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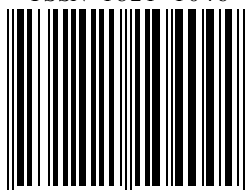
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SADRŽAJ CONTENTS

TOM 63-64

Vladan POPOVIĆ, Vera LAVADINOVIĆ

DEPENDENCE OF DOUGLAS-FIR MEAN DIAMETER ON GEOGRAPHIC ORIGIN OF CANADIAN PROVENANCES IN SEEDLING NURSERY CONDITIONS

7

Snežana STAJIĆ, Vlado ČOKEŠA, Zoran MILETIĆ, Ljubinko RAKONJAC
CHANGES IN THE GROUND FLORA COMPOSITION OF ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE, DOUGLAS-FIR AND LARCH STANDS AT THE SITE OF HUNAGRIAN OAK AND TURKEY OAK WITH HORNBEAM

17

Milorad VESELINOVIĆ, Dragana DRAZIĆ, Biljana NIKOLIĆ, Suzana MITROVIĆ, Nevena CULE, Marija NESIĆ
SEED GERMINATION ANALYSIS IN ORDER TO IMPROVE THE PRODUCTION OF SEEDLINGS

27

Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ, Radovan NEVENIĆ, Zoran PODUŠKA, Renata GAGIĆ SERDAR, Ilija DJORDJEVIĆ, Goran ČEŠLJAR
THE INTENSITY OF EROSION IN THE CATCHMENT OF THE TORRENT LEŠJANSKI DO

33

Ljiljana BRASANAC-BOSANAC, Tatjana CIRKOVIC-MITROVIC, Nevena CULE
ADAPTATION OF FOREST ECOSYSTEMS ON NEGATIVE CLIMATE CHANGE IMPACTS IN SERBIA

41

Nevena CULE, Ljubinko JOVANOVIĆ, Dragana DRAZIC, Milorad VESELINOVIĆ, Suzana MITROVIC, Marija NESIĆ
INDIAN SHOOT (CANNA INDICA L.) IN PHYTOREMEDIATION OF WATER CONTAMINATED WITH HEAVY METALS

51

Radovan NEVENIĆ, Svetlana BILIBAJKIC, Tomislav STEFANOVIĆ, Zoran PODUSKA, Renata Gagić SERDAR, Ilija ĐORĐEVIĆ, Goran ČEŠLJAR
FOREST CONDITION MONITORING: INTENSIVE MONITORING OF AIR POLLUTION IMPACT ON FOREST ECOSYSTEMS AT LEVEL II SAMPLE PLOT KOPAONIK

65

Suzana MITROVIĆ, Milorad VESELINOVIĆ, Dragica VILOTIĆ, Nevena ČULE, Dragana DRAŽIĆ, Biljana NIKOLIĆ, Marija NESIĆ
TEMPORARY DEPOSITED OF DEPOSOL AS THE POSSIBLE AREA FOR SHORT ROTATION PLANTATION ESTABLISHMENT – MODEL CASE

