Zbornik gozdarstva in lesarstva, 61, 2000, s. 75 - 93

GDK 416:176.1 *Quercus robur* L., +176.1 *Quercus petraea* (Matt.) Liebl.: 145.7: (497.12):(497.13)

Prispelo / *Received*: 14. 03. 2000 Izvirni znanstveni članek
Sprejeto / *Accepted*: 10. 04. 2000 *Original scientific paper*

A STUDY OF IMPORTANT ENTOMOFAUNA IN OAK FORESTS OF SLOVENIA

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Abstract
Insects in 9 research areas in pedunculate oak and sessile oak forests in Slovenia have been studied. We identified 35 insect species as well as two genera from 13 families. The defoliation of oak leaves in studied forests was between 10 and 90 %. More than 80 % of the defoliation was caused by mottled umber and winter moth (*Erannis defoliaria* Cl., *Operophthera brumata* L.). Leaf-roll moths are an important group of pests of oak leaves and acorns. The most numerous is the green leaf-roll moth, *Tortrix viridana* L., followed by *Archips crataegana* Hb., *Laspeyresia splendana* Hb. and *Laspeyresia amplana* Hb. The ratio of appearance of oak sawflies (*Apethymus abdominalis* Lep. and *Apethymus braccatus* Gmel.) was 9 : 1. During the past 10 years, oak miner (*Tischeria complanella* Hb.) has attacked young oak trees heavily. Acorn destroyers (*Balaninus glandium* Mrsh. and *Balaninus nucum* L.) were important acorn pests. During the gradation of defoliators in the Prekmurje region of Slovenia there was an increased population density of their predators, such as ground beetles and burying beetles (*Calosoma sycophanta* L., *Calosoma inquisitor* L., *Carabus* spp., *Xylodrepa quadripunctata* L. We can confirm that the health of oak forests in Slovenia is better than in Croatia and southeastern Europe.
Key words: pedunculate oak, *Quercus robur*, sessile oak, *Quercus petraea*, forest entomology, *Insecta*, Slovenia

RAZISKAVA POMEMBNE ENTOMOFAVNE HRASTOVIH GOZDOV SLOVENIJE

Izvleček
Na devetih raziskovalnih ploskvah v dobovih in gradnovih gozdovih v Sloveniji smo proučili entomofavno. Določili smo 35 vrst žuželk ter dva rodova iz 13 družin. Defoliacija hrastovega listja je bila 10 do 90 %. Več kot 80 % defoliacij sta povzročila veliki in mali zimski pedic (*Erannis defoliaria* Cl., *Operophthera brumata* L.). Zavijači so pomembna skupina škodljivcev hrastovega listja in želoda: najštevilnejši je bil zeleni hrastov zavijač - *Tortrix viridana* L., sledili so mu *Archips crataegana* Hb. ter vrsti *Laspeyresia splendana* Hb. in *Laspeyresia amplana* Hb. Razmerje pojavljanja pozne in zgodnje hrastove grizlice (*Apethymus abdominalis* Lep. in *Apethymus braccatus* Gmel.) je bilo 9 : 1. Miner hrastovega listja (*Tischeria complanella* Hb.) je v zadnjih desetih letih močno napadal hrastov pomladek. Hrastov semenar (*Balaninus glandium* Mrsh.) in leskov semenar (*Balaninus nucum* L.) sta bila pomembna želodova škodljivca. V Prekmurju je bila v času gradacije defoliatorjev povečana gostota populacij njihovih predatorjev, kot so krešiči in mrharji (*Calosoma sycophanta* L., *Calosoma inquisitor* L., *Carabus* spp., *Xylodrepa quadripunctata* L.). Prisotnost predatorjev po gradaciji gosenic defoliatorjev je kazala na dober mehanizem regulacije naravnega ravnovesja v sestojih. Na osnovi analize lahko trdimo, da je zdravstveno stanje hrastovih gozdov v Sloveniji boljše kot na Hrvaškem ter v jugovzhodni Evropi.
Ključne besede: dob, *Quercus robur*, graden, *Quercus petraea*, gozdarska entomologija, *Insecta*, Slovenija

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VSEBINA
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1 INTRODUCTION
UVOD

