ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
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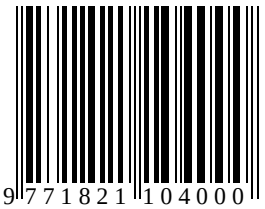
SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 67-68

ZBORNIK RADOVA
TOM 67-68

BELGRADE BEOGRAD
2013.

ISSN 1821-1046



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PROCEEDINGS

INSTITUT ZA ŠUMARSTVO BEOGRAD

ZBORNIK RADOVA

Publisher
Institute of Forestry
Belgrade, Serbia

Izdavač
Institut za šumarstvo
Beograd, Srbija

For Publisher
Ljubinko Rakonjac, Ph.D.

Za izdavača
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Printed in
100 copies

Tiraž
100 primeraka

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Black and White
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Belgrade, 2013

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Beograd, 2013

Cover Page: Author of the Photos Tatjana Ćirković-Mitrović, M.Sc.
Naslovna strana: Autor fotografije mr Tatjana Ćirković-Mitrović

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / chief
editor = glavni i odgovorni urednik Snežana
Rajković. - 2008, T. 57/58- . - Belgrade (Kneza Višeslava 3) : Institute of forestry, 2008- (Beograd : Black and White). - 24 cm

Godišnje. - Je nastavak: Zbornik radova - Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

CONTENT SADRŽAJ
TOM 67-68

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 67-68, 2013 ZBORNIK RADOVA 67-68, 2013

UDK 630*145.78 Lymantria dispar L.:630*411.1(497.11-191.2)"2010/2013"=111
Original scientific paper

GYPSY MOTH (*Lymantria dispar* L.) OUTBREAK IN THE CENTRAL PART OF REPUBLIC OF SERBIA IN THE PERIOD 2010-2013

Mara TABAKOVIĆ-TOŠIĆ[1]

Abstract: *This paper presents the results of research high levels of gypsy moth population in the forest region of Central Serbia in the period from 2010 to 2013 year. The characteristics of the individual phases of outbreak and their spatial distribution were analyzed. In addition to displaying the results of laboratory analizes of egg masses collected, the special attention was paid to the qualitative and quantitative analysis of natural enemies of the gypsy moth.*

Key words: the gypsy moth, forests, outbreak, natural enemies

GRADACIJA GUBARA (*Lymantria dispar* L.) U PODRUČJU CENTRALNE SRBIJE U PERIODU 2010-2013. GODINE

Izvod: *U radu su prikazani rezultati istraživanja visine populacionih nivoa gubara u šumskom području Centralne Srbije, u periodu od 2010-2013. godine. Analizirane su karakteristike pojedinih faza gradacije i njihov prostorni raspored. Pored prikaza rezultata laboratorijske aalize prikupljenih jajnih legala, u radu je posebna pažnja posvećena i kvalitativnoj i kvantitativnoj analizi prirodnih neprijatelja gubara.*

Ključne reči: gubar, šume, gradacija, prirodni neprijatelji

[1] Dr. Mara Tabaković-Tošić, Principal Research Fellow, Institute of Forestry, Belgrade , Serbia

INTRODUCTION

The gypsy moth (*Lymantria dispar* L.), insect in the order *Lepidoptera*, is one of the major pests of broadleaf forests and orchards. It is characterised by a high reproductive capacity, considerable ecological plasticity and polyphagia. It occurs periodically in high numbers (outbreak). Although it is found on four Continents (North Africa, Asia, Europe, North America), the greatest damage is brought to the forests of the Balkan Peninsula, which have all the favourable environmental conditions for the gypsy moth development.

The gypsy moth is an autochthonous species and it often occurs in outbreaks. During the period of seventy years in the central part of Serbia there were five outbreaks, and the sixth outbreak started in the period 2009/2010. The outbreaks do not occur in regular time intervals. Acute and chronic outbreaks are differentiated based on the increase of the number of egg masses per unit area and the attained amplitudes in the stages of eruption and culmination. Acute outbreaks last shorter (4–5 years), the number of egg masses per hectare amounts to several tens of thousands, and the larvae cause the total defoliation in forests and orchards. In chronic outbreaks, the maximal number of egg masses per hectare does not exceed two to three thousand, which is explained by not reaching the culmination stage, so the defoliation does not occur on larger areas. The outbreak duration also depends on the altitude (it lasts for 3–5 years at up to 500 m, 2–3 years at 500 to 1200 m, and at 1200 to 1600 m, the gypsy moth is the member of the biocoenosis if there are host plants). Generally, the previous outbreaks of the gypsy moth in Serbia forests lasted averagely 4.3 years (Marović *et al.*, 1998) (minimum two to three, and maximum five to six years) (Maksimović, 1997). Also, certain phases of outbreak does not happen at the same time, since due to a variety of biotic and abiotic influences come to the gypsy moth dispersal and occupation of new territories. Regular occurrence and characteristics of all outbreaks are their spatial expansion.

