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Effect of temperature on cannibalism rate between green lacewings larvae (*Chrysoperla carnea* [Stephens], Neuroptera, Chrysopidae)

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ABSTRACT

Paper presents a larval cannibalism of green lacewings (*Chrysoperla carnea*), which was observed during the laboratory bioassay on non-target effect of entomopathogenic nematodes against green lacewings larvae. The most probable reason for larval cannibalism were undersized Petri dishes in which the bioassay was performed. Due to large number of larvae per surface unit, frequent crossing of green lacewings larvae appeared and this consequently lead to cannibalism. In most cases larger, elder larvae consumed smaller, younger larvae. Cannibalism increased with temperature rise and was the most intensive at 25 °C. At this temperature the larval mortality was 22.0 % after two days, while after four days the larval mortality reached 31.0 %.

Key words: larval cannibalism, green lacewings, *Chrysoperla carnea*, laboratory bioassay, biological control

VPLIV TEMPERATURE NA STOPNJO KANIBALIZMA MED LIČINKAMI NAVADNE TENČIČARICE (*Chrysoperla carnea* Stephens, Neuroptera, Chrysopidae)

IZVLEČEK

V prispevku je predstavljen kanibalizem med ličinkami navadne tenčičarice (*Chrysoperla carnea*), ki se je pojavil pri laboratorijskem preučevanju neciljnega delovanja entomopatogenih ogorčic na ličinke omenjenega naravnega sovražnika. Najverjetnejši vzrok za pojav kanibalizma so bile premajhne petrijevke, v katerih je potekal poskus. Zaradi velikega števila ličink navadne tenčičarice na enoto površine, je prišlo do pogostega srečevanja ličink in posledično do kanibalizma. V večini primerov so ličinke višjega larvalnega stadija pojedle manjše ličinke. Kanibalizem se je povečeval z višanjem temperature in je bil najbolj intenziven pri 25 °C, kjer je bila smrtnost ličink dva dni po začetku poskusa 22,0 %, po štirih dneh pa 31,0 %.

Ključne besede: kanibalizem, navadna tenčičarica, *Chrysoperla carnea*, laboratorijski poskus, biotično varstvo

1 INTRODUCTION

Cannibalism is a frequent behavior in animals and plays an important role in population dynamics. It is genetically based but controlled or induced by various environmental cues (Polis, 1981). The most frequent types of cannibalism among arthropods are when adults or older larval stages eat juvenile stages or eggs. Not sufficiently protected pupae can be exceptionally cannibalized (Elgar and Crespi, 1992). Sexual cannibalism is appearance where females eat courting males before, during or immediately after copulation (Elgar, 1992; Johns and Maxwell, 1997).

Within the Neuroptera order, cannibalism seems to be correlated with polyphagous feeding habits (Duelli,

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1981). Chrysophid larvae are active hunters, characterized by swift movements, aggressive behavior and fast growth. These larvae are voracious and usually polyphagous predators, therefore their diet also includes prey of the same species (Canard, 1984).

An ecological factor that generally favours cannibalism, particularly in entomophagous insects, is a low availability of food, which may depend to varying degrees upon population density (Elgar and Crespi, 1992). Mochizuki *et al*. (2006) observed 100 % cannibalism among green lacewings larvae in the absence of aphids, but if the aphids were presented, the abundance of the cannibalism was negligible. In most cases happened that the larger, elder, and consequently better fed larvae consumed the smaller, starving, and the younger larvae (Bar and Gerling, 1985). Arzet (1973) reported that after 72 h of starvation the cannibalism occurred between larvae, which were the same size and age. Bar and Gerling (1985) found out that *C. carnea* pupae were eaten only by 3rd-instar larvae. Cannibalism is a disadvantage in mass production of green lacewings larvae for biological control of plants (van Lenteren, 2003). But in natural conditions when the food is in shortage, the cannibalism is only option for survival of individuals and it is the only possibility to prevent local extinction (McEwen *et al*., 2001).

The green lacewings larvae are polyphagous insects and they feed on any soft bodies organisms that are small enough for them to capture, including aphids, scales, mealy-bugs, whiteflies, small caterpillars, leafhoppers, psyllids, thrips, mites, insect eggs and mites and others (Olkowski *et al*., 1996; Strand, 2006). Because the green lacewings larvae are so effective predator of pest insects, they are mass reared and used as biological control agents in America and Europe. Commercial products contain one growth stage (eggs, larvae or pupae) or mixed stages, dependent on producer (van Lenteren, 2003).

2 MATERIAL AND METHODS

The investigation of non-target effect of entomopathogenic nematodes on green lacewings larvae was carried out during 2007 in the Entomological Laboratory of the Chair of Entomology and Phytopathology (University of Ljubljana, Biotechnical Faculty, Department of Agronomy) in Ljubljana, Slovenia (Rojht, 2007). In this laboratory bioassay we came across with larval cannibalism. Commercial preparation of *C. carnea* larvae "Chrysopa" was obtained from the Netherlands company Koopert B. V., Berkel en Rodenrijs.

Laboratory tests were performed in Petri dishes with diameter of 7 cm (Figure 1). On the top of the lid a hole of 2 cm diameter was made. From the exterior side, it was covered with a dence nylon net, to provide a sufficient air circulation and to prevent escaping the insects. In the bottom of Petri dishes a cellulose paper (producer: Tosama d. d., Slovenia) with the same diameter was placed and then 1 ml of suspension of entomopathogenic nematodes was applied with pipette. Leaves of the plants and aphids were used as food for green lacewings larvae. At the end we put in each Petri dish ten green lacewings larvae, the predators of aphids. Petri dishes were then tightened with parafilm and placed in rearing chamber (type RH-900 CH, producer: Kambič, Semič) for 24 hour's darkness at relative humidity 85 %. For each temperature 95 Petri dishes were provided. After second and fourth day the survived larvae of green lacewings and larvae were counted. With counting the missing green lacewings larvae at the same time the larval cannibalism were evaluated.

All statistical analyses (ANOVA, Duncan's multiple range test) were performed using Statgraphics Plus for Windows 4.0 (Manugistics, Rockville, MD, USA) and figure was created with MS Office Excel 2003. The data are presented as untransformed means ± SE.

***Figure 1**: Experimental vessel made for investigation of non-target effect of entomopathogenic nematodes on green lacewings (Chrysopera carnea) larvae. At the same type of vessels the rate of larval cannibalism was investigated (photo: H. Rojht).*

3 RESULTS

Group analysis indicated a statistically significant effect of temperature ($P < 0.0001$) and day after treatment ($P < 0.0001$) on the percentage of cannibalism between green lacewings larvae. The influence of EPN species and nematode concentration were not significant.

***Figure 2**: Cannibalism between green lacewing (Chrysopera carnea) larvae. Bigger and elder larva consumed smaller conspecific larva (photo: H. Rojht).*

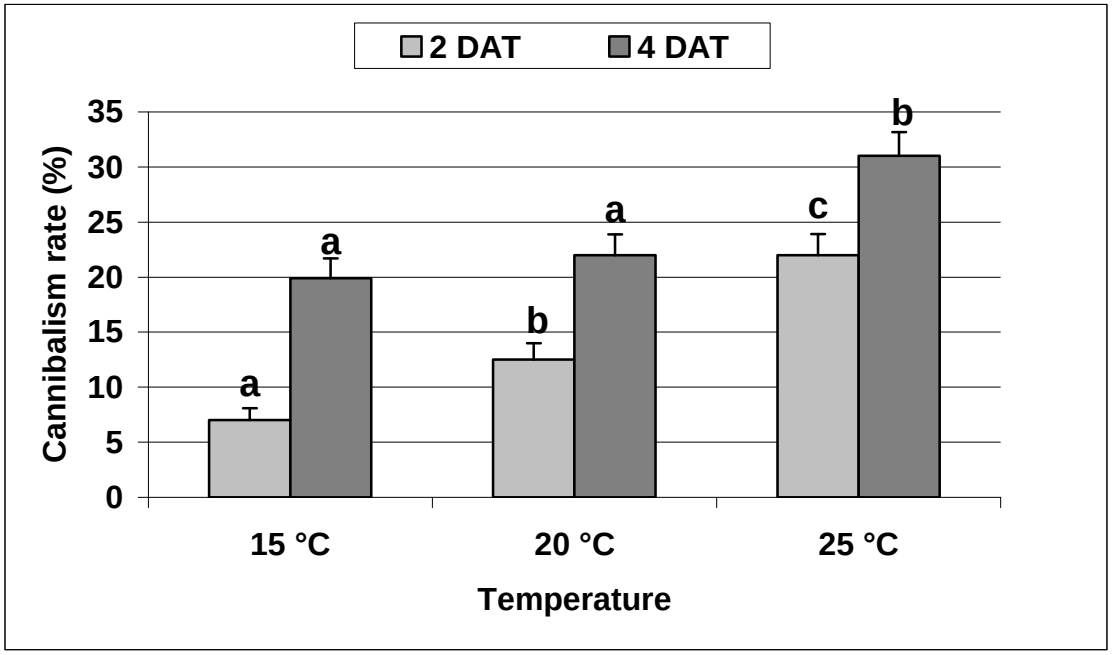

***Figure 3**: Effect of temperature on cannibalism of green lacewing (Chrysopera carnea) larvae two and four days after exposure. Letters above bars represent statistical significant differences (P<0.05) between percentage of cannibalism within one day, respectively. (DAT = days after treatment)*

Appearance of larval cannibalism between green lacewings was abundant. Figure 3 represent the effect of temperature and day after treatment (DAT) on cannibalism abundance. Two (22.0 ± 1.9 %), and four days after treatment (31.0 ± 2.2 %) with entomopathogenic nematodes, the most frequent larval cannibalism was recorded at the highest temperature (25 °C). Two days after treatment, the lowest larval cannibalism (7.0 ± 1,1 %) was found to be at 15 °C, while four days after treatment no significant differences were found between cannibalism rate at 15 (19.9 ± 1.8 %) and 20 °C (22.0 ± 1.9 %).

4 DISSCUSSION AND CONCLUSIONS

Already at the time of receiving the commercial preparation "Chrysopa", we noticed the first signs of larval cannibalism; namely egg-larval and larval-larval cannibalism. The most often cannibalism within larval-larval cannibalism was among larvae of the different size and age, and not cannibalism among larvae of the same size and age. The producer of commercial preparation used suitable stuffing material (husks of buckwheat), which prevented or aggravated contact between *C. carnea* larvae. Moreover, alternative food was also added and commercial preparation was transfered on low temperature. In spite of all the number of C. *carnea* larvae in package was for about 25 % lower than designated on declaration. We also assumed that long transfer from Netherlands to Slovenia, and behavior nature of green lacewings larvae had great influence on appearance of cannibalism.

Laboratory studies performed by Kurbanov (1984) showed that relative humidity, photoperiod and temperature was important in mass rearing of *C. carnea*. Several authors had given different data about optimal temperature values for rearing *C. carnea* larvae. For example Orešek (2003) reared green lacewings larvae at average temperature of 28.6 °C, Milevoj (1999) from 23 to 27 °C, and Duelli (1981) at 25 ± 2 °C. Chiaki and Masashi (1999) reported that the shortest developmental period of one generation of *C. carnea* was at 25 °C. At this temperature the larval development was high and the need for food was greater. In our research the optimal temperature for development of green lacewings was 25 °C, therefore the larvae were very active and cannibalism the most abundant.

In our research the larval cannibalism between green lacewings was presented frequently, despite instructions from previous laboratory rearing methods of *C. carnea* (Milevoj, 1999), in which the aphids were added in excess, and to prevent the chrysophid larvae from encountering one another, obstacles were placed. Obstacles and excessive amounts of food did not entirely prevent larval

cannibalism but only extenuated them (Orešek, 2003). In our experiment we wanted to reduce larval cannibalism with addition of excess amounts of aphids; in spite of that, green lacewings larvae were often consumed by other larvae.

Bar and Gerling (1985) found out that larval cannibalism could occur by chance. To consider that fact, we assumed that a possible reason for larval cannibalism could also be too many *C. carnea* larvae per unit of area. Our experimental pots were obviously too small, therefore the chance of larvae crossing were more often. In such crossing in most of cases the larger, the better fed and the elder larvae consumed the smaller, the hungry and the younger larvae. In the end we can totally exclude larval cannibalism by placing only one green lacewing larvae per one experimental pot, but our scheme of bioassay and laboratory capability did not permit suchlike accession.

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Agris category code: F60

Extraction of phenolic compounds from green walnut fruits in different solvents

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ABSTRACT

The extractive efficiency of phenolic compounds from plant material is greatly depended on the solvent. In our research, methanol and ethanol were used for taking out the phenols from green walnut fruits. The total phenolics and some individual phenolics, such as gallic, chlorogenic, ellagic, sinapic and protocatechuic acid, (+)-catechin and juglone were detected. Total phenolic contents were determined spectrofotometric but individual phenols using HPLC. Amounts of total phenolics were higher when for extraction methanol was used compare to ethanol, in both cultivars, Elit and Franquette. Similar effect of the solvents was observed in the case some individual phenols, such as juglone, (+)-catechin, gallic, protocatechuic and chlorogenic acid. On the contrary, for ellagic and sinapic acid the extraction was better when ethanol was used compare to methanol.

Key words: *Juglans regia* L., ethanol, methanol, juglone, gallic acid, catechin

EKSTRAKCIJA FENOLNIH SNOVI IZ ZELENIH PLODOV OREHA Z RAZLIČNIMI TOPILI

IZVLEČEK

Učinkovitost ekstrakcije fenolnih snovi iz rastlinskega tkiva je v veliki meri odvisna od topila. V našem poskusu smo primerjali ekstrakcijo fenolov iz zelenih plodov orehov z etanolom in metanolom. Določali smo skupne in nekatere posamezne fenolne spojine, kot so galna, klorogenska, elagna, sinapinska in protokatehulna kislina, ter (+)-katehin in juglon. Skupne fenole smo določili spektrofotometrično, posamezne pa s pomočjo HPLC sistema. Vsebnost skupnih fenolov je bila pri obeh sortah, 'Elit' in 'Franquette', večja pri ekstrakcji v metanolu kot v etanolu. Podobne rezultate smo dobili pri nekaterih posameznih fenolih, kot so juglon, (+)-katehin, galna, protokatehulna in klorogenska kislina. Nasprotno je bila ekstrakcija pri elagni in sinapinski kislini bolj uspešna v etanolu kot v metanolu.

Ključne besede: *Juglans regia* L., etanol, metanol, juglon, galna kislina, katehin

1 INTRODUCTION

Walnut (*Juglans regia* L.) naturally occurs in Slovenian forests. For many years the trees are also grown in orchards because of the delicious fruits, which can be eaten raw and are excellent for dessert as well as in baking and confectionery (Prasad, 2003). Before the endocarp hardens, the green fruits including green husks can be pickled in vinegar or sliced and steeped into alcohol. The latter case of use is traditional in Slovenia as well as in Italy in preparation of a walnut liqueur (Štampar et al., 2006; Alamprese and Pompei, 2005).

Walnut fruits are rich in phenolic compounds (Prasad, 2003). Their contents depend on many environmental conditions, as well as genotype of different cultivars

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(Colarič et al., 2005; Solar et al., 2006). Furthermore, the presence of phenols changes during the season (Solar et al., 2006). Phenolics are involved in growth and reproduction and provide plants with resistance to pathogens and predators (Bravo, 1998).

For extraction of polyphenols from plant matter different solvent systems have been used (Chavan et al., 2001) and their efficiency varies. Extraction yield depends on the solvent and method of extraction (Goli et al., 2004). Commonly used solvents for extracting various substances from plant material are water, aqueous mixtures of ethanol, methanol and acetone (Sun and Ho, 2005).

We have analyzed the contents of the total and of some of the individual phenolic compounds in green walnut fruits, extracted with methanol or ethanol. Two cultivars, Elit and Franquette were involved in the research. In scientific researches, extraction of the phenolics is often performed in methanol, but when a walnut liqueur is made, green walnuts are steeped in ethanol. The aim of our study was to ascertain the influence of the solvents on the content of total as well as on some individual phenolic compounds.

2 MATERIAL AND METHODS

2.1 Plant material

Material for analyses was taken from two walnut cultivars, Elit and Franquette in an experimental orchard of the Biotechnical Faculty, located in Maribor (Slovenia). In the end of June, green walnut fruits were picked from three trees of each cultivar.

Two fresh fruits were sliced and ground to a fine powder and 100 mg of the sample was measured into a test tube. The sample was extracted with 5 ml methanol or ethanol in ultrasonic bath for 45 minutes. Then the samples were centrifuged for 7 minutes at 4200 rpm. The supernatant was filtered through polyamide filter Chromafil AO-45/25, transferred into vial prior analyses.

2.2 Total phenols content

Total phenolic content was assessed by using the Folin-Ciocalteau phenol reagent method (Singleton and Rossi, 1965). To 100 µl of the samples, 5 ml of bidestilated water and 500 µl of Folin-Ciocalteau reagent were added. After 30 sec to 8 min, 1.5 ml of sodium carbonate (20% w/v) was added. The extracts were stand for 30 min at 40°C. On the basis of measured absorbances at 765 nm, determination from calibration curve and considering dilutions, the total phenolic content was expressed as gallic acid equivalents (GAE) in milligrams per gram fresh walnut fruits.

2.3 Individual phenols content

The content of individual phenolics in extracts was analyzed on the Thermo Finningan Surveyor HPLC system equipped with photodiode array detector (PDA detector). A Chromsep HPLC column SS (250 x 4.6 mm, Hypersil 5 ODS) protected with a Chromsep guard column SS (10 x 3 mm) was used. The system was controlled using the ChromQuest^{TM} 4.0 Chromatography workstation software system. The chromatographic conditions (mobile phase, gradient program, temperature of column) were similar to those described by Schieber et al. (2001).

Chromatograms were observed at 280 nm. Identification of individual phenolic was qualitatively achieved using method of external standards and quantitatively comparing peak area on chromatograms of samples with those of diluted standard solutions.

2.4 Chemicals

For quantification of phenolics the following standards were used: juglone, gallic and protocatechuic acid from Merck, chlorogenic and ellagic acid from Sigma, (+)-catechin from Roth and sinapic acid from Fluka.

Following chemicals were used for the determination of total phenolics: Folic-Ciocalteu's phenol reagent and gallic acid from Sigma and sodium carbonate from Riedel-de Haën.

Acetonitrile, methanol and acetic acid were HPLC grade from Merck. The water used was bidistilled, purified with a Milli-Q water purification system (Millipore, Badford, USA).

2.5 Statistical analyses

Data were evaluated by one-way analysis of variance (ANOVA) using Statgraphics Plus 4.0 (Manugistics, Inc.; Rockville, USA) software. T-test was performed to determine significant differences at $P<0.05$.

3 RESULTS AND DISSCUSION

Phenolic compounds were extracted from green walnut fruits, cultivars 'Elit' and 'Franquette'. Total phenolic content as well contents of seven individual phenolics, such as gallic, chlorogenic, ellagic, sinapic and protocatechuic acid, (+)-catechin and juglone, were detected. As extraction solvent, methanol or ethanol were compared.

Colarič et al. (2005) ascertained that green unripe walnuts are rich in individual phenolic compounds. The total phenolics content of green walnut fruits extracted in two solvents are presented in Table 1 for cultivars Elit and Franquette. In the case of ethanol, the total phenolic content ranged from 126.2 mg GAE per g in cultivar Elit to 135.3 mg GAE per g in cultivar Franquette. In the case of methanol more phenolic

compounds were extracted in both cultivars. There was significant difference between phenolic contents of the extracts using two mentioned solvents in both cultivars. Also other authors have established that the phenolics content extracts are strongly dependent on the type of the solvent as well as on the different concentrations of solvent (Turkmen et al., 2006; Yilmaz and Toledo, 2006). The extraction yield and extraction efficiency of caffeine and major catechins of green tea were higher with pure methanol comparing to pure ethanol (Perva-Uzunalić et al., 2006). Therefore, methanol proved to have a bit better characteristics as a solvent for polyphenols and anhtocyanins from black currant and grape byproducts than ethanol (Lapornik et al., 2005). On the other hand, Wang and Halliwell (2001) reported that aqueous ethanol was superior to aqueous methanol and acetone for extraction of the flavonoids from tea. In extracting phenolic compounds from peanut skin, ethanol and methanol were more effective than water, with ethanol being the most efficient extraction solvent (Yu et al., 2005). Meanwhile, the methanol was the solvent with best results for phenols from pine sawdust, while in almond hulls ethanol was the best extraction solvent (Pinelo et al., 2004). Jung et al. (2006) also compared the influence of different solvents and they found out that the ethanol extracts contained higher amounts of total phenolics and flavnoids than water and methanol extracts from wild ginseng leaves.

Table 1: The total phenols (mg GAE/g FW) in green walnut fruits, extracted with methanol or ethanol in cultivars Elit in Franquette. Average means and standard errors are presented. *P*-values in last column of the table mark statistically significant differences between the solvents.

	Methanol	Ethanol	*P*-value
Franqette	161.07 ± 7.28	135.27 ± 2.42	0.0041
Elit	148.98 ± 4.74	126.20 ± 5.71	0.0119

In spite of the fact, that higher amounts of total phenolics were extracted in methanol comparing to ethanol, this is not the case for all the individual phenols. The highest values of the analyzed phenols achieved juglone. Its extraction was more effective with methanol than with ethanol. Similar effects of the solvents were observed in the case of (+)-catechin, gallic, protocatechuic and chlorogenic acid (Fig. 1). Kallithara et al. (1995) also indicated that the methanol extraction is best for (+)-catechin, (-)-epicatechin and epigallocatechin, whereas the largest amount of gallic acid were yielded by 75 % of ethanol. In our research 96% ethanol was used, which has proved to be less effective solvent for gallic acid than methanol.

For other analyzed phenols, such as ellagic and sinapic acid, higher contents were gained with ethanol than with methanol. On the Fig.2 their contents are shown for cultivars Elit and Franquette. Also the individual anthocyanin extraction from grape and black currant marc depended on the use of solvent (Lapornik et at al., 2005). Rødtjer et al. (2006) reported that quantification of the total amount of phenolics in the extracts showed that 70% solvent-water mixtures extracted the phenolics more efficiently and contained more complex mixtures of phenolic compounds than the pure solvent extracts did.

Many authors established that the extraction yield of phenols is greatly depending on the solvent polarity (Turkmen et al., 2006; Lapornik et al., 2005). There are some studies, where the influences of the solvent concentration are being studied. Thus, Yilmaz and Toledo (2006) found out that aqueous solutions of ethanol, methanol or acetone were better than a single-compound solvent system for the extraction of the total phenols from Muscadine seed power.

We can conclude that the efficiency of the phenolics extraction depends on the type of the solvent as well on the phenol, which is being isolated. For total phenolics extraction from green walnut fruits methanol was more efficient compare to ethanol. Similar was for some individual phenols, such as juglone, (+)-catechin, gallic, protocatechuic and chlorogenic acid. On the contrary, for ellagic and sinapic acid extraction was better when using ethanol.

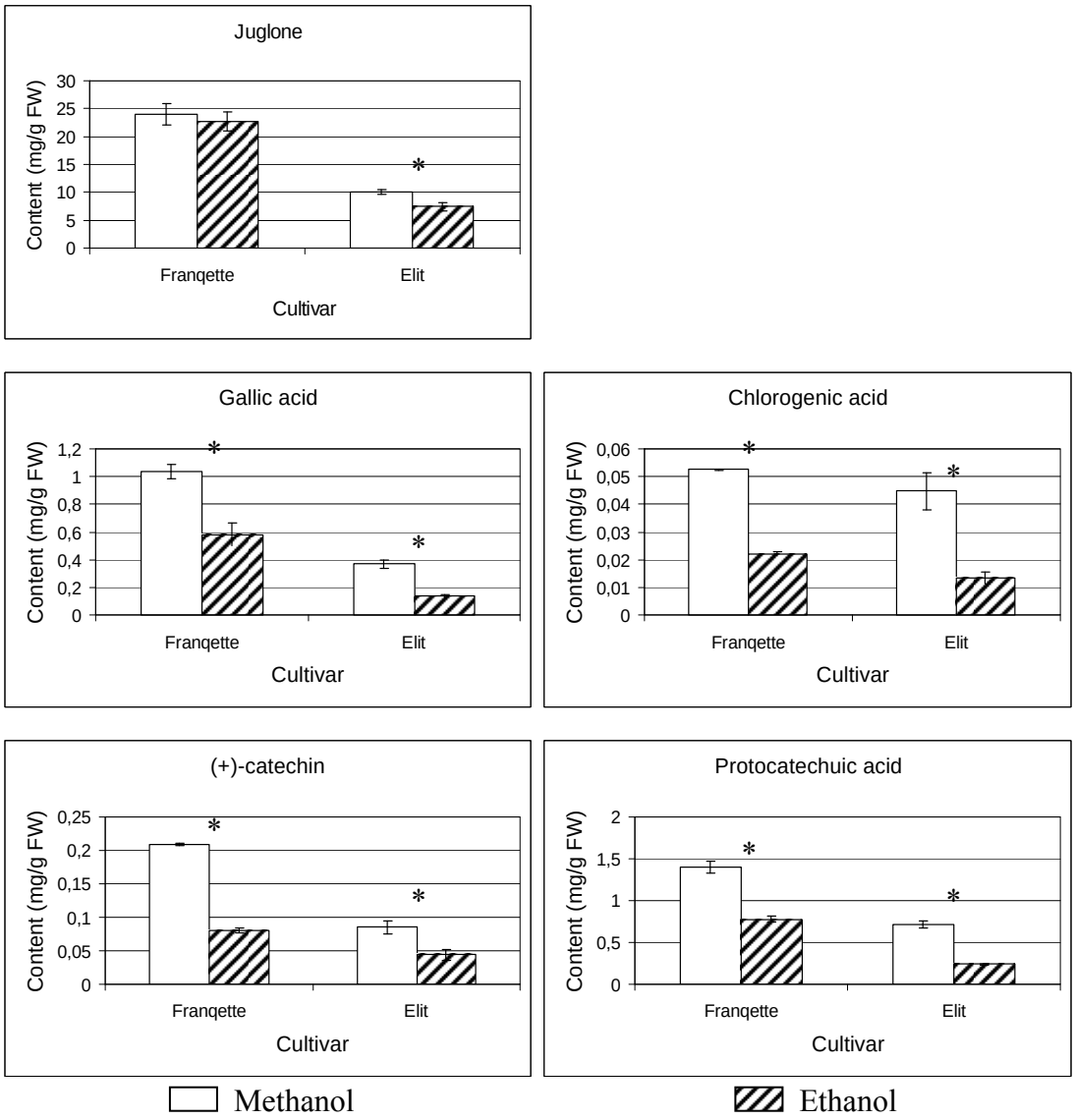

***Figure 1**: The individual phenols (mg/g FW) in green walnut fruits, extracted with methanol or ethanol in cultivars Elit in Franquette. Average means and standard errors are presented. Asterisk marks statistically significant differences between the solvents at P-value < 0.05.*

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Changes in the inner quality parameters of apple fruit from technological to edible maturity

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ABSTRACT

The changing dynamics of organic acids, sugars, phenolics and antioxidant potential in apples from technological to edible maturity was studied. During the time of storage, the content of citric and malic acids generally decreased. The content of sucrose, fructose and glucose decreased significantly in some varieties, while it increased in others. The content of total sugars changed only slightly over the storage period. In the apple pulp, the content level of single phenolics generally changed to a minor extent during storage. In the peel, the content levels of the rutin and quercetin-3-rhamnoside flavonoids remained generally constant during storage, while the level of *p*-coumaric acid increased slightly; on the other hand, the content levels of epicatechin and catechin decreased. In the pulp of most cultivars, there was no significant decrease in total phenolics at edible maturity. In contrast, the apple peel usually has a higher content level of total phenolics at edible maturity than at the time of technological maturity. Therefore, the antioxidant activity of the peel increased from technological to edible maturity.

Key words: fruit, storage, technological maturity, edible maturity, firmness, soluble solids, phenolic compounds, organic acids, sugars

IZVLEČEK

Proučevali smo dinamiko spreminjanja organskih kislin, sladkorjev, fenolnih spojin in antioksidativnega potenciala jabolk od tehnološke do užitne zrelosti. Vsebnost citronske in jabolčne kisline se je med skladiščenjem na splošno zmanjševala. Vsebnost saharoze, fruktoze in glukoze se je v času skladiščenja pri nekaterih sortah značilno zmanjšala, pri drugih pa povečala. Vsebnost skupnih sladkorjev se je med skladiščenjem le malo spreminjala. Na splošno se je vsebnost posameznih fenolov v pulpi jabolk v času skladiščenja le malo spreminjala. V kožici je ostala vsebnost flavonoidov rutina in kvercetin-3-ramnozida v obdobju skladiščenja približno enaka, vsebnost *p*-kumarne kisline se je malo povečala, medtem ko se je količina epikatehina in katehina zmanjšala. Pri večini sort je opaziti v pulpi neznačilno zmanjšanje skupnih fenolov v užitni zrelosti. Nasprotno je kožica jabolk pri večini sort v užitni zrelosti imela večjo vsebnost skupnih fenolov kot v tehnološki zrelosti. Iz tega tudi izhaja, da se je antioksidativna aktivnost kožice od tehnološke do užitne zrelosti povečala.

Ključne besede: plodovi, skladiščenje, tehnološka zrelost, užitna zrelost, trdota, suha snov, fenolne spojine, organske kisline, sladkorji

1 INTRODUCTION

The attractiveness of fruit to consumers is determined by visual attributes that include appearance, size, uniformity, colour and freshness, as well as non-visual attributes such as taste, aroma, flavour, firmness (texture), nutritional value and healthiness. Among these attributes, firmness and aroma appear to be the most important for consumers (Awad and de Jager, 2002; Aaby et al., 2002). Sugars, organic acid and phenolic compounds all contribute to the aroma of apples. Fresh fruit contains these nutritional and healthy

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constituents: minerals, vitamins and phytochemicals, such as carotenoids, flavonoids and phenolic acids. Consumers are becoming more interested in the content of these health-promoting compounds in fruit because of their antioxidant activity (Wang et al., 1996; Robards et al., 1999; Gil et al., 2002). Apple peel, in general, had a 2–9 times higher content level of both individual phenolics and total phenolics (Mikulič Petkovšek et al., 2007). These quantitative differences occurred mainly because of flavonol glycosides as well as high levels of catechins and chlorogenic acid in the peel (Escarpa and Gonzalez, 1998). In particular, phenolics in apple skin showed a much higher contribution to the total antioxidant and antiproliferative activity of the whole apple than those in apple flesh (Wolfe et al., 2003).

Organic acids, sugars and phenolic compounds are produced through metabolic pathways during ripening, harvest, post-harvest and storage, and they are influenced by many factors related to species, variety and technological treatment (Ackerman et al., 1992; Boylston et al., 1994). Storage at reduced oxygen concentrations, i.e. controlled atmosphere (CA), will prolong the life of apples. During CA and low-temperature conditions, the general appearance of stored apples can be maintained for a long period of time, while the production of aromatic compounds decreases (Boylston et al., 1994; Brackmann et al. 1994).

Patterns of change in organic acid, carbohydrates and phenolics during storage are variable (Roth et al., 2007). Roth et al. (2007) reported that sucrose content in apples decreased during storage, while glucose and sorbitol content levels increased. Piretti et al. (1994) found that epicatechin, quercetin glycosides and procyanidins in 'Granny Smith' generally decreased during storage. Similar results were reported for the 'Boskoop' apples about decreasing the concentrations of catechin, epicatechin and phenolic acids (Mosel and Herrmann, 1974). In contrast, some researchers found that the content of phenolics increased during storage (Burda et al., 1990; Napolitano et al., 2004). The majority of researchers reported that no change occurred in the concentrations of simple phenols (mainly chlorogenic acid), flavonoids and anthocyanin during storage (Perez-Ilzarbe et al., 1997; Awad and de Jager, 2000; Golding et al., 2001).

The evidence available on postharvest behaviour of natural compounds in apples is partly conflicting and needs further study. The purpose of this investigation was to find whether the parameters of inner quality of apple fruit changed during storage. At the time of technological and edible maturity of fruit, their maturity parameters were measured, the content of organic acids, sugars and sorbitol was determined as well as the content of individual phenolic substances, total phenols and antioxidant activity. Our interest was in determining whether the content of phenolics in apples decreased from their technological to their edible maturity. Furthermore, we wanted to ascertain if there was a difference in the parameters studied between the group of varieties resistant to apple scab and the susceptible ones.

2 MATERIALS AND METHODS

2.1 Plant material and growing conditions

This experiment was carried out in 2005. Fruit samples for the experiment were taken from apple trees grafted on M9 rootstock growing in Ljubljana (Central Slovenia). Ten trees of three scab resistant cultivars ('Goldstar', 'Rubinola' and 'Topaz') and three scab susceptible cultivars ('Braeburn', 'Jonagold' and 'Golden Delicious') were used in the experiment. Because of favourable weather conditions for apple scab development, the susceptible cultivars were protected against this disease with fungicides; meanwhile, the resistant cultivars were not sprayed. For susceptible cultivars left without spraying, the damage on the fruit caused by apple scab would have been severe, and this comparison would have been impossible. The set-up of such an experiment is also in accordance with normal orchard practices. From each tree, 10 fruit samples were picked (100 fruit samples of each cultivar in total). Fifty of these were immediately used for analysis, the remaining 50 were placed in cold storage (2 ^{o}C, presence of O_2) until they reached edible maturity. Immediately after harvest, the fruit were frozen in liquid nitrogen and stored at -20°C until preparation of the samples.

