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TOM 63-64

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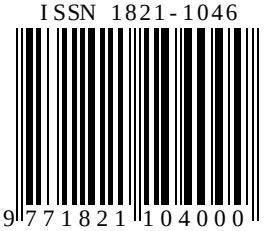

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GYPSY MOTH OUTBREAKS IN FOREST COMPLEXES OF THE BELGRADE REGION IN THE PERIOD 1996-2011

Mara TABAKOVIĆ-TOŠIĆ[1], Dragutin TOŠIĆ[2], Miroslava MARKOVIĆ[3], Katarina MLADENOVIĆ[4], Zlatan RADULOVIĆ[5], Snežana RAJKOVIĆ[6]

Abstract: *The paper presents the results of investigation of a gypsy moth population density level in the forest area of the Belgrade region, in the period 1996-2011. The characteristics of three over-proliferations were analysed, two of which had a character of an outbreak (2003-2005. and 2009-2011.)*

Key terms: gypsy moth, outbreak, forests, Belgrade region

1. INTRODUCTION

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 its high reproductive capacity, a considerable ecological plasticity and polyphagia. Periodically, it occurs in large numbers (over-proliferation or outbreak). Although present in all four continents (North Africa, Asia, Europe, North America), the most damage has been inflicted in the forests of the Balkan Peninsula, where all

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Translation: Dejan Arsenovski

environmental conditions for its development are favourable (Tabaković-Tošić, 2002).

In the region of Belgrade, where forest complexes cover 32,444 hectares, out of which 16,808 ha or 51.8% is in state, and 15,636 or 48.2% in private ownership, timber volume amounts to 2,649,340 m^3, gypsy moth is an autochthonous species and it often occurs in outbreaks. It was considered earlier that gypsy moth outbreaks occur every 8 to 10 years, however, the events in last 50 years disproved that assumption (Mihajlović *et al*., 1998).

Damage caused by gypsy moth is twofold: both direct – defoliation or a loss of leaf mass, and indirect, manifested through the effects of defoliation. Defoliations caused by feeding of caterpillars lead to reduction of increment, absence of fruit bearing, physiological weakening and drying of trees, as well as the creation of favourable conditions for attacks of phytopathogenic micro-organisms, fungi and xylophagous insects, disruption of spatial aesthetics and other. The reference data indicate that a volume increment is reduced by 40-70% in course of one total defoliation, depending on a type of tree and forest, whereas during a partial defoliation it is reduced by 20-25%.

2. INVESTIGATION AREA

The region of Belgrade, the area in which gypsy moth over-proliferation has been investigated, is situated at the contact - transition point between two natural-geographic units of Serbia, Panonnian Plane in the north, and the hilly-mountain Balkan Peninsula in the south. It is located 45° north of Equator and 20.5° east of Greenwich. It covers the surface area of 3,250 km^2. The Belgrade urban agglomeration, with its one million and six hundred thousand inhabitants, is located in this area. Rivers Danube and Sava divide the region into the north, lowland, morphologically homogenous part (alluvial plains and terraces of 80-100 m altitude) and the south, morphologically heterogeneous part (fluvio-denuded plateaux of 100-200 m altitude); foothills of 200-500 m altitude and horsts of the mountains Avala, of 511 m altitude, and Kosmaj, of 628 m altitude). The climate is moderate continental and, according to Köppen classification, the *Cfb* climate dominates in the region. The average annual air temperature is 11.9ºC. January is the coldest (the average temperature is 1.1ºC), and July the warmest month (the average temperature is 21.7ºC). The mean annual maximum temperature is 16.6ºC, and the minimum temperature is 7.9ºC. The number of days with temperature above 30°C, so-called tropical days, is 31 on average, and the number of summer days with temperature above 25°C is 95 per year. The average annual insolation is approximately 2,000 hours. The highest insolation, about 10 hours per day, is in July and August, and the highest cloudiness is in December and January, when sun shines on average 2-2.3 hours per day. The mean annual relative air humidity is 69%. The average amount of precipitation is approximately 685 mm (maximum in June, 90.4 mm; minimum in October, 40.3 mm). The average annual number of snowfall days is 28. The region is characterised by air silences (183‰) and south-east wind (‘*košava*’) (145‰), which most commonly occurs in the cold half of a year, with the speed of 40 to 70 km/h (Hydro-meteorological Institute of Serbia).