The damage caused by the gypsy moth is twofold: direct - defoliation or the loss of leaf mass, and indirect, expressed as the consequences. Defoliation caused by caterpillar feeding lead to the loss of increment, absence of fructification, physiological wakening and tree dying, as well as to the creation of favourable conditions for the infestation of phytopathogenic microorganisms, fungi and xilophagous insects, disturbance of the aesthetical appearance, etc. It should be noted that the consequences of harmful effects of gypsy moth on broadleaf species are very dependent on their origin, vitality, and environmental conditions. For example, the impact of the loss of the annual increment of trees was much lower in forest stands of vegetative origin than generative, which is understandable because otherwise growth trees in these stands is much smaller.

RESULTS, DISCUSSION AND CONCLUSIONS

During the last 70 years, since the Report-diagnose-forecast service has been functioning in the region of Serbia in plant protection - forest protection, the gypsy moth had 6 outbreaks of acute type, i.e. 1945–1950, 1952–1957, 1961–1966, 1995–1999 (Mihajlović *et al.*, 1998) and 2003-2006. Due to the above facts, every year in all broadleaf forests (during the outbreaks also in coniferous forests) disregarding the ownership category (state and private), the gypsy moth density is controlled pursuant to the guidelines of the Report-diagnose-forecast service in the fields of plant protection – forest protection. The gypsy moth density in forests is controlled by the method of permanent (25x25 m) and temporary (10x10 m) sample plots, as well as by the march-route method and method of traps with sex attractant with female odour used to lure the male gypsy moths to traps (pheromone traps) (Tabaković-Tošić and Jovanović, 2007).

It is very important to determine precisely the infestation intensity and to define the infested area spatially, because they are the decisive factors for the selection of the control method and time.

Permanent sample plots are controlled every year, and temporary plots are established when it is estimated that there is an outbreak hazard. The march-route method and pheromone traps are applied as the supplement when the gypsy moth is in latency (low density), and they are obligatory methods during the outbreak.

During the assessment of the number of the gypsy moth egg masses per unit area (1 hectare), care was taken to encompass all forest complexes. This is especially important in the regions with the infestation of very severe intensity (more than 500 egg masses per hectare), because the damage rates resulting from the loss of leaf mass, which will be caused by the hatched larvae, are not the same at the infestation of 501 egg masses per hectare and e.g. 50,000 egg masses per hectare (Tabaković-Tošić, 2005).

Table 1: *Outspread of gypsy moth in the central part of Republic of Serbia in the period 2010-2013.*

