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European rose chafer prevalence on cultivated highbush blueberries

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Abstract: The purpose of this study was to detect the prevalence rate of European rose chafer *(Cetonia aurata)* on American highbush blueberries (*Vaccinium corymbosum*). The observation was made from the beginning of flowering to the end of harvest of the blueberry cultivars 'Duke', 'Legacy', and 'Huron'. The incidence occurs during the first harvest of the 'Duke' cultivar. Three rows per cultivar, with 90 plants per row, were monitored during the research. Insects were collected on 15 infested plants per row, randomly selected, and counted. This procedure was repeated every second day, 3 times a day: in the morning, at noon, and in the afternoon. The highest presence of the insect was recorded at the full ripening phase of the 'Duke' cultivar, with 25.5% of bushes being infested and an average of 12.7 beetles per bush counted. The damage percentage varied over the harvesting periods: 29% of the fruits were damaged in the first harvest, 13% in the second harvest, and 8% during the third harvest. While 'Legacy' and 'Huron' stood out with 5.55% and 3.33% of infected bushes, respectively, and minor fruit damage. This research proves that the European rose chafer in the area of the experiment is a harmful pest of early cultivated blueberry cultivars.

Keywords: beetles; 'Duke'; fruit damage; harmful pest; 'Huron'; 'Legacy'

The North American high bush blueberry is a crop that has been widely cultivated in the Republic of Kosovo in recent years. It is considered a crop with high economic potential. Therefore, the interest of potential investors in this crop is increasing. The crop requirements on agroclimatic conditions, such as soil and water pH, are met, and cultivation techniques are at a good level.

The health benefits of blueberry fruits have been proven by many scientific research studies. Blueberries contain a large number of phytochemicals, including abundant anthocyanin pigments. Of their various phytochemicals, anthocyanins probably have the greatest impact on blueberry health functionality (Kalt et al. 2020). Epidemiological studies associate the regular, moderate intake of blueberries and/or anthocyanins with a reduced risk of cardiovascular disease, death, and type 2 diabetes, and with improved weight maintenance and neuroprotection (Kalt et al. 2020). An increasing body of evidence suggests that blueberries and anthocyanins reduce the biomarkers and risk of diseases that constitute major socioeconomic burdens (CVD – cardiovascular disease), (T2DM – type 2 diabetes mellitus), and neurological decline (Kalt et al. 2020). With the strengthening of the link between one's diet and health, several foodstuffs have emerged as possessing potential health benefits, such as phenolic-rich

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fruits and vegetables. Blueberries, along with other berries, given their flavonoid and antioxidant content, have long been considered a particularly interesting health-promoting fruit (Silva et al. 2020). Berry fruits have remedial effects on several diseases, and these health-promoting impacts are associated with their phenolic compounds, which may vary depending on the type and cultivar of the fruit, coupled with other factors, including the climate, agricultural conditions, etc. (Vahapoglu et al. 2021). On the other hand, the commercial benefits are reported to be great. The unique health benefits of blueberries have increased the consumers' demand for this fruit (Qu et al. 2017). The blueberry market is expected to grow significantly in the next few years (CBI 2022). Blueberries are a typical retail fruit in Europe, and they also score well as a healthy snack. Blueberries are becoming increasingly popular in Europe and Asia, where they are seen as a luxury item. Several consumer trends are driving the demand for blueberries. Although the demand is still low compared to other fruits, including apples and grapes, the consumers' growing interest in blueberries has led to a significant increase in the blueberry acreage (Qu et al. 2017). More and more people are becoming health-conscious and looking for foods that are packed with nutrients. The area of organic blueberry production has increased in many regions worldwide, from the development of new plantings or transitioning from conventional to organically certified production (Strik 2014). The genus *Vaccinium* encompasses over 500 distinct species of berry-producing plants, several of which are important to commercial horticulture (Sater et al. 2020).

