IZVORNI I ZNANSTVENI ČLANCI – ORIGINAL SCIENTIFIC PAPERS
UDK 630* 442 (001)

Šumarski list br. 7–8, CXXXIV (2010), 403-410

PARASITOIDS AND HYPERPARASITOIDS OF *ERANNIS DEFOLIARIA* CL. (LEPIDOPTERA, GEOMETRIDAE) IN OAK FORESTS

PARAZITOIDI I HIPERPARAZITOIDI ERANNIS *ERANNIS DEFOLIARIA* CL. (LEPIDOPTERA, GEOMETRIDAE) U HRASTOVIM ŠUMAMA

Milka GLAVENDEKIĆ[1]

ABSTRACT: The research on biology and ecology of Mottled Umber Moth – Erannis defoliaria *Cl. (Lepidoptera, Geometridae) was carried out in the period 1985–2009 in oak forests in Serbia. Mottled Umber Moth was mainly in the latency during the investigation. Only at the locality Miroč in East Serbia and in Forest unit Zlatica (National Park Djerdap), it was dominant in the complex of early defoliators. Natural enemies of* E. defoliaria *and especially parasitoids and hyperparasitoids are important mortality factors.*

Egg parasitoid Trichogramma *sp. (Hym., Trichogrammatidae) was recorded at few localities in the vicinity of Belgrade and in the wide area of National Park Djerdap. They are nonspecific parasitoids. Somewhat more specific* Telenomus minutus *(Hym., Scelionidae) was recorded from East Serbia – locality Miroč. Larval parasitoids are* Protapanteles immunis*,* Cotesia limbata*,* C. jucunda *(Hym., Braconidae);* Casinaria ischnogaster*,* Casinaria moesta*,* Phobocampe crassiuscula*,* Phobocampe pulchella*,* Phobocampe *sp. (Hym., Ichneumonidae),* Euplectrus bicolor*,* Eulophus larvarum *(Hym., Eulophidae),* Blondelia nigripes*,* Phryxe magnicornis*,* P. nemea*,* Peribaea fissiconis *(Diptera, Tachinidae). There are 16 parasitoids recorded. Five species of hyperparasitoids recorded on* E. defoliaria *are following:* Gelis areator*,* Bathythrix lamina *(Hym., Ichneumonidae),* Perilampus ruficornis *(Hym., Perilampidae),* Habrocytus chrysos*. (Hym., Pteromalidae),* Tetrastichus *sp. (Hym., Eulophidae).*

Key words: Quercus *spp., oak,* Erannis defoliaria*, Mottled Umber Moth, parasitoid, hyperparasitoid*

INTRODUCTION – Uvod

A good condition and stability of forest ecosystems is of the main importance of all forest functions. A greater part of forest regions in Serbia is covered with oak climate-zonal communities. The most represented species are sessile oak *Quercus petraea* (Matt.) Lieblein, Turkey oak *Q. cerris* L., Hungarian oak *Q. frainetto* Tenore, Vergilius's oak *Q. virgiliana* Tenore and pedunculate oak *Q. robur* L.

Mottled umber moth – *Erannis defoliaria* Cl. (Lepidoptera, Geometridae) is one of nine outbreaking winter moths, which are responsible to defoliations in oak forests. In Serbia following winter moth species are outbreaking and among the most significant oak defoliators: *Colotois pennaria* L.*, Agriopis aurantiaria* Hbn.*, Erannis defoliaria* Cl., *Alsophila aescularia* D.& Sch., *A. aceraria* D.& Sch., *Operophtera brumata* L., *Apocheima pilosaria* D.& Sch., *Agriopis leucophaearia* D. & Sch. and *A. marginaria* F. (Glavendekić, 1999). Winter moths are defined as a group of species homology as the winter moth fly during autumn and winter, females are apterous or they have reduced wings, they overwinter in egg or pupal stages, the first instar larvae disperse by ballooning with the aid of wind.

Insects feeding on the foliage of live plants are called defoliators. Oak defoliators are mostly moths, sawflies, leaf beetles and weevils. Based on the time of

[1] Associate. Prof. Milka Glavendekić, PhD. (milka.glavendekic@nadlanu.com), University of Belgrade, Faculty of Forestry, Kneza Višeslava 1, Belgrade, Serbia

occurrence, they are divided in early-season (spring) defoliators, the long-season defoliators and late-season defoliators. To early-season defoliators belong species which overwinter in the stages of egg or pupa and whose activity is related to early spring. Their caterpillars feed on the buds or young leaves and their development ends very quickly. This group is faunistically most versatile (leaf rollers, winter moths, noctuid moths, sawflies, oak leaf beetles, weevils). Their defoliations occur chronically and the consequence of defoliation is the reduction of increment (Klepac & Spaić, 1965; Rubcov, 1996). For this reason, defoliators are paid special attention to and the control measures are most often directed against them.