This area is a natural habitat for deciduous tree species (*Quercus cerris* L., *Quercus petraea* (Matt.) Lieblein, *Quercus frainetto* Tenore, *Fagus moesiaca* (Domin, Maly) Czeczott., *Carpinus betulus* L., *Fraxinus excelsior* L., *Fraxinus ornus* L. and other), whereas coniferous trees are introduced sporadically and in small areas.

3. MATERIAL AND METHOD

3.1. Gypsy moth population control

Gypsy moth population control measures were administered in all deciduous forests every year, (during an outbreak period in coniferous forests as well), regardless of their ownership category (state or private), and in accordance with the Instructions supplied by the officials responsible for Report-diagnostic forecast in the domain of plant protection – forest protection. The gypsy moth population control in forests was carried out by means of a permanent (25x25 m) and a temporary (10x10 m) sample plot method, as well as a route method and a method of traps using gypsy moth female sex-attractant for capturing males (pheromone traps).

The determination of the attack intensity and the spatial definition of the attack area are of critical importance, as those determinants present the key factors for selection of a control method and timing: in the egg stadium (mechanical or chemical, from the period of the autumn leaf dropping until the beginning of summer foliation), or in the larva stadium (aerial spraying, conducted at the end of April or in the beginning of May).

Permanent sample plots were subject to control every year, whereas temporary sample plots were controlled only when an over-proliferation threat seemed apparent. The route method and pheromone trap method were applied as additional measures during a gypsy moth latency (low population density) period, whereas they were invariably used during the outbreak period (Tabaković-Tošić, 2002).

3.2. Quantitative and qualitative analysis of gypsy moth egg masses

A detailed quantitative and qualitative analysis of sampled egg masses was conducted at the laboratory of the Institute of Forestry and, depending on the analysed parameter, the ocular method or the method of binocular magnifying glass examination was applied. Additionally, the dynamics of flying out of gypsy moth egg parasitoides imagoes from previously analysed masses was monitored in the laboratory conditions in winter period.

100 randomly sampled, previously cleaned eggs from each egg mass were placed in specially prepared test tubes (with distilled water at the bottom and a cotton wool layer in the middle, intended to prevent a total immersion of eggs). The test tubes with sampled gypsy moth eggs were held in a climate chamber. During the experiment, the air temperature and the light regime had been constant (the temperature 19°C, the light regime – 10 hours night, 14 hours day). The recording of flying out of parasites was conducted daily until it ceased.

4. RESULTS AND DISCUSSION

The occurrence of an outbreak, from the one hand, depends on a gypsy moth physiological constitution, and from the other, on impact of external factors – type and quality of food, meteorological conditions and biotic factors (disease, natural enemies and competitor species) (Janković, 1958; Marović *et al.*, 1998; Mihajlović *et al.*, 1998; Tanasković, 2005).

In the latency period, gypsy moth is a regular member of a forest biocenosis. However, occasionally (when the absence of activity of one or more environmental resistance factors occurs), the pest responds quickly by over-proliferation, i.e. enters into an outbreak phase. The course of an outbreak has four phases: pre-outbreak, eruption, culmination and regression, followed by a period of latency – a regular population density.

The most important qualitative and quantitative parameters indicating a gypsy moth population level increase in one area, are the following: females lay eggs in open places (in the latency period eggs are usually hidden); pronounced gregariousness (grouping instinct); caterpillars feed during the daytime (in the latency period they feed at night); a sexual index value increases, resulting in male predominance at the end of a culmination phase; an increase of caterpillar polyphagy; egg masses contain from 800 to over 1,000 eggs (in the latency period 300-600); the number of egg masses per surface unit significantly increases (Vasić, 1981).

In the course of those investigations, during the process of establishing the number of gypsy moth egg masses per surface unit (1 hectare), particular attention was paid to inclusion of all forests complexes. This aspect was of major importance for the areas in which occurrence of a particularly intense attack was observed (over 500 egg masses per hectare), as the amount of damage manifested through leaf- mass injury, to be caused by hatched larvae, is not the same under the attack of 501 and, for instance, 50,000 egg masses per hectare (Mihajlović *et al*, 2004, Tabaković-Tošić, 2004).