The apples were analysed at two dates in order to determine the content of organic acids, sugars, phenolic compounds and antioxidative potential. The first date coincided with the time of technological maturity of the individual variety and the second one with the edible maturity of the variety. Fruit sampling was performed at technological maturity, which was evaluated using the starch iodine test.

2.2 Maturity and standard quality parameter analyses

Fifty apples of each cultivar were used for measurement, both at harvest and after removal from cold storage. The skin was removed using slicers to a 1-mm cutting depth, and flesh firmness was then measured with a penetrometer equipped with an 11-mm diameter plunger tip; the results were expressed in kg/cm^2. Soluble solids were measured in the juice pressed from the whole fruit. Soluble solids concentration was measured using a digital refractometer (Atago CO., LTD; Japan), and the results were expressed in

°Brix. Starch index was determined with the iodine solution, where the Eurofru scale was used.

2.3 Extraction and determination of sugars, organic acids and phenolic compounds

Sugars and organic acids were prepared as described by Mikulič Petkovšek et al. (2007). The analysis of sugar and organic acid content levels was carried out using high-performance liquid chromatography (HPLC) (Thermo Separation Products equipment, USA). The separation of sugars was carried out using a Rezex RCM-monosaccharide column (300 x 7.8 mm) (Phenomenex, USA). The mobile phase was bi-distilled water, and a refractive index (RI) detector was used for monitoring the eluted carbohydrates according to Dolenc-Šturm et al. (1999) with minor changes. Organic acids were analysed using the Aminex HPX-87H column (300 x 7.8 mm) (Bio-Rad, USA) associated with a UV UV-detector, as described by Dolenc-Šturm et al. (1999). The elution solvent was 4 mM sulphuric acid in bi-distilled water. Phenols were extracted and analyzed using the method of Escarpa and Gonzalez (2000). The content of individual phenols was analysed with the HPLC-PDA system using the Phenomenex Gemini C18 column, and the content of total phenols followed the method with Folin- Ciocalteu reagent (Singleton and Rossi, 1965). Absorption was measured at 765 nm on the UV-VIS spectrophotometer. The content of individual phenols was expressed in mg/kg of sample used. The content of total phenols was expressed in equivalents of gallic acid per kg of fresh sample. Antioxidative activity was measured spectrophotometrically, and the result was expressed in the equiv. of ascorbic acid per 100 g of sample (Brand-Williams et al., 1995). Data were processed statistically using the Statgraphic Plus 4.0 program. One-way analysis of variance ($p<0,05$) was used. The differences between cultivars were tested using the Duncan test and, between maturity dates, using the LSD test at the 0.05 significance level.

3 RESULTS AND DISCUSSION

3.1 Maturity parameters of different apple varieties at the time of technological and edible maturity

As seen in Figure 1-A, the firmness of fruit in all the varieties was significantly reduced over the storage period. Numerous enzymes that cause the cell walls and lamellas to disintegrate during storage are the reason for the reduced fruit firmness. In the process, calcium from the cell walls is transferred to the interior of cells (Teixeira and Ferreira, 1993). In accordance with our results, a decrease in firmness during storage was reported by Drake et al. (1988), Albanese et al. (2007) and Roth et al. (2007), explaining that firmness was reduced at the expense of a water content decrease in fruit. The 'Braeburn' variety was outstanding for the greatest firmness at technological maturity, with values of 10 kg/cm^2.

The content of total soluble matter includes soluble sugars, organic acids, sorbitol, some inorganic substances and vitamins and is an important indicator of the maturity level. The content of total soluble matter in fruit (°Brix) was higher at edible maturity if compared with the the time of technological maturity. The fruit specimens of the 'Braeburn', 'Rubinola' and 'Topaz' varieties had a significantly higher content of total soluble matter at the time of edible maturity than at technological maturity (Fig. 1-B). An increase in total soluble matter of apples during storage was also reported by Drake et al. (1988). Napolitano et al. (2004) measured a higher content of dry matter in some varieties and lower dry matter content in others after 4 months of storage. The increase in total soluble matter may be explained by starch decomposition.

Differences in starch index between the two dates of technological and edible maturity were significant in all varieties. So, the fruit at technological maturity had lower values on the starch index (according to the 1-10 Eurofru scale), while at edible maturity, values on the starch index were statistically higher, which means that the fruit contained less starch (Fig. 1-C). With fruit ripening, the starch content decreases as it hydrolyses into sugars.

3.2 The content of sugars, sorbitol and organic acids in fruit at the time of technological and edible maturity

In the 'Braeburn', 'Rubinola' and 'Golden Delicious' varieties, the content of sucrose at the time of edible maturity increased significantly in comparison to the content of sucrose at technological maturity (Fig. 2-A). In the 'Jonagold' and 'Topaz' varieties, it decreased significantly. Šturm (2001) also reported an increase in the sucrose content level of apples during storage. In contrast, Roth et al. (2007) reported a decline in sucrose content during storage. The content of glucose also increased significantly or remained the same in the majority of varieties (Fig. 2-B). An increase in glucose content in the fruit of 'Elstar' and 'Jonagold' varieties at the time of storage was also reported by Ackermann et al. (1992) and Roth et al. (2007). At the time of edible maturity, the content of fructose increased significantly in comparison to its content at picking in the 'Braeburn', 'Rubinola' and 'Golden Delicious' varieties, and it decreased significantly in the 'Goldstar' and 'Topaz' varieties (Fig. 2-C). A higher fructose content is reported by Ackermann et al. (1992) after picking of the 'Glockenapfel' apple tree variety. We

explain the increased fructose content at the time of storage in terms of the decreased water content in the fruit. Statistical differences concerning the content of sorbitol alcohol sugar during technological and edible maturity were shown only in the 'Goldstar' and 'Topaz' varieties (Fig. 2-D). Šturm (2001) reported a considerable decrease in sorbitol content at picking, which was related to the metabolic processes in the fruit and the transformation of sorbitol into other simple sugars, because of which the content during storage increased. The content of total sugars changed only slightly over the storage time (Fig. 2-E). Similarly, Suni et al. (2000) reported that storage had only a minor effect on the average content of sugars and acids in apple fruit.

As a rule, the content of citric and malic acids decreased during storage (Fig. 3-A, 3-B). It is interesting, however, that the content of malic as well as that of citric acid in the 'Rubinola' variety increased significantly at the time of edible maturity in comparison to the time of technological maturity. A gradual decline of malic and citric acids in apple fruit during storage was also reported by Ackermann et al. (1992) and Roth et al. (2007). Malic acid is the main substrate at respiration; therefore, its content decreases more slowly under CA storage conditions (atmosphere with low O_2 content) than in the cold-storage chamber with a high oxygen content (Roth et al., 2007). Since malic acid represents the greatest share of total organic acids in the apple fruit, the content of total organic acids during storage decreases. The content of shikimic acid during storage increased in most varieties (Fig. 3-C). Significant differences were calculated only in the 'Braeburn' and 'Rubinola' varieties. At the time of edible maturity, these contained statistically more shikimic acid than at technological maturity. Generally, the content of shikimic acid changed very little between the two dates reported in the study of Šturm (2001).

3.3 The content of phenolic compounds and the antioxidative potential of pulp and skin in various apple varieties at the time of technological and edible maturity

The content level of chlorogenic acid in the pulp during storage remained at approximately the same level (Fig. 4-A), while in the skin its content increased slightly between technological and edible maturity; however, the differences are not significant for all varieties (Fig. 6-A). Similarly to our results, Awad and de Jager (2000) reported that the content of chlorogenic acid in 'Elstar' and 'Jonagold' varieties during storage was relatively stable. In the skin of the 'Red Delicious' variety, a linear increase of chlorogenic acid during the time of storage (MacLean et al., 2006) was detected; similar reports may be found concerning the 'Lady Williams' apple tree variety (Golding et al., 2001).

The content of caffeic and *p*-coumaric acids in the pulp between the time of picking and the stage of edible maturity remained at approximately the same level in a certain number of varieties and increased in others (Fig. 4-B, 4-C). Napolitano et al. (2004) also report an increase in the caffeic acid content level in the apple pulp. In the skin of some varieties, the content levels of the caffeic and *p*-coumaric acids increased, while it decreased in other varieties (Fig. 6-B, 6-C). Golding et al. (2001) reported that the dynamics of caffeic and ferulic acids in apples was similar to the dynamics of chlorogenic acid, its content level reaching a peak after 3 months of storage with no further changes in metabolism.

In the majority of varieties, the catechin content in the pulp was slightly higher during storage, but the differences were not statistically significant (Fig. 4-D). An increase of catechin in apple pulp during the 3-month storage period was reported by Napolitano et al. (2004). In the skin, a decreasing trend in catechin content during storage was noticed for 'Golden Delicious' and 'Rubinola' cultivars (Fig. 6-D). The content level of epicatechin in pulp from technological to edible maturity was slightly higher in certain varieties and lower in others (Fig. 5-A). Napolitano et al. (2004) also reported an increase of epicatechin in apple pulp during storage. In the skin, a significant decrease in epicatechin content was noticed between the two dates of technological and edible maturity in the 'Goldstar', 'Rubinola', 'Topaz' and 'Golden Delicious' varieties (Fig. 6-E). Generally, it may be confirmed that the content of the flavan-3-ols catechin and epicatechin in fruit skin decreased during storage. Similar results were found by Burda et al. (1990) and Golding et al. (2001), i.e. that, generally, the content levels of catechin and epicatechin increased in the first two months of storage, but later they gradually decreased or remained constant. During storage, the content of phloridzin in the pulp varied very little (Fig. 5-B), while in the skin its content increased in some varieties and decreased in others (Fig. 6-F). Napolitano et al. (2004) also found minimal oscillations in the phloridzin content level during apple storage. Golding et al. (2001) reported on an increase of the phloridzin content in the skin of 'Crofton' and 'Lady Williams' varieties during storage, while in the 'Granny Smith' variety its quantity during storage remained approximately at the same level or suffered a slight decline.

Among flavonols we determined the content of rutin and quercetin-3-rhamnoside (quercitrin). The content of quercetin-3-*O*-rutinoside (rutin), quercetin-3-*O*-

galactoside (hyperin) and quercetin-3-*O*-glucoside (isoquercitrin) was expressed as an equivalent of rutin. The content of rutin in the skin changed only slightly during storage (Fig. 7-A). Rutin was not identified in apple pulp. Similarly, the content of quercetin-3-rhamnoside changed only slightly during storage (Fig. 7-B). From the results it is evident that the content of both flavonoids, rutin and quercitrin, did not change essentially during storage, which was also reported by Golding et al. (2001).

In the apple pulp, the content of individual phenolic substances changed insignificantly during storage; consequently, the content of total phenols between the two dates changed very little, too. In the majority of varieties, the total phenols remained on a constant level in apple pulp (Fig. 5-G). In contrast, apple skin at edible maturity had a higher content of total phenols than the skin at technological maturity (Fig. 7-C). Leja et al. (2003) also reported a 30 % increase in total phenols in the skin of the 'Jonagold' and 'Shampion' apple varieties during storage. A particularly extreme increase in total phenols occurred in apples stored in an ordinary cold-storage chamber (0 ˚C, presence of air) with high ethylene production. The reason for the increase may be attributed to the fruit's respiration and ethylene synthesis (the synthesis is particularly strong at higher temperatures), which stimulate the activity of the enzyme phenylalanine ammonia-lyase (PAL) (Perez-Ilzarbe et al., 1997). Interestingly, the content levels of all analyzed phenols in the peel of the 'Golden Delicious' cultivar declined between technological and edible maturity.

Antioxidant activity of pulp increased from technological to edible maturity in certain varieties and decreased in others. Only two differences between the two dates were calculated (Fig. 5-D). Napolitano et al. (2004) reported a significant increase in the antioxidant activity of apple pulp after 3 months of storage. This increase is related to the increase of catechin and phloridzin concentrations in apple pulp. Antioxidant activity of skin increased in all varieties during storage (Fig. 7-D). Leja et al. (2003) indicated that the antioxidant activity doubled during the four-month storage period. The reason for the increase in antioxidant activity is attributed to a higher content of total phenols.

From the results for changes in sugars, organic acids and phenolic substances during storage, no significant differences emerge between the varieties resistant to apple scab and those susceptible to it. Therefore, it cannot be claimed that a connection exists between resistance to apple scab and the dynamics of change in phenolic compounds in apples during storage. The content levels of total sugars and total phenolics in apple pulp changed only slightly over the storage period. In contrast, the apple peel at edible maturity usually has a higher content level of total phenolics than the peel at the time of technological maturity. Hence, the antioxidant activity of peel increased during storage.

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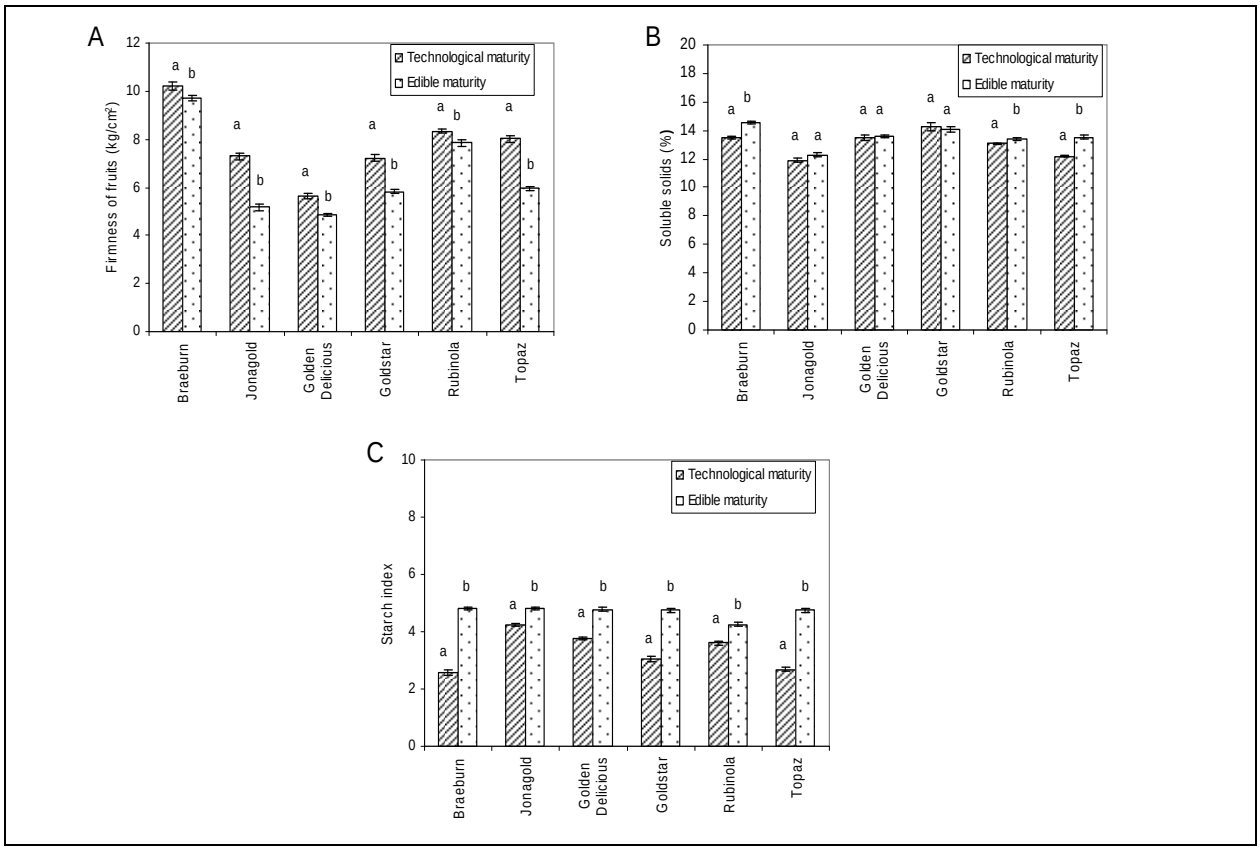

***Figure 1**: Changes in fruit firmness, soluble solids and starch index of fruit in various apple cultivars during storage.*

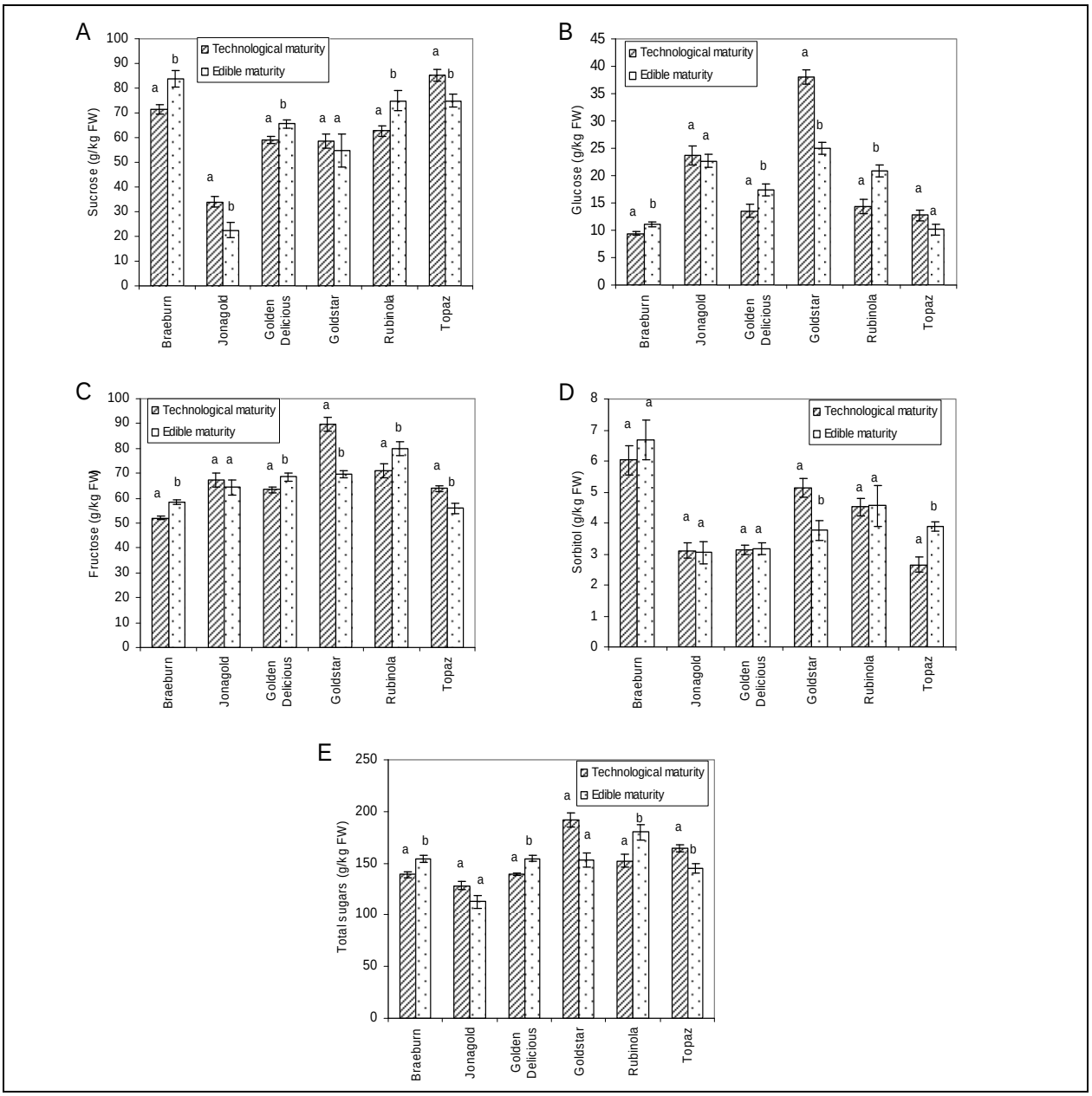

***Figure 2**: Changes in the sucrose, glucose, fructose, sorbitol and total sugars content (g/kg FW) of fruit in various apple cultivars during storage.*

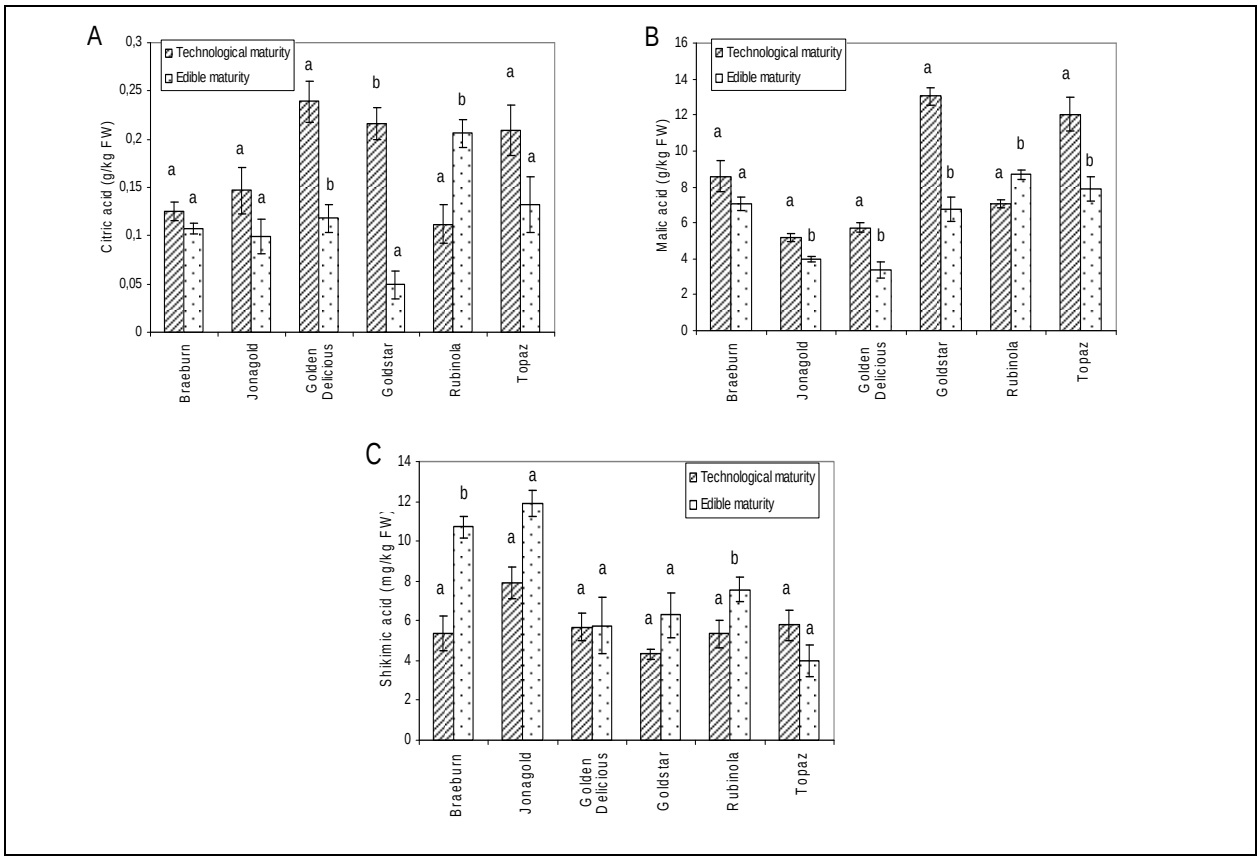

***Figure 3**: Changes in the content of citric, malic (g/kg FW) and shikimic acids (mg/kg FW) in fruit of various apple cultivars during storage.*

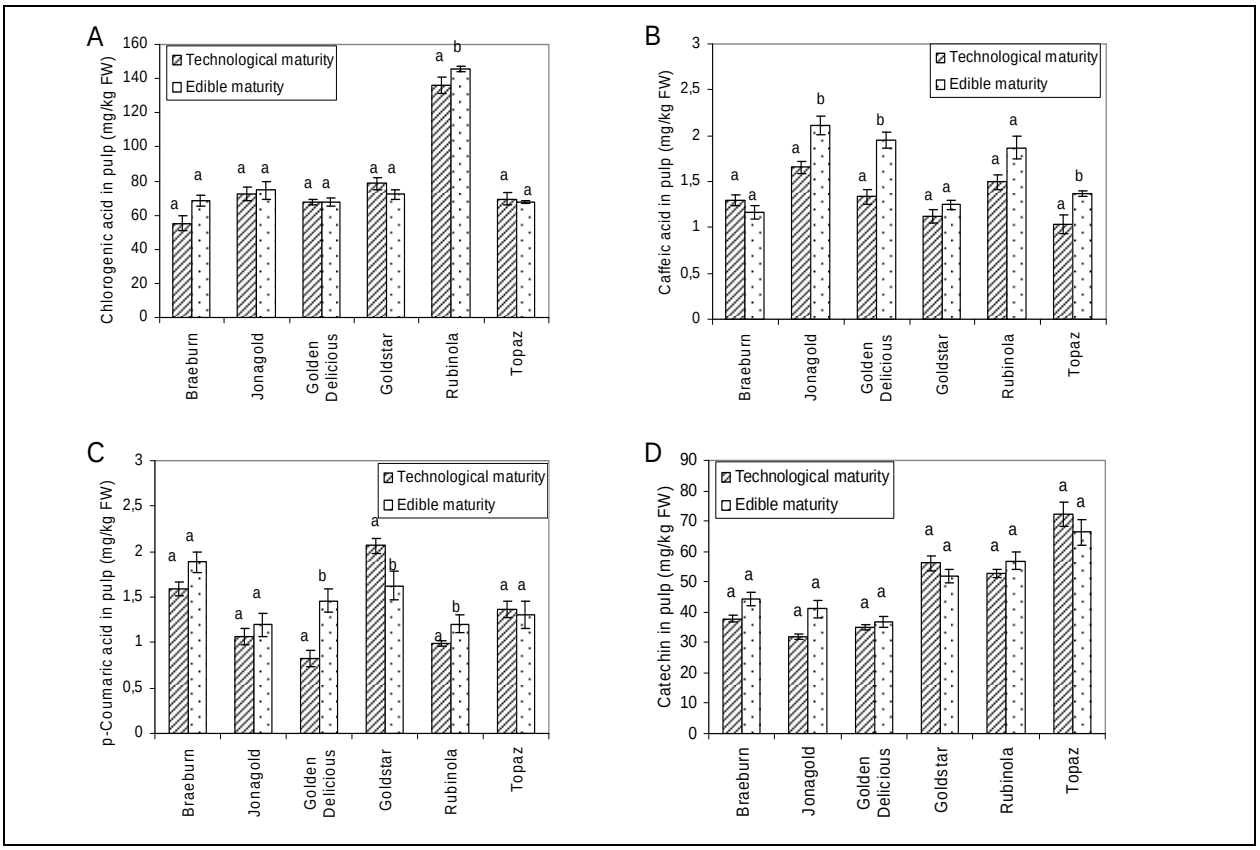

Figure 4: *Changes in the content of single phenolics (mg/kg FW) in the pulp of various apple cultivars during storage.*

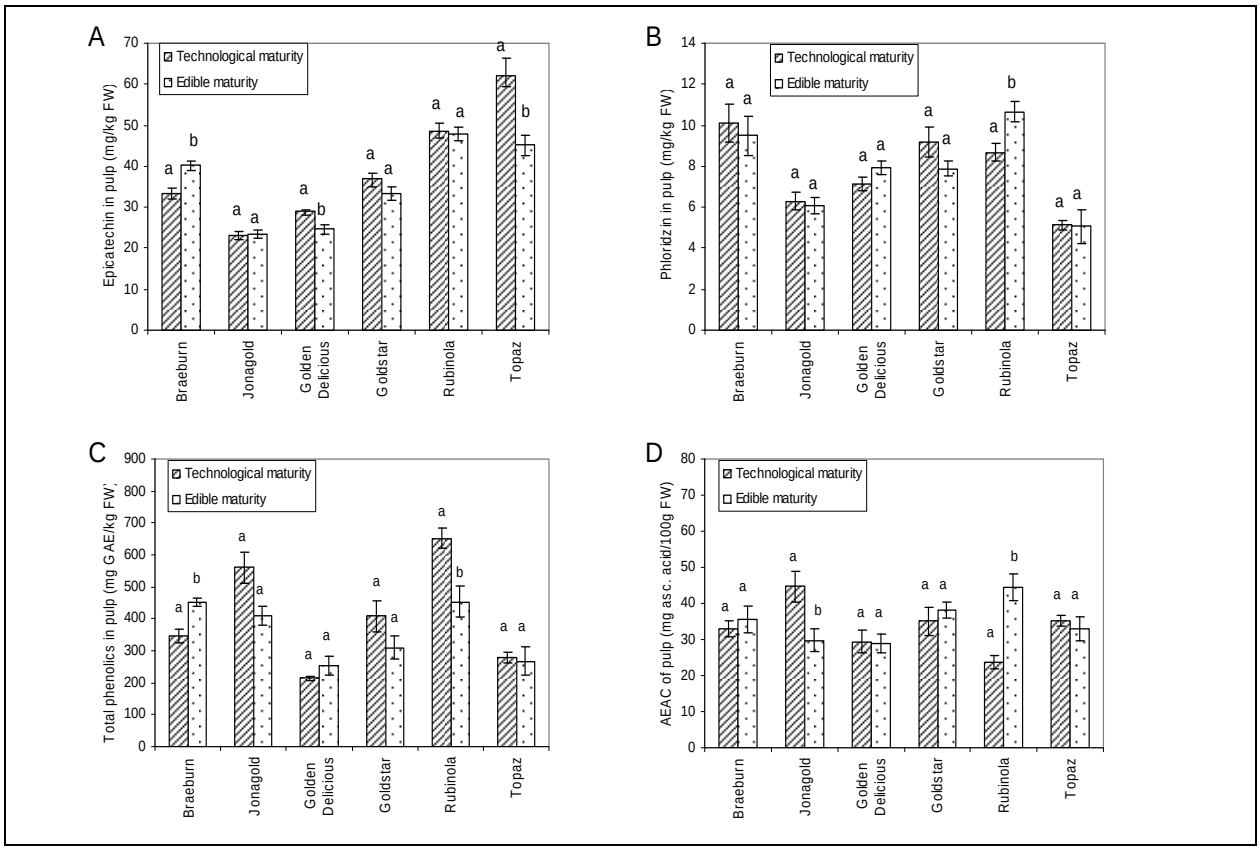

***Figure 5**: Changes in the content of single phenolics (mg/kg FW), total phenolics (mg GAE/kg FW) and antioxidant activity (mg/100g FW) in the pulp of various apple cultivars during storage.*

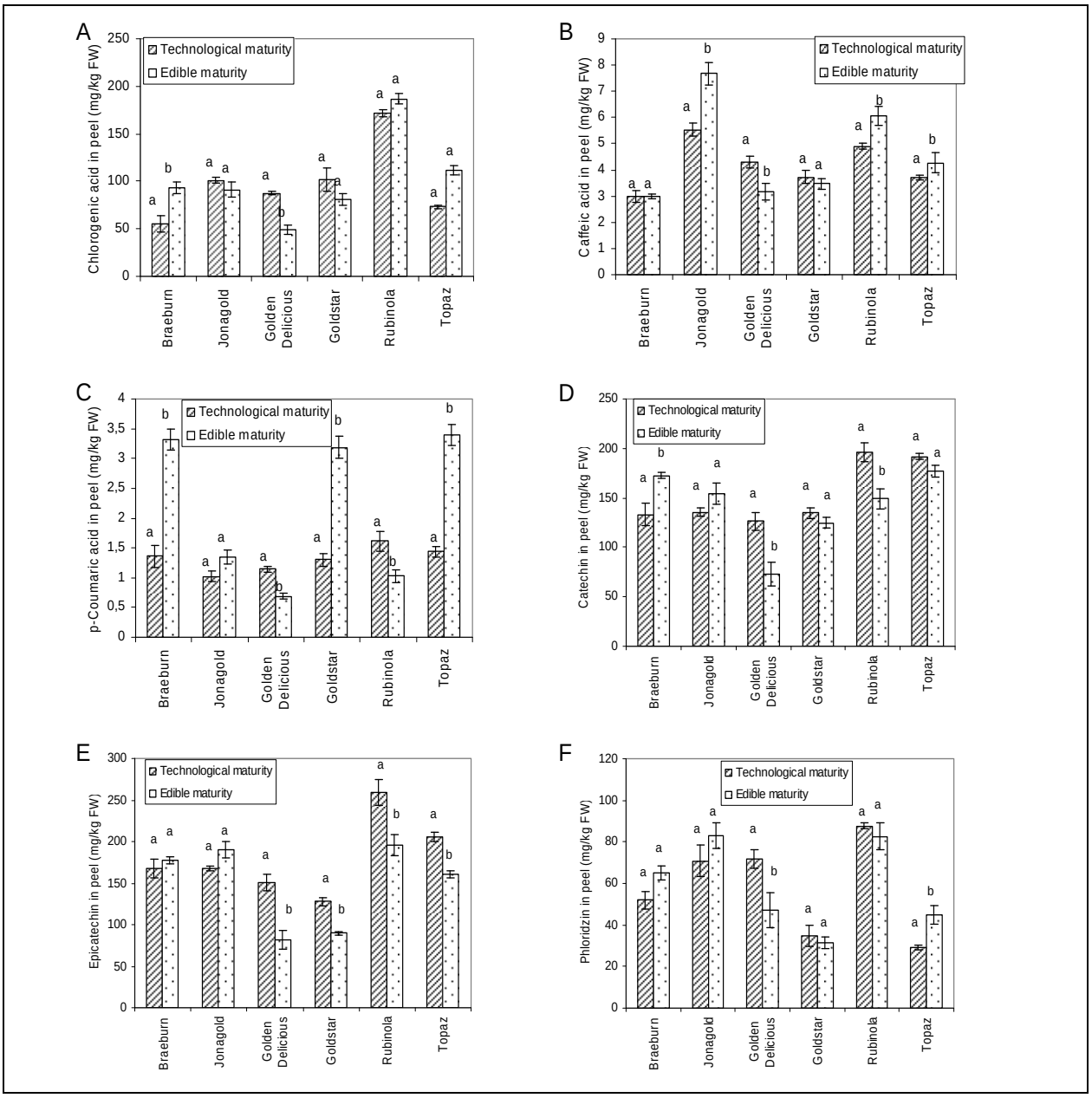

***Figure 6**: Changes in the content of single phenolics (mg/kg FW) in the peel of various apple cultivars during storage.*