Oak forests, especially those dominated by pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Lieblein), are threatened because of dieback. The intensity of dieback differs for different regions. This is influenced by a number of abiotic and biotic factors. Biotic factors, mainly insects, appear to be decisive factors in the decrease in ecosystem vitality. In Slovenia in 1983 and 1985, mottled umber and winter moth (*Erannis defoliaria* Cl., *Operopthera brumata* L.) supposedly performed total defoliation of younger oak stands in Krakovski gozd. In the spring of 1991 and throughout 1992, the same stands of oak experienced defoliation, caused by gradations of oak sawflies (*Apethymus abdominalis* Lep. and *Apethymus braccatus* Gremlin, TITOVŠEK 1992). In 1992, there was a suspected gradation of mottled umber and winter moth in oak-white beech forests in the Hraščica, Ginjevec in Murska šuma (Poročilo o zdravstvenem stanju... 1992). There are reports from 1975 and 1977 of a medium intensity attack of the green leaf-roll moth in Slovenian oak fortests in the Dravsko polje (TITOVŠEK 1994). In Slovenia, gipsy moth (*Lymantria dispar* L.) appears on the border of its areal. Oak forests in the pre-pannonian phytogeographical region are dominated by the continental ecological race, while in the sub-mediterranean phytoclimatic region the mediterranean ecological race predominates. During periodic over-proliferation in the pre-pannonian region the gipsy moth appeared in forest complexes dominated by pedunculate oak (Žitkovci, Ginjevec, Hrašica): in 1947 and 1948 it performed defoliation of 30 ha of pedunculate oak forest in Ginjevec. The next gradation lasted from 1954-1956. Two strong gradation followed: one from 1970 to 1973 in Žitkovci and another from 1991 to 1992 in a stand of *Robinia* sp. in Rakičan (TITOVŠEK 1994, Poročilo o zdravstvenem stanju... 1992). In the sub-mediterranean region of Slovenia, it appeared in gradations from 1937-1938, 1947-1948, 1954-1956, 1965-1966, 1973-1975 and 1986-1987. Gradations of gipsy moth appeared in the lower Karst region and in Trnovski gozd 1937-1938, 1947-1948 and 1954-1956, as well as to a lesser extent from 1965-1966 and 1973-1975. Strong local gradations of gipsy moth appeared in Skalnica above Solkan from 1965-1966 and from 1986-1987 (TITOVŠEK 1994). In Slovenia the oak weevil (*Rhynchaenus quercus* L.) accompanies all oaks stands (TITOVŠEK 1987).

In addition to the above-mentioned important and dangerous defoliators of oak ecosystems, we regularly record a large number of other phytophagic insects, mainly from the groups of leaf-roll moth, bark beetles and scale lice (JURC / HRAŠOVEC 1999). In the Polana district, there was a total defoliation of bird cherry (*Prunus padus* L.) from 1998-1999 in stands of alder forest (*Alnetum* s. lat.), which damaged 40-50 % of bird cherry (BELAK / LEJKO 1999). The total defoliation was caused by the full-spotted ermel (*Yponomeuta evonymella* L.) (JURC 1999).

Oak in Croatia (in the Slavonian forests) were already beginning to decay over a large area in 1909 (HARAPIN / ANDROIĆ 1996). The authors claim that the reason for this dieback was the high level of defoliation caused by the gipsy moth at the same time as the appearance in that area of the oak powdery mildew (*Microsphaera alphitoides* Griff. et Maubl). The dieback of that period represented a big forestry problem at that time (KOENIG 1911). OSTOJIĆ (1913) claims that defoliation was a secondary effect while a fall in the level of the groundwater was the primary reason for the dieback. In low-lying oak forests in Croatia, harmful entomofauna and their effect on the stability of pedunculate oaks stands has been studied in detail (HRAŠOVEC / HARAPIN 1999).

Among a number of biotic factors, we studied the influence of entomofauna, mainly defoliators, on the dieback of oak forests. The purpose of our research was to determine the species composition and the population sizes for individual species of harmful and beneficial entomofauna in the oak forests of Slovenia. Our results were intended to determine the role of harmful entomofauna, especially defoliators, on the health and stability of the ecosystem in oak forests.

2 MATERIALS, METHODS AND RESEARCH AREAS
MATERIALI, METODE IN RAZISKOVALNO OBMOČJE

In the spring, summer and autumn of 1993 and 1998, we examined the experimental plots. We recorded and collected entomofauna which we considered to have a possible influence on the health and stability of the oak forest. In the spring and summer, a climber cut the oak branches from the top of the trees. The branches were placed in bags, and lowered to the ground. The entomofauna present on the collected branches was registered

and collected. In addition, we determined the percentage of defoliation and acorn yield. The collected green branches, with individual species of insects at various levels of development, were brought to the laboratory and kept fresh in containers with water until adult stages of the individual insect species were reached. The bred insects were mounted and determined. During the summer examination period (30.08. - 9.9.) there was a special emphasis on leaf damage due to defoliators as well as damage to acorns.
Insect species were determined according to keys by Patočka (1980), Schwenke (1978), Schwerdtfeger (1970), Brauns (1964), and Escherich (1931).

