NEW RESEARCH ON THE EVOLUTION OF *Lymantria monacha* L. (LEPIDOPTERA, LYMANTRIIDAE) IN THE CONDITIONS OF THE YEAR 2019 AND THE CONTROL OF THE PEST POPULATION WITHIN THE MIERCUREA SIBIULUI FOREST RANGE (ROMANIA)

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Abstract. The Miercurea Sibiului Forest District administers an area of 14,911 ha forest fund public property of the state with an altitude ranging from 1100 to 1950 m. The following production units are included in the forestry fund (UP Bistra, UP IV Ciban, UP V Pod). From this surface, an area of 2970.4 ha, i.e. approximately 19.9%, was affected by pests (biotic and abiotic) in 2019; the infested area was maintained at the level of 2018. The present study is a continuation of the research carried out from the year 2011 and includes the analysis of the evolution of the defoliator *Lymantria monacha* L., 1758 under the conditions of 2019. Of the three monitored production units, where a set of 81 pheromone traps was installed, the largest number of butterflies of *Lymantria monacha* at a control point, during the entire observation period, was registered in UP III Bistra, the administrative unit 162B, where 64 specimens were captured.

Keywords: *Lymantria monacha* L., Miercurea Sibiului Forest District (Sibiu county, Romania), pheromonal traps.

Rezumat. Noi cercetări cu privire la evoluția speciei *Lymantria monacha* L. (Lepidoptera, Lymantriidae) în condițiile anului 2019 și controlul populației dăunătorului în cadrul Ocolului Silvic Miercurea Sibiului (România). Ocolul Silvic Miercurea Sibiului administrează o suprafață de 14,911 ha fond forestier proprietate publică a statului ce se află între 1100-1950 m altitudine. În componență fondului forestier intră următoarele unități de producție (UP Bistra, UP IV Ciban, UP V Pode). Din acestă spuprafață în cursul anului 2019 a fost afectată de dăunători (biotici și abiotici) o suprafașă de 2970.4 ha aproximativ 19,9%, suprafața infestată s-a menținut la nivelul anului 2018. Prezentul studiu este o continuare a cercetărilor desfășurate începând cu anul 2011 și cuprinde analiza evoluției defoliatorului *Lymantria monacha* L., 1758 în condițiile anului 2019. Din cele trei unități de producție monitorizate, în care au fost instalate un set de 81 de capcane feromonale, cel mai mare număr de fluturi de *Lymantria monacha* la un punct de control, pe toată perioada de observații au fost înregistrați în UP III Bistra, unitatea administrativă 162B, unde au fost capturați 64 de exemplare.

Cuvinte cheie: *Lymantria monacha* L., Ocolul Silvic Miercurea Sibiului (Sibiu, România), capcane feromonale.

INTRODUCTION

The Miercurea Sibiului Forest District has forests in the area of Sebeş Valley, for a length of 93 km. The forest vegetation in the Miercurea Sibiului Forest District falls into 24 natural types of forest, of which the following prevail: spruce with *Vaccinium myrtillus* and *Oxalis acetosella* (m) 23%; spruce with *Vaccinium myrtillus* (i) 28%; spruce with green moss (m) 19%. The following production units are found in the bypass: UP III Bistra, UP IV Ciban, UP V Pod. In the production unit V Pod – the dominant species is spruce (100%); in unit IV Ciban – 99% spruce and 1% beech, and in unit III Bistra – 70% spruce and 30% other species (fir and beech).

In 2019, the sanitary condition of the forests within the Miercurea Sibiului Forest District can be considered good,considering that no massive attacks of diseases and pests, fires or mass drying events have been reported. The forests within the Miercurea Sibiului Forest District have a high degree of self-regulation, as well as a good recovery capacity.

Among the destabilizing and limiting factors encountered in the perimeter of the bypass we can list: wind and snow breaks and breaks, abnormal drying, pest attacks: *Grylotalpa grylotalpa*, *Melolontha melolontha*, *Hylobius abietis*, *Hylastes* sp., *Ips typographus*.

