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THE BIOLOGICAL INTEGRATED CONTROL OF THE PEST POPULATIONS IN THE FOREST ECOSYSTEM HOREZU, VALCEA COUNTY

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Abstract: In the forest ecosystem Horezu (Valcea county) they were recorded useful and also neutral insects, but in this paper are presented the pest insects in the forest vegetation: *Lymantria d*ispar Linnaeus, 1758 (Erebidae Family), *Tortrix viridana* Latreille, 1803 (Tortricidae Family) and *Coleophora laricella* Hubner, 1817 (Coleophoridae Family).The purpose of this study was the monitoring the multiplication of the pest insects "en masse", especially the defoliator insects and it present the abundance data per years with the evolution in time of the populations and also the biological control methods, by means of the pheromonal traps in the period between the years 2005-2019.The knowledge of the pest evolution had an important role in the forest protection and the researches made in the Forest District permitted the recording and the pest discover. The results had as a purpose to realize the prognosis for a short or a longer time of the evolution of the pests. The permanent research and the gathering of the data were important for the identification the characteristics of the pests and their infestation degree. It was established the number of the pheromonal traps for every pest and per every year, depending on the attack degree.

Keywords: biological control, Forest District Horezu, insects pests, *Lymantria dispar, Tortrix viridana, Coleophora laricella.*

INTRODUCTION

In Romania, the health state of the forests is reflected in the instability degree of the forestry ecosystems, determined by numerous natural factors, but also by the intervention of the anthropic ones, or because of the deficient management of the forest ecosystems.

The focuses of the defoliator's pests, as a rule, have not a homogeneous structure, but rather are characterized by a complex structure, with a predominance of a one or another pest. The spatial spread and the intensity of the development of the defoliator pests focuses on the forests situated in the forestry fond Horezu, in the last 14 years, indicates the fact that yearly is affected about 10-15% from the forest surface.

The Forest District Horezu is situated in the central-vest part of the Vâlcea county, in the middle basin of the Olteț river, in the center of the Getic- Piemont, including the Polovraci- Horezu depression and the Slătioarei Hill (Fig.1).

From point of view phyto-climatic, the forests that belong to the Forest District Horezu, are situated in the following vegetation levels: hilly with oak trees, beech trees and oak-beech trees (F.D.3)-74%; hilly with oak trees (Turkey oak, oak, mixture of these and roads of the hills (F.D.2)- 26%. The Forest District Horezu manages in the present, three production units as following: U.P. I Sinești, U.P.II Horezu, U.P.III Copăceni, on a total surface of 3.886 ha. From point of view of height, this is between 240 m. and 530 m., the average height being of 385 m.

The territory of the studied unit is framing in the continental climate with hills and forests (II Bp6) that is a climate as a rule warmer than the other hilly regions, with rainfalls more than 600mm./yearly, characterized by two maximums (one at the begin of the summer and the other in autumn) and the yearly average temperature over 9ºC.

After Köppen, the territory of U.P.II Horezu belongs to the climatic province D.f.b.x. with moderate summers and harsh winters, and the temperature of the warmest month does not exceed 22 C. The first frost takes place at the end of the vegetation period, and the last frost with 2-4 days after the beginning of the vegetation period, that indicates the fact that are late frosts, that could produce sometimes damages of the forest vegetation, especially in the case of the oak trees. So, it produces the leaves fall and the flowers degradation, that means a weak and rare fructification of these species

The thermic potential of the ecosystem is expressed by the amount of the temperatures higher than 0ºC (the bioactive period) is about 4000ºC that shows a favourable potential of the oak trees.

The climate characterization from the studied territory was made on base of the data furnished by the weather forecast station in Targu-Jiu. The soils belong to the luvisoils and protisoils classes, being predominant the typical luvosoils (90%), followed by the stagnant luvosoils (8%).

The pests that produce the biggest damages recorded in the Forest District Horezu are: *Lymantria dispar* Linnaeus, 1758 (gypsy moth), Erebidae Family, *Tortrix viridana* Latreille,1803 (green oak leaf roller), Tortricidae Family and *Coleophora laricella* Hűbner, 1817 (larch casebearer), Coleophoridae Family.