The first data about *E. defoliara* outbreaks in oak forests from 1887 to 1898 are given by Langhoffer, 1899. Long-term study of winter moths in Croatia - Slavonia oak forests were undertaken in 1960 (Spaić, 1974). The significance of winter moths in Serbia, as forest pests was emphasised by Tomić, 1980; Vasić & Tomić, 1980. Predators and parasitoids of herbivores can reduce the pests or prevent their outbreak. After multiannual application of DDT preparations in the suppression of gypsy moths in forests, ecological study was undertaken in the fifties of last century, in order to find alternate methods of forest insect pests suppression (Pschorn - Walcher, 1977). These researches were aimed at the development of the concept of biological control applied in Canada, where the outbreak of the winter moth was suppressed by biological control (Embree, 1966). The application of biological methods in the control of forest insect pests was studied by Mihajlović, Lj., (1986), Harapin (1992), Glavendekić (1992) and many other authors. Based on the literature, 53 parasitoids and 11 hyperparasitoids have so far been identified for *E. defoliaria* in Europe (Herting, 1965, 1976; Čapek, and Čepelak, 1981; Čapek, 1985; Djorović, 1980). The most of parasitoids belong to Hymenoptera (41 species) and the rest belong to Diptera (Tachinidae 11 species and Phoridae one species). The majority of hyperparasitoids are from family Ichneumonidae (10 species) and only one species from the family Perilampidae (Hymenoptera, Chalcidoidea). The following parasitoids in Serbia were recorded on mottled umber moth: *Cotesia jucunda* Marsh., *Meteorus versicolor* Wesm. (Hymenoptera: Braconidae), *Eulophus larvarum* L. (Hymenoptera: Eulophidae) and *Phorocera obscura* Fall. (Diptera: Tachinidae).

MATERIAL AND METHODS – Materijali i metode rada

The research done on all development stages of *E. defoliaria* Clerck, 1759. The research was carried out by field and laboratory methods. Field work included standard methods of entomological research of moths in all development stages. The method of exposure in nature was applied to eggs and larvae by using sticky bands at the time of female activity. Females laid eggs in bark crevices below sticky bands. The parts of the bark with eggs were cut and the samples were taken to the laboratory for rearing and processing. Sticky bands were also used for larval exposure, but in April and May.

To monitor population dynamics and the change of quality composition of winter moths, absolute and relative abundance of *E. defoliaria* was assessed every year. Caterpillar density was assessed when they were predominantly the second and partly the third instars. Absolute abundance was assessed by counting the leaves or opened buds and caterpillars in the sample. Relative abundance was assessed based on the number of caterpillars on 1000 leaves.

Biology and ecology of *E. defoliaria* were studied on the following localities and types of forests: 1. Fruška gora Mt., Brankovac, Compartment 41 – forest of Turkey oak and sessile oak (*Quercetum petraeae-cerris*) on brown and lessive brown soil on serpentinite. 2. Forest Unit Košutnjak - one sample plot was set aside in the forest of sessile oak, Turkey oak and hornbeam (*Carpino-Quercetum petraeae-cerris)* on brown forest soil and lessive brown forest soil. The second in the plantation of red oak (*Quercus rubra* L.) on humus brown forest soil. The third one was set aside in the association *Orno-Quercetum pubescentis-virgilianae.* 3. Forest Unit Mala Moštanica compartment 52 – artificially regenerated stand of black locust and a mixture of oaks are established on a typical site of Hungarian oak and Turkey oak. 4. Forest Unit Avala, Compartment 15, in a climatogenic community *Quercetum frainetto-cerris aculatetosum* on lessive brown forest soil. 5. Forest Unit Jamena – Radjenovci, Visoka šuma, compartment 4c – forest type pedunculate oak and hornbeam (*Carpino Quercetum roboris*) on brown forest soil to lessive brown forest soil in the non-flooded area. 6. Forest Unit Visoka šuma Lošinci, compartments 1a, 2d, 15a. – forest type pedunculate oak, hornbeam and Turkey oak (*Carpino-Quercetum robori-cerris typicum)* on brown forest soil to lessive brown forest soil. 7. Forest Unit Visoka šuma Lošinci, compartment 23g. – forest type pedunculate oak, hornbeam and Turkey oak *(Carpino-Quercetum robori-cerris typicum)* on lessive to semigley soils. 8. Forest Unit Miroč, compartment 73a – forest of sessile oak *Quercetum montanum typicum*) on brown soils. 9. Forest Unit Porečke šume, compartment: 54b – forest type beech and sessile oak (*Querco-Fagetum typicum)* on acid brown and lessive acid brown soil. 10. Forest Unit Porečke šume, compartment 54 f – forest type sessile oak (*Quercetum montanum typicum*) on acid brown soil. 11. Forest Unit Zlatica, compartment 93a – forest type sessile oak (*Quercetum montanum typicum*) on acid