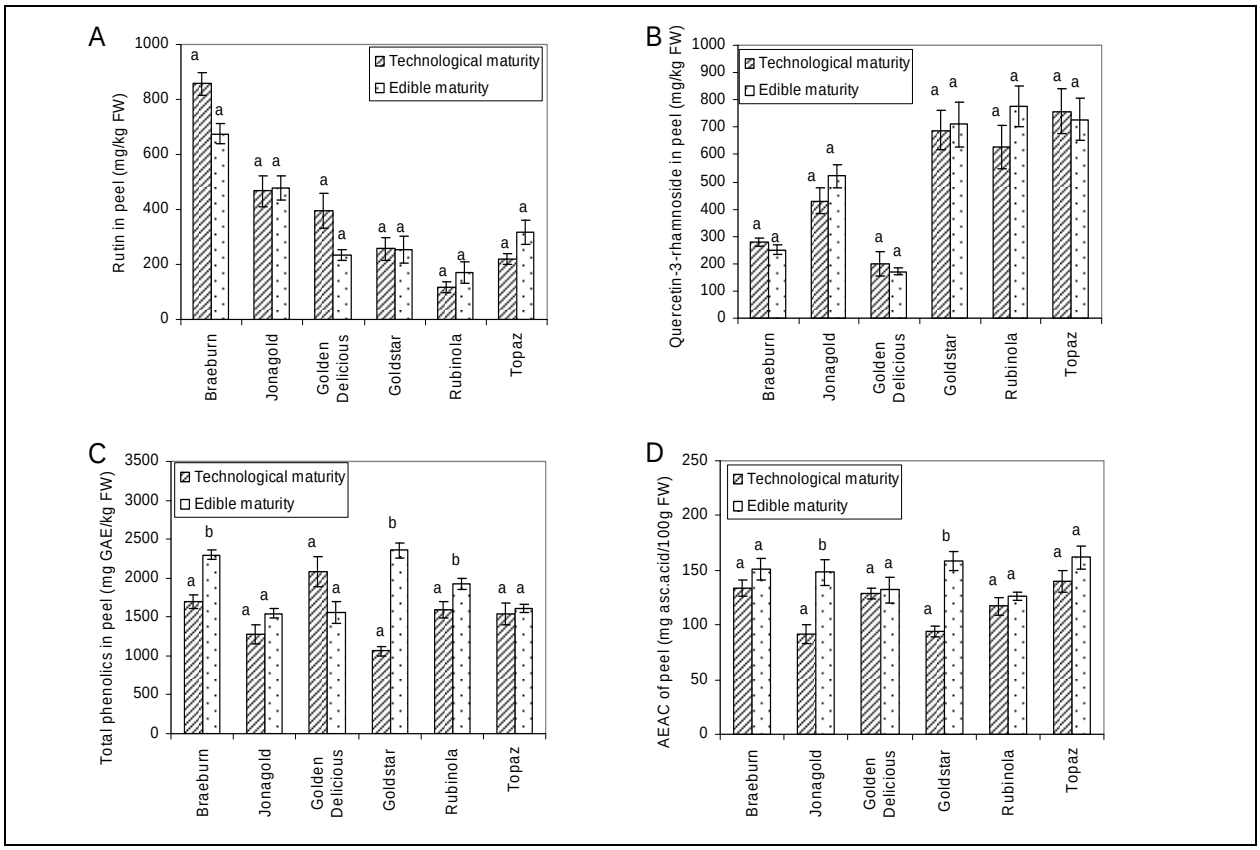

***Figure 7**: Changes in the content of single phenolics (mg/kg FW), total phenolics (mg GAE/kg FW) and antioxidant activity (mg/100g FW) in the peel of various apple cultivars during storage.*

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Insecticidal activity of four different substances against larvae and adults of sycamore lace bug (*Corythucha ciliata* [Say], Heteroptera, Tingidae)

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ABSTRACT

In a paper the results of insecticidal activity of two known insecticides (deltamethrin and imidacloprid), thujone and essential oil of rosemary against the larvae and adults of sycamore lace bug (*Corythucha ciliata*) are presented. The experiment was conducted in a laboratory, under room conditions. We tested the activity of each product in three different concentrations. The most desirable insecticidal activity had deltamethrin, which caused almost 100 % mortality of both developmental stages of the pest at all three concentrations. Succeeding products were imidacloprid, which caused 89.6 % larval mortality at recommended concentration, and essential oil of rosemary, which caused 81.7 % adult mortality at 1 % concentration. Larvae of sycamore lace bug were significantly more susceptible to tested products than adults. Significantly the lowest mortality was determined one day after treatment (41.7 %), while the highest mortality was stated three days after treatment (71.3 %). For future reduction of the damage caused by the studied pest on plane trees, we recommend the application of thujone and essential oil of rosemary, which appeared to be environmentally more acceptable substances. In our study both agents showed a middle satisfying activity in controlling larvae and adults, but they have also obvious repellent activity, which leads to their better efficacy in the open.

Key words: *Corythucha ciliata*, sycamore lace bug, rosemary, thujone, imidacloprid, deltamethrin, efficacy, mortality, larvae, adults, laboratory testing

INSEKTICIDNO DELOVANJE ŠTIRIH SNOVI NA LIČINKE IN ODRASLE OSEBKE PLATANOVE ČIPKARKE (*Corythucha ciliata* [Say], Heteroptera, Tingidae)

IZVLEČEK

V prispevku so predstavljeni rezultati insekticidnega delovanja dveh znanih insekticidov (deltametrin in imidakloprid), tujona in eteričnega olja rožmarina na ličinke in odrasle osebke platanove čipkarke (*Corythucha ciliata*). Poskus je bil opravljen v laboratoriju, v sobnih razmerah. Učinkovitost vsakega od pripravkov smo ugotavljali pri treh različnih koncentracijah. Najboljše insekticidno delovanje je imel deltametrin, ki je pri vseh koncentracijah povzročil skoraj 100 % smrtnost obeh razvojnih stadijev škodljivca. Sledi mu imidakloprid, ki je pri priporočeni koncentraciji povzročil 89,6 % smrtnost ličink in eterično olje rožmarina, ki je pri 1 % koncentraciji povzročilo 81,7 % smrtnost odraslih osebkov. Ličinke platanove čipkarke so bile signifikantno bolj občutljive na preizkušane pripravke kot odrasli osebki. Signifikantno najmanjšo smrtnost smo ugotovili prvi dan po tretiranju (41,7 %), največjo pa tretji dan po tretiranju (71,3 %). Za prihodnje zmanjševanje škodljivosti preučevane žuželke na platanah pa priporočamo uporabo tujona in eteričnega olja rožmarina, ki sta okoljsko sprejemljivejši snovi. Obe sta v našem poskusu pokazali srednje zadovoljivo delovanje na ličinke in odrasle osebke, a imata tudi dokazano repelentno delovanje, s čimer lahko na prostem pričakujemo njuno boljšo učinkovitost.

Ključne besede: *Corythucha ciliata*, platanova čipkarka, rožmarin, tujon, imidakloprid, deltametrin, učinkovitost, smrtnost, ličinke, odrasli osebki, laboratorijsko preizkušanje

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1 INTRODUCTION

The native land of sycamore lace bug (*Corythucha ciliata* [Say], Heteroptera, Tingidae) is North America. This insect species was the most probably introduced into Europe over the port Genova in Italy (Őszi *et al*., 2005) and its appearance on plane trees in Old continent is stated since 1964 (Maceljski, 1985). In Slovenia, this species was for the first time recorded in 1975 (Gogala, 1981/82). Nowadays, it is generally spread on plane trees all over the country. The bug was the most damaging in the eighties of previous century, but todays the range of its noxiousness is somewhat smaller due to natural enemies (Milevoj, 2004).

Adult is less than 4 mm in lenght. The broadened areas around and behind the head and the wing covers are partially transparent and gauze- or lace-like in structure. The wings are usually partially transparent. The swarming starts at the end of April or in the beginning of May and in favourable conditions the females can stay active till December. Females lay eggs of first generation on leaves already one week after swarming started, eggs of the second generation are laid at the end of June or at the start of July, and eggs of the third generation are laid along with favourable weather conditions in August or September. They overwinter as adults under loose bark of plane trees, leaf litter and crevices, and tolerate extreme temperatures as low as -24 ºC (Jurc, 2005).

The adults of sycamore lace bug feed on the undersides of leaves with sucking juice, causing dessication of tissue, first near the veins, and subsequently affecting the entire leaf, which may drop prematurely. They produce droplets of liquid frass, which dry out as black spots on the lower surface of the leaves. Beside black excrements also many dark larvae and their casts can be found on the undersides of the leaves (Jurc, 2005). In addition to damaging trees with sucking plant juice and as such weakening them, the sycamore lace bug has become a major nuisance in Europe, as plane tree is a very popular shade tree in parks. And if trees are bothersome with this pest also aesthetic look suffers (Maceljski, 1995). In Europe sycamore lace bug feeds on American plane tree (*Platanus occidentalis* L.), Hybrid plane tree (*P.* x *hispanica* Muenchh.) and in minor extent also on Oriental plane tree (*P. orientalis* L.) (Jurc, 2005). In late summer or in autumn the feeding damage of sycamore lace bug is the most apparent on the upper surface of the leaves, initially causing a white stippling that can eventually progress into chlorotic or bronzed foliage and premature loss of leaves. In cases of severe infestations, trees may be defoliated in late summer. The bug has several natural enemies, which can reduce its numerousness during the growing period. Control of sycamore lace bug in foreign countries is related first of all to treat the barks in autumn or in early spring with the aim to supress the overwintering adults (Halbert and Meeker, 2001).

Rosemary (*Rosmarinus officinalis* L.) is evergreen Mediterranean shrub from the mint family (Lamiaceae). It is used in culinary, medicine and cosmetic industry (Petauer, 1993). Essential oil of rosemary acts as a repellent to insects (Thorsell *et al*., 1970; Hori, 1998; Amer *et al.*, 2001; JiSen and ErrLieh, 2005), toxically or contact insecticidal (Padin *et al*., 2000; Amer *et al*., 2001; Papachristos and Stamopoulos, 2002; Isman, 2008) and reduce oviposition and feeding (Dover, 1985). Some constituents, which are in rosemary essential oil, are in a number of commercial insecticides (Isman, 2008).

Thujone is a cyclic ketone and an active component of essential oils (Petauer, 1993). It can be found in many plant species, such as: absinthium (*Artemisia absinthium* L.), common wormwood (*A. vulgaris* L.), common sage (*Salvia officinalis* L.), clary sage (*S. sclarea* L.), tansy (*Tanacetum vulgare* L.) and northern whitecedar (*Thuja occidentalis* L.) (Albert-Puleo, 1978). The name to this substance was given after the northern whitecedar from which it was extracted for the first time (Patočka and Plucarb, 2003). Thujone acts as a repellent agents to insects (Alfaro *et al*., 1981; Hwang *et al*.., 1985). SangKyun *et al*. (1997) confirmed high mortality of the western corn rootworm larvae due to acute poisoning with thujone. Beside previous charasteristic, thujone has also antibacterial properties (Nin *et al*., 1995).

The aim of our research was to study the activity of two synthetic insecticides (deltamethrin and imidacloprid), which application in other countries is advised when controling sycamore lace bug on plane trees (Kukedi and Palmai, 1992; Marchetti, 2003). At the same time we wanted to compare their efficacy with two environmentally acceptable products (rosemary and thujone). In case if the efficacy of natural products would be at least comparable to the efficacy of synthetic insecticides, we would have a good basis for the implementation of environmentally friendly products into strategy of controling sycamore lace bug. This step could contribute to protection of the environment in which we live.

2 EKOFIZIOLOŠKA VLOGA AM GLIV

AM glive so zelo pomembne pri kroženju hranil in ogljika v naravi, čeprav zaradi kompleksnosti in omejenega poznavanja njihova vloga v tem kontekstu pogosto ni zadosti upoštevana. Pri arbuskularni mikorizi se običajno pojavlja mutualističen tip simbioze, odnos, kjer je glivni partner energetsko povsem odvisen od gostiteljskih rastlin (biotrof), saj je preskrba glive z ogljikovimi hidrati popolnoma vezana na gostitelje. V zameno za rastlinske asimilate AM glive preskrbujejo rastline z mineralnimi hranili. Fosfatni ioni v tleh pogosto tvorijo netopne spojine z večino kationov (Al^{3+}, Fe^{3+}, Ca^{2+}) in tako postanejo za rastlinske korenine težko dostopni. Ker je fosfor v tleh zelo slabo mobilen element, pogosto predstavlja omejujoč dejavnik rasti rastlin. V nasprotju s prepričanjem izpred nekaj let, je v zadnjem času vedno več dokazov, da lahko poleg preskrbe s fosforjem AM glive vplivajo tudi na preskrbo rastlin z drugimi hranili, z mikroelementi (Cu, Zn) ter kot kaže tudi z dušikom. Z uporabo stabilnih izotopov dušika in ogljika ($^{15}N/^{13}C$) so ugotovili, da lahko kolonizacija z AM glivo *Glomus hoi* obenem vpliva na razgradnjo organske snovi v tleh ter poveča privzem dušika v rastlino iz organskega materiala (opad trav) (Hodge in sod., 2001), vendar pri teh procesih še ni poznana vloga drugih talnih mikroorganizmov pri razgradnji organskega materiala (Smith in Read, 2008). Podobno Govindarajulu in sod. (2005) poročajo o novo odkriti presnovni poti AM gliv, ki vključuje vgradnjo anorganskega dušika v aminokislino arginin znotraj zunajkoreninskega micelija in asimilacijo dušika v rastlino preko znotrajkoreninskega micelija ob razgradnji arginina. Izboljšana preskrba rastlin s hranili je najbolj izpostavljena vloga glive v mikorizi, poleg te pa ima simbioza rastlin z AM glivami še druge pozitivne učinke (Smith in Read, 2008) kot so izboljšana preskrba rastlin z vodo, varovanje pred patogeni in boleznimi, varovanje pred škodljivimi snovmi (npr. težke kovine), dokazana pa je tudi vloga zunajkoreninskega micelija in kot kaže tudi nekaterih produktov AM gliv (npr. glomalina) pri stabilizaciji strukturnih agregatov tal (Wright in Upadhyaya, 1998) ter s tem pozitiven vpliv na strukturo in rodovitnost tal.

2 MATERIALS AND METHODS

The experiment in which we studied insecticidal activity of two synthetic insecticides (deltamethrin and imidacloprid) and two plant substances (essential oil of rosemary and thujone) against the larvae and adults of sycamore lace bug was carried out in 2008 in Entomological Laboratory of the Chair of Phytomedicine, Agricultural Engeeniring, Crop Production, Grassland and Pasture Management (Dept. of Agronomy, Biotechnical Faculty) in Ljubljana. We used the following products: contact insecticide Decis 2.5 EC (manufacturer: Bayer CropScience SA, Lyon, France; active ingredient deltamethrin 25 g/l), systemic insecticide Confidor SL 200 (manufacturer: Bayer CropScience, Monheim, Germany; active ingredient imidacloprid 200 g/l), α+β-thujone technical (manufacturer: Sigma-Aldrich, Buchs, Switzerland) and essential oil of rosemary (distributor: Ars Trade, Trzin, origin Tunisia). Larvae and adults of sycamore lace bug were collected from the leaves of Hybrid plane trees (*Platanus* x *hispanica* Muenchh.) in Ljubljana. From the same trees also undamaged leaves were collected. They were used later in the experiment in a Petri dishes.

We conducted the experiment at room conditions (22±2 °C, natural sunlight). We applied products Decis 2.5 EC and Confidor SL 200 at following concentrations: 50 % (one half of recommended dose for sucking insects, stated in instructions for use), 100 % (recommended dose for sucking insects, stated in instructions for use) and 200 % (double recommended dose for sucking insects, stated in instructions for use). Recommended dose of insecticide Decis 2.5 EC is 0.04 % for sucking insects and for Confidor 200 SL the same dose is 0.05 %. For thujone and essential oil of rosemary we applied concentrations, which showed in our preliminary experiments to be appropriate and so we set concentrations for thujone at 0.01 %, 0.1 % and 1 % and for essential oil of rosemary at 0.1. %, 0.5 % and 1 %. We selected these concentrations on the basis of insecticidal activity ob both substances on other studied pests and their phytotoxicity. For better mixing of thujone and essential oil of rosemary with water we used sticky extending agent Nu-Film-17 (manufacturer: Lances Link SA, Geneva, Switzerland, active ingredient di-1-p-menthen 96 %).

We carried out the experiment in plastic Petri dishes, which were 14 cm in diameter. We put a filter paper (manufacturer: Tosama d.d., Vir, Slovenia) on the bottom of each Petri dish and above a leaf of Hybrid plane tree was laid. In treatment with Confidor SL 200 we first soaked leaves of plane tree in a solution with a appropriate concentration of insecticide, allowed leaves to dry up and only then we put 10 larvae or 10 adults of studied pest in individual Petri dish. In other treatments we laid first in each Petri dish 10 larvae or 10 adults and only then used hand sprayer and sprayed leaves according to concentrations. In control (untreated) Petri dishes we only soaked leaves in water. Each treatment in an experiment was repeated ten times.

We assessed larval and adult mortality of sycamore lace bug one, two and three days after exposure to the substances with counting dead specimen. The results were adjusted with Abbott's formula for corrected mortality (Abbott, 1925). We evaluated results of corrected mortality (analysis of variance, Duncan's multiple range test, $P \leq 0.05$) with Statgraphics Plus for Windows 4.0 software and for graph displays we used MS Office Excel 2003.

3 RESULTS WITH DISCUSSION

Pooled statistical analysis showed that larval and adult mortality were significantly influenced by day after treatment ($P < 0.0001$), substance ($P < 0.0001$) and their concentration ($P < 0.0001$). Significantly the highest mortality was caused by insecticide Decis 2.5 EC (97.4 ± 0.5 %), followed by α+β-Thujone (49.5 ± 1.9 %). Significantly the lowest mortality caused essential oil of rosemary (40.4 ± 2.1 %) and insecticide Confidor SL 200 (39.1 ± 1.9 %). We determined significantly the lowest mortality first day after treatment (41.7 ± 2.2 %) and the highest mortality third day after treatment (71.3 ± 1.7 %). Sycamore lace bug larvae were significantly more susceptible to tested substances (62.4 ± 1.4 % mortality) than adults (50.8 ± 1.8 %).

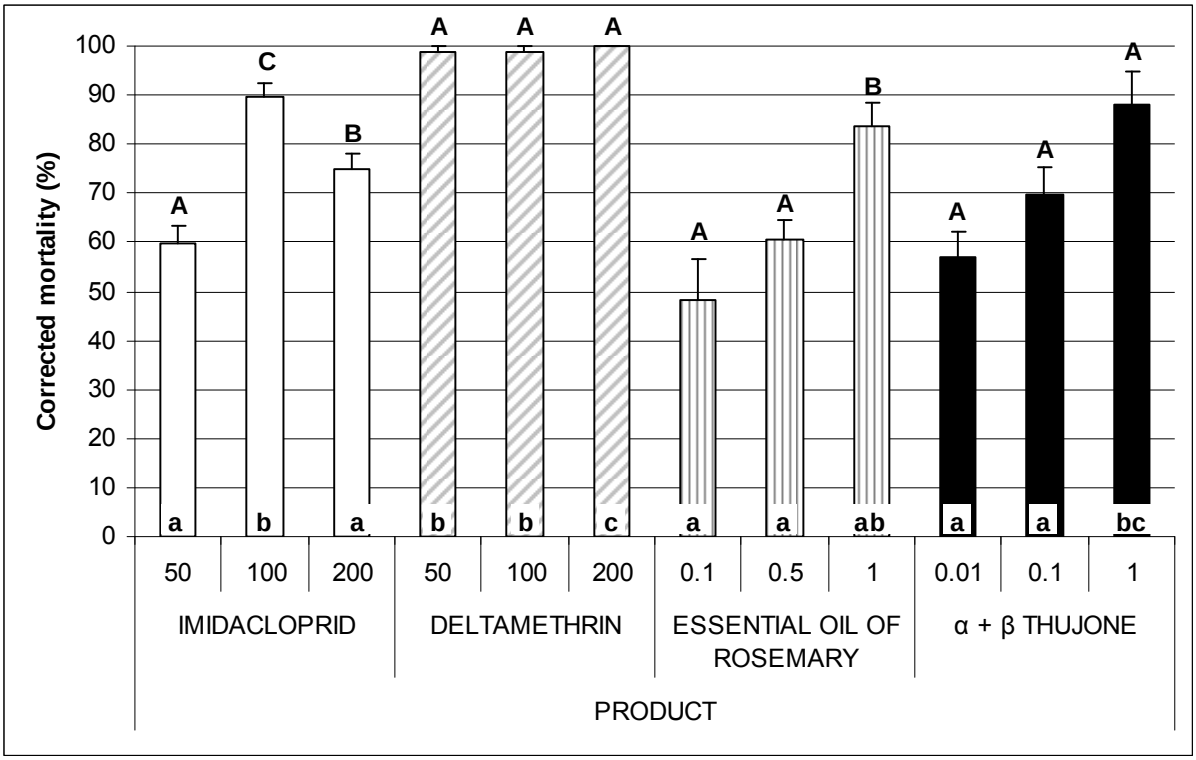

***Figure 1**: Percentage of larval mortality of sycamore lace bug (Corythucha ciliata [Say]) regarding the product and their concentrations three days after treatment. Different capital letters correspond to statistically significant differences between different concentrations within each substance and lower-case letters correspond to statistically significant differences between comparable concentrations of different substancess (Duncan's multiple range test, P ≤ 0.05). Values 50, 100 and 200 denote to one-half, recommended and double recommended concentration of substances and values 0.01, 0.1, 0.5 and 1 denote to concentrations of the substances. All values are expressed as precentage.*

For the time being there are no registered insecticides for controlling sycamore lace bug in Slovenia, although they cause damage on plane trees all over the country. In Hungary, they recommend spraying of tree trunks with deltamethrin in March as a control method (Kukedi in Palmai, 1992). Also in our experiment deltamethrin caused the highest mortality of larvae and adults of sycamore lace bug; already for a half lower concentration from that which is recommended for sucking insects, namely caused almost total mortality of exposed individuals (98.8 ± 1.2 % mortality by larvae and 98.9 ± 1.1 % mortality by adults) (Figs. 1 and 2).

In North America more measures in controlling sycamore lace bug are known among which also an application of systemic insecticide, which is applied into the soil or injected into the bark, is known (Halbert and Meeker 2001). Systemic insecticide imidacloprid was also used in our experiment, however, it did not showed such an efficacy as contact insecticide deltamethrin. Highest mortality, which was caused by Confidor, was besides recommended concentration for

sucking insect attained by larvae at 89.6 ± 2.7 % and by adults at 59.1 ± 5.1 %. At double recommended concentration the mortality was surprisingly lower (larvae at 74.8 ± 3.3 % and adults at 49.4 ± 4.6 %). We attribute this result to repellent activity of the product in such a high concentration to studied pest. Suchlike individuals fed less intensive or avoided to treated surface. For these two reasons their mortality was lower.

Essential oil of rosemary was generally observed as effective as systemic insecticide imidacloprid; satisfying enough at concentration of 1 % it controlled larvae (83.6 ± 4.8 % mortality) and adults (81.7 ± 5.5 % mortality). We did not find statistically significant differences between thujone and essential oil in their efficacy at 1 % concentration. Thujone controlled larvae and adults similar as rosemary, and former substance at 1 % concentration caused 88.1 ± 6.6 % larval mortality and 76.2 ± 4.8 % adult mortality.

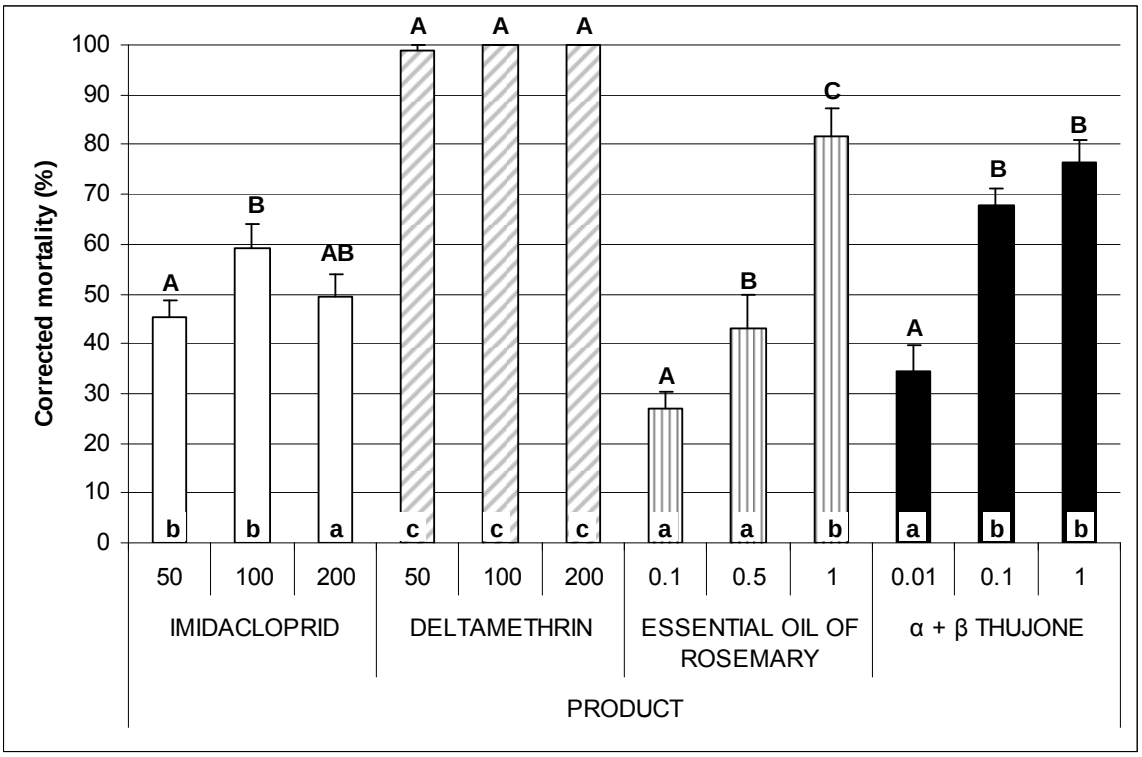

***Figure 2**: Percentage of adult mortality of sycamore lace bug (Corythucha ciliata [Say]) regarding the product and their concentrations three days after treatment. Different capital letters correspond to statistically significant differences between different concentrations within each substance and lower-case letters correspond to statistically significant differences between comparable concentrations of different substance (Duncan's multiple range test, $P \leq 0.05$). Values 50, 100 and 200 denote to one-half, recommended and double recommended concentration of substances and values 0.01, 0.1, 0.5 and 1 denote to concentrations of the substances. All values are expressed as precentage.*

For controlling sycamore lace bug in the near by future there should be used environmentally acceptable measures, yet spraying of tall trees such as plane trees are in urban area is less and less desired and also costly when taking into account the efficacy (Halbert and Meeker 2001).

Among environmentally acceptable approach belong also raking and destroying of defoliated leaves in autumn and peeling off senescened layer of bark in November (Kukedi and Palmai, 1992). Thujone and essential oil of rosemary, which have among others also repellent activity to insects (Hwang *et al*., 1985; Hori, 1998), could be applied on/under the bark of plane trees in autumn time usually before adults start to find the place to overwinter. In such a way mentioned substances, which showed in our experiment also middle satisfying activity in controlling larvae and adults of sycamore lace bug, could diverted them from places appropriate for overwintering and their number would diminished. At the same time the bark from previous years, which has beautiful and decorative appearance, could stay.

4 ACKNOWLEDGEMENT

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First record of a cold-active entomopathogenic nematode *Steinernema kraussei* (Steiner) (Rhabditida: Steinernematidae) in Slovenia

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ABSTRACT

In preceding researches on occurrence of entomopathogenic nematodes in Slovenia, which started in 2007, we already recorded *Steinernema affine* (Bovien), *S. feltiae* (Filipjev) and *S. carpocapsae* (Weiser). In April 2008, 120 soil samples from 24 locations were collected in Gorenjska, Notranjska and Primorska regions as well as in Ljubljansko barje. The presence of entomopathogenic nematodes was confirmed in 9 samples from 6 locations. Only the sample C46, which was taken in the village Podbrezje in Gorenjska region, was sent to genetic analysis. Molecular biological analysis have proved the identity of the sample with the species *Steinernema kraussei* (Steiner). This was the first record of *Steinernema kraussei* in Slovenia.

Key words: entomopathogenic nematodes, Slovenia, *Steinernema affine*, *Steinernema feltiae*, *Steinernema carpocapsae*, *Steinernema kraussei*, biological control

IZVLEČEK

PRVA NAJDBA ENTOMOPATOGENE OGORČICE *Steinernema kraussei* (Steiner) (Rhabditida: Steinernematidae) V SLOVENIJI

V predhodnih raziskavah preučevanja razširjenosti entomopatogenih ogorčic v Sloveniji, ki potekajo od leta 2007, smo ugotovili zastopanost vrst *Steinernema affine* (Bovien), *Steinernema feltiae* (Filipjev) in *Steinernema carpocapsae* (Weiser). V aprilu 2008 smo na območjih Gorenjske, Notranjske, Primorske in Ljubljanskega barja na 24 lokacijah nabrali 120 talnih vzorcev. Zastopanost entomopatogenih ogorčic smo ugotovili v 9 vzorcih z 6 lokacij. V nadaljnjo genetsko analizo smo poslali le vzorec C46. Ta je bil odvzet v vasi Podbrezje na Gorenjskem. Z molekulsko analizo smo identificirali vrsto *Steinernema kraussei* (Steiner). Gre za prvo odkritje omenjene vrste entomopatogene ogorčice pri nas.

Ključne besede: entomopatogene ogorčice, Slovenija, *Steinernema affine*, *Steinernema feltiae*, *Steinernema carpocapsae*, *Steinernema kraussei*, biotično varstvo

1 INTRODUCTION

Entomopathogenic nematodes (EPNs) from genera *Steinernema* Travassos and *Heterorhabditis* Poinar are obligatory parasites of numerous insects (Ishibashi and Choi, 1991). They live in symbiotic relationship with bacteria from genera *Xenorhabdus* and *Photorhabdus* (Forst *et al*., 1997). Momentarily, 70 species of EPNs

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are classified into families Steinernematidae (56 species) and Heterorhabditidae (14 species) (Yilmaz et al., 2008).

EPNs are cosmopolitan animals, while we can find them on all continents, with the exception of Antarctica (Griffin et al., 1991; Hominick, 2002). Although EPNs are pathogenic to many pest insect species (Poinar, 1979), their successful commercial application is limited to relatively low number of insects (Grewal and Georgis, 1999; Shapiro-Ilan et al., 2002).

Application of EPNs in biological control was traditionally engaged in controlling soil pests until some years ago (Ishibashi and Choi, 1991). Results from researches in the last two decades indicate also their potential against foliar pests, but only under special conditions (Arthurs *et al*., 2004). Poorer efficacy of EPNs in controlling foliar pests is a consequence of unsuitable (too low) moisture (Lello *et al*., 1996), exposure to extreme temperatures (Grewal *et al*., 1994), and ultraviolet radiation (Gaugler and Boush, 1978). These factors are known as crucial for survival of the nematodes (Kaya, 1990). For this reason the efficacy of EPNs in the open is therefore often worser as expected, although predecessor laboratory tests shows rather better efficacy (Buitenhuis and Shipp, 2005).

In the last period biological potential of EPNs has influenced the large number of new investigations, in which scientists want to find new species of EPNs and their symbiotic bacteria (Hominick et al., 1996; Mráček et al., 2006; Nguyen et al., 2006; Tóth and Lakatos, 2008); with a desire to also study other topics, which are indirectly or directly connected with the efficiency of EPNs in biological control of insect pests: biodiversity, ecology, evolution, biochemistry, symbiosis and molecular genetics (Burnell in Stock, 2000; Li et al., 2007).