We studied entomofauna in long-term research plots of the Slovenian Forestry Institute. The surface of each research plot measures 1 ha (Fig.1):
Plot 1- Krakovski gozd. GGO Brežice, GGE Krakovski gozd, dep. 40 d; 170 m above sea level; exposure 0; inclination 0^0; *Querco robori-Carpinetum* W 1968, *Stellario bulbosae-Carpinetum* T (1924) 1960; soil type: middle strong gleyed swampy soils (amphigleys) on pleistocene clays and loams.

Plot 2- Cigonca. GGO Maribor, GGE Slovenska Bistrica, dep. 43 e; 265 m above sea level; exposure 0; inclination 0^0; *Querco robori-Carpinetum* W 1968, *Stellario bulbosae-Carpinetum* T (1924) 1960; soil type: strong gleyed swampy soils (amphigleys) on alluvial loams.

Plot 3- Hraščica. GGO Murska Sobota, GGE Ravensko, dep. 24 a; 163 m above sea level; exposure 0; inclination 0^0; *Querco robori-Carpinetum* W 1968, *Stellario bulbosae-Carpinetum* T (1924) 1960; soil type: middle deep brown soils (cambisols) on gravel covered with loams.

Plot 4- Bojanci. GGO Novo mesto, GGE Črnomelj, dep. 194 b; 270 m above sea level; exposure NW; inclination 5-25^0; *Querco-Carpinetum* var. geogr. *Epimedium alpinum*, Z 1967; soil type: deep (in spots shallow) lessive soils (luvisols) on limestone.

Plot 5- Polom. GGO Kočevje, GGE Vrbovec, dep. 91, 93 a; 360-380 m above sea level; exposure W and varied; inclination 0-20^0; *Querco petraeae-Fagetum* K (1961) 1971 s. lat.; soil type: medium deep to deep lessive soils (luvisols) on limestone.

Plot 6- Panovec. GGO Tolmin, GGE Panovec, dep. 86; 142 m above sea level; exposure SE; inclination 5^0; *Carici umbrosae-Quercetum petraeae* P 1981 var. geogr. *Sesleria autumnalis* D 1986; soil type: deep brown soils (cambisols), illuvialed and pseudogleyed, on flysch sandstone; a suburban forest of particular community importance as a forest study trail.

Plot 7- Dobrava. GGO Brežice; 0 above sea level; inclination 0^0; *Querco robori-Carpinetum* W 1968; *Stellario bulbosae-Carpinetum* T (1924) 1960; soil type: swamped, very strong gleyed soils (hypogleys) on uncarbonated loamy alluvium.

Plot 8- Bukovnica. GGO Murska Sobota, GGE East Goričko, dep. 27; 230-240 m above sea level; exposure SW; inclination 10^0; *Hacquetio-Carpinetum* var. *Carex pilosa* K 1974; soil type: slope pseudogley, very shallow, on sandy clay.

Plot 9- Pišece. GGO Brežice, GGE Pišece, dep. 6 c; height above sea level 450-490 m; exposure J; inclination 28^0; *Hacquetio-Fagetum* var. *Ruscus hypoglossum* K (1956) 1961; soil type: shallow to deep illuvial soils (luvisols), in spots regolithic rendzinas, on limestone (SMOLEJ / HAGER 1995).

Picture 1: Locations of the experimental plots
Slika 1: Karta vzorčnih ploskev

3 RESULTS
REZULTATI

3.1 RESULTS OF SAMPLED ENTOMOFAUNA AND ACORNS FOR INDIVIDUAL RESEARCH PLOTS
REZULTATI VZORČENJA ENTOMOFAVNE IN ŽELODA NA RAZISKOVALNIH PLOSKVAH

Plot 1- Krakovski gozd. We established the presence of small number of oak sawfly (*Apethymus abdominalis* Lep.). During the summer we recorded a 10-50 % defoliation of well developed dark-green foliage. We collected 72 larvae of sawflies and caterpillars. We discovered three egg nests of gipsy moth and collected 145 acorns. They were

attacked by larvae *Balaninus gladium* (106 acorns), *Laspeyresia amplana* (7 acorns), *Laspeyresi splendana* (3 acorns); fungi infected 22 acorns; 7 acorns or 14 % were healthy.

Plot 2- Cigonca. Partial defoliation was established. Individual oak trees had good harvests. We found egg nests of gipsy moth. We collected 155 larvae of sawflies and caterpillars. *Pristiphora abietina* Christ. was found on spruce needles. Altogether we collected 262 acorns, of which: 102 acorns were attacked by *Balaninus* sp., 8 acorns by *Laspeyresia amplana*, and 16 acorns by *Laspeyresia splendana*; 81 were infected by fungi; 136 acorns or 51 % were healthy.