The identification and management of cultivated blueberry pests in areas where this crop has been recently introduced is a challenge. It is very important to monitor the pests' appearance and abundance as the conditions of their occurrence can change rapidly (Skendžić et al. 2021). As stated by many authors, insect destructiveness is related to changes in the climate, cultivars, or other conditions. Rose chafers (Cetoniinae) are a large group of flower visitors within the pleurostict Scarabaeidae that are characterised by their distinctive flight mode with nearly closed forewings (Šípek et al. 2016). The available literature describes *Cetonia aurata* (Linnaeus, 1758) as a beetle, 20 mm long, that has a metallic, structurally coloured green and a distinct V-shaped scutellum. The scutellum is the small V-shaped area between the wing cases; it may show several small, irregular, white lines and marks. The underside of the beetle has a coppery colour, and its upper side is sometimes bronze, copper, violet, blue/black, or grey. Rose chafers damage many different types of flowers, fruits, trees, and shrubs. They feed on plants for three or four weeks, generally until late June (Fremlin 2020). At first, adults fly in their area of emergence, then move onto different crops or spontaneous vegetation, being attracted by the volatile substances of plants (Ahrens et al. 2013). The same authors concluded that adults feed on pollen and nectar for which they have adapted mouthparts; they fly very fast with their wing cases down, which have a curvature adapted for that (Fremlin 2020). While the adults of *Cetonia aurata* feed on pollen and are frequent visitors of many types of wild and cultivated flowers, their larvae feed on decaying wood and organic matter (Ahrens et al. 2013). The larvae are predominantly saprophagous or saproxylophagous and are frequently found in the soil, rotten wood, and tree cavities (Puker et al. 2014). Their life cycle typically lasts 2 years (Fremlin 2018). Cetoniidae is a diverse family containing approximately 4 000 species, most of which feed on flowers and fruits. Certain species have shown a preference for determined habitats (Neto et al. 2018). In the past, rose chafer was considered to be only a secondary pest. The beetle is studied more widely, and its damage has been reported on various crops, such as sweet corn and peach trees (Lohonyai et al. 2018), grapes (Kulkarni 2018), and oil-bearing rose plantations. Toth et al. (2005) reported the damage caused by *Cetonia aurata* and *Protaetia cuprea* to peach fruit as a possible serious problem in Hungary. The North American green June beetle (*Cotinis nitida*) feeds on figs and other fruits, often causing great damage. The seasonal alternation and local vegetation environment are considered to be the main mechanisms regulating the abundance, species richness, and behaviour of insects (Neto et al. 2018). The rose chafer *Protaetia cuprea* (Fabricius, 1775) has a broad range extending from Europe to Mongolia and Northern China. *Protaetia cuprea* shows an exceptionally wide range of ecological preferences (Vondráček et al. 2018). Motivated by market opportunities, today's interest in blueberry cultivation has increased in the Republic of Kosovo, specifically for the North American highbush type. Therefore, the objective of this study was to find out if *Cetonia aurata* is a harmful insect in fields with cultivated blueberries and to what extent. Its presence on the

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site has been noticed for years, mainly in forests with deciduous trees which border the blueberry plantation. However, no damage to the cultivated crops has been reported.

MATERIAL AND METHODS

The study was conducted in 2023 in a blueberry plantation of 4.5 ha established in western Republic of Kosovo, in Junik village at coordinates 42°27'00.9"N 20°20'35.1"E. The cultivated blueberry cultivars 'Duke', 'Legacy' and 'Huron' were observed for the presence of *Cetonia aurata*. The planting distances were established at 3 m by 1 m (3 m × 1 m), and the cultivation practices were consistent across all three cultivars. The area between the rows is kept green, with natural grass which is mulched regularly. A deciduous forest dominated by oak (*Quercus*), hornbeam (*Carpinus orientalis*), *Fraxinus ornus*, hop-hornbeam (*Ostrya carpinifolia*), common hazel (*Coryllus avellana*), and hawthorn (*Crataegus monogyna*) stretches on the western side of the field. A strip of native spontaneous dwarf elder (*Sambucus ebulus* L.) occurs on the eastern border of the plantation.