The present paper has as a purpose the study about the biological control- by means of the pheromonal traps- of the insect pest populations and the presentation of the new data about the forestry pests in one ecosystem in the Valcea county. These data are added to those already published about the forest's ecosystems in Miercurea Sibiului (Sibiu County) (STANCĂ-MOISE

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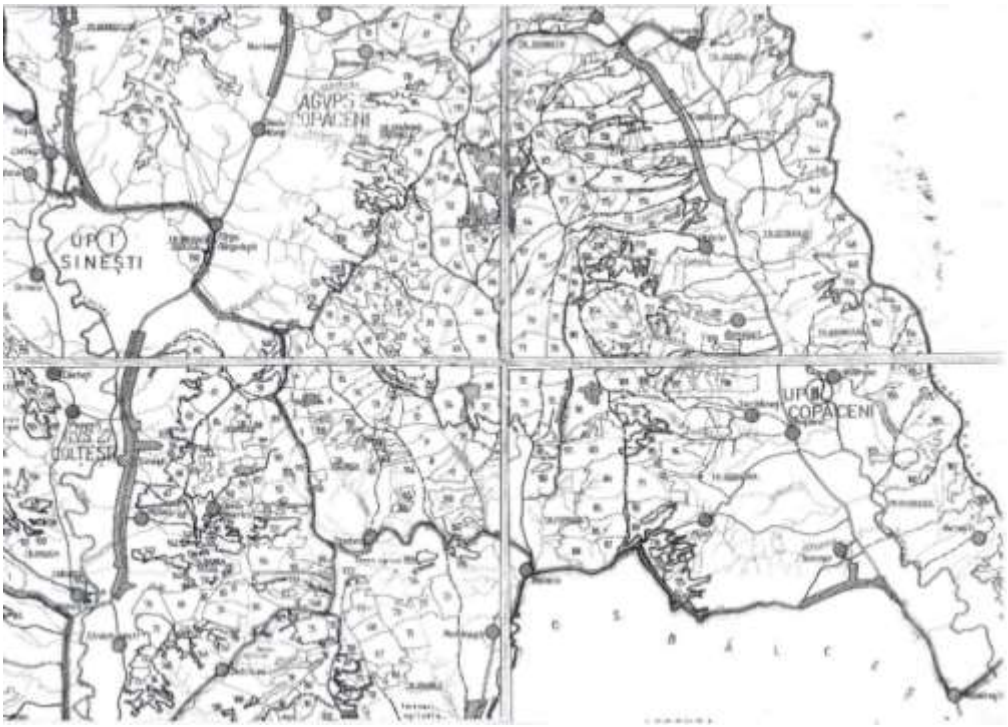

Fig.1. The map of the Horezu Forest District (sursa Horezu Forest District).

MATERIALS AND METHODS

As a limitative method of the pest population of *L. dispar* in the forest ecosystem Horezu, they were used, during the period between the years 2005-2018, the panels traps with Atralymon (Fig.2). They were used in the oak tree's forests in the mixture with beech trees, where the oak trees have a percentage of 50%.

The pheromone that is a sexual attractant emitted by female, was used both for detection and as a means for the interruption of the mating, because the males were especially captured.

The capture of the pest *L. dispar* in the studied ecosystem was made by means of the pheromonal traps of the panel type with adhesive, the traps that were placed on the tree's trunks in the zones where it was recorded the presence of these species.

The trap was fixed at the maximum height of 1,5 m. distance from soil, the pheromonal lure being placed in the center of the panel, with the range of the trap of 75 m.

The biological control of the pest *T. viridana* in the studied ecosystem was made easier in the stages of the caterpillar, pupa, and adult. In the stages of caterpillar and pupa, I observed the existence of the species in May and June months, in the superior part and in the crown of the higher trees or in the trees from the skirt of the forest where I searched the twisted leaves, that are characteristic for these attacks.