77

<i>Miloš KOPRIVICA, Bratislav MATOVIĆ</i> RELIABILITY OF THE STAND REGRESSION MODELS DEVELOPED ON THE BASIS OF SAMPLE PLOTS	87
<i>Mara TABAKOVIĆ-TOŠIĆ</i> GYPSY MOTH PREDATORS, PARASITES AND PATHOGENS IN BELGRADE FORESTS IN THE PERIOD 2010-2011	101
<i>Mara TABAKOVIĆ-TOŠIĆ, Dragutin TOŠIĆ, Miroslava MARKOVIĆ, Katarina MLADENOVIC, Zlatan RADULOVIĆ, Snežana RAJKOVIĆ</i> GYPSY MOTH OUTBREAKS IN FOREST COMPLEXES OF THE BELGRADE REGION IN THE PERIOD 1996-2011	113
<i>Miroslava MARKOVIC, Snezana RAJKOVIC, Katarina MLADENOVIC</i> SIMULTANEOUS ATTACK OF LYMANTRIA DISPAR L. AND MICROSPHAERA ALPHITOIDES GRIFF. ET MAUBL. ON QUERCUS SPECIES (Q. CERRIS, Q. FARNETTO AND Q. PETRAEA) IN CERTAIN PARTS OF SERBIA FROM 2004 TO 2006	123
<i>Katarina MLADENOVIC, Bojan STOJNIĆ, Miroslava MARKOVIĆ</i> SPIDER MITES AND PREDATORY MITES (ACARI: TETRANYCHIDAE, PHYTOSEIIDAE) ON OAK TREES IN THE CITY OF BELGRADE AND ITS VICINITY	133
<i>Vesna GOLUBOVIĆ ĆURGUZ, Zoran MILETIĆ</i> SOIL EXAMINATION FOR THE PURPOSE OF FORECASTING OCCURRENCE OF ENTOMOPATHOGENIC AND BENEFICIAL MICROORGANISMS	141
<i>Ilija DJORDJEVIĆ, Radovan NEVENIĆ, Zoran PODUŠKA, Renata GAGIĆ, Goran ČEŠLJAR, Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ</i> ASSESSMENT OF THE SYSTEM FOR MANAGING PROTECTED AREAS IN THE REPUBLIC OF SERBIA	151
<i>Zoran PODUŠKA, Svetlana BILIBAJKIĆ, Renata GAGIĆ-SERDAR, Goran ČEŠLJAR, Ilija ĐORĐEVIĆ, Tomislav STEFANOVIĆ, Radovan NEVENIĆ</i> IMPACT OF INNOVATIVENESS ON NEW TECHNOLOGY IMPLEMENTATION IN FORESTRY COMPANIES	161

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**SIMULTANEOUS ATTACK OF *LYMANTRIA DISPAR* L. AND
MICROSPHAERA ALPHITOIDES GRIFF. ET MAUBL. ON *QUERCUS*
SPECIES (*Q. CERRIS*, *Q. FARNETTO* AND *Q. PETRAEA*) IN CERTAIN
PARTS OF SERBIA FROM 2004 TO 2006**

Miroslava MARKOVIĆ¹, Snezana RAJKOVIĆ¹, Katarina MLADENOVIĆ¹

Abstract: *This paper presents research conducted in three regions in the Republic of Serbia – around Kragujevac, Pozarevac and Vrnjacka Banja – as there are large zonally situated areas populated by oak clusters (the most common oak species in these regions are *Quercus farnetto*, *Q. cerris* and *Q. petraea*). At permanently established sample plots examinations were conducted to assess chlorosis, defoliation and damages caused by the gypsy moth and powdery mildew instigators.*

The aim of this paper was to perform preliminary examinations and determine whether there is any connection between the magnitude of the mildew infections and that of the gypsy moth attacks on Hungarian oak, Turkey oak and Sessile oak trees in the territory of Serbia and whether there are differences in attacks among the three oak species. The largest number of defoliated Sessile oak trees with severe chlorosis were recorded during the year 2005, which was followed by the strongest attacks of the powdery mildew and gypsy moth on the same species.

Key words: Turkey oak, Hungarian oak, Sessile oak, Gypsy moth, Powdery mildew

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SIMULTANI NAPAD *LYMANTRIA DISPAR* L. I *MICROSPHAERA ALPHITOIDES* GRIFF. ET MAUBL. NA *QUERCUS* VRSTAMA (*Q. CERRIS*, *Q. FARNETTO* I *Q. PETRAEA*) U PERIODU OD 2004. DO 2006. GODINE U NEKIM DELOVIMA SRBIJE