Plot 3- Hraščica. At our spring monitoring on May 5th we established a total defoliation of pedunculate oak. In excess of 50 % of trees were without leaves. Gipsy moth was present in a *Robinia* sp. plantation in the direct vicinity of the research area. The total defoliation was caused by hunch-back (fam. *Geometridae*), green leaf-roll moth (*Tortrix viridana* L.) and other defoliators. After the culmination of defoliators, a predator species of the family burying beetles (*Xylodrepa quadripunctata* L.) appeared. After the elimination of the caterpillars the predator started cannibalizing its own species. In the summer period we found no acorns in stands that experienced defoliation in spring.

Plot 4- Bojanci. During the spring monitoring of the top of the trees we noticed no defoliation. During the summer it was noted over the entire area, but only in trace amounts. We collected 17 caterpillars. We collected larvae of the species *Antheraea yamamai* Guer. We collected 167 acorns. Insects had attacked 70 % of the acorns; fungi infected 46 % of the acorns; 51 acorns or 30 % were healthy.

Plot 5- Polom. At our spring monitoring on May 7th we established the presence of scale insects (*Kermes quercus* L., *Asterolecanium variolosum* Ratz.). Pedunculate oak was in full bloom. Collected samples of branches showed occasional partially damaged of leaves due to defoliators. We collected 117 caterpillars: hunch-backs, winter moths (*Operophthera brumata* L.) and caterpillars of green leaf-roll moth. Oak miner (*Tischeria complanella* Hb) was found on oak leaves. Galls were found on acorns (*Andricus quercuscalicis* Burgsd.) and on leaves (*Cynips quercusfolii* L. and *Neuroterus numismalis* Ol.). There were relatively few acorns and only 53 were collected. Insects attacked 29 acorns; fungi infected 17 acorns; 11 acorns or 21 % were healthy.

Plot 6- Panovec. There were no samples of damaging entomofavne on leaf and branch samples. The acorn harvest was very good and 347 acorns were collected. We recorded insect caused damage in 136 acorns; fungi infected 143 acorns; 68 acorns or 20 % were healthy.

Plot 7- Dobrava. *Apethymus abdominalis* Lep. was found in larger numbers, as well as a single specimen of the species *Apethymus braccatus*. We collected 72 caterpillars and larvae of sawflies. The acorn harvest was good and 598 acorns were collected. *Balaninus* sp. caused damage to 298 acorns, the species *Laspeyresia amplana* to 16 and *Laspeyresia splendana* to 17; infections with fungi were found in 230 acorns; 37 acorns or 6 % were healthy.

Plot 8- Bukovnica. At our first monitoring defoliation was not established. During our summer monitoring we noticed bite-caused leaf damage in the form of small holes. We found 7 caterpillars. The acorn harvest was bad. Of acorn damaging species only the genus *Balaninus* sp. was found.

Plot 9- Pišece. At our spring monitoring we did not record any defoliation. We established the presence of winter moth and green leaf-roll moth. During our summer monitoring we recorded 20 % defoliation as holes along the leaf edges. We found only a few healthy acorns.

3.2 INSECT SPECIES DETERMINED IN THE RESEARCH AREAS
VRSTE ŽUŽELK DOLOČENE NA RAZISKOVALNIH OBMOČJIH

GEOMETRIDAE: Operophthera brumata L., Erannis defoliaria Cl., Apochemia hispidaria Den. et Schiff., Biston strataria Hufn., Agriopis aurantiaria Hb., A. leucophalaria Den. et Schiff., Collotois pennaria L., Alsophila aescularia Den. et Schiff.
NOCTUIDAE: Orthosia cruda Schiff., O. stabilis Schiff., Lithopane ornitopus Hufn., Spodoptera sp.
SATURNIIDAE: Antheraea yamamai Guer.
LYMANTRIIDAE: Lymantria dispar L.

TENTHREDINIDAE: Apethymus abdominalis Lep., A. braccatus Gmel., Pristiphora abietina Christ.
TORTRICIDAE: Tortrix viridana L., Archips crataegana Hb., Laspeyresia amplana Hb., L. splendana Hb.
TINEIDAE: Tischeria complanella Hb.
CYNIPIDAE: Andricus quercuscalicis Burgsd., Cynips quercusfolii L., Neuroterus numismalis Ol.
COCCIDAE: Kermes quercus L., Asterolecanium variolosum Ratz.
CURCULIONIDAE: Balaninus glandium Mrsh., B. nucum L., Stereonychus (Cionus) fraxini Deg.
CARABIDAE: Calosoma sycophanta L., C. inquisitor L., Carabus spp.
SILPHIDAE: Xylodrepa quadripunctata L.
LARVAEVORIDAE (TACHINIDAE): Compsilura concinnata Rond., Phryxe vulgaris Fall., Tachina larvarum L.