brown soil. 12. Forest Unit Zlatica, compartment 96a - forest type beech and sessile oak (*Querco-Fagetum typicum*) on acid brown and lessive acid brown soil. 13. Forest Unit Kožica, compartment 30b – forest of sessile oak and Turkey oak (*Quercetum petraeae cerris pauperum*) on acid brown and lessive acid brown soils. 14. Forest Unit Kožica, compartment 31a – forest of submontane beech (*Fagetum submontanum)* on deep eutric brown soils (brown forest soil and brown soil on loamy sediments). 15. Forest Unit Bukovik, compartment 4a – coppice forest of Hungarian oak and Turkey oak with Eastern hornbeam (*Quercetum frainetto - cerris carpinetosum orinetalis*) on dystric and eutric brown soils. 16. Forest administration Raška, Forest unit Kosovac – coppice forest of Hungarian oak and Turkey oak with Eastern hornbeam (*Quercetum frainetto - cerris carpinetosum orinetalis*) on dystric and eutric brown soils.

RESULTS – Rezultati

Biology and population dynamic of mottled umber moth

Biologija i populaciona populacijska dinamika velikog mrazovca

Erannis defoliaria Clerck, 1759 – Mottled umber moth, Grosser Frostspanner, голяма зимна педомерка, veliki mrazovac. During our study the first adults were found in the third decade of November, and the last ones in the first decade of January. Females oviposit individually or in small groups around the buds, in bark crevices or in other hidden places. Caterpillars can vary in the colour (figure 1).

Figure 1 Caterpillars of E. defoliaria
Slika 1. Gusjenice E. defoliaria

It was recorded in all localities, most often in a lower population density. In Forest unit Miroč, however, it was dominant (65% of early season defoliator population). It exceeded threshold on the locality National Park Djeradp in Forest unit Zlatica, comp. 54f in 2002 (213 larvae/1000 leaves). In compartments 101, 95 and 55 relative abundance was from 98–123 larvae/1000 leaves in 2009.

Winter moth population dynamics has been studied in different forest types. It was found out that frequent outbreaks are characteristic for the following forest types: forest of Turkey oak and sessile oak (*Quercetum petraeae-cerris*) on brown and lessive brown soil on serpentinite; forests of sessile oak (*Quercetum montanum typicum*) on acid brown soil; in the forest of Hungarian oak and Turkey oak with Eastern hornbeam (Q*uercetum frainetto-cerris carpinetosum orientalis*) on dystric and eutric brown soils; in the association *Orno-Quercetum pubescentis-virgilianae* and in the artificially established stand of mixed oaks at Mala Moštanica. In plantations of pedunculate oak with hornbeam in forest unit Visoka šuma Lošinci outbreaks of winter moths are frequently observed. Winter moths occur regularly, but as a rule there are no outbreaks in the forest of sessile oak, Turkey oak and hornbeam (*Carpino-Quercetum petraeae-cerris)* on brown forest soil and lessive brown forest soil.

Distribution and bioecology of mottled umber moth parasitoids

Rasprostranjenje i bioekologija parazitoida velikog mrazovca

During our study on parasitoids of *E. defoliaria* in oak forests following species were recorded:

Protapanteles immunis Haliday, 1834 (Hymenoptera: Braconidae) is a parasitoid of *E. defoliaria* and *A. marginaria* caterpillars. It is recorded in Forest units: Mala Moštanica, Rađenovci, Visoka šuma, and Bukovik.

Cotesia limbata Marshall, 1885 (Hymenoptera: Braconidae) was recorded in several localities as the parasitoid of *A. leucophaearia*, *E. defoliaria* and *O. brumata* caterpillars. It was found in Forest unit Mala Moštanica and Visoka šuma Lošinci.

Figure 2 Larvae of E. defoliaria with Braconidae
Slika 2. Larva E. defoliaria sa brakonidom

Cotesia jucunda Marshall, 1885 (Hymenoptera: Braconidae) was recorded in Forest units: Košutnjak, Mala Moštanica, and Bukovik. It was reared from the caterpillars of mottled umber moth (figure 2).

Casinaria ischnogaster Thoms., 1887 (Hymenoptera: Ichneumonidae) was observed in Forest unit Košutnjak, as the parasitoid of *A. marginaria* and *E. defoliaria* caterpillars.

Casinaria moesta Grav., 1829 (Hymenoptera: Ichneumonidae) was observed in Forest units Mala Moštanica, Košutnjak and Avala. All specimens of this species were reared from the caterpillars of the mottled umber moth.

Phobocampe crassiuscula Grav., 1829 (Hymenoptera: Ichneumonidae) was observed in the Forest units Košutnjak and Mala Moštanica as the parasitoid of *E. defoliaria* and *A. pilosaria* caterpillars.

Phobocampe pulchella Thoms., 1887 (Hymenoptera: Ichneumonidae) was observed in Forest units: Košutnjak, Mala Moštanica, Bukovik and in Visoka šuma Lošinci. It was reared from the caterpillars of *A. leucophaearia, E. defoliaria* and *O. brumata.* Larvae of parasitoid leave the host before pupation (figure 3).