There is no decaying material used as mulch in the plantation, nor any piled in the vicinity of the plantation, which could provide a development environment for the beetles. However, the deciduous forest is growing naturally without human intervention, so even the wood waste is not managed. A 6 m wide road separates the plantation from the forest and the dwarf elder strip. The row length of the blueberries is between 190 and 230 m.

Research was conducted in two directions: evaluation of the degree of infestation and the damage caused by it.

Infestation degree. The observation was made during the flowering period until the end of the fruit harvest. The experiment was designed as a randomised block with three rows per cultivar, containing 90 bushes per row. Initially, bushes with insect presence were identified along the row. Fifteen infested bushes per row were randomly selected. Thus, insects were collected and counted from 45 plants per cultivar in total. Sampling is conducted every second day from the beginning to the end of the harvest for each cultivar. The insects were collected with dense net bags so that the entire bush was covered with the bag, and the insects were shaken into the bag. Then the insects were counted. This procedure was repeated 3 times: in the morning, midday, and afternoon.

Fruit damage evaluation. One hundred mature fruits were harvested from the bushes in the experiment. Then, the number of damaged berries was deducted from the total number of harvested berries. The data were tabulated and processed statistically by using the SPSS version 20.0.0 software to generate tabulated reports, charts, descriptive statistics, and conduct statistical analyses.

RESULTS AND DISCUSSION

The presence of insects was recorded at the beginning of berry ripening of the 'Duke' cultivar, which is the first cultivar to ripen.

An average of 23 plants per row, or 25.55% of the plants, were infested out of 90 plants in the observation of the 'Duke' cultivar. The number of beetles on the plantation decreases significantly at the time of the late cultivar ripening. Five plants of the 'Legacy' cultivar, or 5.55%, were noticed to be infested, while on the rows of the 'Huron' cultivar, out of 90 plants taken into observation, 3.33% or three plants, were recorded with the presence of *Cetonia aurata*. The average number of insects collected per bush of the 'Duke' cultivar was 12.7 insects. The average number of insects per bush on the 'Legacy' cultivar was 3, while the average number of insects per bush on the 'Huron' cultivar was 0.27. The largest number (20 per bush) was collected during the first fruit harvest period of the 'Duke' cultivar, the first one to ripen. The results suggest that the infested bushes per row differ significantly between the three groups (Table 1). 'Duke' and 'Legacy' have significantly different mean infested bushes, as do 'Huron' and 'Duke'. The confidence interval for the mean difference between 'Duke' and 'Legacy' is [16.58, 19.82]. The confidence interval for the mean difference between 'Huron' and 'Duke' is [–21.82, –18.58]. Based on the P-values and confidence intervals, the mean difference between 'Duke' and 'Legacy' is statistically significant ($P < 0.05$). The mean difference between 'Huron' and 'Duke' is also statistically significant ($P < 0.05$). However, there is no statistically significant difference between 'Legacy' and 'Huron' ($P = 0.013$).

All pairwise comparisons show a significant difference in the average number of beetles per bush between the groups (Table 2). 'Duke' has signifi-

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Table 1. Average number of infested bushes of blueberry cultivars per row (Tukey's HSD test results)

(I) Group	(J) Group	Mean difference (I–J)	Standard error	Significance level	95% confidence interval	
					lower bound	upper bound
'Duke'	'Legacy'	18.200*	0.653	0.000	16.58	19.82
	'Huron'	20.200*	0.653	0.000	18.58	21.82
'Legacy'	'Duke'	–18.200*	0.653	0.000	–19.82	–16.58
	'Huron'	2.000*	0.653	0.013	0.38	3.62
'Huron'	'Duke'	–20.200*	0.653	0.000	–21.82	–18.58
	'Legacy'	–2.000*	0.653	0.013	–3.62	–0.38

Tukey's HSD test: A post-hoc analysis following an analysis of variance (ANOVA), used to compare the mean differences between groups
*significance at 0.05 probability level