4 DISCUSSION
RAZPRAVA

We established the presence of a large number of species from the family *Geometridae* (hunch-backs). More than 80 % of defoliations were caused by two species: mottled umber and winter moth. Hunch-backs appear periodically in gradations (SCHWERDTFEGER 1970, SCHWENKE 1978). Other found species caused significant defoliations only on individual branches or on the undergrowth level of trees and bushes. According to the number of species, moths (*Noctuidae*) are the most numerous family of the ordo *Lepidoptera* (butterflies). A relatively small number of pest species are found in forests. The species found and identified are not important defoliators. This is confirmed by literature sources (BRAUNS 1964).

From the family *Saturniidae* we established only the species *Antheraea yamamai* Guer. According to our observations, this species appears less and less often going form the east to the west of the Balkan peninsula pedunculate oak areal (HARAPIN 1988). Caterpillars of this butterfly species are attacked by a virus, which causes a disease similar to polyedria found in gipsy moth caterpillars.

From the end of the last century and the beginning of the twentieth century until the 1960's, gipsy moth was the most important pest in oak forests. For more than 100 years the gradation of the gipsy moth population appeared in a cyclical type of a temporal fluctuation curve (KOVAČEVIĆ 1956). Over the past 30 years it has appeared in large gradations less often. In cases when it does appear the outbreaks are localized. The caterpillars bred from egg nests collected in Prekmurje had a high mortality rate (78 %). In Croatian pedunculate oak stands oak sawflies appeared in large numbers in the 1950's and were controlled by spraying from airplanes. With respect to oak sawflies, the species *Apethymus abdominalis* is normally present in 90 % of Croatian forests and *Apethymus braccatus* in 10 %. These two species are found in the same ratio in Slovenia, where they caused total defoliation in the Krakovski gozd (TITOVŠEK 1992).

Leaf-roll moths are an important group of pests affecting oak leaves and acorns. The most numerous species is green leaf-roll moth- *Tortrix viridana*, followed by the species *Archips crataegana*. A similar ratio of these two species was recorded during the last 30 years in Croatia. Most importnantly, oak leaf-roll moths attack stands with a high degree of light. The pests of acorns (*Laspeyresia splendana*) and nuts (*Laspeyresia amplana*) can reduce the quality of the acorn harvest substantially (HARAPIN 1993).

Oak miner (*Tischeria complanella*) is a typical oak leaf pest. In the past it attacked mostly leaves in the top of the trees, but in the last ten years it has moved to the lower parts and harshly attacks young oak trees as well as plants in nurseries. The damage caused by this pest is significant. In the Slovenian climate, the species produces two generations annually.

Gall wasps (*Cynipidae*) attack all types of trees and bushes. Oak is host to more than 90 % of all gall wasp species. Apart from the three above-mentioned species, others can also be found. By forming zoocecidies on acorn gall wasps substantially reduce the amount of acorns useful for reproduction. Cases have been known in which an entire rich harvest was lost due to gall wasps. This happens frequently on the island of Krk in Croatia (MATOŠEVIĆ 1993). Gall wasps are even more important in years with a low seed harvest.

Scale insects harm the host by sucking out its juices, indirectly reducing its resistance to harmful abiotic and biotic factors. We found two types of scale insects with a severe attack. In the last ten years, we have noticed increasingly severe attacks of scale insects in oak stands. This causes a strong degree of physiological weakness in the hosts. Conditions for severe attacks of scale insects are drought periods and physiologically weakened trees (DELLA BEFFA 1961).

Weevils are important pests in oak forests over the entire oak areal. We found three species. Acorn destroyers (*Balaninus glandium, Balaninus nucum*) are seerious acorn pests. We established their presence at almost all research locations. In addition, we identified ash's weevil (*Stereonichus fraxini*). The damage to ash leaves was minor.

Ground beetles (*Carabidae*) are typical forest denizens and predators. The two species found (*Calosoma sycophanta, C. inquisitor*) are indicators of a natural equilibrium in the forests. We captured a number of samples of the two species as well as several other predators (*Carabus* spp.). The populations of the two mentioned genera (*Calosoma, Carabus*) are sensitive to insecticides and are strongly affected when defoliators are repressed with chemical substances. Ground beetles were found in almost all research areas.