It has been observed the fly of the adults at the end of the May month and the beginning of the June month around the crowns of the trees, between the hours 18-20. The intensity of the infestation was established in the stages of egg, pupa and the pupal exuviae, the intensity is determined further depending on the probable percent of defoliation (FAZELI M.J, ABAI M., 1990).

They were noticed the stages of pupa and pupal exuviae from the period of 20-25 May till the beginning of the month July when all caterpillars were transformed in pupa. In every lot where they were defoliated, there were selected three trees of control, being distributed in a uniform way on the studied surface. These percentages of defoliation depending on the medium number of pupas and pupal exuviaes, are for orientation, because they have values greater than in springtime.

The Production Unit Copăceni 3 was the most affected by the attack of this pest. This is formed by six corps of forest (Țuțur, Aglasău, Copăceni 1, Balaciu, Aninoasa, Copăceni 2). In these forest surfaces, the age of the trees is between 40-100 years. In the composition of the forest 5 Go (oak) and 5DT, are also diverse forest species of hard essences.

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Fig.2. The pheromonal traps to control the species *L. dispar* (foto. orig.).

In the Forest District Horezu, the control of the *C.laricella* was collapsed by means of the pheromonal traps Atralar (Fig.3), that were mounted at a distance of 0,1 ha. in the perimeter of the surface occupied by larch. After the monitoring in the field of the species, it has been observed an increased efficiency of the lures that have a specific attractant content in dose of 1 mg/lure.

The traps of Atralar proved to be the most efficient in the capture of insects. This is the reason why it is recommended to be introduced in the biological control of the pest *C.laricella*.

Fig.3. The pheromonal traps to control the species *C. laricella* (foto. orig.).

RESULTS

L.dispar was brought in Europe from North America in 1869 and along the time there were studied numerous methods of the biological control (HOWAED L.O., FISKE W.F., 1911; BURGESS A.F., CROSSMAN S.S., 1929, FUESTER R.W, and colab., 1975; GRUBER F., and colab., 1978; SERRÃO, M., 2002). Approximately 80 species of the natural enemies,

parasitoides, predatories and the patogenous agents they were introduced from 1906 till the present, but most of them were not efficient because of the absence of the alternative hosts (HOY M.A., 1976; ASSADI M., and colab., 2012; CSÓKA G., and colab., 2014; PETERSON N.C., SMITLEY D.R., 1991; ZHANG G.C., and colab., 2005).

In Romania, *L.dispar* is considered as a pest that bring the most important damages, by attack of more than 270 wooden species. In the oak forests in mixture with the beech trees it consumes especially the leaves of oak, beech, hornbeam, poplars, elm trees, willow trees, but in cases of over multiplication, it can attack the linden trees or even the acacia that it doesn't like. The insect produces damages trough defoliation that could produce the death of the affected species (MATSUKI M., and colab., 2001; RODEN, D.B., MATTSON, W.J., 2008; TAVAKOLI, M., and colab., 2018) The severe attacks are produced mainly in the regions of steppe and sellotape, but also in the old trees, rare and it consists in the severe defoliations, sometimes with repetition, in time of 2-3 years, one after the another (LECHOWICZ M.J., JOBIN L., 1983; TOBIN P.C., and colab., 2012). The attacks damage the partial or total yearly growth and produce the loss of the fructification, but also the drying of the branches and the tips (KEENA M.A., and colab., 2008; MIRZOYAN S.A., MIRZOYAN V.S., 2006¸ TOBIN P.C., and colab., 2013).

The biological control of the species *L.dispar* in the studied ecosystem was realized beginning with the year 2005. After the centralization of the data obtained during 14 years of study, on could observe the evolution of the pest *L.dispar* in the period between the years 2005-2018 (Table 1.) in the studied ecosystem in the correlations with the conditions of temperature in every year (Table 2).

Table 1.