Izvod: Ispitivanja u ovom radu su vršena na 3 područja u Republici Srbiji - Kragujevac, Požarevac i Vrnjačka Banja, na kojima se zonalno nalaze veće površine pod hrastovim sastojinama (najčešće vrste hrastova na ovim područjima su *Quercus farnetto*, *Q. cerris* i *Q. petraea*). Pregledi su rađeni na stalnim bioindikacijskim tačkama, na kojima je vršena ocena hloroze, sušenja i evidentirana oštećenja od gubara i prouzrokovala pepelnice. Cilj ovog rada je bio da se izvrše preliminarna ispitivanja i utvrdi da li postoji veza između intenziteta zaraze pepelnicom i jačine napada gubara i na sladunu, ceru i kitnjaku na području Srbije i da li postoji razlika u napadu na ove tri vrste hrastova. Najviše suvih stabala kitnjaka i stabala sa jakom hlorozom bilo je tokom 2005. godine, što je bilo praćeno i najjačim napadom pepelnice i gubara na ovoj vrsti.

Ključne reči: cer, sladun, kitnjak, gubar, pepelnica

1. INTRODUCTION

Serbia is considered a medium forested country. According to the latest data by the National Forest Inventory for the year 2009, 29.1% of the total land area of Serbia is under forests.

The total forested land area in Serbia amounts to 2,252,400 ha, with oak forest area of 720,800 ha. Out of these, Turkey oak forests (*Quercus cerris* L.) cover 345,200 ha and Sessile oak forests (*Quercus petraea* /Mattuschka/ Liebl.) cover 173,200 ha, whereas Hungarian oak (*Quercus farnetto* Ten.), English oak (*Quercus robur* L.) and Downy oak trees (*Quercus pubescens* Willd.) populate 159,600 ha, 32,400 ha and 10,400 ha respectively (the National Forest Inventory of the Republic of Serbia, 2009).

There are a dozen oak species in Serbia, of which the above said ones are considered the most important forest trees (Gajic, Tesic, 1992).

As the basis of various national and international policies, sustainable forest management is based on the information on the key factors affecting the health of forests. Such information is collected through extensive, long-term and intensified monitoring of the forest condition conducted within *ICP Forests (the International Co-Operative Programme on Assessment and Monitoring Air Pollution Effects on Forests)* and *the Convention on Long-Range Transboundary Air Pollution (CLRTAP)* of the EU. Their foundations and guidelines were defined by the working group of the European Forestry Commission (EFC) and the International Food and Agriculture Organisation (FAO). The foundations of the current ICP manual as the method for harmonised continuous forest condition monitoring were laid by the United Nations – European Forestry Commission (Freiburg, 1984).

Sustainable forest management includes regular monitoring of the occurrence and dissemination of severe diseases and pests, which is particularly significant for forest protection in practice.

Large-scale drying of oak forests is partly a result of the presence of powdery mildew caused by the pathogen fungus *Microsphaera alphitoides* Griff. et Maubl. (1910), which particularly affects new, young foliage susceptible to infection. Oak powdery mildew presents a serious problem for seedlings in nurseries as well as for naturally and artificially introduced young plants. In adult trees, it reduces height growth and hinders natural forest restoration. The infections occur from the beginning of May up to the end of the vegetation period.

Pathogens causing powdery mildew are obligate parasites which belong to the order *Erysiphales*. Their presence has been noticed in over 1,300 deciduous plants in 28 countries all over the world. Powdery mildew pathogens occur in 256 species of trees and bushes (Nef and Perrin, 1999). Being epiphyte, they develop on the leaf surface, enter through the epidermis of the host cells and take the nutrients from the host plant by means of haustoria with specialised structure.

Mildews occur mostly in forest trees, where they are most apparent. They are distributed all over the world, especially in the USA and Europe. Occasionally they occur in beech, alder, birch, sycamore, sweet chestnut, maple, willows, poplars and other tree species. More than 30 species of the *Quercus* genus are susceptible to mildew instigators. Conifers are resistant to this pathogen (Karadzic, 2010).

A more intensive research of the gypsy moth began in Serbia in the 1920s because at the time it was considered, alongside the oak powdery mildew (*Microsphaera alphitoides* Griff. et Maubl.), to be the major factor leading to the deterioration of oak forests.