Figure 3 Larvae of Ichneumonidae
Slika 3. Larva Ichneumonidae

Phobocampe sp. (Hymenoptera: Ichneumonidae) was reared from the mottled umber moth caterpillars originating from Forest unit Bukovik.

Euplectrus bicolor (Swed., 1795) (Hymenoptera: Eulophidae) was found in Forest unit Visoka šuma Lošinci, reared from the mottled umber moth caterpillar.

Eulophus larvarum (Linnaeus, 1758) (Hymenoptera: Eulophidae) was the most abundant parasitoid of young caterpillars of *E. defoliaria* during the investigation at several localities: Forest unit Rađenovci Visoka šuma, Visoka šuma Lošinci, compartment 1, 2, compartment 22, compartment 23. In Forest unit Mala Moštanica it was reared from caterpillars of the mottled umber moth, *A. leucophaearia* and *O. brumata.*

Trichogramma sp. (Hymenoptera: Trichogrammatidae) is egg parasitoid recorded in the region of the Forest Administration Belgrade, Mala Moštanica. From the winter moth and mottled umber moth eggs collected in March, adults emerge in late April. In the National Park Djerdap, Forest unit Zlatica, compartment 59 and Boljetinska Reka, compartment 44, the eggs of *O. brumata*, *E. defoliaria* were collected at March, 27th and the first wasps hatched in the laboratory on April, 27th.

Telenomus minutus Ratzeburg (Hymenoptera: Scelionidae) was reared from eggs of *O. brumata, A. aurantiaria* and *E. defoliaria* in the Forest unit Miroč, compartments 73/74.

Blondelia nigripes Fall., 1810 (Diptera: Tachinidae) was recorded in Forest units: Avala, as parasitoids caterpillars of the mottled umber moth and *A. marginaria.* In Forest unit Visoka šuma Lošinci, compartments 1 and 2 it was reared from the winter moth, *A. pilosaria*, *A. leucophaearia* caterpillars. In Forest unit Bukovik, *B. nigripes* was reared from the *C. pennaria* caterpillars. Population dynamic of this species is connected with outbreaks of various winter moths and it was the most abundant in the phase of retrogradation.

Phryxe magnicornis Zetterstedt, 1838 (Diptera: Tachinidae) in Forest unit Mala Moštanica was recorded as the parasitoid of the mottled umber moth caterpillars. It is also recorded also in the Forest unit Visoka šuma Lošinci, compartment 1 and Forest unit Bukovik as the parasitoid of the winter moth caterpillars.

Phryxe nemea Meigen, 1824 (Diptera: Tachinidae) was reared from several Forest units: Visoka šuma Lošinci, compartment 22 and Avala from the mottled umber moth caterpillar. From Forest unit Mala Moštanica and Košutnjak it was reared from grown up caterpillars of *C. pennaria* and *E. defoliaria.* In Forest unit Boljetinska Reka, it was obtained from *O. brumata* caterpillar. In Forest unit Bukovik *P. nemea* was reared from caterpillars of the winter moth the mottled umber moth and *C. pennaria.*

Peribaea fissicornis Strobl, 1909 (Diptera: Tachinidae) was recorded in the Forest unit Mala Moštanica as

Figure 4 Larvae of E. defoliaria with Tachinidae
Slika 4. Larva E. defoliaria sa tahinidom

the parasitoid of *A. marginaria* caterpillar. In Forest unit Visoka šuma Lošinci, compartment 22 it was reared from the mottled umber moth caterpillar.

There are all together 16 parasitoid species recorded on *E. defoliaria* in oak forests in Serbia. The most frequent species was *Phryxe nemea*, which was recorded at 6 localities. On four localities were recorded *Phobocampe pulchella* and *Phryxe nemea.* The highest diversity of parasitoids was in Forest unit Mala Moštanica, where 11 of 16 species were recorded. High diversity of parasitoids was also found in pedunculate oak plantation mixed with hornbeam in Forest unit Visoka šuma Lošinci, where 50% of parasitoid species were recorded. It is easy to distinguish parasitized caterpillars by tachinide due to chorion on the front part of its body and dark marking around it (figure 4).

Distribution and bioecology of mottled umber moth hyperparasitoids

Rasprostranjenje i bioekologija hiperparazitoida velikog mrazovca

During our study on hyperparasitoids of *E. defoliaria* in oak forests following species were recorded:

Gelis areator Panzer, 1804 (Hymenoptera: Ichneumonidae) was found in two Forest units: Avala, Compartment 15, and Forest unit Kosovac as a hyperparasitoid of mottled umber moth and winter moth caterpillars.

Bathythrix lamina Thomson, 1884 (Hymenoptera: Ichneumonidae) was recorded in the Forest unit Avala. It was reared from the cocoon *Casinaria* sp. (Hymenoptera, Ichneumonidae) as a secondary parasitoid of *E. defoliaria*.