The evolution of the pest *L. dispar* L., 1758 in the Horezu Forest District, during the years 2005-2018

The year	Number of races Set	Maximum number of butterflies catch nothing	Total number of butterflies	Average temperature value / year (ºC)
2005	24	1	2	+10.3
2006	25	2	8	+9.7
2007	30	2	18	+11.5
2008	30	39	337	+11.2
2009	30	15	186	+11.2
2010	40	26	405	+11.0
2011	40	19	201	+10.1
2012	40	18	260	+11.6
2013	40	23	334	+11.4
2014	40	4	51	+11.7
2015	40	13	55	+11.4
2016	20	10	84	+11.1
2017	30	17	119	+10.8
2018	30	10	119	+11.9
Total	**459**	**199**	**2179**	

If in the years 2005-2007 the presence was recorded by capture of a small number of samples, between 1-18, but beginning with the year 2007, on could see an increase of the pest population being captured more than 337 samples in 2008. By using the pheromonal traps that produced a diminishing of the number of captured adults till 186 samples. But the intensity of attack repeated in the year 2010, when it was recorded maximum of collected samples from the last 13 years (405 samples). In the following three years 2011-2013, the number of captures started to grow in the numerical progression from 201 in the year 2011, till 334 samples in the year 2013.

Because of the methods of the biological control applied in the perimeter of the forest fond Horezu, but also of the unfavorable climatical conditions, on could observe a regress of several the samples captured in the period of the years 2014-2016, when the number begin to grow again, till 119 samples in the year 2018.

Table 2.

The value of temperatures, averages, maximums, and minimums over the years 2005-2018

The year	The average value (ºC)	Minimum value ºC (date)	Maximum value ºC (date)
2018	11.9	-16.8 (01.03.2018)	+30.5 (02.08.2018)
2017	10.8	-27.7 (10.01.2017)	+35.7 (05.08.207)
2016	11.1	-22.1 (20.01.2016)	+33.1 (17.06.2016)
2015	11.4	-25.2 (01.01.2015)	+34.0 (20.07.2015)
2014	11.7	-9.8 (31.01.2014)	+32.6 (13.08.2014)
2013	11.4	-13.9 (10.01.2013)	+34.6 (29.07.2013)
2012	11.6	-22.1 (01.02.2012)	+37.9 (25.08.2012)
2011	10.1	-20.2 (31.01.2011)	+32.7 (13.06.2011)
2010	11	-23.9 (25.01.2010)	+33.2 (13.06.2010)

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2009	11.2	-18.1(10.01.2009)	+32.2 (03.08.2009)
2008	11.2	-17.1 (05.01.2008)	+33.7 (15.08.2008)
2007	11.5	-8.8 (06.02.2007)	+37.3 (24.07.2007)
2006	9.7	-22.1 (25.01.2006)	+31.6 (20.08.2006)
2005	10.3	-23.2 (10.02.2005)	+31.9 (31.07.2005)

In the future years we recommend a monitorization of the pest population and the acquisition of a number more numerous of the pheromonal traps that could deserve a control zone on a larger surface from the forest fond.

T.viridana forms a category of a pest that attacks the oak, hornbeam, elm tree, beech tree and also the fruit bearing trees (WITKOWSKI Z, 1975; STOCKI J., 1994). The green moth of the oak attacks especially the rare forest, older, but also the ones with a more reduced consistence in sylvosteppen, the most powerful defoliation being in the skirt of the forest and in the top of the high trees (ADOMAS J., 1988). This insect produces massive defoliations, repeated many years, one after the other, mainly when they multiplied in the same time with other species (DISSESCU G., and colab., 1980¸ VOICESCU I., 1996).

After the attacks, generally, the oak trees lose the fructification. These attacks could be easy recognized because of the twisted leaves including inside the caterpillars, pupas or pupal exuviates that belong to this defoliator (FADEEV A.V., 1988¸ TRIGGIANI O., LIA J.J.,1989).

After the analysis of the data collected in the field, we can tell that the surface attacked by *T.viridana* was of 1455 ha., from the total of 1455 ha. owned by the Forest District Horezu.

