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INSECT DEFOLIATORS AND THEIR INFLUENCE ON OAK FORESTS IN THE DJERDAP NATIONAL PARK, SERBIA

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Abstract - The study of oak phytophagous insects was performed in the period 1992-2010 in the region of the Djerdap National Park. More than a third (36.67%) of the phytophages in oak forests are frequent and can occasionally cause local outbreaks. The early spring defoliator phytophages so far identified in the oak forests of the Djerdap National Park are outbreak species and are significant agents of forest ecosystem degradation and decline. The most frequent species are *Tortrix viridana* and *Operophtera brumata*. It was found that *Quercus petraea* was more affected by dieback then *Q. cerris* and *Q. frainetto*.

Key words: Defoliators, *Quercus*, Tortricidae, Geometridae, Noctuidae, oak dieback

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INTRODUCTION

Insects feeding on the foliage of live plants, whether they can destroy the assimilation organs completely or not, are called defoliators. During the study of oak phytophagous insects it was found that 121 species of insects were trophically related to Sessile Oak (*Quercus petraea*), Turkey Oak (*Q. cerris*) and Hungarian Oak (*Q. frainetto*) in the region of the Djerdap National Park (Glavendekić and Mihajlović, 2004). Regarding systematic classification, oak defoliators are mostly moths, leaf beetles and weevils. Based on the time of occurrence, they are divided into three groups: early-season defoliators, species which overwinter in the stages of egg or pupa, and species whose activity is related to early spring. This group is faunistically varied, comprising leaf rollers, winter moths, noctuid moths, oak leaf beetles, weevils, etc. The long-season defoliators include a smaller number of species which undergo a population outbreak and have a special economic and ecological significance (gypsy moths, brown-tail moths, European lackey moths, oak flea beetles). Their defoliations are very dangerous for plants because they occur when the plant has already used up its store for the formation of new buds. Late-season defoliators are the species which emerge later in spring or during summer or which have two generations. Their significance is lower because the plants can stand the loss of assimilation organs without difficulty in these periods.

During the study period 1992-2002, early season defoliators dominated in the oak defoliator complex (Glavendekić and Mihajlović, 2004). Recent studies indicate that the outbreaks of Tortricidae, Noctuidae and Geometridae can overlap with gypsy moth outbreaks (Reindl, 1993; Glavendekić and Mihajlović, 2006). A cumulative harmful effect on oak trees was prolonged from April, when the majority of early season defoliators feed, until the end of June when the gypsy moth caterpillars complete their development. Due to defoliation and the emergence of new leaves, physiological weakening is the most intensive from the second half of May until the middle of June. It is common that a powdery mildew attacks new leaves in June. *Microsphaera alphitoides* Griff. and Maub. (Erysiphales, Erysiphaceae) is the most significant causing the decline of seedlings and affecting the natural regeneration on oak stands. This fungus, together with gypsy moth and honey fungus (*Armillaria mellea* (Vahl) P. Kumm.) participates in

the decline of old oak trees (Karadzić and Milijašević, 2005). In oak forests in the Djerdap National Park *Phytophthora quercina* H.S was observed. When its presence coincides with a high degree of defoliation, increased decline in oak stands can occur. In some forest compartments more than 30% of oak forests were affected by dieback. The research in North Western Russia over 22 years revealed that for younger oak trees higher mortality rates were observed than for larger individuals of the respective species (Drobyshev et al., 2009). Besides tortricids, the winter moths were of the greatest significance. Their caterpillars feed on the buds or young leaves and their development ends very quickly (early-season defoliators). According to the available literature data and our results, there are 16 species of winter moths in Serbia of which 13 occur in oak stands (Glavendekić, 2002).

The fluctuations of insect populations depend on abiotic and biotic ecological factors. Their continuous collective effects harmonize the population abundance of the species with environmental conditions. The outbreaks of our most important defoliators are usually cyclical (*Tortrix viridana*) and they can also often be eruptive (*L. dispar* and Geometridae). It is very difficult to forecast eruptive outbreaks. While insects remain in latency for a long time, they can suddenly appear in very high abundance. The previous study showed that forest insect pests characterized by eruptive outbreaks are kept in latency by their natural enemies (predators, parasitoids and pathogens).

MATERIALS AND METHODS

The study of oak phytophagous insects was performed in the period 1992-2010. The research was carried out by field and laboratory methods. Field work included standard methods of entomological research of the moths in all development stages. To monitor the population dynamics of oak defoliators and changes of the composition of insects, the absolute and relative abundance of the individual species was examined. Absolute abundance was assessed by counting the leaves or buds and caterpillars in the sample. Caterpillar density was assessed when they were predominantly in the second and partly in the third instars. Relative abundance was assessed based on the number of caterpillars on 1000 leaves. The research was conducted at 8 localities in Eastern Serbia: Miroč, 73a. - high forest of Sessile Oak on brown soils (a complex of xero-mesophilous Sessile Oak and hornbeam forests); Porečke Forests, 54 b. - forest-type beech and Sessile Oak on acid brown and washed out acid brown soil; Porečke Forests, 54 f - forest-type Sessile Oak on acid brown soil; Zlatica, 93 a. - forest-type Sessile Oak on acid brown soil; Zlatica, compartment 96 a. - forest-type beech and Sessile Oak on acid brown and washed out acid brown soil; Kožica, 30 b. - Sessile Oak and Turkey Oak forests on acid brown and washed out acid brown soils