Researches regarding the control of pest populations within the Miercurea Sibiului Forest District have been carried out by authors starting 2011 and continuing today (STANCĂ-MOISE, 2014, 2016; STANCĂ-MOISE & BLAJ, 2017a; STANCĂ-MOISE et al., 2017b). They studied the dynamics and evolution of the defoliator, proposing methods and means of combatting them. The studies carried out are the results of the research for the beetle species (*Hylobius abietis* and *Ips typographus*) (STANCĂ-MOISE & BLAJ, 2017b; STANCĂ-MOISE et al., 2018a, c).

Specialized articles on this pest have been published by researchers from different countries of the world (ALTENKIRCH et al., 1986; BEJER, 1998; BEXA et al., 2013; DZIADOWIEC et al., 1985; FUESTER et al., 1975; GRUBER et al., 1978; HUMPHREYS & ALLEN, 2002; KEENA, 2003; PENG et al., 2016; SCHWERDTFEGER, 1981).

From the data provided in 2020 by CABI org., the worldwide presence of this pest is as follows: in Asia it has been reported in 25 countries, and in Europe in 36 countries, including in Romania (MIHALCIUC et al., 1988, 1989, 1997, 1998, 2000; OLTEAN et al., 2003).

MATERIALS AND METHODS

The monitoring of the dynamics and evolution of the populations of the defoliator *Lymantria monacha* L. is studied starting with 2011 and was carried out within the bypass according to the Order no. 42 / 13.03.1987 specifically for spruce forests in which the fir participates with over 30%, regardless of the age of the trees.

Within the Miercurea Sibiului Forest District, in 2019, a number of 81 control points were installed: 29 traps in UP III Bistra mounted in the time interval between 15-19.07.2019, 29 traps in UP IV Ciban installed between 17-19.07.2019 and 23 what in the V unit Pod installed between 16-19.07.2019, using AntraLymon pheromone nets mounted on plastic panel traps with adhesives (glues omitted), produced by the "Raluca Ripan" Chemistry Institute Cluj-Napoca.

In order to cover the entire area that could be infested, the pheromone runs were placed in a monitoring system (1:20.000) so that it would be a control point at about 200 ha.

The inventory of the traps was done between July and September when the butterfly flight takes place. The period of verification and registration of catches covered seven intervals: July 20-26, August 22-27, August 3-9, August 10-16, August 17-23, August 24-31 and September 1-15 (Tables 5, 7, 9).

RESULTS AND DISCUSSIONS

Following the monitoring of the evolution of the species of the defoliator *Lymantria monacha* L. during the year 2019 (Tables 1, 2, 3), after the centralization and analysis of the data obtained in the field, we invented a number of 2,011 samples captured in the three production units (Tables 4, 6, 8).

In the production unit III Bistra, where the age of the trees is of 35-150 years, the dominant species being the spruce in a proportion of 70%, the pheromone traps were placed during the time period 16-19 July 2019. In the perimeter of this production unit, the distribution of the traps was as follows (10 inside the forest, 18 in the middle, 1 in the upper area and 29 at the edge of the massif). From these collection points, a number of 872 butterflies were captured (Tables 5, 6).

Table 1. The situation of caught butterflies *Lymantria monacha* L., in the year of 2019.

Forest District	Surface (ha)	Installed panels	Captured butterflies			
			Total	Panels	Light sources	On the bark
III Bistra	4300	29	872	872	-	-
IV Ciban	2400	29	724	724	-	-
V Pode	2000	23	415	415	-	-

Table 2. The situation of caught butterflies *Lymantria monacha* L., with the help of pheromone traps, in the year of 2019.

Production unit	Administrative unit	Captures per panel		Average number of captures/panel	Maximum number of captures/panel
		1-50	51-100		
III Bistra	168 B	27	2	30.07	64
IV Ciban	15/16	28	1	24.97	54
V Pode	175 A	23	0	18.04	24

Table 3. The situation of caught butterflies *Lymantria monacha* L., at panel traps over the last five years in the production unit III Bistra.

Year	Administrative unit	Maximum numbers of captures
2015	162 B	50
2016	162 B	64
2017	162 B	84
2018	162 B	70
2019	162 B	64

From the analysis of the data in the field and their centralization, we can notice that between July 20 and 26, 144 butterflies were captured, August 22-27 – 175 specimens, August 3-9 – 127 specimens, August 10-16 – 161 specimens, 17 -23 August – 134 specimens, 24-31 August – 97 specimens and 1-15 September – 34 specimens, from the analysis of these data we can that say most specimens were captured during the period July 27-August 2, when the adult flight curve reached its peak value.