As a conclusion of this study, we can certify the fact that this species is the main pest of the forest fond Horezu. After the centralization of the captures of the pest species *T.viridana* (Table 3) on can see that the most affected forest was Balaciu with a surface with 640 ha., followed by Aninoasa with 428 ha., Copăceni 1, with 140 ha. and Țuțur with 130 ha. The less attacked was the forest Aglasău with 82 ha. and the smallest value being recorded on the surface of the forest Copăceni 2, with 35 ha attacked by this pest.

Table 3.

Forecast of probable damages caused by the defoliator *T. viridana*, in 2018-2019, within the Horezu Forest District

The name of the forest body	**Production unit**	**Administrative unit or group of administrative units (a.u)**	**Total area *(ha)***	**The surface of which**					
				actually infested, of which	**by degrees of injury probable**				
					f.s.	s	m	p	f.p.
ȚUȚUR	III Copăceni	Jan-33	130	130	130	0	0	0	0
AGLASĂU		50-54	82	82	82	0	0	0	0
COPĂCENI		64-102	140	140	140	0	0	0	0
BALACIU		37-40,80-88,7-10	640	640	640	0	0	0	0
ANINOASA		89-97,137-155,183-190	428	428	428	0	0	0	0
COPĂCENI		124-125	35	35	35	0	0	0	0
TOTAL:			**1455**	**1455**	**1455**	0	0	0	0

By analysis of the damage degree for six forests and by finding several alive eggs/the attacked buds, on could conclusion that the attack degree is one very weak, because the value of the report was smaller than 0,10%.

During the observations in the field, in the years 2018-2019, on can affirm that the pests were recorded more in the egg phase, being identified in the administrative unit (u.a.) 124-125 Copăceni 2, that has 35 ha. of forest (Table 4).

Table 4.

The situation of the surfaces of the stands infested with defoliating insects, from 2018-2019, within the Horezu Forest District

The name body of forest	**U.P.**	**u.a.**	**Surface u.a *(ha)***	**Composition**	**Age trees (years)**	**Probable percentage of defoliation caused by insects: (%)**									**Infested area (ha), included** in the area of:	
						T.v			**Ge.**			**L.d**		**Cumulative**	**Total**	**Monitorized**
						in the stage of:										
						L	**A**	**O**	**L**	**P**	**A**	**L**	**O**			

ANINOASA	III COPĂCENI	137-155	300	5GO5DT	50-100			0			4			4	300	300
ANINOASA		183-190	50	6GO4DT	60-100			0			4			4	50	50
ANINOASA		89-97	78	5GO5DT	40-90			0			4			4	78	78
COPĂCENI		64-102	140	5GO5DT	40-90			0			5			5	140	140
COPĂCENI		124-125	35	6GO4DT	50-100			2			5			7	35	35
BALACIU		37-40	220	5GO5DT	50-100			0			2			2	220	220
BALACIU		80-88	360	6GO4DT	50-100			0			2			2	360	360
BALACIU		10-Jul	60	6GO4FA	60-100			0			2			2	60	60
AGLASĂU		50-54	82	5GO5DT	50-100			0			2			2	82	82
ȚUȚUR		Jan-33	130	5GO5DT	60-100			0			2			2	130	130
TOTAL:			**1455**											**34**	**1455**	**1455**

***The abbreviations: T.v** – *T. viridana*, **Ge.** – Geometridae, **L.d** – *L. dispar*;
*** Stages of evolution of insects: O** – egg, **L** – larva, **P** – pupa, **A** – adult.
U.P.- production unit, **u.a.-** administrative unit, **GO**-oak, **DT**- other woody species.

C. laricella is a part of the defoliator insects of resinous trees. This moth is considered one of the most important pests of the larch trees, producing defoliations by piercing leaves in form of needles (ALTENKIRCH W, WINKEL W., 1990). It usually attacks the trees in age of 10-40 years, but also the older ones of 80 years, or the saplings in age between 2-4 years. The attack takes place at the leaves in form of needles, mainly the ones situated on the edge of the outside branches. The pierced needles are wilted, bleached, having the aspect of the damages produced by frost. In the case of a strong attack, when the competition for food is high, the caterpillars descend at the inferior part of the crown by threads of silk. They are preferable the isolated trees, the sunbathed ones, but also the trees from the skirt of the forest, in a pure forest, or in the mixture of different trees (JAGSCH A., 1973; TABAKOVIC-TOSIC M., and colab., 2020).