FOREST ESTATE	AREA UNDER ATTACK BY THE GYPSY MOTH (ha)																			
	MAGNITUDE OF ATTACK (egg masses/ha)																TOTAL			
	WEAK (1-10)				MEDIUM (11-100)				STRONG (101-500)				VERY STRONG (more than 500)							
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
PUBLIC ENTERPRISE SRBIJAŠUME																				
Beograd	826	928	199	0	2024	323	162	0	865	94	0	0	21	120	0	0	3736	1466	361	0
Boljevac	25	977	7952	1671	0	756	9797	6788	0	319	4505	33399	0	76	35530	27624	25	2128	57785	69482
Vranje	0	0	0	376	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	376
Despotovac	0	0	406	5558	0	0	448	7112	0	0	0	7891	0	0	0	13420	0	0	854	33981
Ivanjica	0	0	430	168	0	0	131	52	0	0	0	685	0	0	0	288	0	0	561	1193
Kragujevac	0	283	983	272	0	0	3	618	0	0	14	153	0	0	2	475	0	283	1012	1518
Kraljevo	0	0	330	360	0	0	503	258	0	0	174	668	0	0	202	948	0	0	1210	2235
Kruševac	1094	1573	1427	1256	235	0	5154	5383	0	0	863	15450	0	0	643	14848	1329	1573	8086	36937
Kuršumlija		485	8166	2265	0	0	841	7792	0	0	89	3941	0	0	0	3774		485	9097	17772
Kučevo	1254	313	2549	552	0	81	15492	967	0	0	3056	11167	0	0	3737	70951	1254	394	24834	83638
Leskovac		100	2063	1435	0	0	1296	5686	0	0	125	1398	0	0	0	9753		100	3484	18272
Loznica	2323	12893	14706	13705	334	9160	4514	4446	20	1341	2288	673	0	0	0	40	2677	23394	21509	18864
Niš	0	47	883	1856	0	0	481	1747	0	0	33	1371	0	0	0	569	0	47	1397	5543
Pirot	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
Raška	0	0	0	82	0	0	0	76	0	0	0	25	0	0	0	8	0	0	0	191
Užice	0	510	120	122	0	0	0	0	0	0	0	0	0	0	0	0	0	510	120	122
Total	**5522**	**18109**	**40214**	**29699**	**2593**	**10320**	**38822**	**40925**	**885**	**1754**	**11147**	**76821**	**21**	**196**	**40114**	**142698**	**9021**	**30380**	**130310**	**290145**
PUBLIC ENTERPRISE NATIONAL PARK ĐERDAP																				
Total	**+?**	**-**	**3783**	**0**	**0**	**-**	**13566**	**4688**	**0**	**-**	**9239**	**10839**	**0**	**-**	**17176**	**27947**	**+?**	**-**	**43764**	**43474**
PUBLIC ENTERPRISE BORJAK VRNJAČKA BANJA																				
Total	**0**	**-**	**6720**	**0**	**0**	**-**	**1350**	**971**	**0**	**-**	**150**	**305**	**0**	**-**	**150**	**25**	**0**	**-**	**8370**	**1300**
FACULTY OF FORESTRY, UNIVERSITY OF BELGRADE																				
Total	**0**	**-**	**-**	**300**	**0**	**-**	**-**	**400**	**0**	**-**	**-**	**900**	**0**	**-**	**-**	**400**	**0**	**-**	**2000**	**2000**
SERBIAN ORTHODOX CHURCH – MONASTERY FORESTS																				
Total	**+?**	**?**	**?**	**49**	**?**	**?**	**?**	**1065**	**?**	**?**	**?**	**1518**	**?**	**?**	**?**	**436**	**+?**	**?**	**?**	**3068**
THE CENTRAL PART OF REPUBLIC OF SERBIA																				
TOTAL	**5522**	**18109**	**50717**	**30048**	**2593**	**10320**	**53738**	**48049**	**885**	**1754**	**20536**	**90383**	**21**	**196**	**57440**	**171506**	**9021**	**30380**	**184444**	**339987**



Pictures 1-3. *Forest Administration Negotin, autumn 2012 – gypsy moth egg masses*

In August 2010 and 2011, there were a regular controls of the gypsy moth population level in all forests of central Serbia. Gypsy moth was detected on 9,021 and 30,380 ha of broadleaf forests. In 2011, the infestation intensity was weak on 59.6% of the area (up to 10 egg masses/ha), it was medium on 34.0% (11 to 100 egg masses/ha), strong on 5.8% (101 to 500 egg masses/ha) and very strong on 0.6% (more than 500 egg masses/ha) (Table 1).

Total broadleaf forest area in the central part of Republic of Serbia, in which the gypsy moth egg masses were detected in August 2012 was 184,444 ha. The largest areas were under very strong infestation intensity (57,440 ha or 31.2%), then under medium (53,738 ha or 29.1%), weak (50,717 ha or 27.5%) and finally under strong attack (20,536 ha or 11.2%) (Table 1).

In August 2013, the detailed inspection of permanent and temporary sample plots as well as the sampling points, and the march-route survey of private forests show that the gypsy moth infestation was identified on 339,987 ha, which is eleven times larger than in the first year, and two times then second year of outbreak (Table 1).

The final goal of the gypsy moth density control is forecasting, and it is not created only based of the density of egg masses. For the precise forecasting, it is necessary to perform the laboratory analysis of egg masses in the aim of getting the parameters significant to the assessment of the population viability.