Table 1. *Outspread of gypsy moth in the forests of Belgrade region in the period 1991-2011 (number of oviposited egg masses at the end of summer period)*

YEAR	ATTACK INTENSITY AND ATTACKED AREA								TOTAL
	Low intensity 1-10 egg masses/ha		Medium intensity 11-100 egg masses/ha		High intensity 101-500 egg masses/ha		Severe intensity over 500 egg masses/ha		
	ha	%	ha	%	ha	%	ha	%	
1996.	746,00	100	0	0	0	0	0	0	**746,00**
1997.	998,0	100	0	0	0	0	0	0	**998,0**
1998-2002. – gypsy moth latency period									
2003.	10,00	0,3	349,75	8,9	1729,82	44,2	1824,62	46,6	**3914,19**
2004.	2,00	0,03	473,00	7,6	417,00	6,7	5354,00	85,7	**6246,00**
2005.	2343,11		46,00		22,00		26,00		**2437,11**
2006-2008. – gypsy moth latency period									
2009.	825.53	22,1	2023,74	54,1	865,19	23,2	21,20	0,6	**3735.66**
2010.	922,37	22,7	2066,68	50,8	984,80	24,2	92,89	2,3	**4066.74**
2011.	959,67	65,5	291,66	19,9	94,38	6,4	120,24	8,2	**1465,95**

As can be seen from the data in the Table 1, the population level increase in the investigation area, observed in the period 1996-1997, did not assume a character of an outbreak. The attack intensity is within the category of mild, whereas the attacked area was relatively small and limited to the forests in the Management unit Avala.

The mechanical and chemical control measures, undertaken in the egg stadium, most probably caused the sudden interruption of over-proliferation, prevented spreading of attacked area and restored gypsy moth population density to a normal level, at which it does not inflict economic and ecological damage to forest tree species.

The gypsy moth latency period in this area lasted for five years, and it was followed by a repeated occurrence of over-proliferation (2003), which would assume all characteristics of an outbreak in the following years. Mechanical and chemical suppression measures undertaken in the egg stadium and administered in autumn of 2003 and winter of 2004, did not produce satisfactory results, due to an enormous number of egg masses, laid high in stems and crowns. In the summer period of 2004, air-suppression in the larva stadium was conducted, by means of a biological preparation D-stop (active ingredient: spores and crystals *Bacillus thuringiensis* ssp. *kurstaki*), which also proved ineffective. A partial or total defoliation occurred in the entire area. On the account of an enormous number of voracious larvae and lack of food, a large number of caterpillars died, but nevertheless, a sufficient number of them remained, continuing their development. In autumn of 2004, newly-laid gypsy moth egg masses were found in the area of 6,246 ha.

Following the partial elimination of egg masses, performed in the autumn-winter period in spring of 2005, a repeated air-suppression was conducted in the larva stadium, but this time a third generation chemical insecticide Dimilin SC 48 (active ingredient diflubenzurone) was selected. The performed suppression was effective and, in autumn of 2005, it resulted in a low number of laid egg masses (approximately 10 per hectare), on a nearly three times smaller area. The suppression in the summer period resulted in a termination of the outbreak period and commencement of the latency period in following year. It should be pointed out that the above-mentioned preparations are highly selective and ecologically safe, and applied in ultra low volumes (ULV) (Tabaković-Tošić i Jovanović, 2007).

The third gypsy moth over-proliferation cycle during the investigation period also had every characteristic of an outbreak, with the exception that this time the attacked area was far smaller. The regression phase occurred in autumn 2011, and it was a result of the successful gypsy moth suppression in the egg stadium and the increased activity of gypsy moth natural enemies (parasites and predators).

Picture 1. *August 2004. – laying of egg masses at the Management unit Lipovica*
(author: Gordana Jančić)

Picture 2. *June 2004. – total defoliation at the Management unit Kosmaj*
(author: Mara Tabaković-Tošić)

Picture 3. *August 2004. – laying of egg masses at the Management unit Kosmaj*
(author: Gordana Jančić)

The analysis of gypsy moth egg masses, collected in the area of the Management unit Beograd (Table 2), had been conducted at the laboratory of the Institute of Forestry every year during the investigation period. The average number of eggs in an egg mass ranged from 108.7 (2005) to 739.6 (2003). The egg mass with the largest number of eggs (1449) was submitted to the Institute in 2003 from the department 24b – MU Guberevačke šume. The percentage share of vital eggs in the total number of eggs ranged, on average, from 58.8 in 2005 to 90.5 in 2009.