Perilampus ruficornis (Fabricius, 1793) (Hymenoptera: Perilampidae) was recorded in several Forest units: Rađenovci, Compartment 4, from the Tachinidae cocoon; Forest unit, Mala Moštanica, Forest unit Miroč, Compartment 73/74, from Tachinidae cocoon reared from the *E. defoliaria* caterpillar.

Habrocytus chrysos Walker, 1836 (Hymenoptera: Pteromalidae) was reared from *E. defoliaria* caterpillar originating from Forest unit Mala Moštanica. The host died in the second instar.

Tetrastichus sp. (Hymenoptera: Eulophidae) was reared from the several localities: Forest unit Mala Moštanica – from *O. brumata* and *A. leucophaearia* caterpillars; Forest unit Visoka šuma Lošinci, compartment 23 – from *O. brumata* caterpillars; Forest unit Visoka šuma Lošinci, compartments 1 and 2 – from caterpillars of *A. aescularia*, *A. leucophaearia*, *E. defoliaria* and *O. brumata*.

Influence of parasitoids and hyperparasitoids on population dynamic of E. defoliaria

Uticaj parazitoida i hiperparazitoida na populacionu populacijsku dinamiku E. defoliaria

Population dynamics of parasitoids and hyperparasitoids were studied in the culmination and in the first years of the postculmination phase. Hyperparasitoids fly before primary parasitoids. Their larvae were found in the caterpillars before the primary parasitoid infected the caterpillar. It is significant, however, that hyperparasitoids coincidence with primary parasitoid larva was low compared to their frequency. In the phases of retrogradation and latency, the coincidence was even lower at some localities. Parasitoids and hiperparasitoids are well adapted to their hosts. Locally they can contribute to break down of the gradation. At the locality Kožica we recorded the calamity of winter moths in 1992. Parsitism of mature caterpillars was 68.97%. The presence of hyperparasitoids in them was only 6.9%, the coincidence of parasitoids and hyperparasitoids was 3.45%. In the following year, relative abundance of winter moths decreased by half, but the percentage of parasitized caterpillars remained very high – 37.5%. The presence of hyperparasitoids was recorded in 15.63% of caterpillars and all of them coincided with primary parasitoids.

Absolute parasitism of exposed caterpillars and pupae was recorded on the locality Brankovac. In the first postculmination year 64.51% of caterpillars were parasitized. The hyperparasitoid larvae were present in 12.90% of caterpillars and the coincidence of parasitoids and hyperparasitoids occurred only in 9.68% of caterpillars.

In Forest unit Košutnjak in exposed conditions, the abundance of parasitoids varied from 27.27% to 43.75%. Infestation of hyperparasitoids was very high and it varied from 38.46% to 93.75%. The degree of their coincidence, however, was not harmonised. The highest percentage of caterpillars infected by parasitoid and hyperparasitoid larvae was 31.25%, i.e. averagely only 17.29% caterpillars.

The results of t-test (LSD), for the differences regarding the time of sampling proves that there is no statistically significant difference in parasitism depending on the time of sampling of younger caterpillars. This can be an important warning to the experts who plan forest protection, especially if repressive measures of control are applied. Suppression should be applied against early instars of larvae (e.g. about 20th of April), because in this way the natural potential of parasitoids is going to be preserved. This depends of local climate, elevation and specific ecological conditions.

To determine the level of egg parasitoids, the method of exposing eggs was applied at many localities. Thus egg parasitoid *T. minutus* was identified at the locality Miroč, compartments 73/74. Total parasitism of winter moth eggs was 43.24%. Almost 30% of *O. brumata* eggs were parasitized. Although *E. defoliaria* was

dominant at the locality Miroč, eggs of this species were less parasitized (8.11%). Egg parasitism of *A. aurantiaria* was lower - only 5.4%. Parasitized eggs are brown, so they can be readily differentiated from the eggs parasitized by wasps *Trichogramma* sp. The dissection of dead eggs revealed the presence of *T. minutus* larva in them.

In the Forest units Zlatica, Boljetinska reka and Mala Moštanica the wasps *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) were reared from winter moths eggs. Parasitized eggs are distinguished by their almost black colour. In this way, we can assess the parasitism even after the eclosion of parasitic wasps. The winter moth eggs were parasitized between 16.33% at Boljetinska Reka, compartment 44, to 33.95% at Zlatica, compartment 96. It was found out that the majority of eggs died from other causes (e.g. predators). At Zlatica, compartment 59, the total mortality of eggs was 58.49%. In Zlatica, compartment 96 egg mortality was 44.65%.