At the time of defoliator gradation in Prekmurje the species *Xylodrepa quadripunctata* was numerous and had eliminated a large number of caterpillars. The species was present on more than one half of all research plots. It represents an important regulator and is an indicator of natural equilibrium in the environment.

True flies (*Tachinidae*) are an important group of parasites of caterpillars that appear in forest tree species. The family *Tachinidae* has a large number of species. In our research plots we identified the four most common and most important species of true flies. They were bred in the laboratory from defoliator caterpillars. On average, 17 % of host caterpillars in all research plots were affected by true flies. Several species of true flies are still in the process of identification.

5 CONCLUSIONS
ZAKLJUČKI

Our research showed that a large number of pests attack oak. LANGHOFER (1926), with data from 1874, determined more than 500 pests that parasitise oak. In our research we list species that were caught or observed in the field. Some were identified based on the typical damage symptoms found on plant materials, while some were bred in the laboratory and identified later.

Some pests, such as for example hunch-backs (*Geometridae*) and green leaf-roll moths (*Tortrix viridana*) are common to all research areas. In most research plots we found one or two dominant species, such as the oak sawflies in Krakovski gozd and the winter moth and the green leaf-roll moths in Hraščica.

In most locations we noted a partial or total defoliation, appearing over 10 to 90 % of the total leaf area.

Hunch-backs are represented by a relatively large number of species, from which only mottled umber and winter moth traverse into gradation. Moths (*Noctuidae*) can be neglected as important defoliators.

We recorded a relatively large percentage of destoyed acorns caused by acorn destroyers. Damage to acorns caused by the gall wasps was negligable.

The presence of predators (ground beetles, burying beetles) after the gradation of defoliator caterpilllar in Hraščica indicates a good mechanism of regulation of the natural equilibrium. This is confirmed by the presence of a large number of polyphagic caterpillar parasites, especially true flies such as *Compsilura concinnata*, *Phryxe vulgaris* and *Tachina larvarum*.

Pedunculate oak and sessile oak in Slovenia are healthier than those in neighboring Croatia where they exhibit a known dieback scheme: total defoliation, oak powdery mildew (*Microsphaera alphitoides*) and *Armillariela mellea* (Vahl ex Fr.) as well as destroyed water-air regime in the ground (HARAPIN 1991).

Dieback of oak crowns is not a common occurrence in Slovenia – we established only indiviual isolated cases of dieback. In southeastern Europe and in Croatia this is a typical occurence. Oak forests in Slovenia are more stable due to a lack of frequent and severe total defoliations. Oak forests in Slovenia are mostly mixed forests without gaps in the crowns where numerous predators and pest parasites reside.
Based on observations and records of defoliation in the spring and summer period and on the basis of visual evaluation, we believe that oak forests in Slovenia are in relatively good condition when compared with oak forests in southeastern Europe.

The described facts and obtained results show that damaging and beneficial entomofauna, as a biotic factor, has an important role in the health and stability of oak forests in Slovenia.

6 SUMMARY

We studied the effect of entofauna, especially defoliators on dieback of pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Lieblein) forests in Slovenia. The study was performed in the spring, summer and autumn of 1993, 1994 and 1999. The study covered nine established research areas of the Forestry Institute of Slovenia of which five were covered with pedunculate oak and four with sessile oak. In the spring and summer a climber cut branches in the top of the trees, placed them in bags and lowered them to the ground. Entomofauna from the cut branches were registered and collected, and we evaluated acorn harvest and the percentage of defoliation. The cut green branches with individual insects in various developmental stages were taken to the laboratory, put in water and kept long enough to breed adult insects. The material was then processed, prepared and determined. During the summer monitoring period we put special emphasis on defoliator-caused damage to leaves originating in the summer period and acorn damage. We identified 35 insect species from two genera and 13 families, namely: 1. fam.- *Geometridae*: *Operophthera brumata* L., *Erannis defoliaria* Cl., *Apochemia hispidaria* Den. et Schiff., *Biston strataria* Hufn., *Agriopis aurantiaria* Hb., *A. leucophalaria* Den. et Schiff., *Collotois pennaria* L. and *Alsophila aescularia* Den. et Schiff.; 2. fam.- *Noctuidae*: *Orthosia cruda* Schiff., *O. stabilis* Schiff., *Lithopane ornitopus* Hufn. and *Spodoptera* sp.; 3. fam.- *Saturniidae*: *Antheraea yamamai* Guer.; 4. fam.- *Lymantriidae*: *Lymantria dispar* L.; 5.fam.- *Tenthredinidae*: *Apethymus*

