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Spatial distribution of insect pests in the vineyards (Case study: Topoľčianky, Slovakia)

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Abstract

Insect pests are unequally distributed in the vineyard and the environmental factors (most importantly temperature) varies significantly even on the scale of a single vineyard. This paper aims to interpret the spatial distribution of insect pests on the model species of *Lobesia botrana* in the context of climatic and vegetation conditions. The research was carried out in the model vineyard in Topoľčianky, where during the period from May to September 2019, seven pheromone traps were installed in three cycles.

Keywords: insect pests; vineyard; *Lobesia botrana*; pheromone trap; Topoľčianky

Introduction and Objectives

Vitis vinifera and viticulture as such are hugely influenced by various climatic factors and characteristics of the physical environment. Apart from abiotic factors of the environment, many biotic interactions influence the grapevine. One of these factors is the presence of various organisms being either beneficial or harmful for the grapevine [1]. Historical records warn us about the importance of studying the complex interactions between the pests and their host plant. If they are not understood sufficiently, they may have devastating consequences on the grape-growing, as it was in the case of the phylloxera epidemic in the mid-19th century. This epidemic devastated the wine-producing industry in France and had substantial consequences on the grape-growers across Europe [2]. This historical example outlines the importance of studying the pests and monitoring their occurrence in the vineyard.

In this study, the harmful insect species are the main scope. Insect pests can represent various threats for the viticulture - they can directly cause damage on their own; or act as vectors of economically important diseases. Grape-growers, therefore, seek countermeasures to reduce the harmful impacts of the insect pests. However, the interactions between the insect pests and the grapevine are usually not simple, and it is generally known that they differ significantly from country to country, region to region, and, as we discuss in this article, even on a level of an individual vineyard. Therefore, it is almost impossible to generalize the

practices adopted to control the insect pests on a large scale, and it is vital for the grape-growers to monitor and study the insect pests in their own vineyards. Based on the data from previous years, we were expecting the possible occurrence of a few insect pests that are known to occur in the vineyards in this area. These included *Lobesia botrana* (Denis & Schiffermüller) (Lepidoptera: Tortricidae), *Harmonia axyridis* Pallas (Coleoptera: Coccinellidae), *Daktulosphaira vitifoliae* Fitch (Hemiptera: Phylloxeridae), *Byctiscus betulae* (Linnaeus) (Coleoptera: Rhynchitidae), and *Vespula vulgaris* (Linnaeus) (Hymenoptera: Vespidae). Apart from these well-known pests, we hypothesized that *Scaphoideus titanus* Ball (Hemiptera: Cicadellidae), species recently introduced to Slovakia [3], might be possibly detected. Similarly, the occurrence of the Asian hornet, *Vespa velutina* Lepeletier (Hymenoptera: Vespidae) was considered possible, given its rapid spread in Europe in the last decade [4]. Our article aims to study the interactions between the insect pests and the grapevine within the selected model vineyard. At the same time, our study tries to interpret the occurrence of the insect pests in the context of the characteristics of the physical environment and hence develop a better understanding of the complex relationships that have already been mentioned.

Materials and methods

The research was realized in the vineyard with an area of 66.66 ha in the Topoľčianky village (Zlaté Moravce district). The research was realized from May to September of 2019. Three cycles of data collection were realized (25.5.2019 – 28.6.2019; 28.6.2019 – 10.8.2019; 10.8.2019 – 6.9.2019). The beginning of the first cycle was adjusted to the phenophase of budding when the grapevine is generally most susceptible to insect pests. The end of the collection was adjusted to the beginning of the grape harvest. The cycles were unequally long due to intensive agrotechnical interventions (fertilization and pesticide spraying) at the end of July, which means that the collection of the traps had to be postponed by a few days. To capture the insect pest individuals, we used the species-specific pheromone traps. The location of pheromone traps is spatially uniform, respecting the variability of relief. In total, seven pheromone traps were situated in the studied vineyard. Six pheromone traps were accompanied by thermal dataloggers and one was accompanied by meteorological station. The dataloggers as well as the insect traps were located in the leaf wall of the vineyard in the height about 80 centimetres above the ground. As a model species, the European grapevine moth (*Lobesia botrana*) was selected. The focus on *Lobesia botrana* pest was put in respect with supposed most extensive distribution in the vineyards (based on observations from the previous years). The samples were evaluated in the laboratories of Széchenyi István University in

Mosonmagyaróvár (Hungary). As outlined in the objectives, our focus was to evaluate the spatial distribution of the species in reliance to environmental conditions. We tried to demonstrate the correlation between pest occurrence and environmental variables (climate, vegetation) by using a simple linear regression (coefficient of determination R^2).