The average egg parasiticity ranged from 3.7 in 1996 to 40.8% in 2005. The above-stated parasiticity values should not be considered final, as they concern laboratory conditions, which prevent the activity of a number of parasites and predators, to which egg masses are exposed in nature.

Table 2. *Laboratory analysis of gypsy moth egg masses sampled from representative trial plots in the area of FMU Beograd*

Year	Number of egg masses	Average number of eggs in an egg mass						
		Fertilised				Unfertilised		Total
		Vital		Parasitised				
		N	%	N	%	N	%	N
1996	37	397.2	88.5	16.4	3.7	35.2	7.8	448.8
1997-2002 gypsy moth latency period								
2003	297	590.7	79.8	144.0	19.5	4.9	0.7	739.6
2004	154	325.8	74.0	111.8	25.4	2.7	0.6	440.3
2005	38	63.9	58.8	44.4	40.8	0.4	0.4	108.7
2006-2008 gypsy moth latency period								
2009	60	457,1	90.5	44,2	8.7	4,0	0.8	505.3
2010	100	474.8	85.8	70.4	13.5	3.9	0.7	549.1
2011	100	389.0	81.0	91.4	18.4	3.2	0.6	483.6

The results of the analysed quantitative and qualitative parameters of gypsy moth egg masses confirm the above-stated assertion that the increase of gypsy moth population density above normal values in the forest area of Belgrade region in the period 1996-2011 occurred three times, whereas only two population increases had a character of an outbreak.

The dynamics of flying out of parasite imagoes from the previously analysed egg masses was monitored in special trials. Only two egg parasites species *Anastatus japonicus* Ashmead (syn. *A. disparis* Ruschka) and *Oencyrtus kuwanae* (Howard) were present every year. Their percentage ratio was relatively consistent in every year - 30:70%, with clear domination of *Oencyrtus kuwanae.*

5. CONCLUSIONS

After a thirty-year long interval of latency, the increase of the gypsy moth population density above the normal level occurred three times in the forest area of Belgrade region in the period 1996-2011, whereas two population increases (2003-2005 and 2009-2011) had a character of an outbreak.

The control measures undertaken in egg and larva stadia, although adequately prepared and timely applied, did not always produce satisfactory results (2003–2005). In the period between 1996 and 1997, a suppression conducted in the egg stadium was effective, since the intensity of the attack was mild in the entire area and egg masses were laid in places accessible for their elimination.

In the period 2009-2011, a regressive phase occurred as a result of a successful gypsy moth suppression in the egg stadium, as well as the increased activities of gypsy moth natural enemies (parasites and predators).

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OVER-PROLIFERATION OF GYPSY MOTH IN FOREST COMPLEXES OF THE BELGRADE REGION IN THE PERIOD 1996-2011

Mara TABAKOVIĆ-TOŠIĆ, Dragutin TOŠIĆ, Miroslava MARKOVIĆ,
Katarina MLADENOVIĆ, Zlatan RADULOVIĆ, Snežana RAJKOVIĆ

Summary

Following a thirty-year long interval of latency, an increase of the gypsy moth population density above the normal level occurred three times in the investigation area in the period 1996-2011, whereas two population increases (2003-2005 and 2009-2011) had a character of an outbreak.

The increase of gypsy moth population level in 1996-1997 did not assume character of an outbreak. The intensity of the attack was within the category of mild, whereas the attacked area was relatively small and limited to forests of Management unit Avala.

The mechanical and chemical control measures, undertaken in the egg stadium, most probably caused the sudden interruption of over-proliferation, prevented spreading of attacked area and restored gypsy moth population to a normal level, at which it does not inflict economic and ecological damage to forest tree species. A gypsy moth latency period in this area lasted for five years, and it was followed by a repeated occurrence of over-proliferation (2003.), which would assume all characteristics of an outbreak in following years. Mechanical and chemical suppression of gypsy moth in egg stadium, conducted in autumn of 2003 and winter of 2004 did not produce satisfactory results, due to an enormous

number of egg masses, laid high in stems and crowns. In the summer period of 2004, the air-suppression conducted in the larva stadium, by means of a biological preparation D-stop (active ingredient: spores and crystals *Bacillus thuringiensis* ssp. *kurstaki*), also proved ineffective. A partial or total defoliation occurred in the entire area. On the account of an enormous number of voracious larvae and lack of food, a large number of caterpillars died, but nevertheless, a sufficient number remained, continuing their development. In autumn of 2004, newly-laid gypsy moth egg masses were found in the area of 6,246 ha.