At the moment there are some companies on the market, which generate bioproducts on the basis of EPNs (Willmott et al., 2002). In biological control of pests in plant protection limited number of EPNs is commercialy available: *Steinernema feltiae, S. carpocapsae, S. kraussei, S. riobrave, S. scapterisci, Heterorhabditis bacteriophora in H. megidis H. marelata, H. zealandica*). Due to before mentioned facts, it is important to study domestic soil fauna on the occurrence of EPNs, while in many countries these organisms are treated as exotic organisms and therefore their application is limited to laboratory researches.

In Slovenia, momentarily only entomopathogenic nematodes *Steinernema feltiae* and *S. carpocapsae* have a status of indigenous species (MAFFab, 2008, Laznik et al., 2008bc); therefore only this two nematodes can be applied in the field. With the researches, which results we also present in this paper, we want to enlist as more species of entomopathogenic nematodes as it is possible, while in foreign countries they worth as alternatives to insecticides in controling pest insects. The strain C46 (*Steinernema kraussei*), which we present in a current paper, we plan to use in extensive experiments in the future; first in the laboratory and afterward, when its status will be administratively entrenched, also in the field.

2 MATERIALS AND METHODS

In April 2008, we examined 120 soil samples from 24 different locations on the occurrence of EPNs in Slovenia. The soil samples, five from each sampling place, were taken in Gorenjska, Notranjska and Primorska regions as well as in Ljubljansko barje. We used »*Galleria* bait method«, which is the most frequently used method for EPNs detection from soil. After the death of greater wax moth (*Galleria mellonella* [Linnaeus]) larvae, we dried cadavers for 12 days and put them in so-called »white trap« (Bedding and Akhurst, 1975) to separate the nematodes from death larvae. The suspension, which was acquired in this way, was used for artificial infection of the larvae of greater wax moth. Following procedure contained the use of centrifuge and 5 % concentration of sodium hypochlorate. The aim of this process was to acquire infective juveniles from the suspension. We confirmed the presence of the nematodes in 9 soil samples from 6 locations. Only 1 positive sample, C46 (taken in the forest near village Podbrezje in Gorenjska region [N Slovenia, 46°17′N, 14°16′E, 403 m alt.] was identified to this time.

3 RESULTS

To confirm the identification of isolated nematodes from larvae of wax moth, a selected sample was analysed by molecular biological approach. Genomic DNA was extracted from individual nematodes and PCR was performed to multiply ITS region using primers TW81 and AB28 after Hominick et al. (1997). PCR product were reisolated from 1 % TAE-buffered agarose gel using QIAquick Gel Extraction Kit (Qiagen, USA) (Fig. 1). Reisolated sample was sequenced in the laboratory of Biological Research Centre in Szeged,

Hungary. The sequence was submitted into GenBank public database (Accession Number: EU914856). Sample DNA sequence was compared to sequences of species *Steinernema* using BLAST search in National Centre for Biotechnology Information (NCBI) web site (www.ncbi.nlm.nih.gov). The sequences producing significant alignments and at least 99 % identity were derived from *Steinernema kraussei*: GenBank Accession No. AY230175 and AY171264 (Spiridonov *et al*., 2004) (Fig. 2).

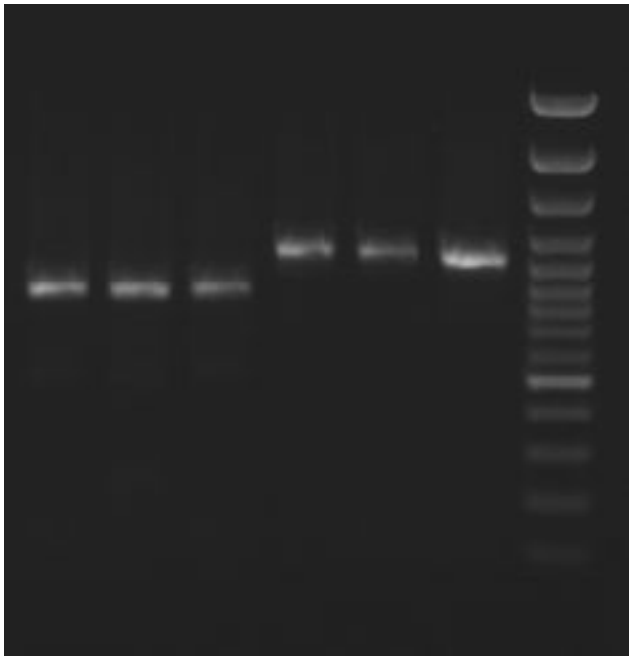

***Figure 1**: 1% TAE buffered agarose gel, in the 7th lane: GeneRuler 100 bp DNA Ladder Plus (Fermentas), in the 4th, 5th and 6th lane: PCR product of our sample C46, using the primer pair specified in the text. The two most strength fragment in the ladder are 500 and 1000 bps length.*

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EU914856  1    GAGCTTATCCATTT-CTTGGCTTCAAATGAATCGAGCTGAATC-TTTGCTG-TCTGTTTC  57
AY230175  195  ..............A.....A.....................-.......-.T......  252
AY171264  3    ..............A.....A.....................-.......-.T......  60
DQ375757  175  ..............A.....A.....................G.......-.T...C..  233

EU914856  58   GAAGCGATGTATTCTCTCAACAAACGGCTATGAAGGGTTTCTGTAGGTGTCTGGAGCAGT  117
AY230175  253  ............................................................  312
AY171264  61   ............................................................  120
DQ375757  234  ..G..A............T.T...........T.......A.................  293

EU914856  118  TGTATGTGCGTGACTGTGGTGATG-GACATTTGAGTTCTTCTGGAACTAGAATTAAAGAA  176
AY230175  313  ......................-.............................. .....  371
AY171264  121  ......................-.............................. .....  179
DQ375757  294  ......A..............-.............G.-.-.............. .....  350

EU914856  177  GTCTGTTACGACTCGCCGTTCTT-AAAAAACTTCAATTAACGTTTGAACAATTTGACTGC  235
AY230175  372  ......................-.............................. .....  430
AY171264  180  .....C...............-.............................. .....  238
DQ375757  351  .....A..............A.....................T..........  410

EU914856  236  ACCAGCCGTAGGTGTAATTAAAGATTTATCAAGTCTTGTCGGTGGATCACTCGGTTCGTA  295
AY230175  431  ............................................................  490
AY171264  239  ............................................................  298
DQ375757  411  ..............C.............................................  470

EU914856  296  GTTCGATGAAAAACGGGGCAAAAACCGTTATTTGGCGTGAATTGCAGACATATTGAACGC  355
AY230175  491  ............................................................  550
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AY171264  299  ..........................................................  358
DQ375757  471  ..........................................................  530

EU914856  356  TAAAATTTTGAACGCAAATGGCACTATCAGGTTTATATCTGTTAGTATGTTTGGTTGAGG  415
AY230175  551  ..........................................................  610
AY171264  359  ..........................................................  418
DQ375757  531  ..........................................................  590

EU914856  416  GTCGATTAATTCGTAACTTGCAGTCCGCCGTGNCTGTTCTTTC-GATCAGCTACTTGATC  474
AY230175  611  ............................A.........-.................  669
AY171264  419  ............................A.........-.................  477
DQ375757  591  ......................T..T...A.....-....C...T..T....C...-  648

EU914856  475  TG--------C---ATTGCTGATCGAGTACCTGT-TAGGTATGTGAACTTTTGATAGTCT  522
AY230175  670  ..---------.---...................-.......................  717
AY171264  478  ..---------.---...................-.......................  525
DQ375757  649  ..G-------.-----.C.................-.C...........-...........  695

EU914856  523  AATTCGTTTCTTA---A--T------GT-----A---A--CGAGCTATCTTTGAATTCTG  561
AY230175  718  ..............---.--.------..-----.---.--.....................  756
AY171264  526  ..............---.--.------..-----.---.--.....................  564
DQ375757  696  ..........C..---.--.C-----.A-----.---.--.....................  735

EU914856  562  -TGCTTTGTATA-TTTGGTGTTT------CGGCGCGTTTCTTGCCGACTGAAT-TGTACG  612
AY230175  757  -...........-.........------.........................-......  807
AY171264  565  -...........-.........------.........................-......  615
DQ375757  736  G...G......C-.........------.........................-.C......  787

EU914856  613  GACGTAACAGTACGTATAT-GCTTCAATTT-AT-T---CAGATG-CCCT-AATG-TTACA  663
AY230175  808  ..................-.........-..-.---......-....-....-.....  858
AY171264  616  ..................-.........-..-.---......-....-....-.....  666
DQ375757  788  ----------.......-.........G.----------.....-T.-.C....T  830

EU914856  664  TCACTCGACACAACACGTTTCGTTTGTTGAATAATTGCGCAAGAAA--G-AAACTTTT-C  719
AY230175  859  ..................................................--.-.........-.  914
AY171264  667  ..................................................--.-.........-.  722
DQ375757  831  ............................G....C......-...TT.T........T.  889

EU914856  720  G-TT---ACGACCTCAACTCAAGCAAG  742
AY230175  915  .-..TT-...................  939
AY171264  723  .-..TT-...........          739
DQ375757  890  .-..TTT...................  915
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Figure 2: *Multiple sequence alignment of the ITS rDNA region (including partial fragments of the 18S and 28S rDNA genes) of 4 Steinernema species. Code EU914856 correspond to the Slovenian isolate of Steinernema kraussei (C46). Codes AY230175 and AY171264 are Steinernema kraussei strains from Germany and Russia. Code DQ375757 correspond to Steinernema akhursti strain from China.*

4 DISCUSSION

Genetic studies proved that the nematode species is *Steinernema kraussei* (Steiner, 1923). The ITS1-5.8S-ITS2 region, including the partial 18S and 28S rRNA genes (flanked by above primers) of Slovenian isolate C46, is 742 bp long. BLAST searches (Altschul *et al*., 1990) in GenBank showed that Slovenian isolate C46 (Fig. 1) has a high similarity (99 %) with those sequences available for *S. kraussei* populations (e.g. accession numbers AY230175 and AY171264). Sequence of other species from *feltiae* group, namely *S. akhursti* was obtained from GenBank searches that exhibited a lesser degree of similarity with the Slovenian isolate and other *S. kraussei* populations (e.g. accesion number DQ375757) (Fig. 1). The present study constitutes the first report of *S. kraussei* in Slovenia. In Europe, until now *S. kraussei* was already recorded in Austria, Belgium, Great Britain, Czech Republic, Germany, Slovakia, Switzerland, Island, Norway, Spain in Bulgaria and in many other parts of the world (for a detailed EPN species distribution see Hominick, 2002).

We can place mentioned species into »*feltiae* group« of nematodes from genus *Steinernema* (Nguyen, 2006); for infective juveniles it is known that they are between 700 and 1000 µm long. This nematode lives in symbiosis with bacterium *Xenorhabdus bovienii* (Boemare and Akhurst, 1988; Fischer-Le Saux et al., 1998). It is *Steinernema kraussei*, the first recorded EPN species (Glaser and Fox, 1923), when attack and death by this EPN was observed in Japanese beettle (*Popillia japonica* Newman). In the same year Steiner renamed this species to *Aplectana kraussei*, but in 1927 Travassos changed the original name of the genus and used the name *Steinernema* (Laznik in Trdan, 2008a).

Numerous researches showed that *S. kraussei* is efficient at low temperature (from 6 to 10 ºC) (Long et al., 2000). It was mainly studied when controlling black vine weevil (*Otiorhynchus sulcatus* [Fabricious]) and they have found out also over 80 % efficiency at low temperature; meanwhile some other species (*S. carpocapsae, S. feltiae* and *H. megidis*) have not shown satisfying efficiency (Long et al., 2000; Willmott et al., 2002; Haukeland, 2007). Efficacy of *S. kraussei* in low temperature has a big importance in plant protection, specially when applying in the open, while temperature, beside UV radiation and moisture, represents the most important limiting factor aforesaid biological agents (Kaya, 1990).

After the first record of *Steinernema kraussei* in Slovenia, we expect that the use of these biological agents against insect pests will become important alternative to insecticides. These will be especially desired against the pests, which is not easy to control with insecticides, due to their massive occurrence in the period of harvesting, against the pests, which are resistant to insecticides etc. In the future experiments, C46 strain of *S. kraussei*, will be used against different agricultural pests under laboratory conditions as well as in the open field.

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Influence of row spacing on the yield of ten cultivars of soybean (*Glycine max* (L.) Merrill)

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ABSTRACT

In the period 2001-2005 block field trials with ten soybean cultivars (*Glycine max* (L.) Merrill): Aldana, Borostyan, Essor, Ika, Kador, Major, Nawiko, Olna, Tarna and Tisa with three repetitions have been designed on the experimental field at the Biotechnical Faculty in Ljubljana with the purpose of studying the influence of sowing density on crop yield. Planting of soybean was performed manually each year in the beginning of May using the 50 cm row spacing (wide rows) and 25 cm spacing (narrow rows), the distance between seeds in a row was 15 cm. In each case of row spacing, the soybean cultivar and the year of the experiment influenced the mean yield of the soybean. For the dense sowing, the significantly higher yield of soybean (3428 kg/ha) was detected compared to the thin sowing (2690 kg/ha). The significant influence of the cultivar was found in every year in case of the thin sowing, where the yield in the 2001 (the year of the drought) was significantly lower compared to other years. For the thin sowing, the most productive cultivar was the Borostyan (3974 kg/ha), the lowest mean yield was recorded for the cultivar Aldana (1472 kg/ha). For the dense sowing, significantly higher soybean yield was confirmed in 2005 (3760 kg/ha), compared to the years 2002 (3145 kg/ha) and 2003 (3239 kg/ha), when the yields were significantly lower. The cultivar Aldana recorded the lowest yield (2110 kg/ha) also in the case of dense sowing, while under the same growing conditions, the cultivar Tisa (5171 kg/ha) proved to be the most productive cultivar. Considering the length of the growing period and the yield, the medium late cultivars Borostyan, Essor, Tarna, Major and Olna and the medium early cultivar Nawiko could be recommended for sowing in central parts of Slovenia. Despite higher productivity of Tisa, Ika and Kador cultivars, their late maturity is less suitable for machine harvesting on lager land areas. Based on our data on productivity, growing period and other economically significant characteristics of soybean cultivars, together with selected row spacing, the experts will be able to suggest to producers cultivars and production practises to ensure high and dependable yields of soybean.

Key words: soybean, *Glycine max*, cultivars, field trials, row spacing, growth conditions, growth period, grain yield

IZVLEČEK

VPLIV MEDVRSTNEGA RAZMIKA NA PRIDELEK DESETIH KULTIVARJEV SOJE (*Glycine max* (L.) Merrill)

V obdobju 2001-2005 so bili na poskusnem polju Biotehniške fakultete v Ljubljani zasnovani bločni poljski poskusi z desetimi kultivarji soje (*Glycine max* (L.) Merrill), in sicer: Aldana, Borostyan, Essor, Ika, Kador, Major, Nawiko, Olna, Tarna in Tisa v treh ponovitvah, z namenom preučitve vpliva gostote setve na pridelek zrnja. Setev soje je bila izvedena vsako leto na začetku maja, in sicer ročno, na medvrstna razmika 50 cm (redka setev) in 25 cm (gosta setev), razmik med semeni v vrsti pa je bil 15 cm. Pri obeh medvrstnih razmikih sta na povprečni pridelek soje vplivala kultivar in leto poskusa. Pri gosti setvi je bil ugotovljen signifikantno večji pridelek soje (3428 kg/ha) kot pri redki setvi (2690kg/ha). Signifikanten vpliv kultivarja na pridelek se je pokazal v vseh letih pri redki setvi, pri čemer je bil pridelek v letu 2001 (sušno leto) signifikantno manjši kot v ostalih letih. Najbolj roden kultivar pri redki setvi je bil Borostyan (3974 kg/ha), najmanjši pridelek pa smo ugotovili pri kultivarju Aldana (1472 kg/ha). Pri gosti setvi smo potrdili signifikantno največji pridelek soje v letu 2005 (3760 kg/ha), v primerjavi z letoma 2002 (3145 kg/ha) in 2003 (3239 kg/ha), ko sta bila pridelka signifikantno manjša. Kultivar Aldana (2110 kg/ha) je imel najmanjši pridelek tudi pri gosti setvi, medtem ko je bil v istih rastnih razmerah najbolj roden kultivar Tisa (5171 kg/ha). Glede na dolžino rastne dobe in velikost pridelka lahko za setev v osrednji Sloveniji priporočamo srednje pozne kultivarje Borostyan, Essor, Tarna, Major in Olna ter srednje zgodnji kultivar Nawiko. Kljub večji produktivnosti kultivarjev Tisa, Ika in Kador, je njihova pozna zrelost manj ustrezna pri strojnem spravilu na večjih zemljiščih. Le na podlagi poznavanja produktivnosti, dolžine rastne dobe in drugih gospodarsko pomembnih lastnosti kultivarjev soje pri izbranem medvrstnem razmiku, bodo lahko strokovnjaki svetovali pridelovalcem, tako, da bo pridelek zrnja velik in zanesljiv.

Ključne besede: soja, *Glycine max*, kultivarji, poljski poskusi, medvrstni razmik, rastne razmere, dolžina rastne dobe, pridelek zrnja

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[1] ibid.

1 INTRODUCTION

Soybean (*Glycine max* (L.) Merrill), the most important protein legume and oilseed with approximately 100 million hectares planted lands around the world, is only grown on few tens of hectares of lands in Slovenia. For decades Slovenia has been importing vegetable proteins for animal feed, however soybean could be added to human diet as well. It is important not to neglect to the benefits arising from soybean's abiliy to fix nitrogen, as a leguminous plant in the crop rotation (Čremožnik, 2004; Štepic, 2004; Kocjan Ačko, 2005).

Potential soybean producers are mostly organic farmers, who are facing the dilemmas of selecting the suitable planting and harvesting times, sowing density (crops sown usually to the 50 cm row spacing are often very weedy). Problems are also caused by a small selection of cultivars that have been tested in Slovenia and the lack of machine equipment for the harvesting of grains. The type of sowing and the size of row spacing (sowing density) have an important influence on grain yield. To assure and reach the production potentials, we have to establish the length of the growing period and optimum sowing density for the cultivar that we are planning to grow on certain area. According to the research results (Vratarić, 1986; Carlson, 1973; Moore, 1991; Lueschen, 1992; Devlin, 1995; Elmore, 1998; Holshouser and Whittaker, 2002; Pedersen and Lauer, 2003; Štepic, 2004) the yields of grain, grown in smaller row spacing (10 to 25 cm), were higher compared to greater row spacing (50 to 90 cm). The latter finding needs to be tested for individual cultivars under the conditions of their planned production and considering also their growth habit (capability of branch formation and the length of the growing period). After the year 2004, Slovenian producers can sow any cultivar listed in the Common catalogue of the European Union also in Slovenia, which caused a drop in the number of cultivars under the official testing, which causes shortage of relevant information on economically significant characteristics of the cultivars, mostly for the crops that we are trying to re-introduce due to the needs of the crop rotation or alternative uses and ways of production and nutrition. Since numerous foreign cultivars are not suitable for the production in Slovenia (some of them would not reach their full harvest maturity) we can not entirely rely on the descriptions of their characteristics coming from the areas where they are traditionally grown and which are not entirely comparable to Slovenia.

The purpose of the soybean field trials was to determine the influence of the row spacing to the yield of ten soybean cultivars. Results of the testing of soybean cultivars at the experimental field of Biotechnical Faculty will, at least partly, replace the testing of these cultivars in official field trials and help us select the suitable cultivars according to the length of the growing period and selection of the row spacing that assure higher yields of grains.

2 MATERIALS AND METHODS

2.1 Study site and background of the research

In the year 2001 we have designed the experiment on the experimental field at the Biotechnical Faculty in Ljubljana (46°04'N, 14°31'E, 299 m altitude) with ten soybean cultivars: Aldana, Borostyan, Essor, Ika, Kador, Major, Nawiko, Olna, Tarna and Tisa (UPOV, 1998; Ileršič and al., 2000; Čremožnik, 2004), under the framework of international cooperation and education with the goal of describing the distinctness, uniformity and stability of soybean cultivars (DUS).

Seed was planted manually in field plots that were 1.5 m x 4.6 m (6.9 m^2), using the row spacing of 50 cm and 15 cm within row spacing at the planting depth of 3 to 5 cm. The field experiment was set up in three replications, with block random distribution of ten cultivars in three repetitions. When monitoring the habitus of the mature plants, we discovered that, in the stage of full blooming or until the pod formation, only the latest cultivars covered the row space, for early and medium late cultivars the rows remained split (UPOV, 1998). Larger than necessary row spacing was the reason that we decided to study the influence of the row spacing on the yield of the crop. In the period from 2002 to 2005 all ten cultivars were sown not only to the 50 cm row spacing (wide rows), but also at the 25 cm row spacing (narrow rows), other characteristics of the experiment remained the same as in the year 2001.

2.2 Studied material

Soybean cultivars originating from five European countries were used, three were from France (Essor, Kador, Major), two each from Croatia (Ika, Tisa), Hungary (Borostyan, Tarna) and Poland (Aldana, Nawiko) and one from Slovenia (Olna). The cultivars Aldana, Borostyan, Essor, Ika, Nawiko and Tarna are listed in the Common catalogue of the European Union cultivars, the Olna cultivar is - despite its expired registration, still the most widespread cultivar among Slovenian producers.

2.3 Field experiment

Soybean was sown in the crop rotation after the cereals - that is on the May 14. 2001, May 7. 2002, May 6. 2003, May 4. 2004 and May 5. 2005. During the pre-sowing preparation the land was fertilized with nitrogen in the amount of 60 kg/ha (27-percent KAN), and the seed was not inoculated with the *Bradyrhizobium japonicum* bacteria. For the thin sowing, three rows were sown on individual parcel and for the dense sowing - six rows. In the case of incomplete emergence we filled in the gaps with repeated sowing when the plants were 5 cm

high. We reduced the tweediness, mainly in case of thin sowing by hoeing twice between the rows, first time at the plant height of 10 to 20 cm, the second time before blooming.

2.4 Field observations and evaluation

We have monitored the growth and development of all cultivars and in technological ripeness of the grain we manually plucked the pods for each cultivar separately, that was in the period from 4. 9. to 23. 10. in 2001, from 30. 8. to 25. 10. in 2002, from 28. 8. to 15. 10. in 2003, from 29. 8. to 20. 10. in 2004 and from 28. 8. to 19. 10. in the year 2005. Pods have been dried in the dryer at the temperature 40 to 45 ºC, and the grains were then threshed and weighted. For each cultivar we measured humidity on a sample of grains using the humid meter Pfeuffer he 50, and the yield calculated to 8% moisture, which is the prescribed value for storing the oil seeds. The yield was expressed in kg/ha. Regarding the date of sowing and harvesting we have calculated the growing period for all tested cultivars and distributed them into maturity groups according to the international classification from 000 to X. (Gagro, 1997; UPOV, 1998). Regarding the length of the growing period the soybean cultivars were arranged into classes - very early cultivars from maturity groups 000 and 00, remaining on the field from 70 to 80 days; the growing period of early cultivars with the mark 0 is 90 days; medium early to very late are grouped in groups from I. to X. with the ten days difference between the groups.

2.5 Data analysis

The data about the yield (kg/ha) of ten cultivars of soybean were analysed using a general analysis of variance (the results of the yield from both types of sowing in all years were pooled) and individual analysis of variance (the results of the yield for only one type of sowing were treated). Means were separated by Student-Newman-Keuls's multiple range test at $P < 0.05$. Before analysis, each variable was tested for homogeneity of treatment variances. If variances were not homogeneous, data was transformed to log(Y) before multifactor ANOVA. All statistical analysis was performed with Statgraphics Plus for Windows 4.0 (Statistical Graphics Corp., Manugistics, Inc.). Data is presented as untransformated means ± SE.

2.6 Weather conditions in the period 2001 to 2005

The analysis of mean temperatures and precipitations in Ljubljana from April to October (Monthly…, 2001 to 2005) showed important differences between the years. The year 2001 importantly stands out, when the mean temperatures in July (21.9 °C) and August (22.9 °C) were among the highest and above the long term mean and at the same time both months were very dry (48 mm and 33 mm of rain); also October was unusually dry in that year with only 68 mm precipitations. June, July and August heat was significant for every year of the research, but drastic shortage of rain was recorded only in 2001. Mean monthly air temperatures for September were gradually rising from the year 2001 to 2005; also October temperatures were rather high (11.5 to 13.0 °C), and above the long term mean values with the exception of the October 2002, when the mean temperature was only 8.8 °C. The highest differences in mean annual quantity of precipitations were detected already in summer and moreover in autumn months (rain showers), the highest mean quantity of precipitations in September was recorded in the years 2001 (305 mm) and 2005 (294 mm), extremely wet was also October in 2004 (287 mm).

3 RESULTS AND DISCUSSION

3.1 Comparison of yields with thin in dense sowing

Analysis of variance showed a significant influence of the year of the trial, of the cultivar and row spacing to the mean yield of soybean ($P<0.05$). The highest yield of ten soybean cultivars was recorded in the year 2005 (3263±184 kg/ha), and significantly the lowest in the years 2002 (2899±94 kg/ha) and 2003 (2952±162 kg/ha). The mean yield of soybean, sown to the shorter row spacing was significantly higher (3428±126 kg/ha) compared to the yield of the soybean, sown to larger row spacing (2690±86 kg/ha). This was also the main reason why in continuation we analysed mean yields separately - according to the row spacing.

With the general analysis of variance for the period 2002-2005 we have detected the significant influence of the cultivar ($P<0.05$) on the mean yield of soybean for both types of sowing - dense and thin – (Table 1.). Out of all ten cultivars, results showed the lowest yield for the cultivar Aldana (1791±137 kg/ha) and the two most productive cultivars were Borostyan (4242±234 kg/ha) and Tisa (4216±309 kg/ha), which did not differ from one another. Cultivars that significantly different from one another were Ika (3138±61 kg/ha), Tarna (3381±123 kg/ha) and Kador (3702±205 kg/ha). There was no significant difference between the yields of Olna (2272±106 kg/ha) and Major (2342±107 kg/ha) or between Nawiko (2748±141 kg/ha) and Essor (2757±148 kg/ha).

Mean yields varied between the dense and thin sowing for approximately 1900 kg (Tisa), for 1200 kg (Kador), for 900 kg (Essor), for 600 kg (Aldana and Nawiko) and 500 kg was the difference for the Borostyan, Olna and Tarna cultivars, the lowest mean difference between the dense and thin sowing, which is approximately 220 kg, was recorded for cultivar Ika (Table 1).

3.2 Yield of cultivars - thin sowing

With the use of general analysis of variance we established the significant influence of the year of the trial and of the cultivar to the mean yield of soybean (in both cases $P<0.05$). For the thin sowing we detected no statistically significant differences in the mean yield of cultivars between the years 2002 (2654±131 kg/ha),

2003 (2654±190 kg/ha), 2004 (2676±194 kg/ha) and 2005 (2765±179 kg/ha). In the year 2001 the mean yield of the same cultivars was significantly lower (1814±136 kg/ha) compared to other years. Weather conditions, mostly the dry July and August in 2001 are considered the main cause of the differences in the yield.

***Table 1**: Mean yield of ten cultivars of soybean (Glycine max (L.) Merrill) for thin and dense sowing in block field trials on the experimental field of Biotechnical faculty in Ljubljana (Slovenia) in the period 2002-2005.*

Cultivar	Mean yield (kg/ha) - thin and dense sowing	Mean yield (kg/ha)		Difference in the yield (kg) between the two sowings
		thin sowing	dense sowing	
Aldana	1791	1472	2110	638
Borostyan	4242	3974	4510	536
Essor	2757	2296	3218	922
Ika	3138	3029	3248	219
Kador	3702	3118	4285	1167
Major	2342	2160	2524	364
Nawiko	2748	2448	3047	599
Olna	2272	2010	2535	525
Tarna	3381	3135	3627	492
Tisa	4216	3261	5171	1910

Considering the mean yield of soybean in the period 2001-2005, significantly the lowest yield was recorded for the cultivar Aldana (1340±119 kg/ha), and significantly most productive was the cultivar Borostyan (3501±356 kg/ha). There was no significant difference among the yields of Ika (2902±104 kg/ha), Tarna (2911±161 kg/ha), Kador (3048±96 kg/ha) and Tisa (3066±149 kg/ha), but their yields were significantly higher compared to Olna (1981±100 kg/ha), Major (2022±154 kg/ha), Nawiko (2155±211 kg/ha) and Essor (2225±83 kg/ha), among which we detected no significant difference as well.

With individual statistical analysis of mean yields of soybean we detected the significant influence ($P<0.05$) of the cultivar in every year (Figure 1). In 2001 we confirmed significantly the lowest yield for Aldana (814±170 kg/ha) and Nawiko (982±75 kg/ha) cultivars, significantly the highest yield was recorded for Kador (2767±24 kg/ha), Ika (2392±312 kg/ha) and Tisa (2288±8 kg/ha) cultivars (Figure 1). We detected no significant differences between Olna (1866±24 kg/ha), Essor (1937±141 kg/ha) and Tarna (2016±78 kg/ha), Borostyan (1610±6 kg/ha) and Major (1470±48 kg/ha) cultivars. Their yields were significantly higher compared to cultivars Aldana and Nawiko, while - only for the cultivars Major and Borostyan - it was significantly lower than for the three most productive cultivars.

In 2002 significantly the lowest yield was recorded for Aldana (1848±172 kg/ha), Essor (2042±142 kg/ha), Major (2243±29 kg/ha), Nawiko (2317±188 kg/ha) and Olna (2358±391 kg/ha) and significantly the highest yields were confirmed for the cultivars Ika (2916±39 kg/ha), Tarna (3083±242 kg/ha), Borostyan (3124±82 kg/ha), Tisa (3195±244 kg/ha) and Kador (3412±399 kg/ha). There were no significant differences in their yields between cultivars Major, Nawiko, Olna , Ika, Tarna, Borostyan and Tisa.

In the year 2003 cultivars Aldana (1412±20 kg/ha), Olna (1761±36 kg/ha), Essor (2167±65 kg/ha), Nawiko (2167±94 kg/ha) and Major (2174±14 kg/ha) were significantly the least productive and significantly the highest yield was reached by the cultivars Borostyan (4094±485 kg/ha) and Tisa (3565±72 kg/ha). There were no significant differences in their yields between cultivars Kador (2957±87 kg/ha), Ika (3138±94 kg/ha) and Tarna (3217±145 kg/ha), but their yield was significantly higher compared to the first five cultivars and significantly lower compared to the yield reached by the cultivar Borostyan.

In the year 2004 significantly the lowest yield was recorded for Aldana (1185±55 kg/ha) and Major (1754±507 kg/ha), significantly the most productive was the cultivar Borostyan (4337±18 kg/ha). There were no significant differences in their mean yields between Major, Olna (2159±101 kg/ha), Nawiko (2510±78 kg/ha) and Essor (2513±81 kg/ha), the same was true also for cultivars Nawiko, Essor, Ika (2955±129 kg/ha), Tisa (3007±80 kg/ha), Kador (3067±87 kg/ha) and Tarna (3275±145 kg/ha).

In the year 2005 significantly the lowest yields were recorded for Aldana (1442±22 kg/ha) and Olna (1760±22 kg/ha), with significantly the highest yield the

cultivar Borostyan (4341±77 kg/ha) stood out. Mean yields of Essor (2464±43 kg/ha), Major (2471±399 kg/ha), Nawiko (2797±58 kg/ha), Tarna (2964.8±80 kg/ha), Kador (3036±138 kg/ha) and Ika (3107±64 kg/ha) cultivars were not significantly different one from the other. There were no significant differences also between the yields of Tisa (3275±72 kg/ha), Ika, Kador, Tarna and Nawiko cultivars.

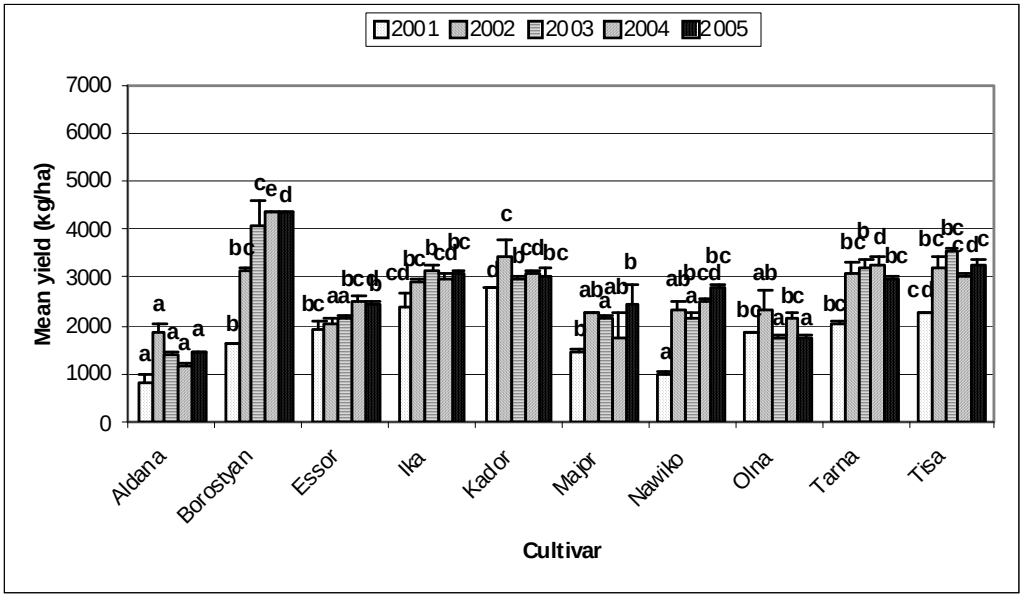

***Figure 1**: Mean yield (±SE) of ten soybean cultivars (Glycine max (L.) Merrill) with 8-percent humidity of the grains in the field trials on the experimental field at Biotechnical Faculty in Ljubljana (Slovenia) in the period 2001-2005. Data shown are analysed by multifactor ANOVA followed by Student-Newman-Keuls's multiple range test (P<0.05) for separation of means. Values carrying the same letters do not differ significantly.*

3.3 Yield of cultivars - dense sowing

With the general analysis of variance we detected a significant influence of the year of the trial and of the cultivar to the mean soybean yield (in both cases P<0.05). For the dense sowing of the ten cultivars significantly the highest yield was established for the year 2005 (3760±283 kg/ha) and significantly the lowest mean yield for the years 2002 (3145±112 kg/ha) and 2003 (3239±251 kg/ha). The mean yield of ten soybean cultivars in the year 2004 (3567±312 kg/ha) was significantly higher than in the two previous years and significantly lower than in 2005.

