WINTER MOTH, *OPEROPHTERA BRUMATA* (*LEPIDOPTERA: GEOMETRIDAE*) - A PEST PROBLEM FOR BLUEBERRY ORCHARDS IN WESTERN ROMANIA

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Abstract. *The species Operophtera brumata, due to its extreme polyphagy, is a potential pest of major importance for many fruit-growing areas in Europe and in Romania. In the western part of Romania, this species of geometrids is more abundant than any other defoliator, and its larvae are extremely harmful, significant damage being produced in the orchards of fruit trees and shrubs, but also in deciduous forests. The most recent infestation with larvae of this pest was reported in 2022, on the southern side of a private blueberry orchard in the Bocșa area, where the blueberry bushes were defoliated only in limited areas. In the autumn of the same year, the adults were also collected with the help of pheromone traps. The following year, 2023, the infestation was more widespread, 10% of the orchard area was infested and chemical treatments had to be applied. The paper aim was to analyse the structure and dynamics of the pest population in order to understand the regularity of its reappearance and the rapid growth of the population. The aim of this paper was to evaluate the biological activity of Operopthera brumata species in Bocșa area under 2023 climatic conditions. A significant correlation between temperature and the period of effective dispersal of adults was found, as the daily dynamics of adult populations of Operophtera brumata increased with increasing temperature from the time the first adult emerged until their density decreased to a level where they no longer caused damage.*

Keywords*: winter moth, Lepidoptera, Geometridae, blueberry, orchards*

INTRODUCTION

Extreme weather events have reduced crop productivity worldwide and climate change poses a serious threat to agriculture and food security. Future projections indicate that the global average temperature is expected to increase by between 2.0 and 6.4°C, an unprecedented increase with significant impacts on weeds, diseases and pests. Rising temperatures in combination with unpredictable rainfall have led to an increase in the incidence and abundance of insect pest species, an increase in their geographical distribution, number of generations and winter survival (ALOTAIBI, 2023).

The majority of insect communities exhibit seasonal variation due to their reproductive strategies and the dependence of their life cycle on climatic factors, in particular temperature, showing strong temporal and spatial variation, particularly over the past five years. In temperate regions, insects show marked temporal variation in abundance and activity, mainly in response to changing temperature and photoperiod (WOLDA, 1988), whereas in lower latitudes with distinct wet and dry seasons, precipitation rather than temperature and photoperiod may be equally influential (HAMER ET AL., 2005). Such effects of temperature and precipitation on phytophagous insects, including defoliating lepidopteran pests, may be mediated indirectly through host plant accessibility and suitability, which is also directly related to environmental factors (FEENY, 1970). An increasing number of researchers (DAMIEN & TOUGERON, 2019; RENNER & ZOHNER, 2018) have emphasised that the seasonal patterns and associated biological processes in insect communities are being altered by the ongoing climate

change, resulting in the disruption of food webs and leading to insect outbreaks and attacks with significant yield losses. To manage these insect pests, it is essential to understand the temporal variability of ecologically sensitive communities and their ecological correlates.

Fruit shrub orchards have been identified as vulnerable to anthropogenic environmental change due to their high rates of local endemism and the fact that some insect species occur in narrow elevation ranges and cause significant damage (McCain & Colwell, 2011, Elsen & Tingley, 2015). While community-level fluctuations in population size are known for many orchard ecosystems in temperate regions (Choi & An, 2013), much less is known about the dynamics of lepidoptera in fruit shrub orchards. In our country, few studies (Dissescu, 1967; Simionescu et al., 1992, 2001, 2012; Tomescu & Nețoiu, 2006) address the problem of lepidopteran pests in orchards, and progress is hampered by a lack of long-term spatio-temporal data.

It is well established that the species *Operopthera brumata* occurs in approximately decade-long cycles, causing extensive defoliation and often death of the host plant (Tenew, 1972; Altenkirch, 1991; Hogstad, 1997; Klemola et al., 2006).