The level of egg parasitism of winter moths in natural population in the management unit Zlatica, compartment 59 was 33%. Larval eclosion was recorded from 41.51% of eggs, whereas 25.47% eggs died during the embryonic development. In the Forest unit Zlatica, compartment 96, the parasitized eggs were almost 34%. The mortality during the embryonic development was 10.7% According to the report of the Diagnose-forecasting service, a mass occurrence of winter moths was forecast for the spring in 1992 in these compartments, but it failed. The efficiency of egg parasitoids in the management unit Boljetinska Reka, compartment 44, was somewhat lower, there were altogether 16.33% parasitized eggs. Egg mortality during embryonic development was 14.28%.

DISCUSSION – Rasprava

Many authors give the data on population dynamic of *E. defoliaria* (Patočka et al.,1968; Glavendekić, 1988, 1999). During our study, mottled umber moth was recorded in all localities, most often in a lower population density except in East Serbia, where it was dominant compared to the populations of other early-season defoliators.

Winter moth population dynamics has been studied in different forest types. Based on our own data and literature, it is evident that frequent outbreaks of 9 winter moth species are of chronic type and characteristic for the following forest types: forest of Turkey oak and sessile oak (*Quercetum petraeae-cerris*) on brown and lessive brown soil on serpentinite at the locality Brankovac; forests of sessile oak (*Quercetum montanum typicum*) on acid brown soil in the locality Porečke šume, compartment 54 f; in the forest of Hungarian oak and Turkey oak with Eastern hornbeam (Q*uercetum frainetto-cerris carpinetosum orientalis*) on dystric and eutric brown soils on Bukovik; in the association *Orno-Quercetum pubescentis-virgilianae* in Košutnjak and in the artificially established stand of mixed oaks at Mala Moštanica. Plantations of pedunculate oak mixed with hornbeam in forest unit Visoka šuma Lošinci are also under threat of winter moths outbreaks.

Winter moths occur regularly, but as a rule there are no outbreaks in the forest of sessile oak, Turkey oak and hornbeam (*Carpino-Quercetum petraeae-cerris)* on brown forest soil and lessive brown forest soil.

The study of parasitoids and hyperparasitoids of *E. defoliaria* shows that parasitic wasps fam. Braconidae are not narrowly specific for the *E. defoliaria*

The fauna of parasitic wasps in the fam. Ichneumonidae is relatively poor also if compared to the fauna of other European countries, Slovakia and the former USSR (Herting, 1965, 1976; Čapek, and Čepelak, 1981; Čapek, 1985). One of the reasons is that winter moths in the study period were in pre-culmination, culmination or in the first post-culmination years, when parasitoid populations in the fam. Ichneumonidae are usually low. They dominate in the phase of latency, while in the culmination phase they retreat before Tachinidae**.**

Eulophus larvarum is the most frequent and the most numerous representative of parasitic wasps in the superfamily Chalcidoidaea. In the conditions of winter moth outbreaks, it is a dominant representative of parasitic Hymenoptera. In the host culmination phase, this species also showed a great upswing of abundance.

Egg parasitoids *Trichogramma* sp. and *Telenomus minutus* have been described. The research was performed in the entire study area, but egg parasitoids were detected only at the locality Mala Moštanica, Zlatica and Miroč. Egg parasitoid *T. minutus* was so far recognized only as the parasitoid of *Orthosia miniosa* (Lepidoptera, Noctuidae) (Kozlov and Kononova, 1983), and *Operophtera* spp. (Glavendekić & Gruppe, 1992).

Tachinidae are the most significant winter moth parasitoids on many localities. The dominance and frequency of *B. nigripes, P. nemea* are expected and in harmony with the results of the study Sisojević and Čepelak, (1998). Tachinids *P. magnicornis,* and *P. fissicornis* were found individually. In the study of population dynamics of early-season defoliators in the Management unit Kožica in the period 1992–1994, a high population density was recorded in 1992, and already in the following year there was a drastic decrease of population density. This was caused, first of all by caterpillar parasitoids, which reduced ca. 67%. The most represented parasitoids were Tachinidae. On that occa-

sion, the above tachinid parasitized 69% of host caterpillars. Parasitoids are mainly dependent on the stage of caterpillars; Braconidae and Chalcidoidaea prefer the younger stages, while Ichneumonidae and Tachinidae more often attack the third instars and older caterpillars.

Some of hyperparasitoids are very broad polyphages (*G. areator*, *Habrocytus chrysos,* and *Pediobius foliorum*), so they were the subject of the study of the parasitoid complex of various hosts: gypsy moth, brown-tail moth, leaf rollers, etc. As it can be concluded from the above study results, parasitoids and hyperparasitoids are predominantly polyphagous. Population density of *E. defoliaria* depends largely on its natural enemies, because they have a significant influence on the population reduction.