Results and discussion

Detailed data about the temperature were necessary for interpretation of the differences in the spatial distribution of studied insect pests. These were provided by the thermal dataloggers and meteorological station situated in close vicinity to the individual insect traps. The recorded data have shown notable differences in temperatures between individual sites (Tab. 1).

Tab. 1. Average, minimum and maximum temperatures in the individual sites in the individual cycles of data collection

1	Time interval	Avg.	Min.	Max.	2	Time interval	Avg.	Min.	Max.
	1.5. - 25.5.2019	12,02	2,63	24,80		1.5. - 25.5.2019	12,26	2,05	26,35
	25.5. - 28.6.2019	21,62	9,53	33,87		25.5. - 28.6.2019	21,91	9,43	36,72
	28.6. - 10.8.2019	21,65	8,21	37,19		28.6. - 10.8.2019	21,93	8,62	36,75
	10.8. - 6.9.2019	22,35	9,56	36,48		10.8. - 6.9.2019	22,58	9,98	36,64
	Avg. (25.05. – 28.06.2019) 21,87					Avg. (25.05. – 28.06.2019) 22,14			
3	Time interval	Avg.	Min.	Max.	4	Time interval	Avg.	Min.	Max.
	1.5. - 25.5.2019	11,81	2,23	23,98		1.5. - 25.5.2019	11,76	1,58	24,16
	25.5. - 28.6.2019	21,81	9,50	34,93		25.5. - 28.6.2019	21,75	9,31	34,57
	28.6. - 10.8.2019	21,28	8,32	35,96		28.6. - 10.8.2019	21,80	8,57	36,69
	10.8. - 6.9.2019	21,97	9,08	35,33		10.8. - 6.9.2019	22,36	8,81	36,35
	Avg. (25.05. – 28.06.2019) 21,69					Avg. (25.05. – 28.06.2019) 21,97			
5	Time interval	Avg.	Min.	Max.	6	Time interval	Avg.	Min.	Max.
	1.5. - 25.5.2019	12,05	0,08	25,24		1.5. - 25.5.2019	12,07	-0,55	26,25
	25.5. - 28.6.2019	21,67	8,57	35,13		25.5. - 28.6.2019	21,53	8,29	34,21
	28.6. - 10.8.2019	21,56	7,70	37,66		28.6. - 10.8.2019	21,35	7,51	36,62
	10.8. - 6.9.2019	22,13	8,18	36,10		10.8. - 6.9.2019	21,96	8,26	35,61
	Avg. (25.05. – 28.06.2019) 21,78					Avg. (25.05. – 28.06.2019) 21,62			
AS	Time interval	Avg.	Min.	Max.					
	1.5. - 25.5.2019	11,98	2,69	26,06					
	25.5. - 28.6.2019	21,55	9,52	34,94					
	28.6. - 10.8.2019	21,40	8,19	36,23					
	10.8. - 6.9.2019	21,94	8,97	34,69					
	Avg. (25.05. – 28.06.2019) 21,63								

As indicated by the differences in temperatures between individual sites, the incidence of caught insect individuals varied, too (Tab. 2). In the model vineyard, our study documented three generations of *Lobesia botrana*, which is consistent with the previous observations in Europe [5] and indicates a warm year in respect with the geographic location of the studied vineyard.

Tab. 2. The incidence of all caught insect individuals on the individual sites and cycles of data collection

the numbers of *L. botrana* are shown in parentheses.

Site	First cycle	Second cycle	Third cycle	All cycles combined
1	28 (2)	15 (9)	33 (0)	76 (11)
2	31 (2)	47 (7)	38 (0)	116 (9)
3	43 (0)	38 (5)	83 (0)	164 (5)
4	34 (0)	27 (0)	32 (1)	93 (1)
5	39 (0)	46 (0)	55 (0)	140 (0)
6	32 (0)	92 (0)	107 (0)	231 (0)
AS	28 (2)	52 (0)	49 (0)	129 (2)
Σ	235 (6)	317 (21)	397 (1)	949 (28)

Even though the used insect traps were installed together with pheromone evaporators species-specific to *L. botrana*, insect pests of different species were caught, e.g. leafhopper *Scaphoideus titanus*. In addition, another insect species, previously not known to occur in Slovakia, *Reptalus panzeri* (Löw) (Hemiptera: Cixiidae), was confirmed. Till recently, it was not considered of much importance in respect to the grapevine.