abdominalis Lep., *A. braccatus* Gmel., *Pristiphora abietina* Christ.; 6. fam.- *Tortricidae*: *Tortrix viridana* L., *Archips crataegana* Hb., *Laspeyresia amplana* Hb., *L. splendana* Hb.; 7. fam.- *Tineidae*: *Tischeria complanella* Hb.; 8. fam.- *Cynipidae*: *Andricus quercuscalicis* Burgsd., *Cynips quercusfolii* L., *Neuroterus numismalis* Ol.; 9. fam.- *Coccidae*: *Kermes quercus* L., *Asterolecanium variolosum* Ratz.; 10. fam.- *Curculionidae*: *Balaninus glandium* Mrsh., *B. nucum* L., *Stereonychus* (*Cionus*) *fraxini* Deg.; 11. fam.- *Carabidae*: *Calosoma sycophanta* L., *C. inquisitor* L., *Carabus* spp.; 12. fam.- *Silphidae*: *Xylodrepa quadripunctata* L.; 13. fam.- *Larvaevoridae* (*Tachinidae*): *Compsilura concinnata* Rond., *Phryxe vulgaris* Fall., *Tachina larvarum* L.

Some pests, such as hunch-backs (*Geometridae*) and green leaf-roll moths (*Tortrix viridana*), are common to all research areas. Most areas had one or two dominant species, like oak sawfly (*Apethymus abdominalis*) in the Krakov forest and winter moth (*Operophthera brumata*) and green leaf-roll moth (*Tortrix viridana*) in Hraščica. Most locations had partial or total defoliation, that appears on 10 to 90% of the leaf surface. Over the past 30 years gipsy moth (*Lymantria dispar*) has appeared less often in large gradations and when they do appear the spreads are locally limited. Caterpillars that were bred from egg nests collected in Prekmurje had a high mortality rate (78%). *Tortricidae* are an important group of oak leaf and acorn pests. The most numerous species is green leaf-roll moth - *Tortrix viridana*, followed by *Archips crataegana*. Pests of acorns (*Laspeyresia splendana*) and nuts (*L. amplana*) can significantly reduce harvest quality. We established a relatively large percentage of acorn destruction caused by acorn destroyers (*Balaninus glandium*, *B. nucum*), while gall wasps cause negligable damage to acorns (*Andricus quercuscalicis*). Oak miner (*Tischeria complanella*) is a typical pest of oak leaves and acorns and causes serious damage to stands. In the last 10 years the attacks of scale insects (*Kermes quercus*, *Asterolecanium variolosum*) to oak forests have been getting more severe. The result has been a serious physiological weakening of the hosts.

The presence of predators like ground beetles (*Calosoma sycophanta*, *C. inquisitor*) and burying beetles (*Xylodrepa quadripunctata*) after gradation of defoliator caterpillars in Hraščica is a sign of a good regulating mechanism in the natural equilibrium. This is confirmed by the presence of a large number of polyphagic caterpillar parasites especially true flies such as *Compsilura concinnata*, *Phryxe vulgaris* and *Tachina larvarum*.

On the basis of observation, defoliation records in the spring and summer, and on the basis of a visual evaluation of oak vitality, we believe that oak forests in Slovenia are in a relatively good state of health when compared to oak forests in southeastern Europe.