Table 2. *Laboratory analysis of gypsy moth egg masses sampled from representative sample plots in the area of Central Serbia.*

Year	Number of		Average number of eggs in an egg mass						
			Fertilised				Unfertilised		Total
	Sample plots	Egg masses	Vital		Parasitised				
			N	%	N	%	N	%	N
2010	80	800	526.9	90.9	48.3	8.3	4.5	0.8	579.7
2011	120	1200	465.8	92.2	34.5	6.9	4.5	0.9	504.8
2012	297	1428	555.6	96.1	14.5	2.8	1.6	0.3	565.7
2013	690	5215	443.6	84.5	76.4	14.8	3.8	0.7	523.8

The analysis of gypsy moth egg masses, collected in the area of the Central Serbia, had been conducted at the laboratory of the Institute of Forestry every year during the outbreaks. The average number of eggs in an egg mass ranged from 504.8 (2011) to 579.7 (2010). The egg mass with the largest average number of eggs (1038.6) was submitted to the Institute in 2012 from Forest Estate Severni Kučaj Kučevo, Forest Administration Kučevo, Management Unit Brodica. The

percentage share of vital eggs in the total number of eggs ranged, averagely, from 84.5% in 2013 to 96.1 in 2012 (Table 2).

Average parasitism of eggs in egg masses at the study localities ranges from 2.8% in 2012 to 14.8% in 2013 (Table 2). The average rates of parasitism should not be taken as final ones, because under these laboratory conditions it is not possible to determine the effect of a series of parasites and predators, to which egg masses are exposed in the field. Regarding the species of egg parasites, in the period 2010-2013 *Anastatus japonicus* Ashmead, 1904 (syn. *A. disparis* Ruschka) accounted from 0 to 37%, and *Ooencyrtus kuwanae* (Howard, 1910) 63-100%.

The data on egg, larval and pupal parasitism, as well as the data on the state of the gypsy moth predators and pathogens at individual localities should also be included in the study. During the observed period, in the gypsy moth populations, the activity of 56 natural enemies of this insect - nineteen predators, twenty-eight parasites, seven parasites or saprophages and two pathogens -was reported. The gypsy moth eggs were attacked by eleven species of the predators [*Trombidium holosericeum* (Linnaeus, 1758); *Forficula auricularia* Linnaeus, 1758; *Carabus latus* Dejean, 1826; *Dermestes erichsoni* Ganglbauer, 1904; *Megatoma pici* Kalik, 1952; *Megatoma pubescens* (Zetterstedt, 1828); *M. undata* (Linnaeus, 1758); *Globicornis nigripes* (Fabricius, 1792); *Julistus floralis* (Olivier, 1790); *Malachus bipustulatus* (Linnaeus, 1758); *Formica sp.*], larvae by six [*Silpha quadripunctata* Schreber, 1759; *Carabus coriaceus* (Linnaeus, 1758); *C. cancellatus* (Linnaeus, 1758); *C. cavernosus* Frivaldsky, 1837; *C. intricatus* (Linnaeus, 1758); *C. scabriusculus bulgarus* Lapouge, 1908] and larvae and pupae by two [*Calosoma sycophanta* (Linnaeus, 1758); *C. inquisitor* (Linnaeus, 1758)] (Tabaković-Tošić, 2011, 2012a, Tabaković-Tošić *et al*., 2013).

There were three parasitic species of the gypsy moth eggs [*Anastatus japonicus* Ashmead, 1904; *Ooencyrtus kuwanae* (Howard, 1910); *Eremioscelio lymantriae* Masnil, 1958], eighteen parasitic species of the gypsy moth larvae [*Casinaria tenuiventris* (Gravenhorst, 1829); *Phobocampe disparis* (Viereck, 1911); *P. pulchella* (Thomson, 1887); *Apanteles glomeratus* (Linnaeus, 1758); *A. lacteicolor* Viereck, 1911; *Cotesia melanoscela* (Ratzeburg, 1844); *C. ocneriae* (Ivanov, 1898); *C. scabricula* (Reinhard, 1880); *Protapanteles liparidis* (Bouček, 1834); *P. porthetrie* Muesebeck, 1954; *P. fulvipes* (Haliday,1834); *Meteorus versicolor* (Wesmael, 1835); *Euplectrus liparidis* Ferrière, 1941; *Exorista larvarum* (Linnaeus, 1758); *Parasetigena silvestris* (Robineau-Desvoidy, 1863); *Compsilura concinnata* (Meigen, 1824); *Blepharipa pratensis* (Meigen, 1824); *B. schineri* (Mesnil, 1939)] , and seven parasitic species of the gypsy moth pupae [*Pimpla instigator* Fabricius, 1793; *P. inquisitor* (Scopoli, 1763); *P. turionellae* (Linnaeus, 1758); *Theronia atalantae* (Poda, 1761); *Lymantrichneumon disparis* (Poda, 1761); *Brachimeria intermedia* (Nees, 1834); *B. femorata* (Panzer, 1798)]. Parasites or saprophages of gypsy moth pupae were represented by seven species [*Agria affinis* (Fallén, 1817); *Kramerea schuetzei* (Kramer, 1909); *Parasarcophaga harpax* (Pandelle, 1896); *P. portshinskyi* Rohdendorf, 1937; *P. uliginosa* (Kramer, 1908); *Muscina pabulorum* (Fallen, 1817); *M. stabulans* (Fallen, 1817)]. Two pathogenic species (*Ld*NPV and *Entomophaga maimaiga*) have been identified (Tabaković-Tošić, 2011, 2012, Tabaković-Tošić *et al*., 2012, 2013).