Considering the mean yield of soybean in the period 2002-2005 Tisa cultivar (5171±374 kg/ha) proved to be the most productive one and the lowest yields were given by cultivar Aldana (2110±206 kg/ha). We detected no significant differences between the other two less productive cultivars Major (2524±123 kg/ha) and Olna (2535±113 kg/ha).

The same can be confirmed for the mean yields of medium productive cultivars Nawiko (3047±224 kg/ha), Essor (3218±164 kg/ha) and Ika (324±101 kg/ha), where their mean values were significantly lower from the mean yields given by cultivars Tarna (3627±205 kg/ha), Kador (4285±413 kg/ha) and Borostyan (4510±413 kg/ha). Between the last two cultivars there were no significant differences in their yields and Tarna cultivar was significantly less productive than the other two.

With the individual statistical analysis for the year 2002, we detected no significant differences in the mean yield of ten cultivars (Figure 2). Mean yield values reached from 2587±71 kg/ha (cultivar Nawiko) to 3874±397 kg/ha (cultivar Tisa). In the year 2003 we confirmed statistically significant (P<0.05) differences in mean yields of soybean cultivars. Aldana (2009±227 kg/ha), Major (2246±217 kg/ha), Olna (2268±94 kg/ha), Nawiko (2618±135) and Essor (2709±117 kg/ha) proved to be the least productive cultivars, significantly the highest yield was given by cultivar Tisa (5550±59 kg/ha). Also Borostyan (4601±109 kg/ha), Kador (3717±239 kg/ha) and Tarna (3555±4 kg/ha) cultivars could be listed among the more productive cultivars.

In the year 2004 significantly the lowest yield was again recorded for cultivar Aldana (1776±6 kg/ha) and cultivar Tisa (6471±297 kg/ha) was significantly the most productive one. We detected no significant differences between the yields of low to medium productive cultivars - Major (2489±69 kg/ha), Olna (2594±14 kg/ha), Nawiko (2964±80 kg/ha), Essor

(2993±80 kg/ha) and Ika (3101±232 kg/ha) cultivars could be listed in this group. The mean yield of Borostyan (5058±72 kg/ha) and Kador (4739±217 kg/ha) cultivars was among the highest during the trials, but significantly lower than the yield given by Tisa.

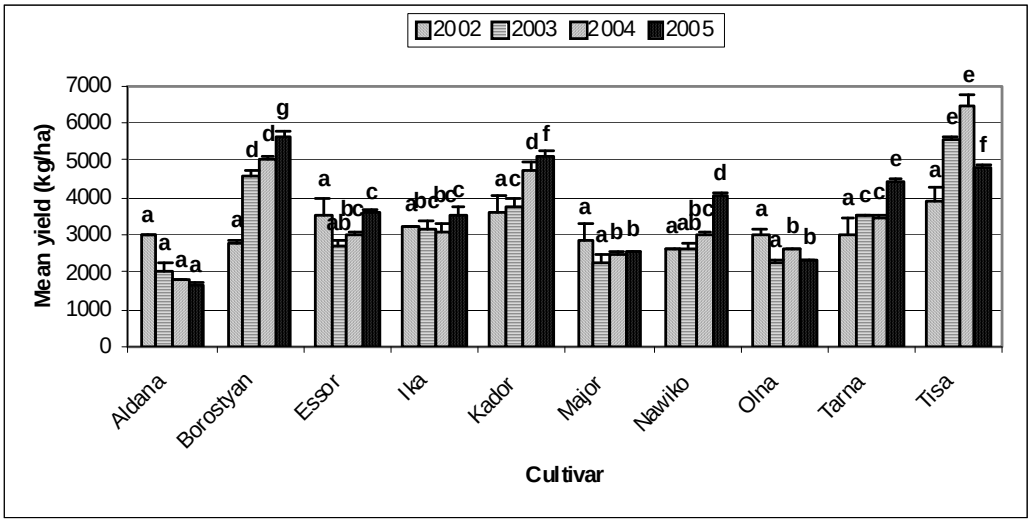

***Figure 2**: Mean yield (±SE) of ten soybean cultivars (Glycine max (L.) Merrill) with 8-percent humidity of the grains in the block field trials on the experimental field at Biotechnical Faculty in Ljubljana (Slovenia) in the period 2002-2005. Data shown are analysed by multifactor ANOVA followed by Student-Newman-Keuls's multiple range test (P<0.05) for separation of means. Values carryng the same letters do not differ significantly.*

***Table 2**: Date of planting and harvesting for ten soybean cultivars (Glycine max (L.) Merrill) in block field trials on the experimental field at Biotechnical faculty in Ljubljana (Slovenia) in the period 2001-2005.*

Cultivar	Date of sowing					Harvest in the period 2001 to 2005
	14.5.	7.5.	6.5.	4.5.	5.5.	
	2001	2002	2003	2004	2005	
	Date of harvest					
Aldana	4.9.	30.8.	28.8.	29.8.	28.8.	28.8.- 4.9.
Borostyan	27.9.	27.9.	14.9.	16.9.	15.9.	14.9.–27.9.
Essor	27.9.	27.9.	14.9.	16.9.	15.9.	14. 9.-27.9.
Ika	23.10.	21.10.	15.10.	18.10.	17.10.	15.9.-23.10.
Kador	23.10.	21.10.	15.10	18.10	17.10.	15.9.-23.10.
Major	11.9.	17.9.	14.9.	16.9.	15.9.	11.9.-17.9.
Nawiko	4.9.	30.8.	28.8.	29.8.	28.8.	28.8.- 4.9.
Olna	27.9.	27.9.	14.9.	16.9.	15.9.	14.9.-27.9.
Tarna	27.9.	17.9.	14.9.	16.9.	17.9.	14.9.-27.9.
Tisa	23.10.	25.10.	15.10.	20.10.	19.10.	15.9.-25.10.

Cultivar Aldana had significantly the lowest yield (1651±43 kg/ha) also in the year 2005, when Borostyan (5644±153 kg/ha) was the most productive cultivar. Olna (2304±43 kg/ha) and Major (2513±49 kg/ha) were significantly more productive than cultivar Aldana, but still less productive than Ika (3522±188 kg/ha) and Essor (3616±22 kg/ha) and there was no significant differences between the two. According their productivity also Nawiko (4021±138 kg/ha), Tarna (4434±88 kg/ha), Tisa (4790±51 kg/ha) and Kador (5109±109 kg/ha) cultivars can be listed into the top half of the list.

. There was the difference of 48 to 55 days between the harvest of the earliest and the latest cultivars.

In every year of the trials, the most early cultivars were Aldana and Nawiko with mean growing period of 115 days, 15 to 20 days later were Borostyan, Essor, Major, Olna and Tarna cultivars with the mean growing period of 135 days, approximately one month later the latest cultivars Ika, Kador and Tisa matured, in the mean remaining on the field for 166 days.

***Table 3**: The length of the growing period for ten soybean cultivars (Glycine max (L.) Merrill) in block field trials on the experimental field at Biotechnical Faculty in Ljubljana (Slovenia) in the period 2001-2005.*

Cultivar	Length of the growing period (days)					Mean growing period (days)
	2001	2002	2003	2004	2005	
Aldana	113	116	114	117	115	115
Borostyan	136	143	131	135	133	135.6
Essor	136	143	131	135	133	135.6
Ika	162	167	162	167	165	164.6
Kador	162	167	162	167	165	164.6
Major	120	133	131	135	133	130.4
Nawiko	113	116	114	117	115	115
Olna	136	143	131	135	133	135.6
Tarna	136	133	131	135	135	134
Tisa	162	171	162	169	167	166.2

Compared to the growing period for soybean stated by Gagro (1997) and UPOV (1998), we can range Aldana and Nawiko cultivars into the medium early maturity class with the growing period of 110 to 120 days; Borostyan, Essor, Major, Olna and Tarna cultivars into medium late maturity class (120 to 130 days) or late maturity class (130 to 140 days) and cultivars Ika, Kador and Tisa can be listed as very late with the growing period of 160 to 170 days.

High oscillations in mean daily temperature and mean quantity of precipitations, which were above the long term mean, affected the length of the growing period in the 2002, when the length of the growing period most deviated from values for other years, which resulted in late ripeness for most of the tested cultivars. The greatest deviations were recorded for Borostyan, Essor and Olna, which were »late« for 7 to 12 days; but the length of the growing period for the earliest and the latest cultivars did not differ much from the data for other years. In the dry year of 2001 two cultivars were earlier with ripening – Aldana, which was harvested 4 days earlier than usually and the growing period of Major was for 11 to 15 days shorter.

4 CONCLUSION

Results from the field trials with ten soybean cultivars in the period from 2001 to 2005 show important differences in productivity of the cultivars when sown to 50 cm row spacing (wide rows) compared to the row spacing of 25 cm (narrow rows), in the length of the growing period of individual cultivars and also the differences between individual years were detected.
When studying the influence of the row spacing on the yield of crop in the period 2002-2005, significantly higher yield (with $P<0.05$) of all soybean cultivars was detected when using the dense sowing (3428 kg/ha) compared to the thin sowing where the mean yield was 2690 kg/ha, at the same time with the thin sowing we had more work mechanically destructing the weeds.
Differences between mean yields of cultivars for dense sowing compared to the thin sowing depended on the cultivar; yields using the dense sowing were higher for 219 kg/ha (Ika) and all up to 1910 kg/ha (Tisa), that means that the longer row spacing also had an influence on the productivity of late soybean cultivars like Ika and Tisa.

A significant influence of the cultivar on the yield ($P<0.05$) was also shown in every year for the thin sowing, where the yield in 2001 (year of the drought) was significantly lower compared to other years. The most productive cultivar for the thin sowing was Borostyan (3974 kg/ha) and the lowest yield was recorded for Aldana cultivar (1472 kg/ha).

For the dense sowing with $P<0.05$ we have confirmed significantly the highest yield of soybean in the year 2005 (3760 kg/ha), compared to the years 2002 (3145 kg/ha) and 2003 (3239 kg/ha), when the yields were significantly lower. Cultivar Aldana (2110 kg/ha) had the lowest yield of grains also for the dense sowing, while under the same growing conditions, cultivar Tisa (5171 kg/ha) was the most productive one.

Regardless of the row spacing the most productive cultivars proved to be Tisa, Borostyan and Kador with mean crop yield calculated from 3700 to 4200 kg grains/ha, medium productive are the cultivars Essor, Ika, Nawiko and Tarna (2700 do 3400 kg grains/ha), the

calculated yield of Major and Olna cultivars was approximately 2500 kg/ha, and the lowest yield was given by Aldana cultivar (1800 kg/ha).

Regarding the length of the growing period we could recommend medium late to late cultivars Borostyan, Essor, Tarna, Major and Olna with the growing period of 131 to 143 days and medium early cultivar Nawiko, which remained on the field for 113 to 117 days, as suitable for sowing in central parts of Slovenia; considering their productivity Nawiko and Borostyan proved to be the most promising cultivars from each of their maturity group. Damp grains and leafs can hinder or prevent machine harvesting of very late cultivars Ika, Kador and Tisa with the growing period of 162 to 171 days, therefore despite their high productivity their production can be very risky.

For the production - there is no need for the introduction of cultivars Aldana, Borostyan, Essor, Ika, Nawiko and Tarna, which are all listed in the Common catalogue of the European Union; other cultivars that are not registered in any EU member state should be registered before their production in Slovenia.

It is our opinion that soybean is an arable crop with good potential for organic farming, for the production of protein animal feed and for alternative nutrition for humans. Higher variety of plants in production is the only way to realise the National strategic plan of rural development 2007-2013, where an important role is given to the crop rotation, mostly for the reduction of the role of maize monoculture (incidence of maize beetle) and for the improvement of cereal crop rotation maize-wheat (barley), which is becoming more common due to reduced production of root and tuber crops on Slovene fields.

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Agris category code: Q03, Q05

Antimicrobial activity of rosemary extracts (*Rosmarinus officinalis* L.) against different species of *Listeria*

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ABSTRACT

Reduction or elimination of chemically synthesized additives from foods is a current demand in food industry. A new approach to prevent the proliferation of microorganisms or protect food from oxidation is the use of essential oils or plant extracts as natural additives in foods. We have studied antimicrobial activity of rosemary extracts (*Rosmarinus officinalis* L.) against different species of *Listeria* and against different strains of *L. monocytogenes*. We used two extracts of rosemary, VivOX 20 and VivOX 40 (Vitiva d.d., Slovenia) containing different levels of carnosic acid. We wanted to proof an antimicrobial activity of selected rosemary extracts with two most commonly used methods: disc diffusion method and broth dilution method. With the disc diffusion method we have obtained the inhibition zone and at the lowest concentrations, where no visible bacterial growth was recorded, were assumed as minimal inhibitory concentration values (MIC). We determined MIC values in the ranges from 625 µg extract/ml EtOH to 5000 µg extract/ml EtOH for VivOX 20 and from 312.5 µg extract/ml EtOH do 2500 µg extract/ml EtOH for VivOX 40 in the medium. We have established that the resistance of *Listeria* species against rosemary extracts depends on: selected extract, selected concentration, various species and strain of *Listeria*. With broth dilution method we have determined minimal bactericidal concentration (MBC), as the concentration giving 0.1 % bacterial survival. With this method we have tested two strains of *L. monocytogenes* and in determinate MBC values in the range from 15.63 µg/ml TSB to 98.5 µg/ml TSB for both tested extracts. Results have confirmed our assumption that resistance of *Listeria* against rosemary extracts depended on the selected strain.

Keywords: pathogens, *Listeria*, *Listeria monocytogenes*, plant extracts, rosemary, antimicrobial activity, carnosic acid, minimal inhibitory concentration, minimal bactericidal concentration

IZVLEČEK

Zahteve potrošnikov po celem svetu so zmanjšati oz. izločiti kemično sintetizirane konzervanse iz živil. Novejše metode preprečevanja mikrobne kontaminacije in oksidacije uporabljajo eterična olja ali rastlinske ekstrakte kot naravne konzervanse. Proučevali smo protimikrobno delovanje ekstraktov rožmarina (*Rosmarinus officinalis* L.) na različne vrste bakterij rodu *Listeria* in seve bakterij *L. monocytogenes*. Uporabili smo dva različna komercialno pripravljena ekstrakta rožmarina, VivOX 20 in VivOX 40 (Vitiva d.d., Slovenija), ki sta vsebovala različno koncentracijo karnozolne kisline. Protimikrobni učinek izbranih ekstraktov smo želeli dokazati z dvema najpogosteje uporabljenima metodama: metoda difuzije v trdnem gojišču in metoda razredčevanja v tekočem gojišču. Pri metodi difuzije v trdnem gojišču smo po inkubaciji odčitali nastale inhibicijske cone, s katerimi smo določili minimalne inhibitorne koncentracije (MIC), kot tiste koncentracije, pri katerih ni bilo vidne rasti bakterij na gojišču. Vrednosti MIC smo določili v območju med 625 µg ekstrakta/ml EtOH do 5000 µg ekstrakta/ml EtOH za ekstrakt VivOX 20 in med 312,5 µg ekstrakta/ml EtOH do 2500 µg ekstrakta/ml EtOH za ekstrakt VivOX 40. Ugotovili smo, da je odpornost listerij proti ekstraktoma rožmarina odvisna od izbranega ekstrakta, izbrane koncentracije ter vrste in seva listerij. Z metodo razredčevanja v tekočem gojišču smo določali minimalne baktericidne koncentracije (MBC), kot tiste koncentracije, pri katerih preživi 0,1 % testnih bakterij. Uporabili smo dva različna seva bakterij vrste *L. monocytogenes* in vrednosti MBC v večini poskusov določili med 15,63 µg/ml gojišča TSB in 98,5 µg/ml gojišča za oba uporabljena ekstrakta. Rezultati so ponovno potrdili našo domnevo, da je odpornost listerij proti ekstraktoma rožmarina odvisna od seva.

Ključne besede: patogeni mikroorganizmi, *Listeria*, *Listeria monocytogenes*, rastlinski ekstrakti, rožmarin, protimikrobno delovanje, karnozolna kislina, minimalna inhibitorna koncentracija, minimalna baktericidna koncentracija

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1 INTRODUCTION

Food market trends are changing. Consumers demand more high-quality foods with fresh like attributes; consequently less extreme treatments and/or additives are being required. Lipid oxidation and bacterial contamination are the main factors that determine food quality loss and shelf-life reduction. Therefore, delaying lipid oxidation and preventing bacterial cross-contamination are highly relevant to food processors. Oxidative processes and bacterial contamination, in turn, contribute to the deterioration in flavour, texture and color of food products (Fernandez-Lopez *et al*., 2004).

Growth of microorganisms in food may cause spoilage or foodborne disease (Del Campo *et al*., 2000). Synthetic additives have been widely used. The trend is to decrease their use because of the growing concern among consumers about such chemical additives. Consequently, search for natural additives, especially of plant origin, has notably increased in recent years. Therefore, the development and application of natural products with both antioxidants and antibacterial activities especially in meat products may be necessary and useful to prolong their storage shelf life and potential for preventing food diseases (Fernandez-Lopez *et al*., 2004).

Rosemary (*Rosmarinus officinalis* L.) originally grows in southern Europe. Its herb and oil are commonly used as spice and flavoring agents in food processing for its desirable flavor, high antioxidant activity and lately as antimicrobial agent (Lo *et al*., 2002; Ouattara *et al*., 1997). Moreno *et al*. (2006) reported that rosemary plants are rich sources of phenolic compounds with high antimicrobial activity against both Gram-positive and Gram-negative bacteria. High percent of the antimicrobial activity they attributed to carnosic acid and carnosol. It is clear that rosemary extracts have bioactive properties, but their antimicrobial activities have not been deeply characterized. Antimicrobial activities of plant essential oils have been known for centuries, but their strong flavor limited their use in food (Del Campo *et al*., 2000).

Although the antimicrobial properties of essential oils and their components have been reviewed in the past (Shelef, 1983; Nychas, 1995), the mechanism of action has not been studied in great detail. Considering the large number of different groups of chemical compounds present in essential oils, it is most likely that their antibacterial activity is not attributable to one specific mechanism but that there are several targets in the cell (Burt, 2004).

Listeria is aerobic, microaerophilic, facultatively anaerobic, catalase positive and oxidase negative, small, regular Gram-positive rod with rounded ends (Rocourt and Buchrieser, 2007) and is frequently present in human environment (Fenlon, 1999). Only two of the six species in this genus are currently recognized to be pathogenic: *L. monocytogenes* and *L. ivanovii*. They cause listeriosis, an opportunistic infection of humans and animals involving severe clinical manifestations such as meningoencephalitis, abortion and septicemia (Vazquez – Boland *et al*., 2001). Human cases of *L. ivanovii* infection are rare (Gandhi and Chikindas, 2007; Zhang *et al*., 2007), being pathogenic mostly for ruminants (Vazquez – Boland *et al*., 2001), whereas *L. monocytogenes* has been recognized as a human foodborne pathogen since 1929 (Painter and Slutsker, 2007; Zhang *et al*., 2007).

Listeriosis is foodborne illness and therefore the rapid and accurate detection of *L. monocytogenes* is important for food safety assurance. *L. monocytogenes* can be found in a wide variety of raw and processed foods. Milk and dairy products, various meats and meat products such as beef, pork, fermented sausages, fresh produce such as radishes, cabbage, seafood and fish products have all been associated with *Listeria* contamination (Gandhi and Chikindas, 2007). The temperature range that permits growth of *L. monocytogenes* is of particular interest to food processors because this pathogen is a psychotropic bacterium. *L. monocytogenes* was reported to grow at temperatures between –1.5 and 45°C (Lado and Yousef, 2007), between pH 4.5 and pH 9.2, optimally at pH 7. It can grow in 10 % (w/v) NaCl and survive at higher concentrations. Survival at low pH and high salt concentration depends strongly on temperature. *Listeria* is one of the few foodborne pathogens that can grow at a_w below 0.93 (Rocourt and Buchrieser, 2007).

The aim of our work was to investigate antilisterial activity of rosemary extracts VivOX 20 and VivOX 40 in concentrations that can be used as natural additives in foods.

2 MATERIALS AND METHODS

2.1 Bacterial cultures and preparation of rosemary extracts

We tested antibacterial activity of rosemary extracts against 4 different species of *Listeria*. As *L. monocytogenes* is well known foodborne pathogen, we decided to use 8 different strains. All used cultures are listed in table 1.

Cultures were grown in BHI broth (Brain Heart Infusion broth, Merck, 1.10493, Germany) at 37 °C for 20-24 h with shaking. Suspension from BHI was then diluted in sterile BP (Butterfield's phosphate buffered dilution water (pH 7.2 ± 0.1)) till final concentration 10^7 CFU/ml. Viable counts were obtained by plating 10-fold dilutions made in sterile BP and plated onto TSA (Tryptone Soy Agar, Oxoid, CM0131, England) in duplicates. After incubating plates for 24-48 h at 37 °C the number of bacteria was calculated as colony forming units.

Table 1: *Listeria* strains used for testing antibacterial activity of rosemary extracts

***Listeria* strain designation**	**Origin, serotype**
Listeria grayi ŽM66	IHG reference strain, /
Listeria innocua ŽM68	Isolated from sausage, /
Listeria ivanovii ŽM65	IHG reference strain, 5
Listeria monocytogenes ŽM51	IHG reference strain, 1/2a
Listeria monocytogenes ŽM52	IHG reference strain, 1/2b
Listeria monocytogenes ŽM53	IHG reference strain, 1/2c
Listeria monocytogenes ŽM58	IHG reference strain, 4b
Listeria monocytogenes ŽM80	Human isolate, 4b
Listeria monocytogenes ŽM92	Isolated from chicken salad, 1/2 c
Listeria monocytogenes ŽM108	Isolated from meat pasty, 4b
Listeria monocytogenes ŽM115	Isolated from Tatarian beefsteak, 1/2 b

ŽM and ŽMJ: Culture collections of laboratory of food microbiology, Department of Food Technology, Biotechnical Faculty, Ljubljana, Slovenia; IHG: Institute for Hygiene and Microbiology, Wuerzburg, Germany

2.2 Rosemary extracts

We used two extracts of rosemary, VivOX 20 and VivOX 40 (Vitiva d.d., Slovenia), containing different levels of carnosic acid (VivOX 20: 22.04 % and VivOX 40: 40.49 % of carnosic acid)

Both extracts, VivOX 20 and VivOX 40, were prepared in absolute ethanol (0.160 g/ml) and these 16 % stock solutions were than diluted ten times till final concentration 156.25 µg/ml. Antibacterial effect of prepared extracts was tested on TSA (Tryptone Soy Agar, Oxoid, CM0131, England) in case of agar diffusion method and in TSB (Tryptone Soy Broth, Oxoid, CM0129, England) in case of broth dilution method.

2.3 Determination of antimicrobial effect of rosemary extracts

The minimum inhibitory concentrations (MICs) and minimum bactericidal concentrations (MBCs) for each extract against eleven *Listeria* strains were determined using a disc diffusion method and/or broth dilution method as a well-standardized and reliable reference methods that are useful for research purpose (Woods and Washington, 1999).

2.3.1 Disc diffusion method

One milliliter of overnight culture of *Listeria* strain was added to each plate containing TSA agar. When the agar was solidified, 4 commercially prepared filter paper discs (6 mm diameter) were added on each plate. Ten microlitres of each dilution of extract was applied on each disc. The control samples were (1) 10 µl of sterile distilled water as negative control and (2) 10 µl of 0.01 % solution of OTC (oxytetracycline, Krka, 743054, Slovenia) as positive control to control the sensitivity of the strains. After a diffusion time of 15 min at room temperature, the plates were incubated at 37 ºC for 24 h. After incubation, the inhibition zones (IZ) was measured in 2 directions and the average values were used to define MIC. The MIC was determined as lowest concentration of the rosemary extract that prevented the growth of listeria during the incubation period. Two replications of this experiment were made.

2.3.2 Broth dilution method

In this part of experiment we used two strains *L. monocytogenes* ŽM58 and *L. monocytogenes* ŽM115. Overnight culture was inoculated in fresh TSB medium with suitable concentration of rosemary extract. Growth of bacteria was followed at 37 ºC with viable cell counts on TSA at regular time intervals for 24 and 48 h. All data are expressed as the average of the experimental results. The MBC was determined as concentration giving 0.1 % bacterial survival (Canillac and Mourey, 2003). Controls containing absolute ethanol or sterile distilled water and no extracts of rosemary were included to verify the effect of the diluent on growth of

Listeria. Using broth dilution method four different conditions were tested:

- incubation of suspensions with 10 % of supplements (0.5 ml culture and 0.5 ml extract in 9 ml sterile TSB medium) for 24 h,
- incubation of suspensions with 20 % of supplements (1 ml culture and 1 ml extract in 8 ml sterile TSB medium) for 24 h,
- incubation of suspensions with 10 % of supplements (0.5 ml culture and 0.5 ml extract in 9 ml sterile TSB medium) for 48 h
- and incubation of suspensions with 20 % of supplements (1 ml culture and 1 ml extract in 8 ml sterile TSB medium) for 48 h.

2.4 Statistical analysis

For statistical analysis SAS (SAS Software. Version 8.01, 1999) was used. Data were tested for normal distribution and analyzed by the GLM (General Linear Model). For data analyses four statistical models were used:

$Y_{ij} = \mu + E_i + e_{ij}$ (Model 1)
$Y_{ij} = \mu + K_i + e_{ij}$ (Model 2)
$Y_{ij} = \mu + B_i + e_{ij}$ (Model 3)
$Y_{ij} = \mu + S_i + e_{ij}$ (Model 4)

where y: the observation parameter, μ = general mean, E_i = effect of extract, K_i = effect of concentration of extract, B_i = effect of different species of *Listeria*, S_i = effect of different strain of *L. monocytogenes*, e = residual random term with variance σ_e^2.

The criterion for significance in the procedure was $p<0.05$ and this indicated that data sets were significantly different between examined places. A significant difference was assigned with a different capital letter.

3 RESULTS AND DISCUSSION

The aim of our research was to investigate antimicrobial activity of rosemary extracts against *Listeria* strains and to find out MIC and MBC values with two most commonly used methods.

3.1 Antimicrobial activity of rosemary extracts determined by disc diffusion method

The antibacterial activity of rosemary extracts against *Listeria* strains which are considered in this study was assessed by evaluating the presence of IZ and MIC values. Results (Table 2), showed that the rosemary extracts have great potential of antilisterial activity against all of the eleven strains tested.

Minimal inhibitory concentration (MIC) values are expressed as µg of rosemary extract per ml of absolute ethanol.

The MIC values for were in the range of 625–5000 µg/ml for extract VivOX 20 and in the range of 312.5-2500 µg/ml for extract VivOX 40. The results of our study showed that VivOX 40 rosemary extract, which contained 40.49 % of carnosic acid, had higher or the same antibacterial effect as VivOX 20, which contained 22.04 % of carnosic acid. These was in accordance with our proposal that carnosic acid was the major bioactive compound of the rosemary extract but also its derivative and other compounds like carnosol, rosmarinic acid, etc. have important antimicrobial activity. Rosemary plants are rich sources of phenolic compounds with high antioxidative and antimicrobial properties, but their antimicrobial activities have not been deeply characterized (Moreno *et al*., 2006). There is also some evidence that minor components have a critical part in antibacterial activity, possibly by producing a synergistic effect between other components (Burt, 2004). The absence of inhibition zone does not necessarily mean that compounds are inactive. For example, non-polar compounds may not diffuse into the culture medium (Moreno *et al*., 2006).

We have established with applied statistical analysis that the resistance of *Listeria* species against rosemary extracts depends on: selected extract, selected concentration of extract, species of *Listeria* and strain of *L. monocytogenes* (Table 3).

***Table 2**: MIC values of rosemary extracts determined with agar diffusion method*

***Listeria* strain**	**MICs (µg/ml)**	
	VivOX 20	***VivOX 40***
L. monocytogenes ŽM51	2500	625
L. monocytogenes ŽM52	2500	1250
L .monocytogenes ŽM53	1250	625
L. monocytogenes ŽM58	2500	1250
L. monocytogenes ŽM80	2500	1250
L. monocytogenes ŽM92	625	625
L. monocytogenes ŽM108	2500	2500
L. monocytogenes ŽM115	1250	312,5
L. ivanovii ŽM65	1250	1250
L. grayi ŽM66	5000	1250
L. innocua ŽM68	2500	1250

***Table 3**: Statistical evaluation or antilisterial results obtained with disk diffusion method*

Selected parameter	*Tested concentration range (μg/ml)*	Inhibition zone (mm)	No. of observation	Statistical group[a]
Extract	VivOX 20	6.69	280	A
	VivOX 40	4.68	280	B
Concentration of rosemary extracts in absolute ethanol (μg /ml)	80000	10.48	56	A
	40000	10.25	56	AB
	20000	9.40	56	B
	10000	8.37	56	C
	5000	7.31	56	D
	2500	5.72	56	E
	1250	3.56	56	F
	625	1.51	56	G
	312.5	0.26	56	H
	156.25	0.00	56	H
Species of *Listeria*	*L. ivanovii*	6.94	40	B
	L. monocytogenes	6.01	320	BC
	L. grayi	5.97	40	BC
	L. innocua	5.02	40	C
Strain of *L. monocytogenes*	*L. monocytogenes* ŽM115	8.01	40	A
	L. monocytogenes ŽM92	7.43	40	A
		7.10	40	A
	L. monocytogenes ŽM51	6.25	40	A
		5.83	40	AB
	L. monocytogenes ŽM52	5.77	40	AB
		3.93	40	B
	L. monocytogenes ŽM108	3.77	40	B
	L. monocytogenes ŽM80			
	L. monocytogenes ŽM58			
	L. monocytogenes ŽM53			

[a] Values followed by the different letters are significantly ($p<0.05$) different from each other at selected parameter

On the basis of results obtained with agar diffusion method, for the further experiments two strains of *L. monocytogenes* were selected. *L. monocytogenes* ŽM115 on which rosemary extracts had the highest antimicrobial effect and *L. monocytogenes* ŽM58 as a strain with the biggest statistical difference comparing with the first selected one (Table 3 and Figure 2).

4.2 Antimicrobial activity of rosemary extracts determined by broth dilution method

MBC values of rosemary extracts for *L. monocytogenes* ŽM58 and *L. monocytogenes* ŽM115 were determined by a broth dilution method. All experiments were repeated at least two times on different days and all data are expressed as the average of the experimental results.

The MBC was read from the graph obtained by plotting the percentage of survival cells ($\log_{10}$) versus the percentage of the corresponding concentration of rosemary extracts (Figure 2). The MBC is the concentration of rosemary extract giving 0.1 % *L. monocytogenes* ŽM58 survival ($\log_{10}$ 0.1 = -1) after 24 h incubation as proposed by Canillac and Mourey, 2003.