RESULTS

The study of oak phytophagous insects revealed that they feed on the bark (2.5%), trunk (16.67%), branches (9.17%), buds (8.33%), leaves (60.83%) and seeds (2.5%) (Fig. 1). The study of the population dynamics of oak defoliators in the Djerdap National Park area began in 1992. In the Zlatica compartment 96 area moths were dominant, in particular the mottled umber moth *Erannis defoliaria* Cl. and the common winter moth *Operophtera brumata* L. (Fig. 2), while *griopis leucophaearia* D.& S. (Fig.3), *Alsophila aceraria* D.& S. and *Colotois pennaria* L. were found individually. A similar composition of defoliators was found in compartment 96 in the same forest unit.

Outbreaks of early defoliators in the Djerdap National Park area were of a chronic nature over a period of at least 20 years, up until 1992, when they were suppressed by the application of a biological agent based on the bacteria *Bacillus thuringiensis 'kurstaki'*. After this, further outbreaks on a wide area of early spring defoliators were not recorded. Another study of the same area was carried out in 2001 and it was established that the defoliators were in latency. Leaf rollers, noctuids and winter moths comprised the complex. Analysis of the qualitative

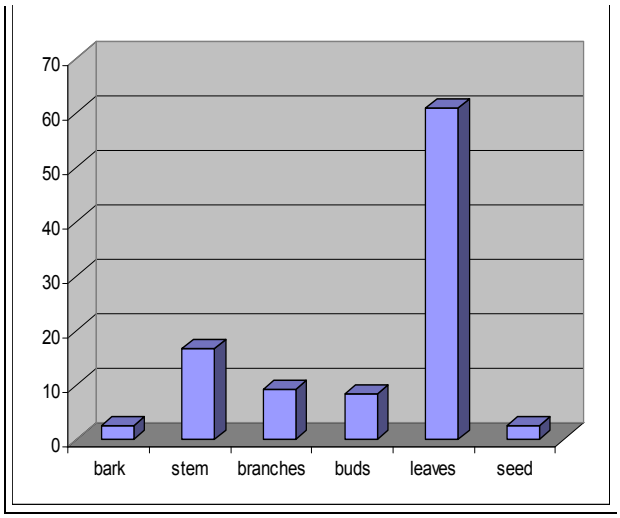

Fig. 1. Phytophagous insects associated to different pars of trees

Fig. 2. *Operophtera brumata* - larvae

Fig. 3. *Agriopis leucophaearia* – larvae parasitized by tachinid fly

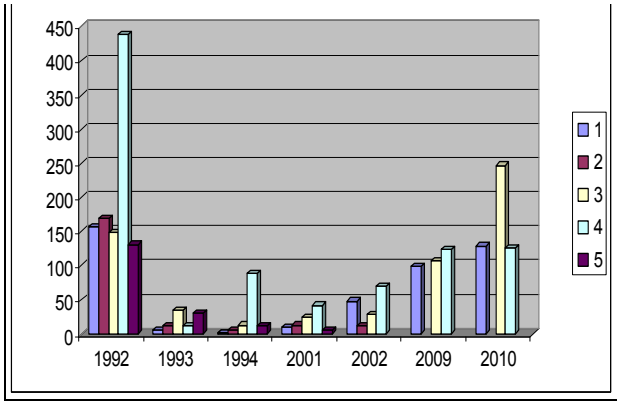

Fig. 4. Relative abundance of oak defoliators in the Djerdap National Park between 1992 – 2010: 1 – Forest unit Zlatica, compartment 5c; 2 – Zlatica, compartment 10; 3 – Zlatica compartment 105; 4 – Porečke šume, compartment 43; 5 – Boljetinska reka, compartment 100.

composition of oak defoliators in the Djerdap National Park area in 2002 identified the winter moths (*Colotois pennaria*, *Operophtera brumata, Erannis defoliaria, Alsophila aescularia* D.&S. *Agriopis leucophaeari*, *Epirrita dilutata* D.& S), leaf rollers (*T. viridana* L., *Aloeima loeflingiana* L. and *P. laechaeana*) and noctuidae (*Orthosia miniosa*, D.&S., *Orthosia cerasi* F. and *Perigrapha* (=*Orthosia*) *munda*), sawflies, individually, and *Ypsolophus* sp. (Lepidoptera, Plutellidae).