Table 2. Average number of beetles per bush of blueberry cultivars (Tukey's HSD test results)

(I) Group	(J) Group	Mean difference (I–J)	Standard error	Significance level	95% confidence interval	
					lower bound	upper bound
'Duke'	'Legacy'	9.706*	0.670	0.000	8.09	11.33
	'Huron'	12.412*	0.670	0.000	10.79	14.03
'Legacy'	'Duke'	–9.706*	0.670	0.000	–11.33	–8.09
	'Huron'	2.706*	0.670	0.001	1.09	4.33
'Huron'	'Duke'	–12.412*	0.670	0.000	–14.03	–10.79
	'Legacy'	–2.706*	0.670	0.001	–4.33	–1.09

Tukey's HSD test: A post-hoc analysis following an analysis of variance (ANOVA), used to compare the mean differences between groups
*significance at 0.05 probability level

cantly more beetles compared to 'Legacy' and 'Huron', and 'Legacy' has significantly fewer beetles compared to 'Huron'.

The damaged fruits were counted by collecting 100 mature berries from every infested bush and deducting the damaged ones from the total number.

The 'Duke' cultivar experienced the most significant fruit damage, with an average of 16.7% over the three harvesting periods. The damage was highest during the first harvest at 29%, then decreased to 13% in the second harvest, and further reduced to 8% in the third harvest. This trend suggests that the fruit damage for the 'Duke' cultivar lessened as the harvesting periods progressed (Figure 1). In contrast, the 'Legacy' and 'Huron' varieties had minor fruit damage.

The analysis of variance (ANOVA) results show that there are significant differences in the fruit dam-

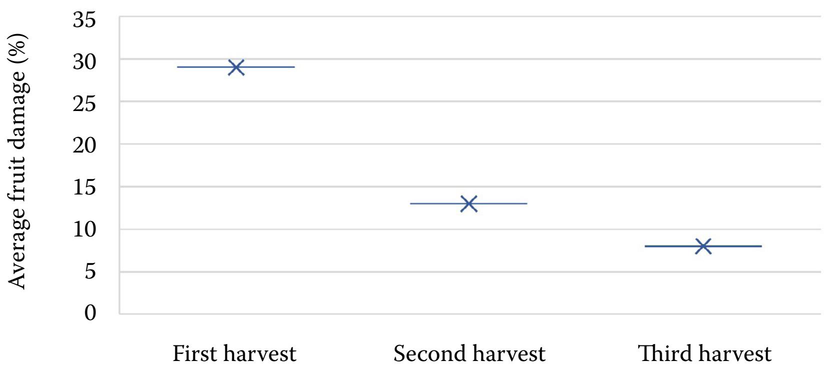

Figure 1. Average fruit damage of 'Duke' blueberry cultivar over the harvesting periods

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age between the groups (first harvest, second harvest, third harvest). The high *F*-value and the very low *P*-value (0.000) indicate that the group means are not all equal, and the differences are statistically significant (Table 3).

The differences in fruit damage between each pair of harvests are statistically significant. The first harvest has significantly higher fruit damage compared to both the second harvest (16.000) and the third harvest (21.000). The second harvest has significantly lower fruit damage compared to the first harvest (–16.000), but is higher compared to the third harvest (5.000). The third harvest has the lowest fruit damage, significantly lower than both the first harvest (–21.000) and the second harvest (–5.000). Tukey's HSD test results indicate that there are significant differences in the fruit damage between the different harvests. The first harvest shows the highest fruit damage, followed by the second harvest, and the third harvest has the least fruit damage (Table 4).

It was noticed that the *Cetonia aurata* infestation was very intensive on the bushes with damaged fruits (Figures 2 and 3). It was not the case with the bushes next to the ones with damaged fruit. It could be because *Cetonia aurata* is attracted by the volatile substances of plants (Ruther 2000).