Reliable management solutions for the reduction of the susceptibility of blueberry orchards to this pest are constantly being sought due to the potentially high economic impact of this defoliating lepidopteran. This paper presents the results of the biological activity of *Operopthera brumata* in the Bocșa area, under the climatic conditions of 2023.

MATERIAL AND METHODS

Investigated area

The research was carried out on the land of a family farm near Bocșa, in Caraș Severin County (45°25'48"N, 21°34'55"E).

The lowland aspect of the area where the experimental field is located is typical of the whole of the Bârzava Plain. The Bârzava Plateau corresponds to the contact area with the western hills and Dognecei Mountains in the east, continuing with the lower reaches of Gătaiei Tabular Plain in the west. The northeastern boundary is the contact with the Silagiului Hills and the Arenișului foothills, a massif fragmented by deep valleys. The southeastern border is formed by the contact with Tirol Hills and Dognecea Mountains; the northwestern border is less visible, since two watersheds develop in this area: Pogănișul to the north and Bârzava to the south. The average height of the relief is 140 m above sea level.

The multiannual average temperature is 10.56°C; the average temperature in July is 21.3°C, while the average temperature in January is -0.3°C.

The study area is classified as having a temperate continental climate, subtype of Banat with sub-Mediterranean tendencies. An analysis of the rainfall shows an average of 558.95 litres per square metre, with a minimum of 477.9 litres per square metre. There is a typical lowland zone in the area, due to the opening of the Moravița Plain towards the Varșețului Ridge, from where there is a fairly strong air circulation from the western sector.

The soil cover is a faithful reflection of the interaction between pedogenetic and anthropogenic factors and the spatial layout of the municipality. Soils are typically eutric cambisols (Lațo & Rusu, 2007).

Data collection

The total area of the experimental field was 27 ha. A grassland system underlies the plantation. The blueberry variety used in the research was Duke.

The study to identify the *Geometridae* species present in the blueberry orchards started in spring 2023.

The first stage in the sampling of the biological material consisted in the direct visual control of the plants, after which the larval attack was reported, followed by the monitoring of the adult populations (in the autumn of the same year), which included the collection with the help of pheromone traps in order to collect the males and the exact assessment of the *Operophtera brumata* population level, in order to develop a control strategy according to the potential impact on production.

To monitor adults (SZONYI et al., 2021; GROZEA et al., 2011, 2021), we used white Delta traps with adhesive and Pherodis dispensers with associated Koppert pheromone to collect *Operophtera brumata* male from early November to mid-December 2023.

Depending on climatic conditions, the frequency of collection (reading) was every 7 to 10 days (GUGEA at al., 2017). For each collection date, 1 trap per hectare was placed, for a total of 27 traps per experimental field. The pheromone was replaced every 3 weeks and the sticky cards every 10 days.

RESULTS AND DISCUSSIONS

In the blueberry orchard in the Bocsa area, Operopthera brumata was the most abundant species recorded in 2023, with a total of 2368 adults collected, averaging 87.7 adults per trap over a 5-week period. Statistical analysis revealed no significant differences in the number of adults captured between traps (Table 1). The p-value (0.764), which is well above the standard significance level ($\alpha = 0.05$), suggests that the observed variation in the number of adults between traps is likely to be due to climatic conditions and other influences rather than significant differences between traps.

Table 1.

Number of adult specimens of *Operophtera brumata* collected from blueberry orchard in the Bocșa area, 2023

Collection date	**N**	**Σ**	**$\bar{x}$**	**S.D.**	**S.E.**	**CV%**	**T (°C)**	**P(mm)**	**RH(%)**
15.11.2023	27	0	0	0	0	0	10.4	14.4	94
22.11.2023	27	109	4.04	2.7940	0.5377	69.21	6.4	0	94
29.11.2023	27	449	16.63	4.8050	0.9247	28.89	1.3	9.6	94
06.12.2023	27	538	19.93	5.0834	0.9783	25.51	2.6	0	85
13.12.2023	27	619	22.93	5.0071	0.9636	21.84	8.8	3	91
17.12.2023	27	653	24.19	5.3711	1.0337	22.21	-1.1	0	99
Total		**2368**	**87.7**						