Conditionally speaking, gypsy moth (*Lymantria dispar* L., *Lepidoptera*, *Lymantridae*) is one of the major pests attacking deciduous forests; it is characterised by a great reproductive power and significant ecological plasticity and polyphagia. Gypsy moth is an indigenous species with optimal conditions for reproduction. It feeds on the leaves of over 500 tree and bush species and is best developed on the species of the *Quercus* genus (Lance, 1983 according to Milanovic, 2010). Gypsy moth caterpillar larvae feed on the leaves of almost all deciduous tree species, forest bushes, shrubs and weeds, all fruiters and green mass of many farming and vegetable crops. Its vitality and adaptability allow for periods of excessive propagation – large-scale gradations. During the 20th century gypsy moth caused immense damages to the economy and various other areas of life. As many as 17 instances of excessive gypsy moth propagation have been recorded up to date.

During these gradations of the gypsy moth (*Lymantria dispar* L.), which last between 3 and 5 years, the first to suffer is oak foliage devoured by the caterpillars. Soon afterwards, oak trees leaf again and the new foliage is attacked by powdery mildew. Following the successive mildew instigators' attacks over several years, oak trees become physiologically weak and vulnerable to the attacks of honey fungus (*Armillaria mellea*), which causes root rot (Karadzic, Milijasevic, 2005).

Damages caused by the gypsy moth (except defoliation) may be indirect, in the form of collateral consequences. Defoliation resulting from larvae food intake lead to the loss in height growth, failure in fruit bearing, physiological weakening and drying of the trees as well as creation of favourable circumstances for attacks by

various pathogenic microorganisms, fungi and xylophagous insects, ruining the aesthetics of the forested area, etc. (Tabakovic-Tosic, 2005). Although it feeds on a large number of plant species, gypsy moth exhibits preference toward species of the *Quercus* genus. In the reference works cited, the most preferred species are English oak and Turkey oak. Recent research suggests that Turkey oak displays more favourable features for the development of the gypsy moth than the other oak species. Out of all significant oak species in Serbia, Hungarian oak remains insufficiently researched in relation to the gypsy moth attacks (Milanovic, 2010).

The aim of this paper was to perform preliminary research and determine whether there is any connection between the magnitude of the mildew infections and the magnitude of the gypsy moth attacks on Hungarian oak, Turkey oak and Sessile oak trees in the territory of Serbia and whether there are differences in attacks among the three oak species.

2. MATERIALS AND METHODS

The Republic of Serbia is involved in the ICP Forests (*the International Co-Operative Programme on Assessment and Monitoring Air Pollution Effects on Forests*) through its Nacional Focal Centre (NFC). Monitoring of the Level 1 forest condition has been performed in Serbia since 2003, during the vegetation periods, at 131 sample plots established within either 16-kilometre or 4-kilometre grid. 68 of these sample plots are situated in oak forests.

Within a sample plot, a quadrat is established, whose central point is permanently marked with a metal stake. The trees for the crown condition assessment are selected systematically as clusters of trees around the 4 loci, which are at a 25-metre distance in 4 cardinal directions from the centre marked with a stake. In this way the nearest 6 trees in each direction are selected (24 in total) and defined as samples for assessment. Samples include all tree species on condition their height is over 60 cm.

Every year, during the vegetation period, the selected trees are observed for the assessment of chlorosis and defoliation and damages are recorded and classified according to the types (entomological, phytopathological and mechanic) and species of instigators. In addition, the exact tree part where damage is observed is recorded (foliage, branches, bark, part of the trunk, base, root, etc.). Chlorosis (decolourisation) is measured by indices ranging from 0 to 3, and branch drying (defoliation) is measured by indices ranging from 0 to 4 (Table 1).