7 POVZETEK

Raziskovali smo vpliv entomofavne, posebej defoliatorjev, na sušenje in propadanje dobovih (*Quercus robur* L.) in gradnovih (*Quercus petraea* (Matt.) Lieblein) gozdov v Sloveniji. Raziskavo smo opravili v spomladanskem, poletnem in jesenskem času leta 1993, 1994 ter leta 1999 na devetih trajnih raziskovalnih ploskvah Gozdarskega inštituta Slovenije, in sicer na petih ploskvah doba in štirih ploskvah gradna. Spomladi in poleti je plezalec sekal hrastove veje v obrši, jih dajal v vreče in spuščal na tla. Na nabranih vejah smo registrirali in zbrali entomofavno, določili smo tudi odstotek defoliacije in obrod želoda. Te nabrane zelene veje, z različnimi razvojnimi stopnjami posameznih vrst žuželk, smo nato v laboratoriju dali v vodo in jih ohranili toliko časa, da smo vzgojili odrasle stadije posameznih vrst žuželk. Material smo nato obdelovali, preparirali in determinirali. Med poletnim pregledom smo posebej pozorno opazovali poškodbe listja zaradi defoliatorjev, ki so nastale poleti, in poškodbe želoda. Določili smo 35 vrst žuželk ter dva rodova iz 13 družin, in sicer: 1. druž.- *Geometridae*: *Operophthera brumata* L., *Erannis defoliaria* Cl., *Apochemia hispidaria* Den. et Schiff., *Biston strataria* Hufn., *Agriopis aurantiaria* Hb., *A. leucophalaria* Den. et Schiff., *Collotois pennaria* L. in *Alsophila aescularia* Den. et Schiff.; 2. druž.- *Noctuidae*: *Orthosia cruda* Schiff., *O. stabilis* Schiff., *Lithopane ornitopus* Hufn. in *Spodoptera* sp.; 3. druž.- *Saturniidae*: *Antheraea yamamai* Guer.; 4. druž.- *Lymantriidae*: *Lymantria dispar* L.; 5. druž.- *Tenthredinidae*: *Apethymus abdominalis* Lep., *A. braccatus* Gmel., *Pristiphora abietina* Christ.; 6. druž.- *Tortricidae*: *Tortrix viridana* L., *Archips crataegana* Hb., *Laspeyresia amplana* Hb., *L. splendana* Hb.; 7. druž.- *Tineidae*: *Tischeria complanella* Hb.; 8. druž.- *Cynipidae*: *Andricus quercuscalicis* Burgsd., *Cynips quercusfolii* L., *Neuroterus numismalis* Ol.; 9. druž.- *Coccidae*: *Kermes quercus* L., *Asterolecanium variolosum* Ratz.; 10. druž.- *Curculionidae*: *Balaninus glandium* Mrsh., *B. nucum* L., *Stereonychus* (*Cionus*) *fraxini* Deg.; 11. druž.- *Carabidae*: *Calosoma sycophanta* L., *C. inquisitor* L., *Carabus* spp.; 12. druž.- *Silphidae*: *Xylodrepa quadripunctata* L.; 13. druž.-

Larvaevoridae (*Tachinidae*): *Compsilura concinnata* Rond., *Phryxe vulgaris* Fall., *Tachina larvarum* L.

Nekateri škodljivci so skupni na vseh raziskovalnih ploskvah, na primer pedici (*Geometridae*) in zeleni hrastov zavijač (*Tortrix viridana*). Na večini ploskev se pojavljata ena ali dve dominantni vrsti, kot je primer s hrastovo grizlico (*Apethymus abdominalis*) v Krakovskem gozdu in malim zimskim pedicem (*Operophthera brumata*) ter zelenim hrastovim zavijačem (*Tortrix viridana*) v Hraščici. Na večini lokacij smo ugotovili delno ali popolno defoliacijo. Zajela je 10 do 90 % celotne listne površine. V zadnjih 30 letih se gobar (*Lymantria dispar*) vse bolj poredko pojavlja v velikih gradacijah, če pa se pojavi, so žarišča lokalno omejena. Gosenice, ki smo jih vzgojili iz jajčnih legel iz Prekmurja, so imele visok odstotek mortalitete (78 %). Zavijači so pomembna skupina škodljivcev hrastovega listja in želoda. Najštevilnejši je zeleni hrastov zavijač - *Tortrix viridana*, sledi ji vrsta *Archips crataegana*. Škodljivca želoda (*Laspeyresia splendana, L. amplana*) lahko bistveno zmanjšata kakovost obroda. Ugotovili smo tudi relativno velik odstotek uničenega želoda, ki ga povzročata hrastov in leskov semenar (*Balaninus glandium, B. nucum*), zanemarljive pa so poškodbe želoda zaradi os šiškaric (*Andricus quercuscalicis*). Miner hrastovega listja (*Tischeria complanella*) je tipičen škodljivec hrastovega listja in povzroča večje škode v sestojih. V zadnjih 10-ih letih opažamo v hrastovih sestojih močnejše napade ščitastih uši (*Kermes quercus, Asterolecanium variolosum*), kar povzroča močnejšo fiziološko oslabitev gostiteljev.

Prisotnost predatorjev- velikega in malega krešiča (*Calosoma sycophanta, C. inquisitor*) in mrharja (*Xylodrepa quadripunctata*) po gradaciji gosenic defoliatorjev v Hraščici kaže na dober mehanizem regulacije naravnega ravnovesja. To potrjuje tudi veliko število polifagnih parazitov gosenic, še posebej muh goseničark, kot so *Compsilura concinnata, Phryxe vulgaris* in *Tachina larvarum*.

Na osnovi opazovanj in popisa defoliacije v spomladanskem in poletnem obdobju ter vizualne ocene vitalnosti hrasta lahko trdimo, da so hrastovi gozdovi v Sloveniji v relativno dobrem zdravstvenem stanju v primerjavi s hrastovimi gozdovi v jugovzhodni Evropi.

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