CONCLUSIONS – Zaključci

1. The parasitoids in the following families were recorded on *E. defoliaria*: Braconidae, Ichneumonidae, Eulophidae, Torymidae, Trichogrammatidae, Scelionidae and Tachinidae. There are altogether 16 species reared from various stages of the host.
2. Abundance of parasitoids depends on the phase of host outbreak. In the phase of culmination, the markedly dominant species are Tachinidae; the abundance of Eulophiadae is elevated, while Ichneumonidae dominate in the latency.
3. Regarding their trophic characteristics, they are mainly polyphagous with a wide spectre of hosts in the group winter moths and order Lepidoptera.
4. Total parasitism of winter moths in natural conditions varied from 16,33% to 33%. Total parasitism in exposed conditions was from 27,27% to 43,75%.
5. Five species of hyperparasitoids of *E. defoliaria* fall into the families Ichneumonidae, Perilampidae, Pteromalidae and Eulophidae and they are polyphagous species.
6. Recorded parasitoid-hyperparasitoid complex is related to the host species in the belt of oak forests. This indicates their co-evolutive relationship. The coevolution between parasitoids and hyperparasitoids to *E. defoliaria* offers an ideal theoretic foundation for the biological control.

ACKNOWLEDGEMENT – Zahvala

I would like to acknowledge tothank Prof. Dr. K. Horstmann, Prof. Dr. J. Kolarov, Prof. Dr. L. Mihajlović, Dr. Kozlov, Dr. Čapek and Dr. Tschorsnig for identification of particular species. Financial support for the research was given by Ministry of Sciences and Technologies Republic of Serbia.

REFERANCES – Literatura

Čapek, M., 1985: Lumčíky (*Hymenoptera, Braconidae*) ako parazity hmyzových lesných škodcov. Lesnícky časopis Ročník 31, Čislo 3: 199–212, Bratislava.

Čapek, M., J. Čepelak, 1981: Zoznam parazitov dochovanych z hmyzich škodcov VII. Tachiny a masisrky. Ročnik 27, čislo 4, 321–332, Bratislava.

Djorović, Đ., 1980: Karakteristike i struktura biocenotičkog kompleksa defolijatora iz reda *Lepidoptera* u hrastovim šumama Kosova. Disertacija, Šumarski fakultet Beograd.

Embre, D. G., 1966: The role of Introduced parasites in the Control of the Winter Moth in Nova Scotia. Can. Ent., Vol. 98:1159–1168, Ottawva.

Glavendekić, M., 1992: Pojava jajnog parazitoida mrazovaca (Lepidoptera, Geometridae) u Severnoj Bavarskoj. Glasn. Šum. fak., br. 74 (1), str. 97–102, Beograd.

Glavendekić, M., 1988: Biološka i ekološka proučavanja defolijatora hrasta iz grupe mrazovaca (Lepidoptera: Geometridae) u šumama okoline Beograda. Magisterij, Šumarski fakultet Beograd.

Glavendekić, M., 1999: Zemljomerke-mrazovci (Lepidoptera: Geometridae) u hrastovim šumama i njihovi najvažniji prirodni neprijatelji. Disertacija. Šumarski fakultet Beograd.

Glavendekić, M., A. Gruppe, 1992: *Telenomus minutus* Ratzb. (Hym., Scelionidae) als Eiparasitoid der Frostspanner *Operophtera brumata* L. und *O. fagata* Scharf. (Lep., Geometridae) in Nordbayern. J. Appl. Ent. Vol. 113: 265–270, Berlin.

Harapin, M., 1992: Primjena biotičkih metoda suzbijanja štetnih insekata u šumarstvu. Glas. Šum. fak. br. 74: 141–149., Beograd.

Herting, B., 1965: Die Parasiten der in Nordwestdeutschland an Obstbäumen und Laubholz schädlich auftretenden Spanner- und Eulenraupen (Lep.: Geometridae, Noctuidae, Thyatiridae*).* Zeit. für ang. Ento., Vol. 55 (3): 236–263, Berlin.

Herting, B., 1976: A Catalogue of Parasites and Predators of Terrestrial Arthropods. Sec. A. Host or Prey/Enemy, Volume VII, Lepidoptera, Part 2 (Macrolepidoptera). CAB: 133–155. London.

Klepac, D., I. Spaić, 1965: Utjecaj nekih defolijatora na debljinski prirast hrasta lužnjaka. Šumarski list, br. 3/4, Zagreb.

Козлов, М. А., С. В. Кононова, 1983: Теленомины фауны СССР (Hymenoptera, Scelionidae, Telenominae). Определители по фауне СССР, издаваемые Зоологическим Институтом Академии наук СССР, “Наука”, Ленинград.

Langhoffer, A., 1900: U šumama štetni kukci Hrvatske i Slavonije II, Šumarski list, br. 5: 1–16, Zagreb.

Mihajlović, Lj., 1986: Najvažnije vrste savijača (Lepidoptera: Tortricidae) u hrastovim šumama Srbije i njihovi paraziti. Disertacija, Šumarski fakultet Beograd.

Patočka, J. (1968): Über die Erforschung forstlicher Lepidopteren an der Forschungsanstalt für Forstwirtschaft in Zvolen. Acta Instituti Zvolenensis, Tomus 1: 257–263, Bratislava.