Damaged blueberry fruits release an aroma due to the presence of volatile compounds (Forney et al. 2022). Olfaction plays an essential role in various insect behaviours, including habitat selection, access to food, avoidance of predators, inter-species communication, aggregation, and reproduction (Ai et al. 2022). The chemical composition that contributes to the unique blueberry flavour includes sugars, acids, and volatile compounds. Sugars are responsible for sweetness, organic acids produce tartness, and volatile compounds contribute to the unique flavour and aroma of the fruit (Forney et al. 2022). The blueberry aroma depends on the interaction of dozens of volatile compounds synthesised by the fruit during ripening (Farneti et al. 2017). In the highbush fruit, approximately 120 unique volatiles have been identified (Sater et al. 2020). Different blueberry cultivars have distinct varietal volatile profiles (Cheng et al. 2020).

This study has proven the destructiveness of *Cetonia aurata*, which varies according to the cultivars and stages of development of cultivated blueberries. In the description given to this insect by different authors, the damage caused by the insect to different parts of different plants is discussed. In the observation area, no damage was recorded on the leaves, flowers and green fruits of the blue-

Table 3. Fruit damage of blueberry cultivars over the harvesting periods (ANOVA test results)

Source	Sum of squares	Degree of freedom	Mean square	*F*-ratio	Significance level
Between groups	2 406.667	2	1 203.333	676.875	0.000
Within groups	48.000	27	1.778	–	–
Total	2 454.667	29	–	–	–

The between-groups row represents the variation among different harvesting periods (first, second and third harvest); the within-groups row represents the variation within each individual harvesting period

Table 4. Fruit damage of blueberry cultivars measured across the harvesting periods (Tukey' HSD results)

(I) Group	(J) Group	Mean difference (I–J)	Standard error	Significance level	95% confidence interval	
					lower bound	upper bound
First harvest	second harvest	16.000*	0.596	0.000	14.52	17.48
	third harvest	21.000*	0.596	0.000	19.52	22.48
Second harvest	first harvest	–16.000*	0.596	0.000	–17.48	–14.52
	third harvest	5.000*	0.596	0.000	3.52	6.48
Third harvest	first harvest	–21.000*	0.596	0.000	–22.48	–19.52
	second harvest	–5.000*	0.596	0.000	–6.48	–3.52

Tukey's HSD test: A post-hoc analysis following an analysis of variance (ANOVA), used to compare the mean differences between groups

*significance at 0.05 probability level

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Figure 2. Insect infestation on the mature fruits

Figure 3. *Cetonia aurata* penetrating the mature berry

berry. Damage was recorded on the ripened berries. 'Duke' is the cultivar with the highest percentage of fruit damage. It is the cultivar that ripens first compared to the other cultivars in the experiment. In the year when the research was conducted, the ripening of blueberries in the experimental area was delayed by at least 8 days compared to other years. This is due to the continuous rains during May and June 2023, with a greater intensity than usual. Damage to the fruits of this cultivar is of economic importance. Damage to the 'Legacy' and 'Huron' varieties is non-significant, even though all the cultivars in the experiment have the same distance from the forest and the *Sambucus ebulus* hedge. The infestation of *Cetonia aurata* in the blueberry plantation decreased with the increase in the flowering of the spontaneous dwarf elder *Sambucus ebulus* plant in the hedge of the blueberry plantation.

An additional study would help to understand the influence of *Sambucus ebulus* on the daily migration of the population of *Cetonia aurata***.** This will help in the evaluation and selection of the sites to establish a blueberry plantation. The introduction of new crop species in areas where they have not been cultivated before requires a study of the natural habitat where these new crops will be cultivated. The relationship between spontaneous plant cultures, which are a host for spontaneous insects, and, as our study proves, form a quiet habitat and are not reported as harmful, can be turned into a harmful habitat for new cultivated crops. According to Lohonyai et al. (2018), *Cetonia* chafers were earlier considered to be secondary pests only. However, their importance has recently been widely recognised (Voigt et al. 2005). Consequently, the demand is growing for the monitoring and selective control of cetoniid chafers depending on the environmental conditions and the phenotype of the plant (Lohonyai et al. 2018).

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