Regarding the density of some predator species, *Trombidium holosericeum, Forficula auricularia*, *Silpha quadripunctata*, *Calosoma sycophanta* and *Carabus sp.* were most abundant ones. *Calosoma sycophanta*, which regularly occurs during the outbreak of the gypsy moth, was found more frequently than other predator species, and it reduced the population size of the gypsy moth both in the larval and imago instars.

At the selected sites in meny regions of Central Serbia the cocoons of the parasitic species from the families Braconidae and Tachinidae were regularly found in spring. Other species were considerably less frequent and were found individually.

The activity of *Lymantrya dispar* NPV was reported at many sites, with the extremely high population sizes of the gypsy moth. For example, *Lymantrya dispar* NPV caused the death of about 20% of L_4 gypsy moth instar at one site in the Forest Administration Lipovica (Forest Estate Belgrade), 17.1% in the Forest Administration Blace (Forest Estate Kuršumlija), 13.3% in the Forest Administration Kraljevo (Forest Estate Kraljevo) (Tabaković-Tošić, 2011, 2012, 2013, Tabaković-Tošić *et al*., 2013). In addition, a large number of the larvae brought from the field and subsequently grown in the laboratory conditions were infested by this pathogenic species (Tabakovic-Tosic *et al*., 2012).

Higher mortality rate of older gypsy moth larval instars was reported in the forest complexes of Belgrade, Valjevo, Krupanj, Kučevo, Kragujevac, Kraljevo, Kruševac, Vrnjačka Banja, Brus, Blace, Donji Milanovac, Negotin and Leskovac regions, in the culmination phase of the new outbreak of the gypsy moth in Serbia. Field and laboratory studies showed the presence of conidia and resting spores of the entomopathogenic fungus *Entomophaga maimaiga* which was the cause of the mortality. This has been the first reports of occurrence of this species in Serbia, i.e. Serbia is the third European country in which this fungus has been reported. It showed to be a powerful reducer of the population size of the gypsy moth, and in both regions it caused the collapse of the outbreak in 2011 (Tabaković-Tošić, 2012, 2013, Tabaković-Tošić et al, 2012, 2013).

Taking into account the significance of the biotic agents of the damage and their capacity of rapid and free spreading, i.e. transmission to huge areas in short time intervals, the regulations of plant protection – forest protection identify the measures and commitments of forest owners and users, which have to be carried out in the aim of preventing the occurrence, detection and control of plant diseases and pests (Forest Law and Law on Plant Protection against Plant Diseases and Pests). Also, taking into account the reports by the professional service, which as ordered by the Directorate of Forests, the Institute of Forestry in Belgrade, with forest protection specialists from PE Srbijašume, PE National Park Đerdap, PE Borjak Vrnjačka Banja, Faculty of Forestry, University of Belgrade and Serbian Orthodox Church – Monastery Forests (the institutions which are authorised for the activities of the Report-diagnose-forecast service in the field of plant protection – forest protection), inspected the broadleaf forests of the Central Serbia, in the aim of registering the area infested by the gypsy moth, and determining the infestation intensity. During the period autumn-winter 2010-2011, 2011-2012 and 2012-2013, the gypsy moth was suppressed in egg stage by mechanical (removal and burning)

and chemical methods (soaking in oil and petroleum) on the total area where weak and medium attack of gypsy moth were determined.

Acknowledgments:
The study was partly financed by the Minstry of Science of the Republic of Serbia, the Project 31070 - SUBPROJECT: New technological methods in the integral protection of forests with the focus on the entomopathogenic fungus Entomophaga maimaiga, as the possible solution to the problem of the frequent occurrences of the outbreak of gypsy moth in the forest ecosystems of Serbia.
The author is particularly grateful to the all colleagues from Public Enterprises Srbijašume, Borjak Vrnjačka Banja and NP Đerdap, for their involvement in the collection of field data about spatial distribution of the gypsy moth.