ANOVA	***Sum of Squares***	***df***	***Mean Square***	***F***	***p-value***	***F crit***
Between Groups	2206.938	26	84.88224	0.781267	0.764393	1.577861
Within Groups	14667.33	135	108.6469			
Total	16874.27	161				

**N - number of captures; Σ - total number of adults/27 deltatraps; $\bar{x}$ - average number of adults/trap;S.D. – standard deviation; S. E. – standard error; CV% - coefficients of variation; T (°C) - temperature; P (mm) - precipitation; RH (%) - relative humidity of the atmosphere.*

An analysis of the evolution of adults in the 27 pheromone traps shows that the most adults were collected from trap 9 (n= 117 adults/trap), but also from traps 26 and 2 (n= 116 and 115 adults/ trap, respectively). The fewest individuals were collected from trap 18 (n = 36 adults/trap), and traps 17 and 6 with 42 adults each. The median and spread of adults collected for each trap appear relatively consistent across traps (figure 1). It should be noted that the highest number of individuals was collected from the traps located in the edge areas of the blueberry plantation, where the bushes were smaller, and the influence of the edge areas -

through spontaneous vegetation - also strongly influenced the number of adults collected. The number of adults collected declined with distance from the edges, with the lowest number of adults being collected from traps located in the central area of the plantation, where the shrubs were more evenly developed and the species of the natural floral composition were not present.

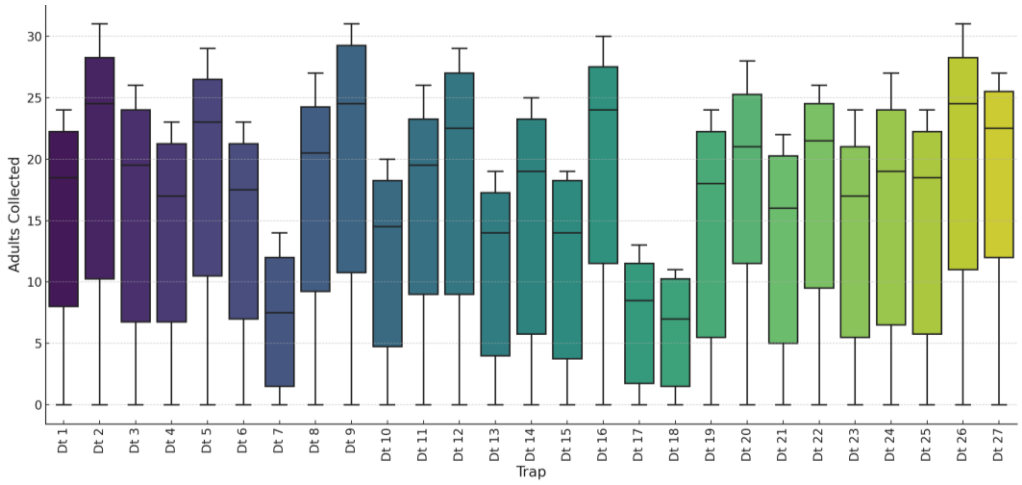

Fig. 1. Distribution of *Operophtera brumata* adult per trap:boxplot diagram

The results obtained are close to those of FORTIN & MAFFETTE (2001), who showed the direct influence of marginal habitats on the population dynamics of lepidopteran populations in the forest zone, through changes in the nutritional quality of the foliage, but also the influence of environmental variability on the developmental rates of butterflies, especially on critical processes in the dynamics of these populations, such as influencing dispersal distances and defining population viability.

Since the collected species are polyphagous, with the advantage of feeding on many host species, and blueberries are one of the primary hosts in blueberry plantations in our country, the diversity of plants as secondary host species around the plantation directly affects their abundance (O'DONNELL, 2015).

During the 32 days in which the adult stage was sampled, oscillating values were recorded, with the highest number of individuals recorded on 17 December 2023 (n = 653). The high frequency may be explained by the frequent presence of primary and secondary host plants: oak (Quercus spp.), maple (Acer spp.), birch (Betula spp.), found in the vicinity of the orchard, located on high hills and surrounded by broadleaf woods.