Following the treatment with a biological preparation in 1992, the population of early defoliators remained in latency until 2002, when a slight growth tendency in certain localities was observed (forest unit Zlatica, compartment 5c and Porečke šume, compartment 43). There were independent local outbreaks of early season defoliators in the studied area in 2001 and 2002. Our research was interrupted in 2003 and the data on population dynamic from 2003-2008 obtained from authorized institution are not reliable. We continued our investigation in 2009, when an increase of relative abundance was observed in all studied localities, and in 2010 a culmination of early spring defoliators occurred (Fig. 4). Whereas in

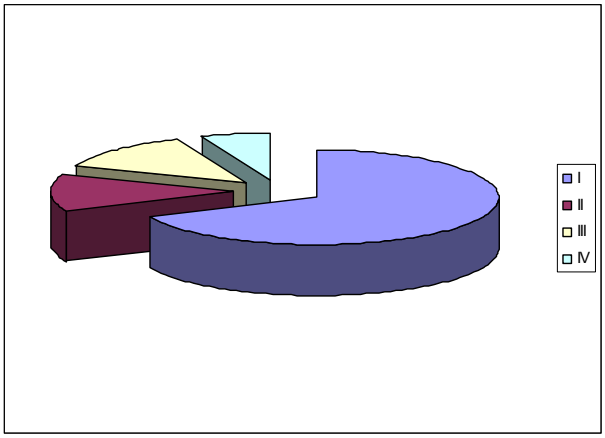

Fig. 5. Distribution of oak dieback index in the Djerdap National park

2002 Geometridae were dominant, in 2009 and 2010 the dominant species was *T. viridana*.

Based on the data provided by the National Forest Inventory in Serbia, the most affected oak species by dieback is *Quercus petraea*. The volume of dead trees is more then 1.5 million m^3 (7.4%). Forest unit "Štrbačko korito" and "Crni vrh" were the most severely affected by dieback.

As for the degree of crown shading, lower oak dieback indexes (I and II) were observed for more than 3/4 of the oak forests in the Djerdap National Park area (Fig. 5).

DISCUSSION

During the years of studying oaks in the forests of the Djerdap National Park, 121 species of phytophagous insects, of which 8.33% were trophically attached to buds and 60.83% to leaves, were identified. More than a third (36.67%) of the phytophagous insects in the oak forests of the Djerdap National Park appeared frequently and sometimes caused local outbreaks (Glavendekić and Mihajlović, 2004). Only 10% of the phytophages recorded in the oak forests of Serbia were outbreak species, economically and ecologically significant in the degradation and decline of forest ecosystems. Half of the outbreak species are trophically bound to oak leaves and represent insect defoliators (green oak leaf roller, common winter moth, mottled umber moth, *A. leucophaearia* (Fig. 3), *A. marginaria*, and gypsy moth).

The appearance of the overlapping of outbreaks of early defoliators and gypsy moths points to one more threat to oak forests, i.e. early defoliators destroy buds and young leaves, causing the oak to foliate again and thereby expending its reserves (Glavendekić and Mihajlović, 2006). If gypsy moths increase in abundance immediately after the consumption of assimilation organs by early defoliators, they cause defoliation while the plant is forced to use its reserves to foliate once more. This foliage is usually exposed to attack by powdery mildew which incurs further physiological weakening (Karadžić and Milijašević, 2005). In the western part of Serbia an overlapping of outbreaks of early defoliators and gypsy moth was recorded in 2005, but at the same time in the Djerdap National Park area the gypsy moth was overpopulated and control with *Bt. thuringiensis 'kurstaki'* aerial application was performed against it. At that time, early spring defoliators with *Tortrix viridana* as dominant species had already totally defoliated the older oak trees. At the time of application, geometrid moths and noctuids were in the last instars of larval development and to some extent they, as well as their natural enemies, were also affected due to a lack of food. After that, an increase in the populations of Tortricidae was observed with culmination in 2010.

Since 1996 *Phytophthora quercina* has been known as a pathogen of the oak (Jung, 1996; Jung et al., 2000). It has been found on the following species: *Q. robur, Q. petraea, Q. cerris* and *Q. ilex*. Inoculation has proved that Sessile Oak seedlings are most susceptible to attacks of the *P. quercina* pathogen. *P. quercina* zoospores infect the fine roots of the oak and destroy them. A few hours after infection, the pathogen is found in the intercellular area of the cortical parenchyma. The pathogen penetrates through the cell wall, creating outgrowths similar to the entrances in the attacked cells (Brummer et al., 2002). The mycelia can also

grow in the larger roots where it causes necrosis. In natural forests it has been shown that in conditions of acid soil and moderate moisture, the *Phytophthora* species cause the withering of roots. Autochthonous microflora cannot inhibit this pathogen (Jönsson, 2004).

The recent dying out of oak forests has been most pronounced in Eastern Serbia, in the Djerdap National Park. In the studied localities a massive dieback of oak forests following the defoliation caused by early spring defoliators has been in evidence. In recent times outbreaks of early defoliators and gypsy moth have overlapped, thus additionally reducing the physiological state of the oak.

In the areas with the highest incidence of forest deterioration the pathogenic fungus *P. quercina*, which colonizes the root and kills it, has been discovered. Research into the mechanisms of aggression by the *P. quercina* pathogen and the interdependence of habitat and biotic factors could elucidate the real dangers posed by pests and pathogenic organisms, and thereby offer a basis for devising a strategy of protection and husbandry of the forests that are under threat.

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