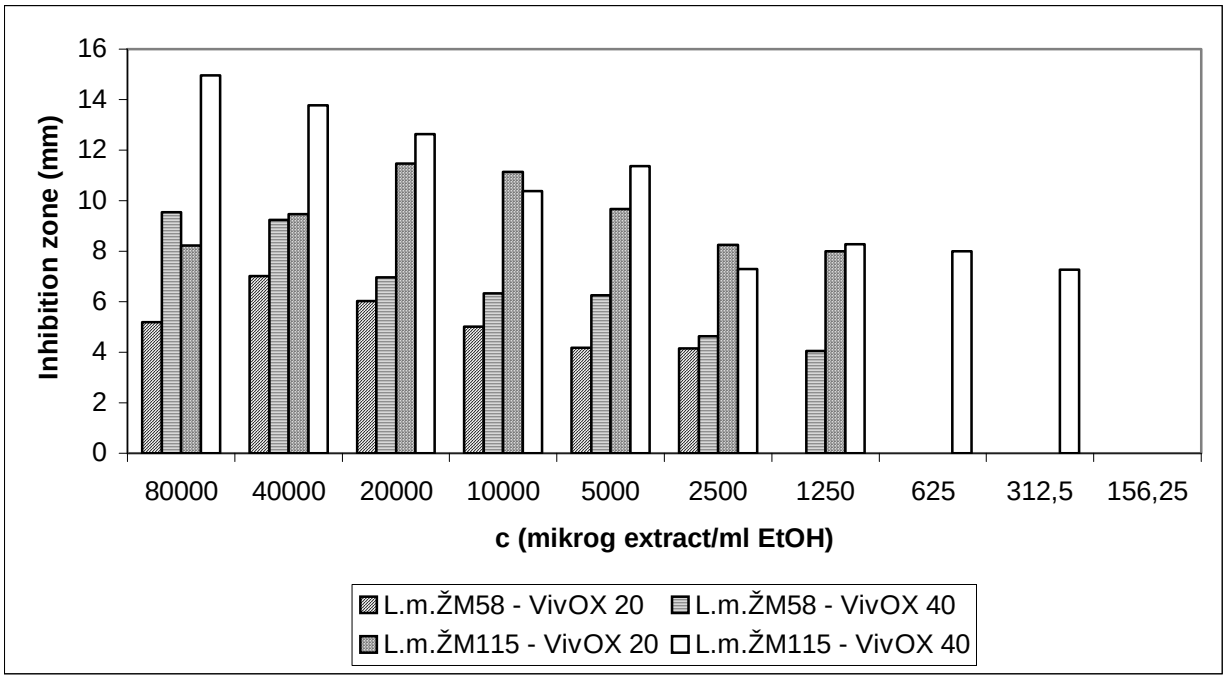

***Figure 1**: The average inhibition zones for L. monocytogenes ŽM58 and L. monocytogenes ŽM115 under the different concentrations of extracts VivOX 20 and VivOX 40*

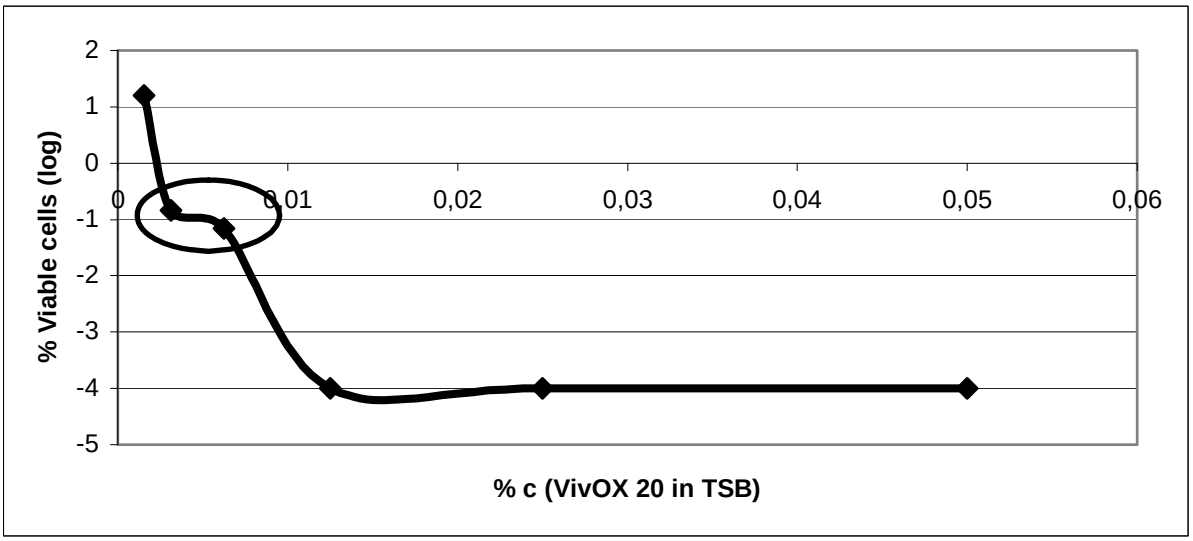

***Figure 2**: The effect of different concentrations of VivOX 20 on the percentage of viable cells of L. monocytogenes ŽM58 after 24 h incubation in TSB broth at 10 % volume of supplement*

Figure 2 shows that MBC is between 0 and 0.01 % of rosemary extract VivOX 20 in TSB broth. For accurate results, we have calculated straight line equation and MBC 0.00539 % extract in TSB broth.

In this example, the calculated MBC value for *L. monocytogenes* ŽM58 was 0.00539 % of VivOX 20 in TSB broth. On the same mode all MBC values were calculated from experimental data for extract VivOX 20 and VivOX 40 under different conditions and results are summarized in table 4.

***Table 4**: MBC values of VivOX 20 and VivOX 40 for L. monocytogenes ŽM115 and L. monocytogenes ŽM58*

Parameter	**MBC (µg/ml)**							
Type of extract	VivOX 20				VivOX 40			
Volume of supplement	10 vol. %		20 vol. %		10 vol. %		20 vol. %	
Incubation time	24 h	48 h	24 h	48 h	24 h	48 h	24 h	48 h
L. monocytogenes ŽM115	401.0	252.5	15.63	40.7	/	/	< 31.25	/
L. monocytogenes ŽM58	53.9	98.5	/	/	42.4	56.0	/	/

MBC: Minimal bactericidal concentration value is expressed as µg of rosemary extract per ml of TSB broth; /: not done

MBC values recorded for both rosemary extracts were often greater after 48 than 24 h incubation (Table 4). VivOX 20 extract was effective against *L. monocytogenes* ŽM115 with an MBC 401 µg/ml after 24 h incubation and 252.5 µg/ml after 48 h incubation, with 10 % of supplements. In contrast, with 20 % of supplements and the same strain of *Listeria*, MBC was 15.63 µg/ml after 24 h and 40.7 µg/ml after 48 h incubation. When 31.25 µg/ml of VivOX 40 extract was used, a 99.9 % inhibition was observed after 24 h. A higher bactericidal effect was found testing extract VivOX 20 with *L. monocytogenes* ŽM58, because 53.9 µg/ml were necessary to obtain MBC after 24 h and 98.5 µg/ml after 48 h incubation with 10 % addition of supplements. VivOX 40 showed similar MBC values against *L. monocytogenes* ŽM58 with also 10 % of supplements: 42.4 µg/ml after 24 h and 56.0 µg/ml after 48 h incubation. The strain of *L. monocytogenes* ŽM115 was slightly less sensitive. We assumed that this strain, isolated from Tatarian beefsteak was exposed to different stress conditions (change in T, pH, etc.) and this consecutively lead to increase strain′s resistance. The results also shows that bigger quantity of supplements in TSB broth decrease MBC, that is why we assumed that this lead to changes the composition of broth.

4 CONCLUSIONS

Here, we describe the antimicrobial activity of rosemary extracts against *Listeria* strains. Our results show that both extracts VivOX 20 and VivOX 40 had a good antimicrobial activity against several strains of *Listeria*. The definition of the MIC and MBC differs between publications and this is obstacle to comparison results between studies. More effective was extract VivOX 40, which contained a higher percent of carnosic acid, but the differences in MIC and MBC between the extracts were not so high, so we assumed that also other compounds in extracts had important antimicrobial activity. We confirmed that antimicrobial activity of rosemary extracts was dependent on selected rosemary extract, concentration of extracts, different species of *Listeria* and different strains of *L. monocytogenes*.

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Local inhabitants' opinion about quality of life inside and outside the Triglav National Park

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ABSTRACT

Article presents results of a research made among local inhabitants inside and outside the Triglav National Park in Slovenia. Including the local inhabitants in the decision making process should have positive influence on further progress of the area. A poll was made among 200 residents for this purpose, in which we wanted to get inhabitants' opinion of quality of life in the area where they live. Results indicate that 36% of interviewees agree that their quality of life is good and 12% claim that it is very good. 68% of inhabitants strongly agree and 25% agree that their area of living needs better employment chances.

Key-words: national park, quality of life, local inhabitants' opinion, Slovenia.

IZVLEČEK

MNENJE LOKALNIH PREBIVALCEV O KVALITETI ŽIVLJENJA V IN IZVEN TRIGLAVSKEGA NARODNEGA PARKA V SLOVENIJI

Članek predstavlja rezultate raziskave, ki je bila izvedena med lokalnim prebivalstvom, ki živijo v in izven Triglavskega narodnega parka v Sloveniji. Vključitev lokalnega prebivalstva v proces soodločanja naj bi pozitivno vplivala na nadaljnji razvoj območja. V ta namen je bila izvedena anketa med 200 anketiranci s katero smo želeli pridobiti mnenje prebivalcev o kvaliteti življenja v območju, kjer prebivajo. Rezultati kažejo, da se 36% anketiranih prebivalcev strinja, da je kvaliteta življenja v območju kjer prebivajo dobra, 12% jih meni, da je kvaliteta življenja zelo dobra. Kar 68% anketiranih prebivalcev se zelo strinja in 25% se strinja s trditvijo, da njihovo območje potrebuje boljše možnosti zaposlovanja.

Ključne besede: narodni park, kvaliteta življenja, mnenje lokalnih prebivalcev, Slovenija.

1 INTRODUCTION

Different experts admit that social factor has a very important role in protected area management (Sewell, 1973, 1974; Grumbine, 1994; Christensen et al., 1996; Trakolis, 2001; Pavlikakis and Tsihrintzis, 2001, 2003a, 2006, Elliott and Udovč, 2005, Rodela and Udovč, 2008). Inhabitants' participation in decision making process and inclusion of their preferences, needs and activities into the management plans ensure their realization and expected results. Research work on social and economic status as well as on preferences and perceptions of the people should be beforehand of all other activities, to avoid the disagreements. The local inhabitants have to be part of the integrated management method (Pavlikakis and Tsihrintzis, 1999, 2000, 2001, 2003a, 2003b, 2006). Also the IUCN (International Union for Conservation of Nature and Natural Resources) believes that local inhabitants taking

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part and having equal rights in the decision making process, is of great significance (IUCN, 1993).

The experts began to discover the importance and role of local inhabitants in projects on development of rural societies not earlier than in 70'. There are more reasons for this and they originate first of all from the fact, that the local inhabitants know, see and understand their area better than anybody else (Barbič, 1991).

Inhabitants should be directly attracted to participate in all preparation phases and in the carrying out of the development programs. "Bottom up" development approach, which is founded on democratic enforcements of developing interests and initiatives, enables realizing the principle of subsidiary in managing the public affairs, releases the personal initiative of local inhabitants and strengthens the mutuality and essential cooperation at performing development activities (Kovačič, 2000, Perpar and Udovč, 2007). It can be said, that the basic condition for success of any rural development project is incorporation of local inhabitants needs (Barbič, 1991, Barbič et al., 2004, Udovč and Perpar, 2007).

Slovenian rural development policy for the period 2007-2013 forms three main axes, which are aimed to increase the competitive position of agriculture and forestry, improvement of environments condition on countryside and improvement of life quality and stimulation of various economic activities in countryside. Single axes include measures for reaching the set goals, supported with financial sources from European agricultural fund for rural development. To the listed axes counts also the methodological axis LEADER, with the "bottom up" approach, what encourages local activity at rural development (Program razvoja …, 2008; Projekt …, 2008).

Purpose of this article is to represent local inhabitants' perception about quality of life in the area where they live and their opinion, what this area needs for better quality of life. The main question was, if there are any differences in quality of life between people who live within the Triglav National Park and those who live outside the protected area.

2 MATERIALS AND METHODS

Data for the analysis were collected within the project "Triglavski narodni park – Analiza izkušenj lokalnega prebivalstva" where we using questionnaire (Rodela, 2007) with 200 randomly chosen local inhabitants within and outside the Triglav National Park. Data assembling took place from 5th till 21st of September 2006. Inside the Triglav National Park 46 residents from 19 villages were questioned, which represents 23% of whole sample. In areas around the Triglav National Park 154 residents from 36 villages were questioned and that represents 77% of the whole sample. Comparing the area of living there was 80 inquiries made in Posočje, 80 in Kranjska Gora and Bled area and 40 in Bohinj area. Questioned people were chosen randomly, by considering next criteria: they had to be full aged, native or having a residence of living in that area, which they define as their home. At poll we wanted to equally include people employed in different economic spheres, namely farmers, tourism contractors, people employed in tourism, other contractors and craftsmen, people employed in bigger and smaller enterprises and people employed in public institutions.

People, who took part in the poll, were asked about following socio-demographic characteristics: town of residence, gender, year of birth, number of members in housekeeping and number of children, legal status, employment status, place of work and education.

The people were also asked to estimate quality of life in the area they live in. Quality of life of local inhabitants was studied with following variables: employment chances, rural development policy, chances of adults educations, conditions for establishing an enterprise or trade activity, conditions to employ small contractors and tradesmen, road connection, public transport access, internet and telephone access, possibilities for entertainment and social connections, medical care, caring for residents needs from local communities and state institutions, cooperation between local contractors, tradesmen and commune and coordination/leadership. Statements about quality of life were rated with seven degree Likert scale, where mark 1 signified, that people totally disagree with the statement and mark 7 signified, that they strongly agree with the statement.

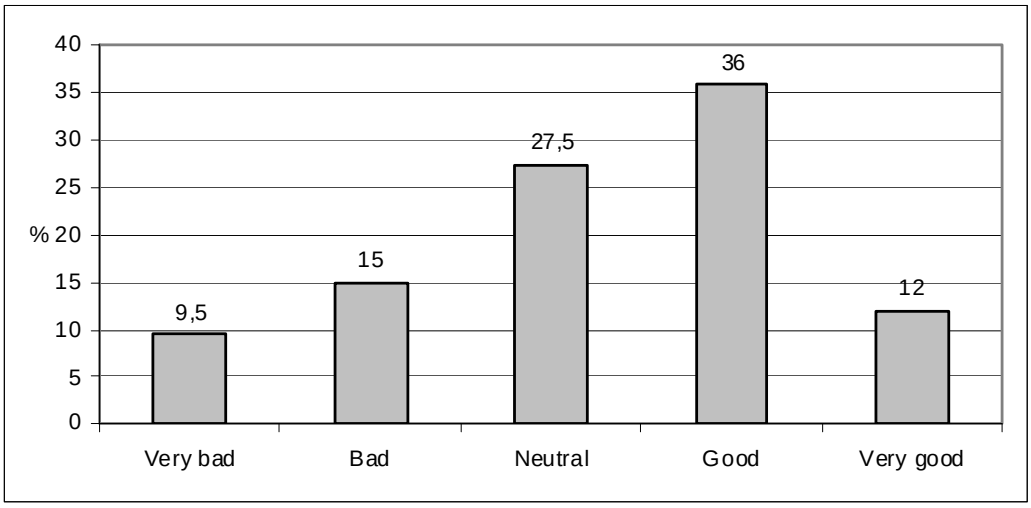
Statistic analysis of the answers was made with use of the SPSS 15.0 programme for Windows. We calculate basics statistic parameters for each variable. Where necessary we joined marks 2 and 3 and marks 5 and 6 on the 1 to 7 scale, because of small number of answers. Differences were tested with Chi-square test.

3 RESULTS AND DISCUSSION

Number of people questioned was equally distributed between women (54.5%) and men (45.5%). Majority of questioned were aged between 26 and 55 years (74.5%), and belong to the most active part of the population. Education level indicates that the majority of interviewees have secondary school education (64.5%).

As for the employment status 14% of people included in poll were farmers, 32.5% employed in tourism and 53.5 employed in other economic branches. 38.5% of questioned people live in families with 2 members, 25.5% in families with 3 members and 25.5% with 4 members. More than one half of the people included in the poll (53%) did not have any children. 21% of asked have only one child and 18.5% had two children. 61% of questioned inhabitants were married, 18.5% were single and 16.5% lived together with a partner. 88.5% of people, who took part in the poll, work in the same commune as they live in and 7% drive on work to the neighbouring commune.

Results show (Picture 1), that 36% of people, who took part in the poll, agree with the statement, that the quality of life in their area is good, and 12% believe that quality of life is very good. 15% of people believe that the quality of life is bad and 9.5% think that it is very bad.



***Picture 1**: Assessment of quality of life by interviewees, 2006*

Inhabitants agree that the area needs above all better employment chances (93%), better rural development policy (88%), more care from state institutions (85%), better employment chances for people with college and high education (84%), more care for inhabitants' needs from local communities (83%), better coordination/leadership (81%) and better road connections (80.5%).

As many as 68% of people taking part in the poll strongly agree and 25% agree with the statement, that their area needs better employment chances. That area needs better employment chances for high educated people and people with college strongly agree 64% and agree 20% of the people questioned.

Additional comments were mostly given by the question about quality of road connections. Residents mentioned above all that the local roads are in bad conditions. Inhabitants of Bled have exposed the problem of increased traffic in mornings and afternoons rush hours and the need for building a bypass around the city centre. In tourist places, as for example Bled, inhabitants think, that above all in wintertime there are not enough opportunities for social interactions and entertainment among locals. What concerns the medical care, inhabitants warn that in the tourist season, because of so many tourists, the need for medical service is higher. Access to public transport is important above all for schoolchildren and students. Public transport (bus, train) should be better connected with school centres and first of all trains should drive more regularly in hours before and after classes. In certain areas there is still bad internet access.

We also asked interviewees if, beside what was already listed needs, they need anything else. 24 or 12% of people included in the poll answered positively and mentioned:

- bio shop
- increased environment protection
- better adoption to peoples' needs for example with setting up a college,
- more people with feeling for countryside, for preserving settlement of countryside,
- bookstore and sports equipment shop,
- development strategy,
- cycling paths,

***Table 1**: Agreement of the interviewees with the given statements*

	I do not agree at all		I do not agree		Undecided		I agree		I strongly agree	
	N	%	N	%	N	%	N	%	N	%
Better employment chances	3	1.5	4	2.0	7	3.5	50	25.0	136	68.0
Better employment chances for high educated people and people with college	4	2.0	7	3.5	21	10.5	40	20.0	128	64.0
Better rural development policy	4	2.0	4	2.0	16	8.0	51	25.5	125	62.5
Better road connection	11	5.5	11	5.5	17	8.5	40	20.0	121	60.5
More care from side of public institutions	5	2.5	6	3.0	19	9.5	56	28.0	114	57.0
More care for inhabitants' needs from side of local communities	4	2.0	7	3.5	23	11.5	68	34.0	98	49.0
Better conditions for small enterprises and craftsmen	3	1.5	11	5.5	32	16.0	56	28.0	98	49.0
Better coordination/leadership	10	5.0	8	4.0	20	10.0	65	32.5	97	48.5
Better medical care	24	12.0	13	6.5	25	12.5	44	22.0	94	47.0
Better conditions for establishing an enterprise or trade activity	7	3.5	10	5.0	38	19.0	56	28.0	89	44.5
Better cooperation between local contractors and commune	8	4.0	6	3.0	45	22.5	57	28.5	84	42.0
More chances for social life and entertainment	28	14.0	19	9.5	19	9.5	60	30.0	74	37.0
Better cooperation between local contractors and tradesmen	9	4.5	10	5.0	50	25.0	61	30.5	70	35.0
Better chances for adult education	18	9.0	16	8.0	25	12.5	74	37.0	67	33.5
Improvement of access to public transport	37	18.5	18	9.0	24	12.0	54	27.0	67	33.5
Better access to telephone, post and internet	74	37.0	28	14.0	21	10.5	37	18.5	40	20.0

- more help with setting new activities, preparation of documentation and financial support,
- finances, that the road infrastructure, public transport, telecommunications, etc would better function - better municipal infrastructure,
- better feeling of a collective, help from craftsmen and contractors and help from commune by different activities,
- better chances for leisure time activities (for example swimming pool),
- better coherence between economic subjects in general,
- to attract people to stay here with assuring more employment opportunities,
- the main problem is, that the area needs, as all the other areas in the country, better legislation system, the system of non-refundable funds are not big enough to help people and they should devote bigger part of the budget for countryside,
- better railway connections,
- more winter tourist, acceleration of winter tourism,
- same chances for countryside and town,
- better social standard,

- better scholarship policy, because of the remoteness from school centres more schoolchildren and students should get scholarships,
- income tax relieves,
- shop,
- more provisions and technical stores,

We were also interested if there are any significant statistical correlations between place of living (Posočje, Bled, Kranjska Gora and Bohinj), area of living (within or outside the protected area), gender, age and education.

Comparison of quality of life and area of living (in or outside the protected area) (Table 2) showed that 13% of people living outside the Triglav National Park and 8.7% of those living within the Triglav National Park believe that the quality of life is very good. That the quality of life is good think 38.3% of questioned living outside the Triglav National Park and 28.3% of those living within the Triglav National Park. 13% of questioned living within the Triglav National Park and 8.4% of those living outside the Triglav National Park think that their quality of life is very bad. That the quality of life is bad think 6.5% of questioned living within the Triglav National Park and 17.5% outside the Triglav National Park (p=0.030). Results show, that the people who live inside the Triglav National Park are less satisfied with their quality of life than those who live outside the park (37% versus 51.3%).

***Table 2**: Quality of life compared to area of living (within or outside protected area)*

			Life quality					
			Very bad	Bad	Neutral	Good	Very good	Total
In/outside	inside	number	6	3	20	13	4	46
		% in/outside	13.0	6.5	43.5	28.3	8.7	100.0
		% life quality	31.6	10.0	36.4	18.1	16.7	23.0
	outside	number	13	27	35	59	20	154
		% in/outside	8.4	17.5	22.7	38.3	13.0	100.0
		% life quality	68.4	90.0	63.6	81.9	83.3	77.0
Total		number	19	30	55	72	24	200
		% in/outside	9.5	15.0	27.5	36.0	12.0	100.0
		% life quality	100.0	100.0	100.0	100.0	100.0	100.0

Statistically significant is also the relation between the area of living (inside or outside the Triglav National Park) and opinion of residents that the area needs better medical services (p=0.005). That the area needs better medical services in higher number agree inhabitants inside the Triglav National park (91.3%), than those living outside the Triglav National Park (62.3%). As much as 65.2% of people taking part in the survey within the Triglav National Park strongly agree and 26.1% agree that the area needs better medical services. 41.6% of questioned outside the protected area strongly agree that the area needs better medical services, where 20.8% of them this statement marked with agree.

Those living inside the Triglav National Park think that this area needs better access to the telephone, post and internet (60.9%). The same opinion has 31.8% of people living outside the Triglav National Park, what is a significant difference (p=0.004).

69.6% of questioned, living inside the Triglav National Park, think that their area needs better coordination/leadership. The same opinion has 84.4% of those living outside the Triglav National Park. 19.5% of people questioned inside the Triglav National Park and just 5.8% of people questioned outside the Triglav National Park disagree with the statement that their area needs better coordination/leadership. In spite of big part of those who have the wish for better coordination/leadership, we see that the part of those is smaller in the Triglav National Park as outside the protected area (p=0.044), perhaps because the protected area has some legally defined structures.

The results also show, that people living within the Triglav National Park (78.3%) miss chances for social interactions and entertainment much more than people living outside the Triglav National Park (63.6%) (p=0.053).

Chi-square test shows that there is statistically significant relation between quality of life and the place of residence (p=0.008). 21.3% of questioned from Bled and Kranjska Gora think, that the quality of life is very good. That the quality is good agree further 40% of people included in the poll living on Bled and Kranjska Gora area. Unhappy with life quality are as much as 32.5% of people from Posočje (Table 3).

***Table 3**: Quality of life regarding the place of living*

			Quality of life					
			Very bad	Bad	Neutral	Good	Very good	Total
Place of living	Posočje	number	8	18	25	25	4	80
		% area	10.0	22.5	31.3	31.3	5.0	100
		% quality of life	42.1	60.0	45.5	34.7	16.7	40.0
	Bled, Kranjska Gora	number	4	8	19	32	17	80
		% area	5.0	10.0	23.8	40.0	21.3	100
		% quality of life	21.1	26.7	34.5	44.4	70.8	40.0
	Bohinj	number	7	4	11	15	3	40
		% area	17.5	10.0	27.5	37.5	7.5	100.0
		% quality of life	36.8	13.3	20.0	20.8	12.5	20.0
Total		number	19	30	55	72	24	200
		% area	9.5	15.0	27.5	36.0	12.0	100.0
		% quality of life	100.0	100.0	100.0	100.0	100.0	100.0

There is statistically significant relation between place of living and the need for better employment chances (p=0.020). In all places residents strongly agree that the area needs better employment chances. Such answer gave 78.8% of questioned from Posočje, 75% of questioned from Bohinj and 53.8% living in Bled and Kranjska Gora.

In Bohinj 85% of interviewees strongly agree and 12.5% agree with the statement, that their area needs better rural development policy. That area needs better rural development policy strongly agree 58.8% and agree 30% residents from Posočje and also strongly agree 55% and agree 27.5% questioned from Bled and Kranjska Gora. The differences among places of living are statistically significant (p=0.022).

As much as 87.5% of questioned from Bohinj strongly agree and 7.5% agree with statement, that the area needs better medical provision. With this statement strongly agree 37.5% and agree 33.8% questioned from Posočje. Results show that 27.5% people from Bled and Kranjska Gora thinks that their area doesn't need better medical services. The differences among places are statistically significant (p=0.000).

Regarding the interviewees' perception of the local leadership 25% questioned from Bohinj, 6.3% from Bled and Kranjska Gora and 3.8% from Posočje do not agree with the statement, that their area needs better coordination/leadership. That the area needs better coordination/leadership agree 88.8% from Posočje, 78.8% from Bled and Kranjska Gora and 70% from Bohinj. The differences among places of living are statistically significant (p=0.002). On the other hand there is a statistical significant difference (p=0.061) in the opinion that the area needs better conditions for establishing an enterprise or trade activity. 85.1% from Posočje, 70% from Bohinj and 61.3% from Bled and Kranjska Gora agree with that.

Table 4 shows, that there is no statistically significant connection between the assessment of the quality of life and gender (p=0.904).

Results also show that 72.5% of women and 53.8% of men strongly agree with the statement, that the area needs better employment chances for high educated people and people with college. With this statement don't agree 9.9% men and just 1.8% women and the difference is statistically significant (p=0.017).

With the statement, that the area needs more opportunities for social interactions and entertainment agrees 78% of women and 53.9% of men. As much as 23.1% of men and just 6.4% of women don't agree with this statement at all. The difference is statistically significant (p=0.000).

Results show, that with the statement, that the quality of life is good, more agree younger people than older (p=0.030). More than half of people included in the poll which are up to 45 years old, agree that the quality of life is good (Table 5).

***Table 4**: Assessment of quality of life compared to gender*

			Quality of life					
			Very bad	Bad	Neutral	Good	Very good	Total
Gender	female	number	11	15	30	38	15	109
		% gender	10.1	13.8	27.5	34.9	13.8	100.0
		% quality of life	57.9	50.0	54.5	52.8	62.5	54.5
	male	number	8	15	25	34	9	91
		% gender	8.8	16.5	27.5	37.4	9.9	100.0
		% quality of life	42.1	50.0	45.5	47.2	37.5	45.5
Total		number	19	30	55	72	24	200
		% gender	9.5	15.0	27.5	36.0	12.0	100.0
		% quality of life	100.0	100.0	100.0	100.0	100.0	100.0

***Table 5**: Quality of life compared to age*

			Quality of life					
			Very bad	Bad	Neutral	Good	Very good	Total
Age	18-25	number	1	2	5	8	3	19
		% age	5.3	10.5	26.3	42.1	15.8	100.0
		% quality of life	5.3	6.7	9.1	11.1	12.5	9.5
	26-35	number	1	6	12	18	5	42
		% age	2.4	14.3	28.6	42.9	11.9	100.0
		% quality of life	5.3	20.0	21.8	25.0	20.8	21.0
	36-45	number	5	11	15	29	9	69
		% age	7.2	15.9	21.7	42.0	13.0	100.0
		% life quality	26.3	36.7	27.3	40.3	37.5	34.5
	46-55	number	5	10	9	11	3	38
		% age	13.2	26.3	23.7	28.9	7.9	100.0
		% quality of life	26.3	33.3	16.4	15.3	12.5	19.0
	56-65	number	7	0	9	6	3	25
		% age	28.0	0.0	36.0	24.0	12.0	100.0
		% quality of life	36.8	0.0	16.4	8.3	12.5	12.5
	66-76	number	0	1	5	0	1	7
		% age	0.0	14.3	71.4	0.0	14.3	100.0
		% quality of life	0.0	3.3	9.1	0.0	4.2	3.5
Total		number	19	30	55	72	24	200
		% age	9.5	15.0	27.5	36.0	12.0	100.0
		% quality of life	100.0	100.0	100.0	100.0	100.0	100.0

That their area needs better access to telephone, post and internet thinks 57.2% people aged between 66 and 76 years, 47.8% people aged between 36 and 45 years, 42.1% people aged between 18 and 25 years, 35.7% people aged between 26 and 35 years, 29% people aged between 46 and 55 years and 24% people aged between 56 and 65 years. People aged between 46 and 65 years in bigger number not agree, that the area needs better access to telephone, post and internet (p=0.054).

There is no statistically significant differences between quality of life and education (p=0.478). Further the results show, that higher the people's education is more they agree with the statement that the area needs more attention from state institutions. Thus as much as 100% questioned with faculty, 85.8% people with vocational college, 83.7% people with secondary school and 64.3% people with elementary education think, that the area needs more attention for inhabitants' needs from state institutions (p=0.000).

Results show, that higher educated people in higher number agree that the area needs better coordination/leadership unlike those with elementary

education. That the area needs better coordination/leadership agree 64.3% people with elementary education, 79.3% of people with faculty, 82.2% people with vocational college and 82.9% of people with secondary school (p=0.024).

4 CONCLUSIONS

Often the local inhabitants are excluded or overlooked at decision-making in different projects. With analyzing the perceptions and responses of local inhabitants we wanted to present the opinion of the local inhabitants living inside or outside the Triglav National Park about quality of life.

With the quality of life is satisfied almost half of the questioned. There is significant statistical difference between the quality of life and place of living (in or outside the Triglav National Park). Results show, that the people who live inside the Triglav National Park are less satisfied with their quality of life than those who live outside the park.

Regardless the place of living the inhabitants agree that their area needs above all better employment chances, better rural development policy, more care from state institutions, better employment chances for people with college and high education, more care for inhabitants' needs from local communities, better coordination/ leadership and better road connections.

There are statistical significant differences among questioned inhabitants, living inside the Triglav National Park and those living outside of it, regarding their opinions that their area needs better medical services, more opportunities for social interactions and entertainment and better access to telephone, post services and internet. In all mentioned cases the inhabitants living inside the Triglav National Park assessed the needs for listed services higher as those living outside. We believe that the identified difference can be explained with fact, that the people living outside the park live in bigger settlements or near to them, where different services are easier accessible and the supply is higher.

The results also show, that less of the interviewees living inside the park, then those who live outside of it, have the opinion that their area needs a better coordination/leadership, what we connect with the fact, that the park is legally regulated.

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Scenario use for fostered adaptation to the future landscape changes[1]

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ABSTRACT

Article presents the review of the theoretical framework for a specific question that arose from the use of the scenario technique in the field of landscape planning. This specific issue is: does the use of scenarios influence the perception of the cultural landscape changes and actions the individuals take to change the cultural landscape? Review includes research articles aiming to approve the influence of scenarios and also case studies of scenario use in the field of landscape planning that perceived possible influence of scenario use on stakeholders. The decision for the review was stimulated by the growing popularity of the scenario-based studies connected with landscape planning and environmental issues. Scenarios are also an important incentive for public participation. The question is whether we can influence relations between individuals and cultural landscape by showing them evidently with scenarios, how the future landscape will look like.

Keywords: land use scenarios, psychological aspects of scenario use, changes of perception and behaviour, cultural landscape changes

IZVLEČEK

SCENARIJI RAZVOJA KULTURNE KRAJINE ZA LAŽJO PREDSTAVLJIVOST SPREMEMB V PROSTORU

Pri vse pogostejši uporabi scenarijev na področju krajinskega in prostorskega planiranja se zastavlja vprašanje, kako scenariji razvoja kulturne krajine vplivajo na dojemanje sprememb kulturne krajine pri deležnikih ter s tem posredno tudi na njihovo delovanje v kulturni krajini. Članek podaja pregled nad posameznimi tujimi raziskavami, ki se vsebinsko navezujejo na vprašanje psihološkega vpliva scenarijev na deležnike, ter primeri uporabe scenarijev v načrtovalskih postopkih, kjer so raziskovalci zasledili relevanten vpliv te metode na deležnike. Uporaba scenarijev v postopkih sodelovanja z javnostjo je zaželena metoda za spodbujanje participacije javnosti, saj scenariji zaradi svoje privlačnosti nemalokrat olajšajo komunikacijo med raziskovalci in javnostjo. Pogosta uporaba scenarijev pri prostorskem planiranju in reševanju okoljskih vprašanj je spodbudila razmislek o tem, da uporaba scenarijev, za prikaz morebitnih prihodnjih sprememb kulturne krajine, vpliva na odnos deležnikov do kulturne krajine.