Pschorn - Walcher, H., 1977: Biological control of Forest Insects. Ann. Rev. Entomol., 22: 1–22. Paolo Alto.

Rubtsov, V. V., 1996: Influence of repeated defoliations by insects on wood increment in common oak (*Quercus robur* L.). Ann. Sci. For. 53: 407–412.

Sisojević, P., J. Čepelak, 1998: Prilog poznavanju faune parazitskih muva tahina (Diptera: Tachinidae) Fruške Gore. U: Zbornik radova o fauni Srbije, Knjiga V, Srpska akademija nauka i umetnosti, Odeljenje prirodno-matematičkih nauka. Beograd.

Spaić, I., 1974: O sušenju hrastika. Šumarski list 7–9: 273–284, Zagreb.

Tomić, D., 1980: Glavne vrste defolijatora hrasta iz fam. Geometridae u Srbiji i mogućnosti unapređenja borbe protiv njih. Glas. Šum. fak., 54: 151–157, Beograd

Vasić, K., D. Tomić, 1980: Štetna šumska entomofauna Deliblatskog peska i njene specifičnosti, Deliblatski pesak, Zbornik radova IV: 113–122, Pančevo.

SAŽETAK: Istraživanja biologije i ekologije velikog mrazovca – Erannis defoliaria Clerck, 1759 (Lepidoptera, Geometridae) provedena su u razdoblju 1985–2009 g. u hrastovim šumama u Srbiji. Veliki mrazovac je za vrijeme istraživanja pretežno pretežito bio u latenci. Jedino u Gazdinskoj Gospodarskoj jedinici Miroč i Zlatica bio je dominantna vrsta u kompleksu ranih defolijatora hrasta. Prirodni neprijatelji, posebice parazitoidi i hiperparazitoidi odnosima ishrane vezani su za stadije ličinke i kukuljice E. defoliaria i važan su čimbenik njegovog mortaliteta.

Istraživanjima su obuhvaćeni svi razvojni stadiji velikog mrazovca. Primijenjene su odgovarajuće metode u laboratoriju i u prirodi, u različitim šumskim zajednicama. Rad na terenu proveden je standardnim metodama entomoloških istaživanja. Metoda ekspozicije u prirodnim uvjetima primijenjena je na stadiju jajeta i ličinke primjenom ljepljivih pojasa pojaseva u vrijeme aktivnosti ženki. Ženke su polagale jaja u pukotine kore ispod ljepljivih pojasapojaseva. Komadi kore s jajima izrezani su i odnošeni u laboratorij na daljnji uzgoj i obradu. Ljepljivi pojasevi upotrjebljeni su i za ekspoziciju gusjenica, pa su stoga obnavljani u travnju i svibnju. Gustoća populacije gusjenica utvrđivana je kada su bile pretežito u drugom larvalnom stadiju i djelomično u trećem larvalnom stadiju. Apsolutna abundanca domaćina utvrđena je brojanjem listova ili otvorenih pupoljaka i gusjenica u uzorku. Relativna abundanca utvrđena je na temelju proračuna broja gusjenica na 1000 listova.

Veliki mrazovac zabilježen prisutan je na svim lokalitima, najčešće u niskoj gustoći populcije. U šumskim upravama Miroč i Zlatica, međutim, on je bio dominantan (65% ranih defolijatora). Gusjenice mogu varirati u boji (slika 1). Jajni parazitoid Trichogramma *sp. (Hym., Trichogrammatidae) utvrđen je na nekoliko lokaliteta u širem području Nacionalnog parka Djerdap i u okolini Beograda. Rod Trichogramma je polifagan i nije specifičan samo za velikog mrazovca. Nešto uže specijaliziran je jajni parazitoid* Telenomus minutus*, koji je utvđen u istočnoj Srbiji na lokalitetu Miroč. Larvalni parazitoidi su:* Protapanteles immunis*,* Cotesia limbata*,* C. jucunda *(slika 2) (Hym., Braconidae),* Casinaria ischnogaster*,* C. moesta*,* Phobocampe crassiuscula*,* P. pulchella*,* Phobocampe sp. *(Hym., Ichneumonidae) (slika 3).* Euplectrus bicolor*,* Eulophus larvarum *(Hym., Eulophidae),* Blondelia nigripes*,* Phryxe magnicornis*,* P. nemea*,* Peribaea fissiconis *(Diptera, Tachinidae). Ustanovljeno je i 5 vrsta hiperparazitoida:* Gelis areator*,* Bathythrix lamina *(Hym., Ichneumonidae),* Perilampus ruficornis *(Hym., Perilampidae);* Habrocytus chrysos *(Hym., Pteromalidae),* Tetrastichus *sp. (Hym., Eulophidae).*

Ključne riječi: Quercus *spp., hrast,* Erannis defoliaria*, veliki mrazovac, parazitoid, hiperparazitoid*