Table 4. The situation of controlling the presence of the defoliator *Lymantria monacha* L., with the help of Atralymon pheromone traps for the year 2019 in the production unit III Bistra.

Adminis-trative unit	Exposure, altitude	Composition	Age	Nr. trees/ha	Location					Installation Date
					Inferior	Medium	Superior	Heavy	Heavy margin	
16B	SV/700	7Fa3Mo	140	190	x			x		19.07.2019
20	SV/980	5Fa3Mo2Br	130	230		x		x		19.07.2019
22/23	SV/920	6Fa4Mo	70	380	x			x		19.07.2019
34	SV/980	10Mo	75	430		x		x		15.07.2019
31	SV/980	9Mo1Fa	75	480		x		x		15.07.2019
36A	SE/1300	10Mo	60	760		x		x		15.07.2019
40A	S/1300	6Mo3Br1Fa	150	350		x		x		15.07.2019
45	E/1400	10Mo	45	850		x		x		18.07.2019
46E	S/1300	10Mo	20	2900		x		x		18.07.2019
61A	N/1450	10Mo	45	1200		x		x		18.07.2019
70A	S/1500	10Mo	55	1600	x			x		18.07.2019
77B	S/1600	10Mo	40	800		x		x		18.07.2019
85A	N/1550	10Mo	40	1100		x		x		18.07.2019
107A	E/1600	10Mo	50	1850	x			x		18.07.2019
110C	NV/1600	10Mo	40	2800	x			x		17.07.2019
116B	NV/1550	10Mo	35	2300		x		x		17.07.2019
118C	NE/1500	10Mo	135	560	x			x		17.07.2019
124A	E/1500	10Mo	70	1700		x		x		17.07.2019
129A	NE/1500	10Mo	75	920		x		x		15.07.2019
134A	NE/1500	10Mo	70	810	x			x		15.07.2019
145	NE/1500	10Mo	55	1420		x		x		15.07.2019
154A	N/1400	10Mo	70	860		x		x		15.07.2019
160A	NV/1300	10Mo	95	900	x			x		18.07.2019
162B	NV/1300	10Mo	95	840		x		x		18.07.2019
164B	NV/1200	10Mo	100	950		x		x		18.07.2019
168B	NV/1200	8Mo2Fa	120	650		x		x		18.07.2019
170	NE/1300	10Mo	130	350			x	x		18.07.2019
180	N/1051	6Fa2Mo2Br	100	350	x			x		18.07.2019
184B	NE/10501	8Fa2Mo	150	280	x			x		18.07.2019

Table 5. Dynamics of butterfly capture of *Lymantria monacha* L., with the help of pheromone traps with Atralymon in 2019 in the production unit III Bistra.

Trap no.	Installation date	Number of captured butterflies							Total
		20-26 VII	27VII-2VIII	3-9 VIII	10-16 VIII	17-23 VIII	24-31 VIII	1-15 IX	
1	19.07.2019	2	2	6	1	1	0	0	12
2	19.07.2019	2	3	1	3	2	0	0	11
3	19.07.2019	3	3	4	5	0	0	0	15
4	15.07.2019	10	20	0	3	5	0	0	38
5	15.07.2019	10	17	1	5	7	0	0	40
6	15.07.2019	12	14	0	2	10	0	0	38
7	15.07.2019	16	13	0	7	0	0	0	36
8	18.07.2019	5	3	2	5	0	0	0	15
9	18.07.2019	6	2	2	2	0	0	0	12
10	18.07.2019	3	1	4	7	0	0	0	15
11	18.07.2019	2	2	2	6	0	0	0	12
12	18.07.2019	4	8	1	3	5	2	0	23
13	18.07.2019	3	8	2	1	1	5	0	20
14	18.07.2019	5	5	3	2	2	4	3	24
15	17.07.2019	3	2	4	3	1	4	0	18
16	17.07.2019	7	6	3	2	5	6	1	30
17	17.07.2019	6	5	6	4	4	3	0	28
18	17.07.2019	5	8	4	4	5	5	0	31
19	15.07.2019	1	2	5	7	5	4	0	24
20	15.07.2019	4	4	12	9	11	5	2	47
21	15.07.2019	2	2	7	10	10	11	7	49
22	15.07.2019	1	3	6	6	3	8	4	30
23	18.07.2019	2	4	5	6	8	2	5	32
24	18.07.2019	6	8	10	6	8	5	1	44
25	18.07.2019	2	2	7	10	10	11	7	49
26	18.07.2019	6	8	10	18	12	9	1	64
27	18.07.2019	7	9	10	15	7	5	1	54
28	18.07.2019	4	6	4	4	6	2	2	28
29	18.07.2019	5	5	6	5	6	6	0	33
TOTAL									**872**