Ključne besede: scenariji razvoja kulturne krajine, psihološki vidiki uporabe scenarijev, vpliv na dojemanje sprememb, spremembe kulturne krajine

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1 INTRODUCTION AND BACKGROUND OF THE REVIEW

Scenarios enable identification and demonstration of the effects of different activities in the real space of the future, which can also influence the present and planned activities. By informing about undesired consequences, scenarios can help the actors (either individuals or institutions which perform the public policies) change their activities and adjust them so that they could avoid the negative effects and strengthen the positive effects on the landscape. Another important aspect of the scenario use is participation of decision makers and public in the decision making process. Scenarios are an easy to understand and convincing tool for presenting potential consequences of alternative decisions as well as for articulating and communicating attitudes and opinions. Use of the scenarios for the purpose of public informing and education proved to be a very helpful tool to promote understanding of the links between planned intervention and environment/space, land-use and changes in living conditions. Many cases showed (e. g. Wollenberg et al., 2000; Shearer, 2005; B. Tress and G. Tress, 2003) that use of the scenarios in participative process foster informed decisions and behaviour. Luke and Rutheford (1999, cited in: Public…, 2003) write about great significance of including the public and stimulation of their co-operation in solving global environmental issues, such as climate changes. Wollenberg et al. (2000) pointed out the influences of the scenarios on spatial planning and management. They found out that scenarios are not only useful for preparation of different measures in case of changes, but they also anticipate changes. Psychological influences of the scenarios on perceptions of the future were assessed by Gregory and Duran (2001) but the research wasn't focused on the use of the scenarios for representing changes of the cultural landscape or the space. The conclusion was that scenarios influence the awareness of different possibilities of the development and also change expectations in respect of probable events in the future.

1.1 Origins and meaning of the scenarios

Scenario–based research began in the middle of the 20th century as an approach in decision-making among alternative futures and to help manage the inherent uncertainties. Applicability in spatial planning began to increase since the early 1970s (Shearer, 2005). The whole spectrum of the scenarios is very broad and they can be used for various purposes.

As alternative views of the future the scenarios can help to manage uncertainties of decisions based on assumptions instead of facts, which is an unavoidable consequence of investigating future. Use of the scenarios to preview potential consequences of different future contexts can help to improve decisions and to direct the development towards desired changes in space. Scenarios present abstract constructions of possible future developments and incorporate different future-oriented studies and techniques. Different aims of future studies and different approaches lead to variety of scenario definitions.

According to Shearer (2005), scenarios are fictional accounts, which represent a process of change over some duration; they describe situations, actions and consequences which are contingently related. The scenarios are understood to be predictive judgments, which describe what could happen, and not predictions which describe what will happen. Scenarios are constructed for the purpose of focusing attention on causal processes and decision points (Kahn and Wiener, 1967, cited in: Shearer, 2005). Another definition introduced by Shoemaker (cited in: Wollenberg et al., 2000) states that the scenarios stimulate creative ways of thinking, which help actors to upgrade the fixed ways of assessing the situation and planning of the activities. This enables them to adjust better to the future. Accordingly Armstrong (Principles..., 2001, p.16) warns that scenarios should not be used to make forecasts, because they could turn out wrong and convincing. Scenarios can lead people to take forecasts seriously. They create an increase in the perceived likelihood of the event and can motivate decision makers to think the situation trough.

1.2 Background of the review

The review focused on the literature that discusses psychological view of the scenario use. Only few articles (Gregory and Duran, 2001, Shearer, 2005, Aligica, 2005) were actually accordant with this subject, many more presented case studies on scenario use and under results or discussion also mention the noticed responses of public (Masini and Vasquez, 2000, Wollenberg et al., 2000, Santelmann, 2004). Nevertheless, this literature is very important, as it also presents the scenario use in fields of landscape or spatial planning. The majority of literature is more business/ economics oriented, mostly dealing with methodology and benefits of the scenario use in strategic planning of company operation (Lindgren and Bandhold, 2003). Also the contribution of futurists must not be neglected since it brings significant knowledge about theory of the scenario building and also of the ethics on the scenario use (Schwartz, 1991; Mannermaa, 1996).

The review shows, just as mentioned by Gregory and Duran (2001), that literature on scenarios mainly presents case studies, but fails to present the efficacy and/or the drawbacks of the scenario use and, in this specific case the facts that make scenarios a tool for

influencing a person or a group of people. The word influencing, like manipulating, has positive and also a negative connotation. Influence (Wikipedia…, 2007) is a term that refers to ability to control or affect indirectly the actions of other people or things. Influence is when the actions or thoughts of individual(s) are changed by other individual(s).

The primary result of the review is the acquired knowledge about the influence of the scenarios on perceptions of the future and on activities or measures individuals take in the landscape. The review will elucidate possibilities of using the scenarios to increase the awareness and to stimulate desired activities in order to prevent negative consequences, or to stimulate positive consequences of the spatial development in the future.

1.3 Scenarios as a tool for research and a tool for planning

The largest share of reviewed articles presents psychological studies of the scenarios and case studies of the scenario use in landscape planning. The first type of literature presents scenarios as a tool for research. Where the results were obtained through guided and controlled experiments in order to prove psychological effects of the scenarios. The second type of the literature are case studies of planning processes that used scenarios as a planning tool to present future changes of landscape and environment. These scenarios are mainly aiming at exchanging the knowledge and the viewpoint of different stakeholders about the future development of landscape or the environment on general.

Both types of scenarios were equally important for the further research aiming at verifying the hypothesis that (land use) scenarios influence the perceptions about the future and activities connected with space and environment.

2 FINDINGS AND DISCUSSION

2.1 Why do scenarios work?

Lately scenarios are frequently mentioned and used in different fields and studies connected with investigating and planning the future, e.g. public policy, strategic thinking, management and planning, also including spatial and landscape planning as special fields. As a scientific tool the use of the scenarios can be questionable. The investigation of the future can not be grounded solely on provable facts, a certain part of it is inevitably speculative. The relevance of the scenarios as a kind of experiment is mostly being questioned in academic circles. According to Aligica (2005), the scenarios have the reputation of being "puzzling". Although the methodology, the toolbox and the forecasting practice are firmly established, the reluctance is presumably for their probable or possible character. Scenarios are cognitive constructs and as such they can and must be first explained from the psychological point of view, especially if we want to elucidate their influence on people's perceptions and actions.

Lindgren and Bandhold (2003, p. 29) suggest that scenarios are powerful as their narrative format (usually in the form of images and stories) is very memorable and enables us to develop an emotional relationship; by forcing the mind to think about qualitatively different directions, one improves the ability to foresee unusual events. Through scenarios complex situations can be reduced to a manageable amount of uncertainty and they are easy to communicate and to discuss. Different authors mention that the use of the scenarios is inherent to people. Thinking in scenarios helps us to understand the logic of developments, clarify driving forces, key factors, key players and our own potential to exert an influence. Scenarios may function both as an inspiration for generating idea and as filters trough which new ideas and projects can be passed. Scenarios may also be used for learning and to drive change. They are powerful in challenging existing paradigms and assumptions, especially for those who are involved in the scenario generation. Therefore scenario workshops are powerful instruments in the process of challenging existing paradigms and creating shared perspectives on the future.

Scenario building is therefore also an intuitive and creative process, but it must be based on thorough research of present and past conditions and future development and trends to ensure the validity of their use. Aligica (2005) questions the epistemic value and knowledge creation of scenarios, since they can not be subjected to empirical proofs and confirmed by "hard" evidence. Author also stresses that scenarios above all have cognitive nature, without it they would be just "pale psychological exercises meant to alleviate fear, to motivate and to please imagination and aesthetic urges about the future". He also cites Fauconnier and Turner that have characterized scenarios as a blend that can have effect in cognition, leading us to modify the initial inputs and to change our view of the corresponding situations. A blend is "a result of cognitive blending that consists of composition, completition and elaboration, and refers to the ability of the mind to take different

concepts or mental constructs, form a cognitive link between them and produce a new concept or mental construct that is a blending of the first two or more" (Fauconnier and Turner, 2002, cited in: Aligica 2005).

The reviewed literature clearly attributes to the scenarios as a very helpful and suitable tool, what is also confirmed by frequent use of scenarios. The role of scenarios is quite heterogeneous, from dealing with uncertainties, forecasting, planning aid, educational means, to assessing the results of different measures and actions. Scenarios as a planning tool are powerful because they can clearly present the future situation in a narrative way, however sometimes this leads to oversimplification, but it is important as it enables the demonstration of complex environments or processes. Mostly the positive characteristics of scenario use prevail over negative. As negative, they have to be mentioned the credibility of the scenarios, doubtful scientific value and what is mostly important for the issue presented in this article, the ability to mislead and influence people if used inappropriate.

2.2 Research of scenario influence

Regardless of how scenarios are created and the purpose of their use they have been marked to have influence on people's expectation about the futures (Gregory and Duran 2001, Shearer 2005). Evidence suggests that the ease with which scenarios are imagined and constructed, or its plausibility, increases the belief that the depicted event could occur. Gregory and Duran (2001) composed a review of research aiming at verifying the influence of different scenarios on expectations and behaviour connected with events presented in scenarios. Main conclusions and issue related findings of resumed research are presented below.

Events that have not yet occurred, and unknown situations are sometimes hard to imagine, but the ability to imagine the future in all kinds of scenarios is very helpful. Tversky and Kahneman (1973) speculated that when a particular event has never occurred to us, or is infrequent, we may construct scenarios of the events occurrence. The ease we construct a scenario with its plausibility then infers the event's likelihood. This presumption was confirmed by Carroll (1979), who made two experiments with scenarios, one included election-outcome results, the other results of a football game. Carroll also established that scenarios may not work on everyone as a result of their previously held beliefs or their experiences. Gregory, Cialdini and Carpenter (1982) and later Gregory, Burroughs and Ainslie (1985) upgraded Carroll's work to self-relevant events that could happen to research participants, and were of a more personal nature (i.e. being arrested for armed robbery, winning a vacation trip, being arrested for shoplifting and having an automobile accident). All these scenarios produced elevated expectancies for their occurrence among participants who imagined them relative to participants that imagined unrelated activities (e.g. going to the library). These studies also demonstrated that the scenario-expectancy effect occurs for both positive and negative events and for events involving one-self not just others. In distinction to these scenarios prepared beforehand, Anderson (1983) tested the "behavioural scripts" - participants had to sketch out drawings depicting them in performing different activities (e.g. donating blood, taking a new part-time job). Sketching activities served to increase expectancies for the occurrence of those events, repetition of the exercise served to enhance the effect. It was interesting that these expectancies wouldn't have changed if the participants were imagining a friend or a disliked person engaging in the same events. This lead Anderson to conclusion that scenario-expectancy effect occurs only when one-self is depicted in scenario. Sherman (1985), Anderson and Godfrey (1987) found out that scenario-expectancy effect is stronger if the events presented in scenarios are easier to imagine. An experiment included engaging in target behaviours both, before and after picturing themselves in different behaviour, also the ease of the imagining the behaviour was rated. The experiment showed that the easier behaviour was to imagine, the more likely the behaviour became. Some additional studies (Levi and Pryor 1987) supported the role of ease as a mediator of the effect. Moreover, there is a difference in imagining the scenarios if the participants are involved in creation of hypothesis or they are just confronted with them. Koehler (1994) found out that participants had greater confidence if they didn't participate in the creation, yet they were aware that assessing the hypothesis was hard.

Once the scenario influence on expectancies of the occurrence of behaviour was established, researchers Gregory, Cialdini and Carpenter (1982) tried to determine whether scenarios can influence the behaviour itself. They tested the hypothesis that people would increase their compliance once they imagined themselves performing the behaviour. As prior research has shown (Aronson, Carlsmith 1962; Sherman 1980, Weaver, Brickman 1974; Anderson *et al.* 1980; Sherman et al. 1981), people are reluctant to abandon or disconfirm their expectancies, especially those for which they have imagined an account. This reluctance could directly influence their performing the behaviour: people reluctant to abandon the expectancy might feel compelled to perform a behaviour consistent with it. Also reluctance to abandon an expectancy could indirectly influence the performance of a behaviour trough attitude changes. Gregory, *et al.* (1982) confirmed that imagined scenarios could influence behaviour. They performed an experiment with residents, to half of whom the scenarios depicting

having a cable television were presented, other half just gained information about CATV. As a result many more residents from the first group, 47 % compared to 20 % from the second group, actually subscribed to CATV as it became reachable. Scenarios that were used here were prepared in advance, however, Sherman and Anderson (1987) asked the participants to picture themselves in certain activity (getting a therapy) and they have gained similar results. Padilla and Gregory (1997) compared both types of scenarios (expert-generated and self-generated) and the results of their experiment suggest that the types of scenarios used may interact with individual differences; some types of scenarios work better for one person than for others. The findings also suggest that researchers may also need to assess the expectancies and attitudes toward events that are not the focal point of the given scenario, because scenarios may have unanticipated and unassessed consequences.

Beside scenario impacts on expectancies of the occurrence of behaviour and behaviour itself, the effects of scenarios on confidence have also been examined. The experiments of Schnaars and Topol (1987) as well as of Kuhn and Sniezek (1996) provide the knowledge that people have greater confidence in their predictions if they have the assurance (trough reading the scenario) that someone else believed in the outcome.

Listed research of scenario influence refers more to the ease with which one constructs the scenarios and their plausibility than to the ease of recalling relevant instances. Also all these examples have no direct connection with environment or landscape or spatial planning however. The research was mainly based on experiments that could be performed in a controlled environment and where credible results could be gathered and evaluated.

The authors of extensive review on scenario influence, Gregory and Duran (2001) conclude that scenarios can be used to enhance the expectancies that an event will occur. Scenarios can also decrease existing expectancies, when they are contradictory to the expectancies. It is then up to practitioners to lead the clients to develop problem-solving strategies for dealing with the problems presented with scenarios. These presented empirical investigations offer the researchers plenty of issues for scientific work and also draw attention to the aspects that should be further investigated, namely the risks of scenario use and the circumstances that might affect the results of scenario use.

2.3 Land use scenarios

In landscape planning scenario refers to different possible stories, or alternative assumptions that underline landscape change; the land cover pattern and functional consequences that may be an outcome of the scenario is referred to as "future" (Steinitz et al., 2003). Such scenarios mainly present the future changes of landscape through changes of land use that consequently result also as changes of land cover pattern.

Land use scenarios are actually a planning tool or aid. Consequently, articles about land use scenarios present case studies of their use. No articles focused on psychological effects of land use scenarios were found. Precisely there were no direct results on landscape scenarios impacts on perceptions, changes of values or behaviour that would be scientifically observed and proven. However, some articles presenting scenario-based planning process also include observations of impacts that scenarios had on the participants.

The authors B. Tress and G. Tress (2003) presented the background and the results of a study concerning participatory planning of the Danish countryside. The study combined scenario technique, photorealistic visualization and participation of stakeholders, in order to identify the interests in the future countryside. Four different extreme scenarios for 2020, based on mono-functional land uses, were presented to stakeholders. The participants had to answer a questionnaire asking for comments on each scenario; this was followed by an open discussion about the presentation and participant's fears, wishes and ideas for future development. An interesting observation was that the participants feared that presented scenarios could come true. The researchers had to repeat to them for several times that the results of this study would not be realised. However, apart from influence of clearly vivid scenarios this could be partly attributed to mistrust of the planning and administration authorities.

According to Wollenberg et al. (2000) scenarios enable managers (of the community forests) to understand better the landscape and larger scale forests, improve cooperation with stakeholders at these levels and to improve adaptiveness not only by responding to changes, but also anticipating them. The role of scenarios was here more educational, but there was a very important issue presented that the use of scenarios can help to anticipate changes. Authors used scenarios as a stimulation of adaptive co-management that relies on iterative social learning among stakeholders and the on-going adjustment of management decisions to be acceptable to relevant actors. Scenarios were here used to encourage critical thinking about risks and system relationships, as they provide the focus on the analysis of uncertainties, drivers of change and causal relationships associated with a potential decision. Scenarios introduce hypothetical possibilities that spur people's imagination and enable them to adjust their

mental habits. The benefit in this case was improved cooperation of stakeholders and facilitated exchange of information; they also influence each stakeholders thinking and actions to enable coordination and improved management. In this experiment stakeholders were treated as actors and were involved in the scenario process. The results have been used for developing land use and forest resource management plans and to provide the basis for residents claims to the use of forest resources located in the national park. In the example of community forestry, scenarios proved to be useful as they broaden the perspectives about how the forests might change in unexpected ways and served as a basis for reaching agreement among different stakeholders. The authors subject that scenarios involving multiple stakeholders can speed up the information exchange and enhance adaptiveness by expanding the availability and flow of information for decision making.

To return back to the European landscape, the case study of Bruns et al. (2000) presents the projection of possible trends of German countryside development. The authors suggest that experiencing landscapes happens in practical projects, and such projects including building and presenting scenarios can help to open the discussion of the future of a particular landscape. By directly involving people as actors of landscape change into analysis, design and planning their knowledge unfolds. The confrontation of different aspects and expectations of the future can finally be realized by the help of professional planners and results in broadly supported plans that are eventually carried out in the real landscape.

Another aspect of scenario use is improving public participation in global environment change assessments and politics. Four different scenarios of energy use represented trough collages were used by Kasemir et al. (2003) in integrated assessment (IA) focus groups in four research regions (Barcelona, Frankfurt, Stockholm and Switzerland). The focus of the study was to develop and apply methods for empirical qualitative studies of public perceptions related to global environmental change. Firstly participants were confronted with current scientific knowledge on climate change with the help of computer models. The study included visual expressions of citizens associations with energy use and its relation to climate change that was followed by the explanation. Participants had to summarize their own views at the end of the process in the form of written citizen reports. They were asked to produce collages on alternative futures using pictures they selected from the magazines provided by the research teams. The collage work was used as a projective technique. Confronted with the unstructured material participants were able to express both hopes and fears trough producing collages. As a concrete task, participants were asked to imagine, how their region might look in thirty years time under two different assumptions: if present trends of the energy use continue (business-as-usual) or if energy use is reduced to half its current level within the next thirty years (strong reduction of energy use). Some of the collages turned out either unambiguously positive or negative, others explicitly showed different types of ambiguity. Collages were than classified according to different positive and negative association categories. Clearly negative collages were only found between business-as-usual scenarios, clearly positive only for energy reduction scenarios. The presentation of collages was accompanied with different emotions; fear, cynicism, black humour, uncertainty, ambiguity and on the other side, positive feelings as hope. Also the regional differences were noticed; different European regions seem to defer in cultural affiliation with regard to complex environmental issues. The project reflected the ability of general public to understand the ambiguities of climate change and a need to bridge the way between experts and lay people considering uncertainties in climate change research to make a more differentiated public debate possible.

The use of scenarios in landscape planning is much broader and as previously mentioned, the use of scenario techniques in landscape planning as well as in other disciplines is gaining popularity. The development of different techniques that enable a vivid presentation of scenarios makes them more and more attractive and convincing. Although only limited number of cases was presented above, they show that the role of land use scenarios is various: scenarios as an aid for learning, discussing, researching and planning. The chosen cases indicate that scenarios actually stimulate the imagination and broaden our knowledge, in this sense they can also influence changes of our perception, expectations about future and also in some cases they can influence our actions and behaviour.

3 CONCLUSION

The review of the literature shows that scenarios are a very diversified and applicable tool. As they can be used in different disciplines and for various purposes also their form and contents vary. The review was carried out to answer the question whether land use scenarios can influence the changes of perceptions and the attitude of the individuals by showing them, how the future landscape will look like.

From a great number of articles dealing with scenarios, articles that present scenarios in the field of landscape planning, articles oriented towards research of psychological influences of scenarios and articles dealing with theory and ethics were examined in this review.

Review indicated a difference between two main purposes of scenario use. Firstly, scenarios as a research tool, used in studies exploring the influence on perception and behaviour of individuals and secondly scenarios as planning tool, aiming at improving communication between different stakeholders, acquiring information from public or individuals, informing about land use and environment changes. As previously mentioned, both ways of scenario use are important for investigating the influence of land use scenarios.

The scenario influence on expectancies and behaviour was clearly demonstrated by scientific experiments, yet, just some of them were indirectly linked with spatial characteristics. There were also many indirect observations and remarks that land use scenarios influence changes of perceptions and behaviour, as they were observed during planning processes. Despite the frequent use of scenarios in landscape planning, the influence of scenarios on perceptions and behaviour of individuals towards landscape is probably difficult to assess or it is not a part of the interest during the planning process. Since there were no articles found, focused on actual psychological influence of land use scenarios, the acquired knowledge on these two aspects of scenario use will have to be combined and widen trough further research. This issue is most important as land use scenarios are often used without sufficient knowledge of their influence on individuals included in planning process and indirectly on landscape and environment.

However the review confirmed that the scenarios permit us to broaden our cognition of events that have not yet occurred. Their vivid form makes it easy to picture environments, persons and other conditions of the future events. By experiencing trough imagination, the scenarios influence our current point of view, depending on our perception abilities, our interest and other personal characteristics.

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Molekulski pristopi pri raziskavah arbuskularne mikorize

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IZVLEČEK

Arbuskularna mikoriza se je razvila v koevoluciji s kopenskimi rastlinami. Čeprav predstavlja eno najbolj razširjenih simbioz na kopnem, še vedno obstajajo številna odprta vprašanja o biologiji arbuskularnih mikoriznih gliv ter njihovi ekološki vlogi v različnih ekosistemih. Z razvojem molekulskih tehnik so raziskave arbuskularne mikorize dobile nove razsežnosti, omogočen pa je bil tudi boljši vpogled v procese, ki se odvijajo v rizosferi oz. širše mikorizosferi, če poleg korenin upoštevamo tudi zunajkoreninski micelij mikoriznih gliv v tleh. V prvem delu članka je predstavljen pregled novejših objav s področja raziskav arbuskularne mikorize s poudarkom na ekološkem in funkcionalnem vidiku, v drugem delu pa tudi kratek pregled metod s poudarkom na tistih, ki se uporabljajo v mikrobni ekologiji.

Ključne besede: arbuskularna mikoriza, arbuskularne mikorizne glive, simbioza, mikrobna ekologija, molekulske metode, Glomeromycota, RFLP, t-RFLP, TGGE, DGGE, PLFA

MOLECULAR APPROACHES IN RESEARCH OF ARBUSCULAR MYCORRHIZA

ABSTRACT

Arbuscular mycorrhiza coevolved with terrestrial plants. Tough it is one of the most wide spread symbioses in terrestrial ecosystems a lot of questions on biology of arbuscular mycorrhizal fungi and their ecological role in different ecosystems still remain to be answered. With development of new molecular techniques novel possibilities for research of arbuscular mycorhiza have opened, enabling new insights into processes taking place in rhizosphere or broader mycorhizosphere, if in addition to roots, extraradical mycelium of mycorrhizal fungi is taken into consideration. In the first part of the paper a review of recent publications in the field of arbuscular mycorrhiza research is presented, with the emphasis on functional and ecological role, in the second part, a short methodological review is given, with the emphasis on methods used in microbial ecology.

Key words: arbuscular mycorrhiza, arbuscular mycorrhizal fungi, symbiosis, microbial ecology, molecular methods, Glomeromycota, RFLP, t-RFLP, TGGE, DGGE, PLFA

1 UVOD

Velika večina rastlin (vključno z gametofiti številnih mahov in praprotnic ter sporofiti večine praprotnic) v naravnem okolju živi v povezavi z mikoriznimi glivami (Smith in Read, 2008). Različni tipi mikorize so prisotni pri približno 80 % vseh kopenskih rastlinskih vrst iz 92 % družin (pri kritosemenkah 84 % vrst iz 94 % družin) (Wang in Qiu, 2006). Med njimi je najbolj razširjena arbuskularna mikoriza, saj so arbuskularne mikorizne (AM) glive koreninski endosimbionti približno 2/3 vseh kopenskih rastlin (Fitter in Moyersoen, 1996). Odnos med rastlinami in AM glivami je starodaven, star več kot 400 milijonov let. Dokaz temu so poleg rezultatov filogenetskih raziskav tudi fosilizirane, arbuskulom in veziklom podobne strukture v plazečih rizomih ene izmed zgodnjih kopenskih rastlin *Aglaophyton major*, ki izvirajo iz devona (Simon in sod., 1993, Redecker in sod., 2002). Arbuskularna mikoriza se je torej razvijala v koevoluciji s kopenskimi rastlinami (Wang in Qiu, 2006). Gliva je s svojim ekstenzivnim zunajkoreninskim micelijem verjetno že takrat primarno vršila vlogo izboljšanja preskrbe rastlin z mineralnimi hranili, predvsem fosforjem (Brundrett, 2002), saj prve kopenske rastline še niso imele razvitih korenin.

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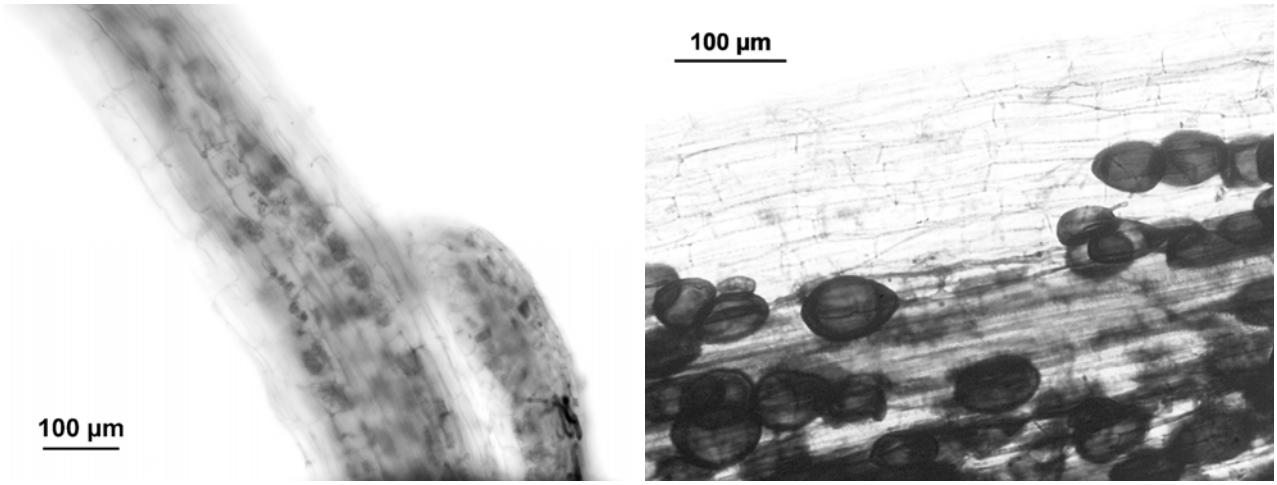
2 EKOFIZIOLOŠKA VLOGA AM GLIV

AM glive so zelo pomembne pri kroženju hranil in ogljika v naravi, čeprav zaradi kompleksnosti in omejenega poznavanja njihova vloga v tem kontekstu pogosto ni zadosti upoštevana. Pri arbuskularni mikorizi se običajno pojavlja mutualističen tip simbioze, odnos, kjer je glivni partner energetsko povsem odvisen od gostiteljskih rastlin (biotrof), saj je preskrba glive z ogljikovimi hidrati popolnoma vezana na gostitelje. V zameno za rastlinske asimilate AM glive preskrbujejo rastline z mineralnimi hranili. Fosfatni ioni v tleh pogosto tvorijo netopne spojine z večino kationov (Al^{3+}, Fe^{3+}, Ca^{2+}) in tako postanejo za rastlinske korenine težko dostopni. Ker je fosfor v tleh zelo slabo mobilen element, pogosto predstavlja omejujoč dejavnik rasti rastlin. V nasprotju s prepričanjem izpred nekaj let, je v zadnjem času vedno več dokazov, da lahko poleg preskrbe s fosforjem AM glive vplivajo tudi na preskrbo rastlin z drugimi hranili, z mikroelementi (Cu, Zn) ter kot kaže tudi z dušikom. Z uporabo stabilnih izotopov dušika in ogljika ($^{15}N/^{13}C$) so ugotovili, da lahko kolonizacija z AM glivo *Glomus hoi* obenem vpliva na razgradnjo organske snovi v tleh ter poveča privzem dušika v rastlino iz organskega materiala (opad trav) (Hodge in sod., 2001), vendar pri teh procesih še ni poznana vloga drugih talnih mikroorganizmov pri razgradnji organskega materiala (Smith in Read, 2008). Podobno Govindarajulu in sod. (2005) poročajo o novo odkriti presnovni poti AM gliv, ki vključuje vgradnjo anorganskega dušika v aminokislino arginin znotraj zunajkoreninskega micelija in asimilacijo dušika v rastlino preko znotrajkoreninskega micelija ob razgradnji arginina. Izboljšana preskrba rastlin s hranili je najbolj izpostavljena vloga glive v mikorizi, poleg te pa ima simbioza rastlin z AM glivami še druge pozitivne učinke (Smith in Read, 2008) kot so izboljšana preskrba rastlin z vodo, varovanje pred patogeni in boleznimi, varovanje pred škodljivimi snovmi (npr. težke kovine), dokazana pa je tudi vloga zunajkoreninskega micelija in kot kaže tudi nekaterih produktov AM gliv (npr. glomalina) pri stabilizaciji strukturnih agregatov tal (Wright in Upadhyaya, 1998) ter s tem pozitiven vpliv na strukturo in rodovitnost tal.

3 MORFOLOŠKE STRUKTURE IN NJIHOVA VLOGA PRI IZMENJAVI HRANIL



Slika 1*: Kolonizacija korenin sivozelenega muhviča (Setaria pumila) z arbuskularnimi mikoriznimi glivami. Arbuskuli so vidni kot temnejše lise, povezane z znotrajkoreninskimi hifami (levo). Na desni sliki so predstavljeni vezikli AM gliv v koreninah travniškega mačjega repa (Phleum pratense). Glivne strukture so bile obarvane z barvilom tripan modro. Posneto z mikroskopom Olympus Provis AX70 in digitalno kamero Olympus DP70.*

Figure 1*: Arbuscular mycorrhizal colonization of Setaria pumila roots. Arbuscules can be seen as darker spots, connected with intraradical hyphae (left). Right, vesicles of AM fungi in roots of timothy grass (Phleum pratense). Fungal structures were stained with trypan blue. Photos taken by Olympus Provis AX70 microscope and digital camera Olympus DP70.*

V mikoriziranih koreninah se znotraj koreninske skorje običajno izoblikujejo značilne morfološke strukture. Najbolj prepoznavni so arbuskuli (Slika 1), pri nekaterih skupinah se namesto arbuskulov pojavljajo le zgostitve, nekakšni zvitki hif, včasih, pri okrog 80 % opisanih vrst AM gliv, pa lahko opazimo tudi vezikle (Slika 1), ki

verjetno služijo shranjevanju rezervnih snovi in v katerih pogosto opazimo oljne kapljice (zaradi občasne odsotnosti veziklov se danes ime »vezikularna arbuskularna mikoriza« opušča in vedno bolj uporablja krajši termin »arbuskularna mikoriza«). K nastanku arbuskula prispevata oba partnerja v simbiozi. Arbuskul predstavljajo fino razvejane nitke gliv (hife), ki so v neposrednem membranskem kontaktu s plazemsko membrano rastlinske celice (periarbuskularna membrana), ki se tesno prilega oblikam razvejanih hif. S tem se ustvari zelo velika membranska površina, ki služi izmenjavi snovi med obema partnerjema. Ob nastanku arbuskula gliva penetrira celično steno rastlinske celice, ne pa tudi same plazmaleme (Hause in Fester, 2005). Gliva tako nikoli ni v neposrednem fizičnem stiku s citoplazmo rastlinske celice, čeprav se zaradi uvihanja plazemske membrane arbuskul navidezno razvije znotraj celice. Celična stena se na razvejitvah arbuskula progresivno tanjša, tako da je premer hif na končnih razvejitvah le še od 1 do 2 μm (cv. Smith in Read, 2008). Potrjeno je, da velika membranska površina arbuskula služi izmenjavi fosfatov med glivo in rastlino (Bucher, 2007), relativno malo pa je znanega o mehanizmih izmenjave drugih hranil med obema partnerjema. Obstaja več hipotez o mestih izmenjave ogljikovih hidratov med rastlinami in glivami, slednja bi, kot poroča Fitter (2006), lahko potekala tudi v apoplastu, kjer hife rastejo med celicami koreninske skorje (intercelularno). Številne nove tehnike danes omogočajo hiter napredek in zelo ciljno raziskovanje samega simbiontskega odnosa in nove vpoglede v mehanizme izmenjave snovi na molekulskem nivoju ter potek ekspresije genov obeh partnerjev v simbiozi (Parniske, 2004, Hause in Fester, 2005, Bucher, 2007, cv. Smith in Read, 2008). Schüßler in sod. (2006) so v reviji Nature objavili opis prvega poznanega transporterja monosaharidov, ki deluje kot H^+ kotransporter z največjo afiniteto za glukozo, ki ji sledijo manoza, galaktoza in fruktoza. Transporter so opisali pri posebnem tipu simbioze med glivo iz debla Glomeromycota *Geosiphon pyriformis* in cianobakterijo *Nostoc punctiforme*, edino poznano tovrstno simbiozo s cianobakterijami, ki obenem tudi nakazuje na možnost še starejšega filogenetskega izvora arbuskularne simbioze (možnost obstoja simbioze s cianobakterijami še pred prehodom rastlin na kopno). V simbiontski fazi *Geosyphon* tvori posebne mehurjaste strukture, ki so funkcionalno primerljive z znotrajkoreninskimi strukturami pri arbuskularni mikorizi, vendar je v tem primeru situacija prostorsko obrnjena, saj glivno tkivo popolnoma obda celico cianobakterije (Wolf in Schüßler, 2005).