Table 1. *Methods of assessing chlorosis and defoliation at sample plots in Serbia*

Foliage chlorosis (decolourisation)		Branch drying (defoliation)	
Indices	Symptoms for foliage chlorosis indexing	Indices	Symptoms for branch drying indexing
0	Change in foliage colour 0 to 10%	0	Branch drying 0 to 10%
1	Change in foliage colour 11 to 25%	1	Branch drying 11 to 25%
2	Change in foliage colour 26 to 60%	2	Branch drying 26 to 60%
3	Change in foliage colour over 61%	3	Branch drying over 61%
		4	Completely dried up trunk – 100%

In order to obtain relevant and objective assessment of the health condition of the trees, examination is performed in mid-vegetation period, approximately at the same time (this is particularly important for deciduous species, due to autumn foliage drying, which may affect defoliation and decolourisation evaluation and render a false assessment of the crown condition).

Research presented in this paper was conducted in three geographically separated regions in the Republic of Serbia – around Kragujevac, Pozarevac and Vrnjacka Banja – as there are large zonally situated areas populated by oak clusters (the most common oak species in these regions are *Quercus farnetto*, *Q. cerris* and *Q. petraea*).

Examinations were performed at permanently established sample plots numbered 18, 20, 21 (in the territory of Kragujevac), 26, 27 and 29 (in the territory of Pozarevac) and 60 and 61 (in the territory of Vrnjacka Banja).

The gypsy moth attacks in the above said regions during the 3-year period were monitored by counting hatches and expressed by means of the following scale:

- weak attack (1-10 hatches per hectare),
- medium attack (11-100 hatches per hectare),
- strong attack (101-500 hatches per hectare),
- very strong attack (over 500 hatches per hectare).

The attacks of powdery oak mildew instigators on oaks in the above said regions in Serbia from 2004 to 2006 are expressed in percentages of the trees affected relative to the total number of trees at a sample plot.

3. RESULTS AND DISCUSSION

Table 2 presents magnitude of the gypsy moth and powdery mildew attacks on Hungarian oak, Turkey oak and Sessile oak trees in Serbia (in the territories of Kragujevac, Vrnjacka Banja and Pozarevac) from 2004 to 2006.

Table 2. *Magnitude of the gypsy moth and powdery mildew attacks on Hungarian oak, Turkey oak and Sessile oak trees in Serbia from 2004 to 2006*

Oak species	Sample plot No.	Region examined	Occurrence of mildew and gypsy moth in oak trees					
			2004		2005		2006	
			mildew	gypsy moth	mildew	gypsy moth	mildew	gypsy moth
<i>Q. farnetto</i>	18	Kragujevac	20	-	20	strong	8	medium
<i>Q. cerris</i>	20		-	-	-	weak	21	weak
<i>Q. farnetto</i>	20		40	-	50	weak	50	weak
<i>Q. cerris</i>	21		-	weak	-	-	-	-
<i>Q. farnetto</i>	21		-	-	-	-	-	-
<i>Q. cerris</i>	60	Vrnjacka Banja	-	-	-	-	-	-
<i>Q. farnetto</i>	60		15	strong	5	weak	2	-
<i>Q. petraea</i>	61		5	weak	-	-	-	-
<i>Q. cerris</i>	26	Pozarevac	2	-	-	-	-	-
<i>Q. farnetto</i>	26		40	very strong	30	very strong	30	strong
<i>Q. petraea</i>	27		-	-	9	weak	13	weak
<i>Q. cerris</i>	29		5	medium	-	weak	-	-
<i>Q. farnetto</i>	29		15	medium	8	weak	5	-

The above table shows that medium, strong and very strong attacks of the gypsy moth were recorded only on Hungarian oak trees, whereas other oak species (Sessile and Turkey oaks) suffered either weak gypsy moth attacks or none at all.

The greater magnitude attacks of powdery mildew instigators were also recorded only on Hungarian oak trees, whereas Sessile and Turkey oaks suffered either weak mildew attacks or none at all.