In the unit of production IV Ciban where the age of the trees is between 15-170 years, the dominant species being the spruce in proportion of 99%, were located the pheromone traps during the time period 16-19 July 2019. On the radius of this unit of production (Tables 6, 7), the distribution of the traps was the following (13 inside the forest, 11 in the middle, 5 in the upper area, 22 in the mass zone and 7 at the mass edge). From these collection points a number of 724 butterflies were captured. From the analysis of the field data we can highlight the fact that in the interval 20-26 July 56 butterflies were captured, 27-2 August – 76 specimens, 3-9 August – 146 specimens, 10-16 August – 146 specimens, 17-23 August – 179 specimens, 24-31 August – 121 specimens and 1-15 September – 0 specimens, from the centralization of these data we can say that during the period 2-17 August were captured most specimens.

Table 6. Dynamics of butterfly capture of *Lymantria monacha* L., with the help of pheromone traps with Atralymon in 2019 in the production unit IV Ciban.

Administrative Unit	Exposure, altitude	Composition	Age	Nr. trees/ha	Location					Installation Date
					Inferior	Medium	Superior	Heavy	Heavy margin	
15/16	S/1300	10Mo	120	450	x			x		18.07.2019
17B	SV/1400	10Mo	70	1450	x				x	18.07.2019
26/27	S/1400	8Mo2Fa	170	980		x		x		18.07.2019
34B	S/1400	10Mo	75	980		x		x		18.07.2019
30B	SE/1300	10Mo	75	1100	x			x		19.07.2019
29B	S/1400	10Mo	75	870			x	x		19.07.2019
12	S/1200	10Mo	100	634	x			x		19.07.2019
72	SV/1300	10Mo	70	1470			x	x		18.07.2019
63	S/1200	10Mo	120	420	x				x	18.07.2019
48	S/1500	10Mo	120	1250	x				x	18.07.2019
40A	E/1250	10Mo	80	1150	x				x	18.07.2019
68	S/1300	10Mo	70	1320	x			x		18.07.2019
54A	SV/1300	10Mo	100	875			x	x		18.07.2019
97A	SE/1300	10Mo	15	2400	x			x		18.07.2019
119A	NV/1400	10Mo	25	2680		x		x		18.07.2019
85A	NV/1500	10Mo	35	178		x		x		18.07.2019
93B	SV/1300	10Mo	80	750		x		x		18.07.2019
103	SV/1250	10Mo	70	650		x		x		17.07.2019
127B	V/1500	10Mo	120	475	x			x		17.07.2019
131B	N/1500	10Mo	100	550		x		x		17.07.2019
135B	SV/1500	10Mo	35	2600	x			x		17.07.2019
154A	E/1400	10Mo	30	2400	x			x		17.07.2019
157C	N/1200	10Mo	45	1823	x			x		17.07.2019
175A	N/1130	10Mo	55	975		x			x	17.07.2019
195A	NV/1250	10Mo	100	791		x		x		17.07.2019
182A	NV/1450	10Mo	115	451		x			x	17.07.2019
179B	NV/1600	10Mo	110	560			x	x		17.07.2019
199	NV/1350	10Mo	50	979			x		x	17.07.2019
158C	V/1300	10Mo	95	560		x		x		17.07.2019

Table 7. Dynamics of butterfly capture of *Lymantria monacha* L., with the help of pheromone traps with Atralymon in 2019 in the production unit IV Ciban.