We followed the dynamics of these populations from November onwards, knowing that the pest overwinters in their egg stage and that integrated management of a plantation requires monitoring to control the pest, and that it is recommended to control the adult stage of the pest before copulation or egg laying. The first individuals were observed on 22 November (Figure 2).

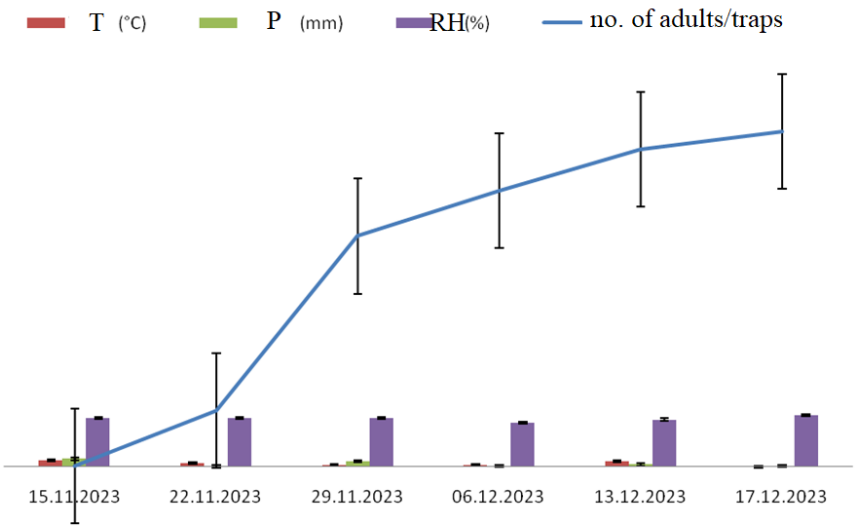

Fig. 2. Population dynamics of *Operophtera brumata* adults in the blueberry orchard of Bocșa area (Caras-Severin County), 2023

After this date, a steady and sustained increase occurred during the 5 weeks of collection until 17 December, when the maximum number of individuals was reached. Chemical treatments with synthetic pyrethroid products containing the active ingredient tau-fluvalinate (Mavrik 2F) were applied due to the high number of individuals exceeding the economic damage threshold on 18 December.

Our results agree with those of CALDERWOOD ET AL. (2023), who emphasized that consistent and continuous monitoring remains key to keeping these populations below the economic threshold of damage, and can create a predictive model based on adult male capture.

Research by NEUVONEN ET AL. (1999) and TENOW ET AL. (2013) has shown that recent climate warming has led to an intensification of geometrid moth outbreaks in all areas of Europe, resulting in increasingly intense dispersal, with a dispersal rate of 7.4 km/yr, a total distance of over 44 km. Therefore, by correlating how populations evolve with temperature, rainfall and humidity, we can also understand how these influence how populations evolve.

ELKINTON ET AL. (2014) highlight the importance of winter temperatures on the evolution of populations of *Operophtera brumata*, as an increasing decrease in temperature would limit the distribution of the species to high hills or lowlands, thus preventing winter moth populations from reaching high defoliation levels. Therefore, another objective of the research was the analysis of the relationship between climatic factors and adult populations of the winter moth.

During the research period, average temperatures, rainfall and relative humidity were monitored, as two of these three factors are key to the evolution of the insect species under study (Table 1). Although a detailed analysis of the climatic conditions is not the main objective of this study, it is an essential part of the research. We found that 2023 was atypical by assessing their influence throughout the active blueberry growing season. It stood out as the warmest of the last five years, with above-average temperatures, prolonged periods of intense heat, abundant but unevenly distributed precipitation and numerous episodes of heavy rain, causing considerable variation in the populations under study.