A very strong gypsy moth attack on Hungarian oak in the territory of Pozarevac took place during the years 2004 and 2005. It was subsequently followed by a most intensive mildew attack (30 to 40%). Similarly, a strong gypsy moth attack on the same oak species in the territory of Kragujevac in 2005 was followed by a mildew attack of 20% magnitude. Only during 2004, in the territories of Vrnjacka Banja and Pozarevac, was there a strong gypsy moth attack followed by a lower magnitude of the mildew infection (15%).

It is also evident from the data in the table above that, during the whole assessment period, mildew infections at almost all locations monitored were proportional to the gypsy moth attacks in magnitude, which applies to all the examined oak species. In other words, when a change occurs and a very strong gypsy moth attack following a large percentage of trees with mildew infection turns into a strong attack, or a strong attack turns into a medium one etc., the infection with this pathogen fungus also subsides. This was the case in Požarevac, when a medium gypsy moth attack on Hungarian oak trees from 2004 turned into a weak attack in 2005 and the magnitude of mildew infection dropped from 15% in 2004 to 8% during 2005. At the same location, a transition from a weak gypsy moth attack in 2005 to a complete absence of the gypsy moth in 2006 was related to the subsidence of the mildew infection from 8% in 2005 to only 5% during the year 2006.

Moreover, a severe mildew infection (40% in the territory of Kragujevac in 2004) with no gypsy attack coinciding increased to 50% in 2005, followed by a weak gypsy moth attack, which remained the same in magnitude the next year, as well as mildew infection.

The impact of the gypsy moth caterpillars on defoliation in oak forests often results in the losses in height growth of up to 30% or even 40% (Klepac, 1966). Financial losses, which may be very high, can thus be easily calculated. Besides, many experts consider reduction in the forest ecological stability an even graver negative effect. On the other hand, successive mildew infections over the course of several years will additionally reduce the height growth of the trees and make them physiologically weak and susceptible to the attacks of other diseases and pests.

In his work, Karadzic (2006) states that, in respect to the most common foliage diseases, no significant differences in susceptibility have been observed among Sessile oak, Hungarian oak and Turkey oak species. When these species are compared by susceptibility to parasitic fungi, the most susceptible is Sessile oak, Hungarian oak comes second and Turkey oak ends up third as the most resistant. In natural clusters of trees, all three species are vulnerable to the attacks of parasitic fungi that occur on both foliage and bark, whereas in urban areas the trees exhibit more vulnerability to the attacks of wood-rotting fungi.

The results of the preliminary examinations conducted and presented in this paper suggest that no direct connection can be established between the gypsy moth attack magnitude and that of the mildew infection, i.e. a strong gypsy moth attack is not always followed by a severe mildew infection the next year. This is, among other things, due to the fact that the magnitude of the infection with this pathogen fungus primarily depends on the climate factors at a certain geographical area during the vegetation period (first of all, relative air humidity and temperature).

Table 3 summarises the health condition of the oak trees at sample plots at all the locations monitored and their mildew infections during the 3-year period.

Table 3. Health condition of oak trees at sample plots in Serbia and mildew and gypsy moth

Oak species	Year	Chlorosis (%)				Defoliation (%)					Trees infected with mildew (%)	Gypsy moth attack magnitude
		0	1	2	3	0	1	2	3	4		
<i>Q. cerris</i>	2004	84.7	12.4	3.0	0.0	56.9	31.4	11.6	0.0	0.0	1.5	very weak
	2005	88.1	8.1	3.0	0.7	44.4	38.9	16.7	0.0	0.0	2.0	weak
	2006	88.5	9.6	1.7	0.2	59.8	30.8	9.2	0.0	0.2	2.9	weak
<i>Q. farnetto</i>	2004	79.5	11.4	6.4	2.7	45.5	32.4	19.3	2.7	0.0	0.7	strong
	2005	75.5	14.6	8.9	0.5	34.4	39.1	25.7	0.7	0.0	2.7	strong
	2006	72.8	20.8	6.4	0.0	51.9	27.5	20.6	0.0	0.0	12.6	medium
<i>Q. petraea</i>	2004	52.1	30.7	14.6	2.6	38.5	41.1	19.8	0.5	0.0	9.9	-
	2005	56.0	22.5	14.1	7.3	25.1	42.9	30.4	1.6	0.0	16.2	very weak
	2006	68.6	20.4	9.4	1.6	34.0	38.2	27.2	0.5	0.0	37.2	weak