Trap no.	Installation date	Number of captured butterflies							Total
		20-26 VII	27VII-2 VIII	3-9 VIII	10-16 VIII	17-23 VIII	24-31 VIII	1-15 IX	
1	18.07.2019	0	4	6	14	18	12	0	54
2	18.07.2019	0	4	4	10	16	13	0	47
3	18.07.2019	0	3	5	9	10	10	0	37
4	18.07.2019	0	0	4	10	13	13	0	40
5	19.07.2019	0	3	2	10	14	12	0	41
6	19.07.2019	0	3	3	6	12	9	0	33
7	19.07.2019	0	3	5	8	11	9	0	36
8	18.07.2019	4	1	0	3	1	3	0	12
9	18.07.2019	0	3	2	5	4	0	0	14
10	18.07.2019	2	0	4	1	5	1	0	13
11	18.07.2019	1	2	6	0	4	3	0	16
12	18.07.2019	1	4	3	4	0	0	0	12
13	18.07.2019	2	4	0	5	1	3	0	15
14	18.07.2019	8	4	2	0	3	2	0	19
15	18.07.2019	6	5	3	2	4	2	0	22
16	18.07.2019	1	0	1	0	4	1	0	7
17	18.07.2019	6	3	2	1	5	2	0	19
18	17.07.2019	1	2	2	1	3	3	0	12
19	17.07.2019	5	3	2	2	0	0	0	12
20	17.07.2019	0	3	7	0	1	4	0	15
21	17.07.2019	5	0	0	4	0	0	0	9

22	17.07.2019	5	5	4	0	4	0	0	18
23	17.07.2019	0	1	4	2	4	0	0	11
24	17.07.2019	2	3	16	10	9	7	0	47
25	17.07.2019	1	2	10	8	5	9	0	35
26	17.07.2019	1	3	15	6	4	0	0	29
27	17.07.2019	2	4	14	10	10	1	0	41
28	17.07.2019	1	2	14	7	5	0	0	29
29	17.07.2019	2	2	6	8	9	2	0	29
TOTAL									**724**

In the production unit V Pod where the age of the trees is between 35-125 years, the dominant species being the spruce in a proportion of 100%, the pheromone traps were placed in the time period 17-19 July 2019. Within the scope of this production unit (Tables 8, 9, 10), the distribution of the traps was the following: 1 inside the forest, 18 in the middle, 4 in the upper area, 17 in the mass zone and 6 at the mass edge. From these collection points, a number of 415 butterflies were captured. From the analysis of the data from the field we can highlight the fact that during 20-26 July 14 butterflies were captured, 27-2 August – 32 specimens, 3-9 August – 60 specimens, 10-16 August – 78 specimens, 17-23 August – 78 specimens, 24-31 August – 107 specimens and 1-15 September – 46 specimens, from the centralization of these data we can say that during the period 24-31 August most specimens were captured.

Table 8.The situation of the control and presence of defoliator *Lymantria monacha* L., with the help of Atralymon pheromone traps for the year 2019 in the production unit V Pod.

Administrative unit	Exposure, altitude	Composition	Age	Nr. trees/ha	Location					Installation date
					Inferior	Medium	Superior	Heavy	Heavy margin	
6/7	V/1350	10Mo	80	420		x		x		18.07.2019
14A	SE/1350	10Mo	120	275		x		x		18.07.2019
20D	N/1500	10Mo	50	1200		x		x		18.07.2019
22A	NE/1300	10Mo	40	700		x			x	18.07.2019
25D	NV/1300	10Mo	70	275		x			x	19.07.2019
183A	N/1300	10Mo	45	420		x		x		19.07.2019
175A	S/1550	10Mo	80	860		x		x		19.07.2019
43A	E/1450	10Mo	85	245			x		x	18.07.2019
63C	N/1550	10Mo	35	1326		x		x		18.07.2019
75C	V/1450	10Mo	40	1525			x	x		18.07.2019
95/96	N/1550	10Mo	85	380			x	x		18.07.2019
82B	S/1550	10Mo	110	245		x		x		18.07.2019
109B	N/1550	10Mo	80	320			x	x		18.07.2019
113A	N/1300	10Mo	70	480	x				x	18.07.2019
126A	S/1500	10Mo	105	450		x		x		18.07.2019
88A	SE/1500	10Mo	70	1250		x		x		18.07.2019
106A	SV/1550	10Mo	100	420		x		x		18.07.2019
134B	S/1450	10Mo	75	420		x		x		16.07.2019
143E	S/1600	10Mo	55	503		x		x		16.07.2019
174A	S/1550	10Mo	145	460		x		x		17.07.2019
151B	S/1500	10Mo	125	432		x			x	17.07.2019
159A	V/1600	10Mo	125	470		x			x	17.07.2019
169C	S/1600	10Mo	120	452		x		x		17.07.2019