In the studied forest ecosystem, the prevention of the excessive multiplication and the attack are made by the creation of the larch forests in mixture with other species.

The control of the pest *C. laricella* was made by the application of the chemical treatments, in the caterpillar stage, usually in the springtime, when the caterpillars are developed, using the fine sprinkles or aerosols.

The flight of the mining moth of the larch needles, released in a period of 4-8 weeks, the majority of the butterflies (more than 80%) during the flight are discovered by means of the pheromonal lures in the first two weeks.

The attractiveness of the lures produces in our country is maintained during the whole flight period.

The execution of the control by means of the pheromonal lures, using a trap at 0,1 ha, is possible and with anticipated results in the larch trees growing with age till 20 years old.

In the future it is recommendable that the list with pest species at the resinous trees could be completed and the achievements till the present constitute only one promising beginning in the biological control by means of pheromonal lures.

CONCLUSIONS

In the forests of the Horezu Forest District in the period between the years 2005-2018 they were recorded attacks especially by *L. dispar, T. viridana* and *C. laricella* and the monitorization of these pests has as an objective the recording and the control of the populations, being identified yearly in every forest the infestation degree but also the corresponding month for control.

To limit the population of the defoliator *L. dispar* in the Horezu Forest District they were used in the period of the years 2005-2018 (Table 1) several 459 panels with Atralymon in the forest with oak trees in the mixture with beech trees the oak trees having a percent of 50%. This method for biological control is efficient because the sexual attractant pheromone emitted by female it was used both for recording but also as a mean for interruption of the mating, because the captured samples were especially the males.

In the present in the Horezu Forest District there were recorded weak attacks of this pest species, the degree of infestation being weak. That is the reason why every year is recommended to do a prophylactic control.

After the analysis of the data proceeded from the field, this paperwork presents that the surface attacked by the pest *T. viridana* was of 1455 ha from the total of 1455 ha owned by Horezu Forest District, this being the principal pest of the forest fond.

C. laricella was recorded in the Horezu Forest District in the May month, in the pure forest of larch but also in the mixture with larch.

After the final presentation, the species is concluded being of the bivoltine class, as it was recorded in the period August-September when we could see the attack of insects on the larch needles.

In the study of caterpillar, it is recorded on branches and needles during their attacks in May month and then

in August-September, having observed both the attacked needles but also the caterpillars in the crown.

The recording of this pest in the Horezu Forest District in the stage of butterfly was made in the month of May.

In order to apply the treatments, this paperwork aims on the thickness of the population of this pest, and the calculation of the report between the number of caterpillars and the number of the attacked buds. In case when the number of caterpillars was more than half of the one of buds, when the attack was a severe one, they were applied the chemical treatments.

The sanitary state of the forests from UP III Copăceni presents a special importance, because a strong infestation could produce high damages both concerning the production of biomass, and the production effect.

Therefore, in order to avoid the potential damages, it is recommended the correct execution but also in time of all the works required by every forest partly.

Proceeding in this way will maintain a corresponding sanitary state and a normal vitality.

After every research that was succesfully done in the forestry ecosystem is noted that the environment factors are important for limitation of the development of the pest populations. The majority of the insects are less resisting at the frost in winter, the cold rains and frost during the flight, that affect the development of the butterflies and the caterpillars, and could damages the multiplication "en masse" of the insects.

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AUTHORS CONTRIBUTIONS

Conceptualization: C. Stancă-Moise; Methodology: C. Stancă-Moise, D. Robu; Data collection: C. Stancă-Moise, D. Robu; Data validation: C. Stancă-Moise; Data processing: C. Stancă-Moise, D. Robu; —original draft preparation: C. Stancă-Moise; —review and editing: C. Stancă-Moise.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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