The main objective of our study was to investigate the possible influence of the climatic (temperature) and vegetation variables on the spatial distribution and dynamics of insect pests in the vineyard. If the occurrence of pests in specific parts of the vineyard was proven to be influenced by the climatic conditions, these results could then be interpreted in respect to geomorphological and topographic conditions of the area. In addition to the climatic conditions, the impact of the presence of the forested area was observed (expressed as the shortest distance to the forested area). The data about temperature were derived for each site of insect trapping and for individual cycles of data collection. Therefore, detailed statistical analysis could be performed to express the dependence of the occurrence of insect pests on the environmental characteristics. The incidence was studied in the case of *L. botrana*, and also the sum of all caught insect individuals. These two groups were studied with respect to the minimum, maximum and mean temperature and the distance from the forested area.

In the case of correlation between the occurrence of insect pests and the distance to the forested area, our assumption was that forest might harbour alternative host plants of the insect pests and therefore represent possible sources of spreading of the pests into the vineyard.

As it is shown in Tab. 3, the number of caught individuals did not correlate with any of the microclimatic conditions or the vicinity to the forested area in both studied groups (*L. botrana* individuals and the sum of all insect species caught).

Tab. 3. Obtained coefficients of determination (R^2) while correlating the number of caught individuals with the microclimatic conditions and the vicinity of the forested area

	<i>L. botrana</i>	Insect sum
Avg. temperature (°C)	0.0099	0.0027
Min. temperature (°C)	0.0002	0.1675
Max. temperature (°C)	0.0381	0.0002
Forest (m)	0.0063	0.0027

Apart from our focus on *L. botrana*, the presence of *Scaphoideus titanus* was confirmed in the vineyard. Given its important role in the epidemiology of Flavescence dorée, currently one of the most devastating diseases of the European vineyards [6], it is essential to monitor its occurrence in the vineyards. Even though Flavescence dorée has not yet been confirmed in Slovakia, the studies performed in other European countries indicate that the introduction of the vector often means consecutive introduction of the disease in the course of several years. Early detection and adoption of countermeasures of the disease can significantly reduce the pressure on the vineyards [7].

Our study also confirmed the occurrence of *Reptalus panzeri*, a species previously not officially documented to occur on the territory of Slovakia [8]. This insect has become of particular interest in the context of grape-growing just recently because it was confirmed to transmit the Bois Noir disease to the grapevine [9].

All these three insect species indirectly cause the damage of grapes by being vectors of important grapevine diseases and therefore it is essential to monitor their occurrence in the vineyard. Even though our study did not conclude clear results in the spatial distribution of *L. botrana* based on microclimatic conditions, the early detection of *S. titanus* and *R. panzeri* represents a first step in the successful prevention of significant economic losses that could be caused by introduction of grapevine diseases associated with these species.

Conclusion

The main objective of study was to interpret the spatial distribution of the insect pests

in the vineyard in the context of the environmental factors. We confirmed that the insect pests are unequally distributed in the vineyard and that the environmental factors (most importantly the temperature) varies significantly, considering the total area of the vineyard. The selected model insect species was *Lobesia botrana*. The presence of this insect pest was confirmed in the studied vineyard. However, the occurrence of the pest populations was not large enough to form clear results to confirm or disprove the species' dependence on the selected factors of the environment. From the results we obtained, *Lobesia botrana* was neither markedly dependent on the temperature characteristics (min., max. and avg. temperature), nor on the distance from the forested area.

For further research of *L. botrana* distribution in the vineyard, we propose suggestions to increase the possibility for obtaining more significant results: 1) the time span of the individual cycles of data collection should be reduced to biweekly or even weekly intervals; 2) the time span of the individual cycles of the data collection should be unified and therefore last the same amount of time. In our study, the time span of the individual cycles was different due to intensive agricultural interventions in the vineyard in July. The suggested reducing of the time span of the individual cycles might also help solve the problem with unequally long duration of the cycles because the probability of agricultural interventions during specific cycles will be reduced.

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