на використанні методики проведення кваліфікаційної експертизи, візуальних методів (маршрутного і детального), методу обліку і опису шкідників, визначення ступеня і балу заселення, відсотку пошкоджених рослин. У результаті досліджень види роду *Viburnum* L. диференційовано за сприйнятливістю до калинового листоїда на: сприйнятливі – *V. opulus*, *V. sargentii*, помірно або малосприйнятливі – *V. lantana* і несприйнятливі або стійкі – *V. sieboldii*,а в умовах саду на помірно або малосприйнятливі – *V. opulus* і *V. sargentii* та стійкі – *V. sieboldii* і *V. lantana*. Найефективнішим заходом механічного контролю калинового листоїда, зокрема в колекційному, гібридному, селекційному і маточному розсадниках, є обрізка окремих гілок з відкладеними на них яйцями шкідника упродовж листопада-березня. З'ясовано, що доцільним заходом є формування в селекційних розсадниках калини біологічних бар'єрів, представлених іншими видами калини (калина Зібольда, калина гордовина), які є менш сприятливими до калинового листоїда, ніж рослини калини звичайної чи калини Сержента, що дасть можливість на ранніх етапах зберегти від пошкодження шкідником цінних генотипів вищезазначених видів калини та запобігти застосуванню екологічно небезпечних хімічних пестицидів.Результати досліджень розширюють відомості про вид *Pyrrhalta viburni* Payk. і можуть бути використанні в екології комах-шкідників, а розроблені заходи дозволять на ранніх етапах контролювати популяції калинового листоїда в системі плодового і декоративного садівництва

Ключові слова: калиновий листоїд; біоекологічні особливості; види рослин роду *Viburnum* L.; заселення і пошкодження рослин шкідником; заходи контролю