Table 9. Dynamics of the capture of butterflies *Lymantria monacha* L., with the help of pheromone traps with Atralymon in 2019 in the production unit V Pod.

Trap no.	Installation date	Number of captured butterflies							Total
		20-26 VII	27VII-2VIII	3-9 VIII	10-16 VIII	17-23 VIII	24-31 VIII	1-15 IX	
1	18.07.2019	1	3	3	5	7	2	1	22
2	18.07.2019	0	2	4	5	9	1	0	21
3	18.07.2019	2	3	5	6	6	1	0	23
4	18.07.2019	2	3	4	5	4	2	2	22
5	19.07.2019	2	2	3	4	6	1	2	20
6	19.07.2019	3	3	4	6	3	3	2	24
7	19.07.2019	3	6	2	2	6	5	0	24
8	18.07.2019	0	4	2	4	2	3	0	15
9	18.07.2019	1	5	2	4	3	2	0	17
10	18.07.2019	0	1	2	3	2	1	0	9
11	18.07.2019	0	0	3	7	5	3	0	18
12	18.07.2019	0	0	4	4	2	6	0	16
13	18.07.2019	0	0	6	3	3	5	0	17
14	18.07.2019	0	0	5	5	4	4	0	18
15	18.07.2019	0	0	4	5	6	5	0	20
16	18.07.2019	0	0	5	6	5	3	0	19
17	18.07.2019	0	0	1	1	0	11	5	18

18	16.07.2019	0	0	1	1	1	6	4	13
19	16.07.2019	0	0	0	1	1	5	4	11
20	17.07.2019	0	0	0	1	0	8	4	13
21	17.07.2019	0	0	0	0	1	10	7	18
22	17.07.2019	0	0	0	0	1	10	8	19
23	17.07.2019	0	0	0	0	1	10	7	18
TOTAL									**415**

Table 10. The situation of softwood trees in which the presence of the defoliator *Lymantria monacha* L. was reported and of the protection measures planned for 2020.

Forestry district	**The surface of the resin trees in which the presence of the pest has been reported (ha)**		**The number of pheromone traps scheduled for 2020**
	2018	**2019**	
UP III Bistra	4300	4300	29
UP IV Ciban	2400	2400	29
UP V Pode	2000	2000	23
Total	**8700**	**8700**	**81**

CONCLUSIONS

The measures to protect the forest against the defoliator proposed for the year 2020 (Table 10), are necessary, timely and are part of the plan of research, monitoring and control of the population of this pest. Within the Miercurea Sibiului Forest District the defoliator *Lymantria monacha* L. is still in the latency stage because no more than 200 butterflies per collection point were captured in the trees under 60 years old or over 500 butterflies per collection point in the trees for over 60 years. In order to avoid extending the outbreaks in which the presence of the pest was reported in 2019 but also in the previous years, the purchase of more than 80 pheromone traps was proposed for 2020, to be installed in the perimeter of the bypass in all three production units, starting with July.

In order to avoid the spread of this pest within the Miercurea Sibiului Forest District, we propose to continue the monitoring system, which will include, as in the previous years, the following stages: the use of pheromone traps in order to keep under control the evolution of the defoliator, studying, processing, centralizing and analysing the data collected from land during each year. If the maximum number of catches has been detected and the appropriate classification of the degree of attack has been made, we issue recommendations for taking specific control measures for each year. According to the specialized literature and the legislation in force, exceeding the threshold of 2000-3000 specimens captured can determine in one flight season the excess of the warning threshold and the occurrence of outbreaks in the following year.

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