Following the partial elimination of egg masses, performed in the autumn-winter period, a repeated air-suppression in the larva stadium was conducted in spring of 2005, but this time a third generation chemical insecticide Dimilin SC 48 (active ingredient diflubenzurone) was selected. The performed suppression was effective and in autumn of 2005 it resulted in a low number of laid egg masses (approximately 10 per hectare), on a nearly three times smaller area. The suppression in summer period led to termination of the outbreak period and commencement of the latency period in following year.

The third gypsy moth over-proliferation cycle in the investigation period also had every characteristic of an outbreak, with the addition of the fact that this time attacked area was far smaller. The regression phase occurred in autumn 2011, and it was a result of a successful suppression of gypsy moth in the egg stadium and the increased activity of gypsy moth natural enemies (parasites and predators).

PRENAMNOŽENJA GUBARA U ŠUMSKIM KOMPLEKSIMA BEOGRADSKOG REGIONA U PERIODU OD 1996-2011. GODINE

Mara TABAKOVIĆ-TOŠIĆ, Dragutin TOŠIĆ, Miroslava MARKOVIĆ, Katarina MLADENOVIĆ, Zlatan RADULOVIĆ, Snežana RAJKOVIĆ

Rezime

U istraživanom području, nakon tridesetogodišnje latence, u periodu od 1996-2011. godine tri puta je došlo do povećanja populacionih nivoa gubara iznad normalne vrednosti, a dva (2003-2005. i 2009-2011. godina) su imala gradogeni karakter.

Povećanje populacionog nivoa gubara u 1996-1997. godini nije poprimilo karakter gradacije. Intenzitet napada je bio u kategoriji slabog, a napadnuta površina je bila relativno mala i ograničena samo na šume u Gazdinskoj jedinici Avala. Preduzete mehaničke i hemijske mere suzbijanja u stadijumu jajeta su najverovatnije uzrokovale nagli prekid prenamnoženja, sprečile širenje površine pod napadom i vratile populacioni nivo gubara na normalnu vrednost, kada ne pričinjava ekonoske i ekološke štete šumskim vrstama drveća.

Period latence gubara u ovom području je trajao pet godina, nakon čega ponovo nastupa njegovo prenamnoženje (2003. godina), a koje će u narednim godinama poprimiti sve osobine gradacije. Mehaničke i hemijske mere suzbijanja gubara u stadijumu jajeta, preduzete u jesen 2003. i zimu 2004. godine nisu dale zadovoljavajuće rezultate jer se radilo o enormnom broju legala položenih visoko na deblima i u krošnjama. U prolećnom periodu 2004. godine izvršeno je aviosuzbijanje u stadijumu larve biološkim preparatom D-Stop (aktivna materija: spore i kristali Bacillus thuringiensis ssp. kurstaki), koje je takođe bilo neefikasno. Na celokupnoj površini došlo je delimičnog ili totalnog golobrsta. Usled enormnog broja proždrvljivih larvi i nedostatka hrane, veliki broj gusenica je uginulo, ali je ostao dovoljan broj koji je nastavio razviće. U jesen 2004. godine novopoloženih jajnih legala gubara je bilo na ukupnoj površini od 6246 ha.

Nakon delimičnog uklanjna jajnih legala, preduzetog u periodu jesen-zima, u proleće 2005. godine ponovo je preduzeto aviosuzbijanje u stadijumu larve, ali ovaj put je odabran hemijski insekticid treće generacije Dimilin SC 48 (aktivna materija

diflubenzuron). Suzbijanje je bilo efikasno, pa je u jesen 2005. godine gubar je položio mali broj jajnih legla (do 10 legala/ha) na skoro 3 puta manjoj površini. Njihovo suzbijanje u jesenjem periodu je rezultiralo završetkom gradacije i nastupanjem latence u narednoj godini.

Treće prenamnoženje gubara u istraživačkom periodu takođe ima sve osobine gradacije, s tim što je ovaj put napadnuta površina znatno manja. Retrogradaciona faza je nastupila u jesen 2011. godine, a posledica je uspešnog suzbijanja gubara u stadijumu jajeta i povećane aktivnosti prirodnih neprijatelja gubara (parazita i predatora).

Reviewer: Ph.D. Vesna Golubović Ćurguz