It is evident from the summarised results in Table 3 that in Turkey oak powdery mildew attacks were very weak during the whole assessment period – from 1.5 to 2.9%, only 2.1% on average. The largest number of Turkey oak trees with powdery mildew infection were recorded during the year 2006 (2.9%). The gypsy moth attacks on Turkey oak were also recorded, yet they were weak during the whole assessment period. With regard to chlorosis, the largest numbers of trees with high chlorosis indices were recorded in 2005, whereas the year 2006 was the least favourable for Turkey oak with regard to defoliation, followed by a more intensive mildew infection.

The powdery mildew attacks on Hungarian oak were also rather weak during the whole assessment period – from 0.7 to 12.6%, or 5.3% on average. The strongest mildew attack on Hungarian oak was recorded in 2006 (12.6%). However, the gypsy moth attacks were strong (within the first two years of the assessment period) to medium (during 2006). In terms of chlorosis and defoliation, the year 2004 was the least favourable for Hungarian oak with the largest numbers of dried trees and those with high chlorosis indices.

During the assessment period, the powdery mildew attacks on the examined Sessile oak trees amounted from 9.9 to 37.2%, i.e. 21.1% on average. A weak mildew attack was recorded in 2004 (9.9%). A medium mildew attack occurred in 2005 and encompassed 22.1% of the Sessile oak trees, whereas a mildew strong attack (16.2%) was recorded in 2006. The gypsy moth attacks were either very weak or they did not occur at all. The largest numbers of dried Sessile

oak trees and those with severe chlorosis were recorded during 2005, which conditions were followed by the strongest attacks of both powdery mildew and gypsy moth.

4. CONCLUSION

The largest numbers of dried Sessile oak trees and those with severe chlorosis were recorded during 2005, which conditions were followed by the strongest attacks of both powdery mildew and gypsy moth.

At locations monitored in Serbia, the strongest powdery mildew infection was recorded on Sessile oak trees, while medium, strong and very strong gypsy moth attacks were recorded only on Hungarian oak trees (during 2004 and 2005). As for the other oak species (Sessile oak and Turkey oak), the gypsy moth attacks were either rather weak or there were none at all. The magnitude of powdery mildew infections varied greatly on different locations due to weather conditions.

No direct connection could be established between the gypsy moth attack magnitude and that of the mildew infection, which is, among other things, due to the fact that the magnitude of the infection with this pathogen fungus primarily depends on the climate factors at a certain geographical area during the vegetation period (first of all, relative air humidity and temperature).

In the future, research of this kind ought to be extended to other areas. For the purpose of timely preparation and organisation of protective measures, regular monitoring of pests and forecasts of pest and disease development for each coming year are of great importance to practical forest stewardship and should be utilised by forest staff.

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SIMULTANI NAPAD LYMANTRIA DISPAR L. I MICROSPHAERA ALPHITOIDES GRIFF. ET MAUBL. NA QUERCUS VRSTAMA (Q. CERRIS, Q. FARNETTO I Q. PETRAEA) U PERIODU OD 2004. DO 2006. GODINE U NEKIM DELOVIMA SRBIJE