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GYPSY MOTH (*Lymantria dispar* L.) OUTBREAKIN THE CENTRAL PART OF REPUBLIC OF SERBIAIN THE PERIOD 2010-2013

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Summary

During the last seventy years in Serbia, the gypsy moth (*Lymantria dispar* L.) had six outbreaks of acute type, i.e. 1945-1950, 1952-1957, 1961-1966, 1995-1999, 2003-2006 and 2010-2014 (2015). During the progradation years of the current outbreak which is still in progress (2010-2011, 2011-2012) the gypsy moth infested the forests of the central part of Republic of Serbia, the area of 9,021 ha and 30380 ha. The culmination occurred in the periods 2012-2013 and 2013-2014, i.e. the infested territory covered 184,444 ha and 339,987 ha.

At some localities the number of oviposited egg masses per unit area (ha) amounted to more than 50,000. The average number of eggs in an egg mass ranged from 504.8 (2011) to 579.7 (2010). The egg mass with the largest average number of eggs (11038.6) was submitted to the Institute in 2012 from Forest Estate Severni Kučaj Kučevo, Forest Administration Kučevo, Management Unit Brodica. The percentage share of vital eggs in the total number of eggs ranged, averagely, from 84.5% in 2013 to 96.1 in 2012. Average parasitism of eggs in egg masses at the study localities ranges from 2.8% in 2012 to 14.8% in 2013 The average rates of parasitism should not be taken as final ones, because under these laboratory conditions it is not possible to determine the effect of a series of parasites and predators, to which egg masses are exposed in the field.

During the observed period, in the gypsy moth populations, the activity of 56 natural enemies of this insect - 19 predators, 28 parasites, 7 parasites or saprophages and 2 pathogens -was reported, but their activity was insufficient for a radical reduction of the gypsy moth population density. Exception to this were Belgrade and Valjevo region, where entomopathogenic fungus *Entomophaga maimaiga* caused the collapse of the outbreak in 2011 and 2012.

GRADACIJA GUBARA (*Lymantria dispar* L.) U PODRUČJU CENTRALNE SRBIJE U PERIODU 2010-2013. GODINE

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Rezime

U proteklih sedamdeset godina u Srbiji, gubar (*Lymantria dispar* L.) je šest puta stupio u gradacije akutnog tipa i to 1945-1950., 1952-1957., 1961-1966., 1995-1999., 2003-2006. i 2010-2014. (2015.) . U progradacionim godinama zadnje gradacije koja je u toku (2010-2011., 2011-2012.) gubar se javio u šumama centralnog dela Republike Srbije na površini od 9,021 i 30,380 ha. U periodu 2012-2013. i 2013-2014. godine došlo je do kulminacije, odnosno širenja teritorija pod napadom na 184.444 i 339,987 ha.

Na nekim lokalitetima broj položenih jajnih legala po jedinici površine (ha) iznosio je i više od 50.000. Prosečan broj jaja u jajnom leglu se kretao od 504,8 (2011.) do 579,7 (2010.). Jajna lgla sa najvećim prosečnim brojem jaja u njima (11038,6) su dostavljena Institutu u 2012. godini iz Šumskog gazdinstva Severni Kučaj Kučevo, Šumske uprave Kučevo, gazdinske jedinice Brodica. Procentualno učešće vitalnih u ukupnom broju jaja kretao se u proseku od 84,5% u 2013. do 96,1 u 2012. godini. Prosečna parazitiranost jaja u jajnim leglima je iznosila od 2,8% u 2012. do 14,8% u 2013. Prosečne stope

parazitizma ne treba shvatiti kao konačne, budući da u kalkulaciju nisu uvrštene vrednosti dobijene prilikom terenskih istraživanja.

Tokom ovih istraživanja, u populacijama gubara, uočena je pojačana aktivnost 56 vrsta njegovih prirodnih neprijatelja - 19 predatora, 28 parazita, 7 parazita ili saprofaga i 2 patogena, ali je njihova aktivnost bila nedovoljna da radikalno umanji populacionu gustinu domaćina i dovede do kolapsa gradacije. Izuzetak od ovoga se desio u šumama Beogradskog i Valjevskog regiona, gde je entomopatogena gljiva *Entomophaga maimaiga* uzrokovala kolaps gradacije u 2011. i 2012. godini.