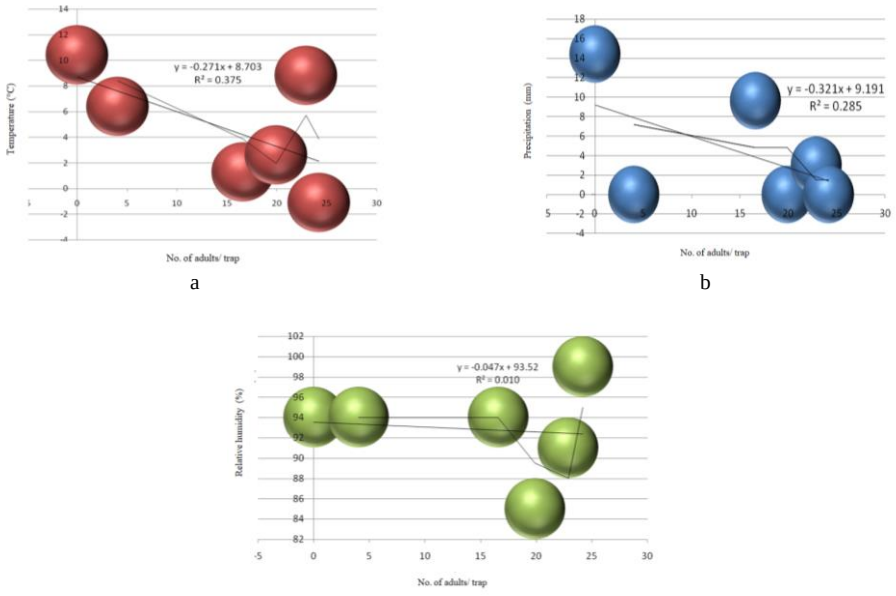

Fig. 3. Correlation between the average number of adults of *Operophtera brum*ata and: a - air temperature; b - precipitation; c - relative humidity, in the blueberry orchard in the Bocșa area, 2023

The correlation coefficient r indicates the strength and direction of the linear relationship between the mean number of adults and temperature. The correlation coefficient, r, was 0.375, indicating a positive but insignificant relationship between the two variables for the autumn 2023 data. The same positive but not significant correlation was also found for the precipitation factor (r = 0.285). For humidity, the correlation coefficient is not significantly different from zero (r = 0.010), so there is not enough evidence to conclude that there is a significant linear relationship between the mean number of adult *Operophtera brumata* and relative humidity. Under the current environmental conditions, as shown in the linear regression model in figure 3 a,b,c, the positive effect of environmental factors on adult populations of *Operophtera brumata* is significant, with correlation rates of up to 37.5%.

General distributions of winter moth adults are closely related to surrounding vegetation, altitude and food availability, and are strongly affected by local air temperature. These factors can directly affect the potential damage caused by this pest by delaying or accelerating the development and reproduction of the species and by increasing or decreasing the numerical density of the population. Studies carried out in different areas and altitudes, both in orchards and in forests, have shown that abundance is largely controlled by climatic factors (HAGEN ET AL., 2007; LAKSFORSMO VINDSTAD ET AL., 2022). On a global and regional scale, the seasonality of temperature is the most important factor influencing numbers and abundance (KARVINEN, 2021).

The number of winter moths was limited mainly by the heterogeneity of the climate, the total amount of hydrothermal reserves, but also by the precipitation gradient. In comparison with other pests that are frequently found in blueberry plantations in the Banat region, the species studied has a narrower range of physiological tolerance to climatic factors.

These results confirm the data that an increase in the average temperatures during the winter months leads to a significant increase in the population. In order to develop a model for

predicting population fluctuations of *Operophtera brumata* in blueberry orchards in the Bocșa area, research should be continued over a longer period of time.

CONCLUSIONS

The *Operophtera brumata* activity results, presented in this study, showed that trapping in peripheral blueberry orchard areas was more effective in capturing adults. Differences in vegetation and shrub size also had a marked effect on adult distribution and capture. Between November and December 2023, mean daily temperatures and precipitation were the most important factors in the development of this species, and positive relationships were found between the number of adults of *Operopthera brumata* and these climatic factors. In addition to the importance of climatic conditions, the study also highlighted the importance of food availability and food preferences in the limiting/expansion of the outbreak of *Operopthera brumata* in western Romania.

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