Miroslava MARKOVIC, Snezana RAJKOVIC, Katarina MLADENOVIC

Rezime

Ispitivanja u ovom radu su vršena na 3 područja u Republici Srbiji - Kragujevac, Požarevac i Vrnjačka Banja, na kojima se zonalno nalaze veće površine pod hrastovim sastojinama (najčešće vrste hrastova na ovim područjima su Quercus farnetto, Q. cerris i Q. petraea). Pregledi su rađeni na stalnim bioindikacijskim tačkama, na kojima je vršena ocena hloroze, sušenja i evidentirana oštećenja od gubara i prouzrokovala pepelnice. Cilj ovog rada je bio da se izvrše preliminarna ispitivanja i utvrdi da li postoji veza između intenziteta zaraze pepelnicom i jačine napada gubara i na sladunu, ceru i kitnjaku na području Srbije i da li postoji razlika u napadu na ove tri vrste hrastova. Gubar (Lymantria dispar L., Lepidoptera, Lymantridae) je jedna od najvećih štetočina lišćarskih šuma, a odlikuje se velikom reproduktivnom moći, znatnom ekološkom plastičnošću i polifagnošću. Gubar je autohtona vrsta sa optimalnim uslovima za razmnožavanje, hrani se lišćem preko 500 vrsta drveća i žbunja, a najbolje se razvija na vrstama iz roda Quercus. Tokom gradacija gubara koje traju 3 do 5 godina, prvo lišće hrasta strada od golobrista gusenica. Ubrzo posle toga, hrast ponovo prolista i to drugo lišće napada pepelnica. Pepelnica hrasta (Microsphaera alphitoides Griff. et Maubl.) je ozbiljan problem na sadnicama u rasadnicima i na prirodnom i veštački unesenom podmlatku. Na odraslim stablima umanjuje prirast i otežava prirodno obnavljanje šuma. Infekcije se ostvaruju od početka maja meseca pa do kraja vegetacionog perioda. Najviše suvih stabala kitnjaka i stabala sa jakom hlorozom bilo je tokom 2005. godine, što je bilo praćeno i najjačim napadom pepelnice i gubara na ovoj vrsti.

SIMULTANEUS ATTACK OF *LYMANTRIA DISPAR* L. AND *MICROSPHAERA ALPHITOIDES* GRIFF. ET MAUBL. ON *QUERCUS* SPECIES (*Q. CERRIS*, *Q. FARNETTO* AND *Q. PETRAEA*) IN CERTAIN PARTS OF SERBIA FROM 2004 TO 2006

Miroslava MARKOVIC, Snezana RAJKOVIC, Katarina MLADENOVIC

Summary

This paper presents research conducted in three regions in the Republic of Serbia – around Kragujevac, Pozarevac and Vrnjacka Banja – as there are large zonally situated areas populated by oak clusters (the most common oak species in these regions are *Quercus farnetto*, *Q. cerris* and *Q. petraea*). At permanently established sampling plots examinations were conducted to assess chlorosis, defoliation and damages caused by the gypsy moth and powdery mildew instigators. The aim of this paper was to perform preliminary examinations and determine whether there is any connection between the magnitude of the mildew infections and that of the gypsy moth attacks on Hungarian oak, Turkey oak and Sessile oak trees in the territory of Serbia and whether there are differences in attacks among the three oak species. Gypsy moth (*Lymantria dispar* L., Lepidoptera, Lymantridae) is one of the major pests attacking deciduous forests; it is characterised by a great reproductive power and significant ecological plasticity and polyphagia. Gypsy moth is an indigenous species with optimal conditions for reproduction. It feeds on the leaves of over 500 tree and bush species and is best developed on the species of the *Quercus* genus. During the gradations of the gypsy moth, which last between 3 and 5 years, the first to suffer is oak foliage devoured by the caterpillars. Soon afterwards, oak trees leaf again and the new foliage is attacked by powdery mildew. Oak powdery mildew (*Microsphaera alphitoides* Griff. et Maubl.) presents a serious problem for seedlings in nurseries as well as for naturally and artificially introduced young plants. In adult trees, it reduces height growth and hinders natural forest restoration. The infections occur from the beginning of May up to the end of the vegetation period. The largest number of defoliated Sessile oak trees with severe chlorosis were recorded during the year 2005, which was followed by the strongest attacks of the powdery mildew and gypsy moth on the same species.

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