4 FILOGENIJA IN MOLEKULSKA EKOLOGIJA AM GLIV

V preteklosti so AM glive taksonomsko uvrščali v red Glomales debla Zygomycota, vendar jih danes na podlagi filogenetskih raziskav uvrščamo v povsem ločeno monofiletsko deblo Glomeromycota (Schüßler in sod., 2001), ki ga trenutno postavljajo ob bok glavnima debloma gliv Basydiomycota in Ascomycota (James in sod., 2006). Izguba arbuskularne mikorize pri rastlinah je sekundarna (Fitter in Moyersoen, 1996), vsi ostali tipi mikorize (ektomikoriza pri drevesih, orhidejska mikoriza, erikoidna mikoriza in drugi) so filogenetsko veliko mlajši, kaže pa tudi, da so se različni tipi ektomikorize in erikoidne mikorize (z izjemo orhidejske mikorize) razvili večkrat in neodvisno, v t.i. vzporedni evoluciji (Wang in Qiu, 2006, cv. Smith in Read, 2008). V primerjavi z arbuskularno mikorizo, ki je najpomembnejši tip mikorize na travniščih ter v gozdovih tropskega pasu, so drugi tipi mikorize konkurenčnejši v drugih habitatih, npr. gozdovi zmernih in hladnejših klimatov, območja z večjo nadmorsko višino, rastišča, običajno revna z dušikom.

Trenutno je na podlagi morfoloških značilnosti, predvsem morfologije in barvanja spor (Slika 2), opisanih manj kot 200 vrst (morfotipov) AM gliv. AM glive tvorijo velike večjedrne spore (po ocenah, vrstno specifično vsebujejo med 800 do 35.000 jeder) premera od 40 do 500 μm, z debelo večplastno steno, ki je sestavljena iz hitina in v nekaterih primerih tudi ß(1-3) glukana (cv. Smith in Read, 2008). Kot kažejo novejše raziskave, so vsa jedra haploidna, kar je bilo dokazano pri vrstah *Glomus intraradices* in *G. etunicatum*, kot tudi pri vrsti *Scutelospora castanea* (cv. Smith in Read, 2008). Ni še dokazov o spolnem razmnoževanju AM gliv, genetske raziskave pa dodatno otežuje večjedrni micelij in dejstvo, da v življenjskem ciklu teh organizmov ni poznanega enojedrnega stadija. Prav tako ni znano ali so jedra znotraj posamezne spore oz. organizma genetsko identična (homokarion) ali ne (heterokarion) (Young, 2008, Rosendahl, 2008). Še več, med hifami iste vrste, predvsem istega izolata (Giovannetti in sod., 2006) se lahko tvorijo anastomoze (fizične povezave), s katerimi je vzpostavljena citoplazemska kontinuiteta, ki omogoča njihovo medsebojno povezanost in tudi migracijo dednega materiala. Biologija in evolucija AM gliv tako predstavljata vroči temi aktualnih znanstvenih polemik (Croll in sod., 2008, Rosendahl, 2008, Young, 2008).

Zaradi velike genetske raznolikosti in problematičnosti definicije taksonov v smislu biološke vrste (ni dokazov o rekombinaciji oz. spolnem razmnoževanju), se danes namesto prej morfološko določene vrste (morfotipa) vedno bolj uveljavlja termin sekvenčni tip oz. filotip, ki znotraj filogentskega drevesa predstavlja monofiletski

grozd več sorodnih sekvenc (Rosendahl, 2008, cv. Smith in Read, 2008). Filogenija AM gliv v veliki meri temelji na 18S rDNK (SSU – mala podenota ribosoma), obstajajo pa tudi že poročila o uporabi mitohondrijske DNK (Croll in sod., 2008).

Glede na to, da so prisotnost arbuskularne mikorize potrdili pri veliki večini rastlin (80% oz. ≈ 200.000 vrst, glej Uvod), bi pričakovali, da relativno majhno število (<200) opisanih vrst AM gliv kolonizira večino rastlin vrstno nespecifično. Tako se je izoblikovalo mnenje, da so AM glive taksonomsko revna skupina. V preteklosti so za taksonomsko določanje vrste AM gliv služili zgolj morfološki znaki, ki pa se, kot kažejo novejše filogenetske raziskave, pri številnih filotipih prekrivajo. Klasični pristopi in številni lončni poskusi, ki so bili zasnovani s čistimi glivnimi inokulumi enega samega morfotipa, so domnevo o vrstno nespecifični kolonizaciji rastlin še dodatno okrepili, saj so pri raziskavah uporabljali zelo omejen nabor AM vrst, ki so kolonizirale večino gostiteljskih rastlin. Dejstvo je, da so bile raziskave omejene samo na tiste taksone gliv, ki jih je bilo sploh možno gojiti in razmnoževati v lončnih poskusih in so tam tudi sporulirale. Kot se je izkazalo kasneje, so bili to predvsem ekološki generalisti.

Slika 2: *Spore AM glive vrste Scutellospora dipurpurescens. Celi spori, posneti v črnem polju s stereolupo Olympus SZH10 in kamero Olympus DP70 (levo). Desno, zdrobljena spora, vklopljena v PVLG. Vidna dvoplastna stena je karakteristična za ta rod. Spore vsebujejo rezervne snovi v obliki lipidov (oljne kapljice). Posneto z mikroskopom Olympus Provis AX70 in digitalno kamero.*

Figure 2: *Spores of AM fungus Scutellospora dipurpurescens. Entire spores (left). Photo was taken in dark field using Olympus SZH10 stereomicroscope and digital camera Olympus DP70. Crushed spore, mounted in PVLG (right). Genus characteristic double-layered spore wall can be seen. Spores contain lipid reserves (oil droplets). Photos taken by Olympus Provis AX70 microscope and digital camera.*

Razvoj molekulskih tehnik je omogočil prehod v raziskovanje arbuskularne mikorize v naravnih ekosistemih. Z uvedbo molekulskih metod v raziskave ekologije AM gliv v okoljskih vzorcih se je kmalu potrdilo, da je dejanska slika v okolju povsem drugačna od tiste, ki je izhajala iz konvencionalnih pristopov. Že kmalu po razvoju prvih za AM glive specifičnih začetnih oligonukleotidov (primerjev) (Simon in sod., 1992, Helgason in sod., 1998, Redecker, 2007), ki so omogočili specifično namnoževanje DNK AM gliv se je namreč izkazalo, da lahko v enem samem centimetru korenine sočasno sobiva tudi do 20 različnih filotipov AM gliv in da je biološka pestrost skupine veliko večja kot lahko sklepamo zgolj na podlagi morfoloških znakov. Danes praktično z vsako raziskavo v nove habitate raziskovalci odkrivajo nove, še neregistrirane taksone AM gliv. Nekateri se pojavljajo samo v koreninah določenih rastlinskih vrst, združba gliv pa je lahko v koreninah različnih rastlin, ki sobivajo v istem habitatu, popolnoma različna (npr. Helgason in sod., 2002, Vandenkoornhuyse in sod., 2003, Johnson in sod., 2005). Zelo malo je znanega o biogeografski razširjenosti AM gliv (Rosendahl, 2008) in o tem, kateri biotski in abiotski dejavniki okolja najbolj vplivajo na sestavo AM združb in kakšna je njihova medsebojna povezava. Rastlinska vrsta in združba lahko prestavlja biotski dejavnik okolja, ki določa katere glive se pojavljajo v katerem okolju, obstajajo pa tudi dokazi v nasprotno smer. Tudi prisotnost ali odsotnost določenih filotipov gliv lahko vpliva na sestavo rastlinske združbe (van der Heijden in sod., 1998), kar pravzaprav, glede na skupno evolucijo kopenskih rastlin in AM gliv ter njihovo tesno povezanost, sploh ni presenetljivo. Nekatere študije že kažejo, da se v agrarnih okoljih

pojavlja več generalistov (Helgason in sod., 1998), najbolj pogostih filotipov, ki so tudi na splošno med AM taksoni najbolje raziskani, saj jih je mogoče gojiti v čistih kulturah in je bilo v preteklosti z njimi izvedenih največ raziskav (npr. *Glomus intraradices*, *Glomus mossae*). Na drugi strani, v bolj specifičnih okoljih (npr. v ekstremnih habitatih – območja naravnih izvirov CO_2 v SV Sloveniji), kjer se pojavljajo močni abiotski selekcijski pritiski, dominirajo novi, prej še neregistrirani in kot kaže bolj specializirani filotipi AM gliv (Maček in sod., 2008). Genetska raznolikost AM gliv bi lahko bila pogojena tudi z njihovo funkcionalno kompleksnostjo (Fitter, 2005). Glede na to, da lahko v zelo majhnem delu korenine sobiva več različnih filotipov gliv, je možno, da različni tipi zavzemajo različne funkcionalne niše in so funkcionalno in morfološko specializirani. Za varovanje rastline pred patogeni je tako verjetno bolj smiseln razvoj obsežnega znotrajkoreninskega micelija, medtem ko je za preskrbo rastline s hranili zelo pomemben ekstenziven zunajkoreninski micelij, ki lahko črpa hranila iz večjega volumna tal. Prav tako se preskrba rastline z vodo lahko izboljša, če je omogočen čim boljši stik korenine s strukturnimi agregati v tleh v neposredni bližini korenine, torej je pomembna stabilizacija talnih agregatov in razvoj micelija ob korenini.

5 UPORABA AM GLIV

Z novimi vpogledi v ekologijo AM gliv in njihovo kompleksnost se razvijajo tudi različne možnosti aplikacije AM gliv v kmetijsko prakso (akcija COST 870, Gosling in sod., 2006, Piotrowski in Rillig, 2008). Potencial za uporabo AM gliv je največji na območjih s sonaravnim kmetijstvom, kjer bi, ob omejeni uporabi gnojil in fitofarmacevtskih sredstev, AM glive lahko služile kot biognojilo v obliki glivnega inokuluma, inokulacija z AM glivami pa lahko izboljša tudi preživetje rastlin v stresnih razmerah (suša, onesnažena tla, obdobje po presajanju, okužbe s patogeni). Pri konkretni izvedbi tovrstnih aplikacij predstavlja največjo težavo dejstvo, da rezultati številnih poskusov, ki so bili izvajani v kontroliranih razmerah, niso neposredno prenosljivi v okolje. Obenem je zelo malo znanega o sezonski dinamiki naravnih populacij AM gliv (Santos-Gonzalez in sod. 2007) ter njihovi sukcesiji v določenem okolju v odvisnosti od okoljskih dejavnikov (Piotrowski in Rillig, 2008), kar kaže na nujnost nadaljnjih raziskav teh tematik in ekologije arbuskularne mikorize v prihodnosti.

6 METODOLOGIJA RAZISKAV AM GLIV

6.1 Konvencionalni pristopi

Poleg novih, molekulskih tehnik se v raziskavah AM gliv še vedno ohranjajo tudi konvencionalni pristopi. Med njimi so najbolj pogosto uporabljane metode za ocenjevanje kolonizacije korenin z AM glivami (Slika 1). Pri teh metodah je korenine potrebno presvetliti z vročim KOH, čemur sledi specifično barvanje glivnih struktur znotraj korenine z barvili (npr. tripan modro, kisli fuksin, tudi navadno črnilo). Za oceno kolonizacije se največ uporabljata dve metodi: pri (1) intersekcijski metodi po Giovanetti and Mosse (1980) preštejemo vsa presečišča koloniziranih in nekoloniziranih korenin s horizontalnimi in vertikalnimi linijami centimetrske mreže na dnu petrijevke, v kateri je vzorec korenin. Za delo uporabljamo stereolupo. Na podlagi tako dobljenih podatkov izračunamo odstotek korenin, ki so kolonizirane z AM-glivami (kvantitativna ocena). Druga metoda je (2) ocenjevanje kolonizacije po Trouvelot in sod. (1986), ki zahteva podrobnejši pregled mikroskopskih preparatov pobarvanih korenin. V vzorcu ocenjujemo mikorizno kolonizacijo ter gostoto arbuskulov v različnih razredih. Na podlagi tako dobljenih ocen lahko kolonizacijo ovrednotimo tako kvantitativno kot kvalitativno (predvsem prisotnost arbuskulov kaže na funkcionalno izmenjavo hranil med simbiontoma).

Spore AM gliv (Slika 2) lahko izoliramo iz substrata s centrifugiranjem v raztopini saharoze in z mokrim sejanjem skozi sito z odprtinami premera 32 μm na katerem ostanejo posamezne spore. Identifikacija spor je zelo kompleksna, vključuje pa njihovo barvanje z Melzerjevim reagentom in ocenjevanje vrstno specifičnih morfoloških struktur v polivinil alkohol-lakto-glicerol (PVLG) vklopljenih spor (spletna stran INVAM – International Culture Collection of (Vesicular) Arbuscular Mycorrhizal Fungi).

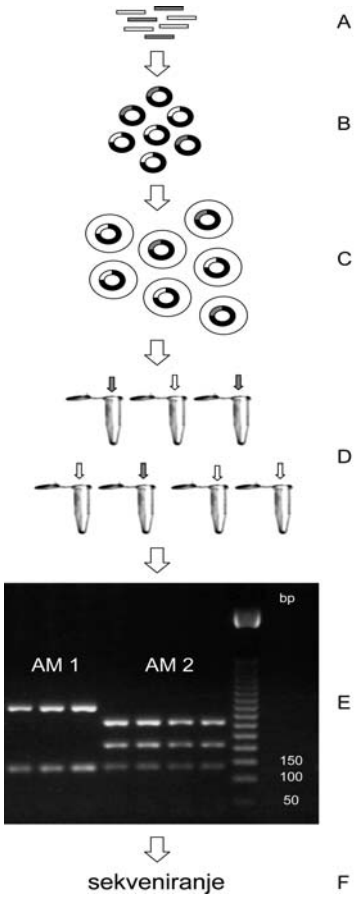
Obstaja tudi več različnih metod za oceno količine zunajkoreninskega micelija AM gliv v substratu. V ta namen vzorce tal suspendiramo v vodi, suspenzijo filtriramo skozi membranski filter in hife gliv pobarvamo z barvilom. Dolžino hif izmerimo pod stereolupo z linijsko intersekcijsko metodo.

6.2 Molekulski pristopi v ekologiji AM gliv

Število novih molekulskih tehnik, ki se uporabljajo za raziskave ekologije AM gliv zelo hitro narašča. V

ekoloških raziskavah uporabljajo številne tehnike, ki bazirajo na tehniki PCR (verižna reakcija s polimerazo). Pri tem je bil ključnega pomena razvoj za AM glive specifičnih začetnih oligonukleotidov (primerjev), saj ob ekstrakciji DNK iz koreninskega materiala dobimo mešanico DNK različnih organizmov. Največ razpoložljivih začetnih oligonukleotidov se nanaša na različne regije znotraj rDNK male podenote ribosoma (SSU) (Redecker in sod., 2003, Redecker, 2007).

V dosedanjih raziskavah je bil najpogosteje uporabljen pristop (Helgason in sod., 1998), ki je prikazan na spodnji shemi (Slika 3). Po izolaciji celokupne DNK iz suhega koreninskega vzorca s primernim izolacijskim kitom (npr. Power Plant DNA Isolation Kit, MoBio – običajno za izolacijo zadošča zelo malo, okrog 50 mg posušenega koreninskega tkiva) sledi (A) amplifikacija približno 550 bp dolgega rDNK fragmenta majhne ribosomske podenote (SSU-rDNK) AM gliv iz izolata (ekstrakta) celokupne DNK s parom začetnih ologonukleotidov AM1 (specifični primer za AM glive, Helgason in sod., 1998) in NS31 (splošni evkariontski primer). Dobimo mešanico produktov PCR vseh namnoženih AM gliv, ki kolonizirajo segment korenine, iz katerega smo izolirali DNK. (B) Po čiščenju produkt PCR kloniramo v vektor (plazmid) in na ta način ločimo posamezne tipe AM gliv. (C) Sledi transformacija vektorja v kompetentne celice *Escherichia coli*.



Slika 3: *Pristop k analizi združbe AM gliv. (A) Amplifikacija DNK AM gliv iz ekstrakta celokupne DNK – gliva AM 1 (temna) in AM 2 (svetla črta), razmerje AM 1:AM 2 = 3:4, (B) kloniranje produktov PCR v vektor, (C) transformacija vektorja v E. coli, (D) drugi PCR, (E) RFLP – 2% agarozni gel, restrikcijska profila dveh AM gliv (AM 1 in AM 2 v začetnem razmerju 3:4), restrikcijski encim Hsp 92II (Promega), (F) sekveniranje in obdelava podatkov.*

Figure 3: *Approach to AM community analysis. (A) Amplification of AMF DNA from the total DNA extract – fungus AM 1 (dark) and AM 2 (light line), ratio AM 1:AM 2 = 3:4, (B) cloning of the PCR products into vector, (C) transformation of vector into E. coli, (D) second PCR, (E) RFLP – 2% agarose gel, restriction profiles of two AM fungi (AM 1 and AM 2 in the initial ratio 3:4), digestion with enzyme Hsp 92II (Promega), (F) sequencing and data analysis.*

Posamezna celica lahko sprejme le po en plazmid. Po inkubaciji čez noč pri 37°C na agarnih ploščah iz posameznih celic *E. coli* dobimo ločene kolonije transformiranih celic. (D) Sledi druga amplifikacija, pri čemer kot matrico uporabimo DNK iz posameznih kolonij ločeno, torej tudi ločeno za vsak posamezen tip AM gliv. (E) Temu sledi še restrikcija z najmanj dvema encimoma in dolžinski polimorfizem restrikcijskih fragmentov (RFLP), kjer število ponovitev posameznega profila RFLP uporabimo kot merilo abundance posameznega tipa AM gliv v začetnem celokupnem vzorcu DNK (glej fazo A) (F) Zadnja faza je sekveniranje produktov PCR izbranih profilov RFLP, čemur sledi obdelava sekvenc, izračuni ter grafični prikaz filogenetskega drevesa. S takšnim pristopom istočasno, poleg kvalitativne analize prisotnosti posameznih filotipov v vzorcu, dobimo tudi podatek o abundanci posameznega restrikcijskega profila, na podlagi katerega je poleg kvalitativne možna tudi kvantitativna analiza mikorizne združbe.

Ekološke raziskave na okoljskih vzorcih ponavadi zahtevajo obsežno vzorčenje, veliko število vzorcev pa pomeni velik časovni in finančni vložek, kar je tudi glavna pomanjkljivost na zgornji shemi predstavljenega pristopa. Poleg omenjene tehnike se v zadnjem času vedno več uporabljajo tudi druge metode, ki omogočajo istočasno obdelavo večjega števila vzorcev. Številne med njimi že dlje časa uporabljajo v različnih vejah raziskav mikrobiologije in mikrobne ekologije tal. Večino tehnik se uporabljanja v kombinaciji s knjižnicami klonov, kar omogoča začetno kalibracijo metode in hitrejšo obdelavo večjega števila vzorcev v kasnejših fazah. Med najbolj pogosto uporabljenimi molekulskimi tehnikami so:

(1) T-RFLP – dolžinski polimorfizem terminalnih restrikcijskih fragmentov (Dickie in FitzJohn, 2007, Mumey in Rillig, 2007). Tehniko so uporabili v številnih študijah o vplivu biotske raznolikosti AM gliv na rastlinsko združbo in obratno (npr. Johnson in sod., 2005, Vandenkoornhuyse in sod., 2003, Helgason in sod., 2002), vključno z vplivom invazivnih rastlinskih vrst na AM združbo (Mummey in Rillig, 2007), pri čemer kot izhodiščni material za izolacijo glivne DNK največkrat uporabljajo rastlinske korenine.
(2) DGGE (denaturacijska gradientna gelska elektroforeza) in
(3) TGGE (temperaturna gradientna gelska elektroforeza) sta v študijah AM gliv redkeje uporabljeni metodi, pri katerih je za karakterizacijo AM združbe možna tudi uporaba DNK, izolirane iz talnih vzorcev (Liang in sod., 2008). Za karakterizacijo mikrobnih združb v okoljskih vzorcih pogosto uporabljajo tudi (4) analizo maščobnih kislin (npr. analiza fosfolipidnih maščobnih kislin – PLFA), ki predstavljajo esencialno komponento vseh živih celic ter obenem zelo uporabne biomarkerje za posamezne skupine v času vzorčenja aktivnih mikroorganizmov, vključno z glivami (Ramsey in sod., 2006, Grigera in sod., 2007). Analiza maščobnih kislin v tleh lahko predstavlja dober način za kvantifikacijo aktivne mase AM gliv (zunajkoreninskega micelija) v talnih vzorcih, pri čemer je uporaba molekulskih metod, npr. (5) kvantitativni PCR v realnem času (quantitative real-time PCR) (Gamper in sod., 2008, Jansa in sod., 2008) ali (6) LAMP (loop-mediated isothermal amplification) (Gadkar in Rillig, 2008) še v fazi razvoja.

7 ZAKLJUČEK

Čeprav arbuskularna mikoriza sodi med najpomembnejše simbioze v naravi, nanjo pogosto pozabljamo, verjetno tudi zato, ker je, če je ne iščemo ciljno, praktično nevidna. Razvoj molekulskih tehnik je omogočil hiter napredek in vedno večje zavedanje ekološkega pomena AM gliv in njihove tesne povezanosti s kopenskimi rastlinami. Pomen arbuskularne mikorize je v ekstenzvnih agroekosistemih še bistveno večji kot na območjih z intenzivnim kmetijstvom, zato lahko pričakujemo, da bo z vedno večjim poznavanjem biologije in ekologije AM gliv lažji tudi prenos uporabe glivnih inokulumov v kmetijsko prakso (biognojilo, biotsko varstvo rastlin, kot kontrola pojava invazivnih vrst, izboljšanje preživetja rastlin v stresnih razmerah idr.). Številne nove metode, s poudarkom na molekulskih in izotopskih tehnikah, danes omogočajo vpogled v do sedaj nevidno, zato lahko v prihodnosti upamo na vedno boljše poznavanje teh povsod navzočih in starodavnih organizmov in razvoj novih možnosti njihove uporabe ter uspešnega sobivanja z njimi.

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9 VIRI

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Parazitske ogorčice polžev

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IZVLEČEK

V prispevku je predstavljen pomen, način delovanja in razvojni krog parazitskih ogorčic polžev, ki so lahko pomembni naravni sovražniki polžev slinarjev (Limacidae) in lazarjev (Arionidae). Polži so na različnih območjih sveta gospodarsko pomembni škodljivci gojenih rastlin, uporaba parazitske ogorčice *Phasmarhabditis hermaphrodita* pa predstavlja za njihovo zatiranje eno od najpomembnejših alternativ kemičnim limacidom. V biotičnem varstvu rastlin so parazitske ogorčice polžev manj preučene kot entomopatogene ogorčice, vendar so bile v zadnjih dveh desetletjih izvedene številne raziskave, s katerimi želijo raziskovalci natančneje preučiti njihov pomen.

Ključne besede: parazitske ogorčice polžev, *Phasmarhabditis hermaphrodita*, biotično varstvo

ABSTRACT

SLUG-PARASITIC NEMATODES

Importance, mode of action and developmental cycle of slug-parasitic nematodes, which can be important biological control agents of slugs from Limacidae and Arionidae families – are presented in the paper. In different parts of the world slugs are economically important pest of cultivated plants, while the use of slug-parasitic nematode *Phasmarhabditis hermaphrodita* is one of the most important alternative for chemical limacides. Until now slug-parasitic nematodes were less investigated as biological control agents compared to entomopathogenic nematodes. In last twenty years many researches had been done with the aim to study their importance more accurately.

Key words: slug-parasitic nematodes, *Phasmarhabditis hermaphrodita*, biological control Glomeromycota, RFLP, t-RFLP, TGGE, DGGE, PLFA

1 UVOD

Mehkužci ali moluski, kamor uvrščamo polže, so nečlenaste živali, katerih telo je deljeno na mišičasto nogo ter drobovnjak, ki ga največkrat pokriva apnenčasta lupina. Med mehkužce uvrščamo polže (tudi gole), školjke in glavonožce. Polži (Gastropoda) so mehkužci z nesimetrično zgradbo telesa. So največja in tudi v vseh pogledih najbolj raznolika skupina mehkužcev, saj živijo tako v morju, sladkih vodah kot tudi na kopnem. Polže na grobo delimo na tiste z hišico (veliki polži – Helicidae) in na tiste, ki hišice nimajo (lazarji – Arionidae) (Velkovrh, 2003).

Številne vrste polžev so znani gospodarsko pomembni škodljivci v kmetijstvu (Ohlendorf, 1999; Barker, 2001). Parazitirati jih morejo različne vrste ogorčic (Mengert, 1953; Morand *et al.*, 2003; Grewal *et al*., 2003a), vendar pa se je doslej v biotičnem varstvu rastlin pred polži uveljavila le vrsta *Phasmarhabditis hermaphrodita* (Schneider) (Wilson in Grewal, 2005). V Avstraliji so v povojih poskusi uporabe nekaterih drugih vrst ogorčic (Rhabditida in Cephalobida) za zatiranje polžev (Charwat in Davies, 1999; Charwat *et al.*, 2000), vendar je še prezgodaj, da bi lahko iz rezultatov teh raziskav potegnili nove smernice v biotičnem zatiranju polžev z ogorčicami.

Vrsto *P. hermaphrodita* je mogoče v Veliki Britaniji dobiti na tržišču kot biotični pripravek Nemaslug® že od leta 1994. Od tam se je prodaja pripravkov z imenovano vrsto ogorčice kot aktivno snovjo do danes razširila v številne druge Evropske države (Wilson in Grewal, 2005). Parazitske ogorčice polžev so v primerjavi z entomopatogenimi ogorčicami (EPO) mnogo manj preučene, zelo malo pa je znanega o njihovi bionomiji, širjenju, kot tudi o njihovi povezavi z bakterijami in različnimi gostitelji (Wilson in Grewal, 2005).

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2 ZGODOVINA PREDSTAVNIKOV IZ RODU *PHASMARHABDITIS*

Vrsta *P. hermaphrodita* je bila prvič opisana že leta 1859, ko je Schneider ogorčico našel v polžu *Arion ater* (L.). Prva najdba EPO sicer datira šele v leto 1923, vendar so se številni raziskovalci zaradi manj specifičnega delovanja raje odločili za preučevanje te skupine ogorčic. Te so zato danes mnogo bolj preučene kot parazitske ogorčice polžev (Wilson in Grewal, 2005).

Leta 1900 (Maupas) je sledila prva raziskava o razvoju in razmnoževanju vrste *P. hermaphodita*. Za to vrsto so potrdili protandrijo (hitrejši razvoj moških spolnih organov, kar pripelje do samooploditve in pojava hermafroditov – avtogamija) in dejstvo, da se v razvojnem krogu ogorčice samice pojavljajo bolj številno kot samci (razmerje 715:1). Leta 1953 je Mengert postavil hipotezo, da se vrsta *P. hermaphrodita* pojavlja le v kopenskih polžih. Vsi zgoraj našteti avtorji so sicer sklepali, da je vrsta *P. hermaphrodita* v njenem razvoju povezana s polži, vendar ni nihče postavil hipoteze o parazitiranju (Wilson in Grewal, 2005).

Mengert (1953) je sklepal, da lahko tri sorodne vrste ogorčic, *Phasmarhabditis hermaphrodita, P. neopapillosa* (Mengert in Osche) in *P. papillosa* (Schneider), živijo v polžih v stadiju dormantnih ličink (angl. dauer juveniles) dokler gostitelj ne umre; vendar pa da same ne povzročijo smrti polžev (izključuje parazitizem). Leta 1993 je Wilson patentiral uporabo ogorčic iz rodu *Phasmarhabditis* (vrsta *P. hermaphrodita*) za zatiranje gospodarsko pomembnih polžev. Pripravek so patentirali pod uradnim imenom Nemaslug® (Wilson in Grewal, 2005). Po patentiranju tega pripravka so sledili številni poskusi, vendar se njihovo število še zdaleč ne more primerjati s tistim, ki ga raziskovalci širom sveta izvajajo z EPO.

3 TAKSONOMSKA SORODNOST

V obdobju 1950-1990 je bilo objavljenih le nekaj raziskav, ki so obravnavale taksonomijo parazitskih ogorčic polžev (Osche, 1954; Andrássy, 1983). Leta 1983 (Andrássy) je izšel obširen pregledni članek o podredu Rhabditina, v katerem je avtor predlagal vključitev novega rodu *Phasmarhabditis*. Rod vključuje pet različnih vrst ogorčic, vendar živijo v povezavi s polži zgolj tri vrste; *P. papillosa*, *P. neopapillosa* in *P. hermaphrodita*. Posamezne vrste se med seboj ločijo po obliki repa (Andrássy, 1983).

Predstavnike vrst *P. neopapillosa* in *P. hermaphodita* ni mogoče ločiti na podlagi morfoloških znakov, ločiti jih je mogoče glede na število samcev v populaciji. V populciji vrste *P. neopapillosa* je razmerje med samci in samicami podobno, medtem ko je pri vrsti *P. hermaphrodita* pojav samcev zelo redek (Andrássy, 1983). Hooper *et al.* (1999) so preučevali morfologijo omenjenih vrst, razlike med njima pa so ugotavljali tudi s proteinsko elektroforezo. Ugotovili so, da morfoloških razlik med vrstama ni, proteinska elektroforeza pa je pokazala na statistično značilne razlike v mobilnosti encima fosfoglukoza–izomeraza. Ker velja izoencimska elektroforeza za učinkovito metodo identifikacije in razlikovanja posameznih vrst (Dalmasso in Bergé, 1983), so avtorji zaključili, da gre za obstoj dveh različnih vrst. Za razliko od EPO, trenutno za različne vrste ogorčic iz rodu *Phasmarhabditis* še ne obstaja knjižnica DNA sekvenc (Wilson in Grewal, 2005).

4 RAZVOJNI KROG

Življenjski krog ogorčic iz rodu *Phasmarhabditis* je slabo preučen. Doslej so raziskovalci razdelili razvojni krog parazitskih ogorčic polžev v tri sklope: saprobiontski, nekromenični in parazitski (Wilson in Grewal, 2005).

4.1 Saprobiontski razvojni krog

Maupas (1900) je gojil ogorčico *Phasmarhabditis hermaphrodita* na razpadajočem mesu dve leti, s čimer je želel dokazati obstoj saprobiontskega razvojnega kroga. Tan in Grewal (2001a) sta dokazala, da se ogorčice lahko razvijajo tako v polžih, kot tudi v njihovih izločkih. S tem sta postavila hipotezo o saprobiontskem razvojnem krogu parazitskih ogorčic polžev. Za razliko od EPO, se vrsta *P. hermaphrodita* lahko razmnožuje na širokem spektru bakterij (Wilson *et al*., 1995a). Če naleti dormantna ličinka (DI) v tleh na mrtvega nevretenčarja, se lahko v njem razmnožuje saprobiontsko (Wilson in Grewal, 2005). Ta lastnost preučevane vrste ogorčic je pripeljala Tana in Grewala (2001a) na idejo, da lahko vrsta *P. hermaphrodita* preživi v tleh tudi tedaj, ko nima na voljo živih gostiteljev in bi bila njena uporaba v biotičnem varstvu rastlin pred polži učinkovita tudi v daljšem časovnem obdobju. To lastnost bioagensa bi lahko uporabili predvsem v posevkih koruze, žita in oljnic, na katerih povzročajo polži pridelovalcem precejšnje težave. Glavna hiba, ki doslej ni bila v prid širši uporabi tega

agensa, pa je prav tako kot pri ostalih biotičnih pripravkih, visoka cena. To zmanjšuje gospodarnost pridelave njegove širše implementacije v sisteme pridelave živeža (Wilson in Grewal, 2005).

4.2 Nekromenični razvojni krog

Ta tip razvojnega kroga sta prvič preučevala Maupas (1900) in Mengert (1953). Mengert (1953) je ugotovil, da lahko dormantna ličinka po vstopu v polža v njem preživi brez nadaljnjega razvoja, in sicer vse dotlej, dokler polž ne pogine. Nato se začne ličinka hraniti z njim. Dormantne ličinke so v takšnem stanju predvsem v polževem plašču, telesu ali v prebavnem traktu. Poznejše raziskave so pokazale, da v večjih osebkih ogorčica *P. hermaphrodita* ne more razviti parazitskega razvojnega kroga, temveč le nekromeničnega (Wilson in Grewal, 2005).

4.3 Parazitski razvojni krog

To obliko razvojnega kroga so Wilson *et al*. (1993a) ter Tan in Grewal (2001a) preučevali predvsem na polžu *Deroceras reticulatum* (Müller). Ugotovili so, da je primarna pot vstopa dormatnih ličink ogorčic v polža prek dorzalnega integumenta vrečke, skozi kratek kanal v votlino plašča. V samem polžu se ogorčica razvija in razmnožuje. Po infekciji se razvije na polžu značilna oteklina na hrbtni strani. Ob močnem napadu ogorčic se le-te razširijo po celotnem telesu polža. Če je napad šibkejši, so ogorčice razširjene zgolj pod polžjo hišico.

Vrsta *P. hermaphrodita* razvije v prvem rodu od 250 do 300 potomcev, ki se nato prek drugega rodu razširijo po celotnem telesu polža. Ob koncu drugega rodu ogorčic polž navadno umre, tretji rod ogorčic pa se nato razvija v kadavru. Ob koncu tretjega rodu se razvije novi rod dormantnih ličink, ki v tleh počakajo na novega gostitelja (Tan in Grewal, 2001a). Smrt polža nastopi v 4 do 21 dneh, v odvisnosti od temperature in stopnje izpostavljenosti različnemu številu ogorčic na začetku. Po okužbi z ogorčico se polž preneha prehranjevati (Glen *et al.,* 2000; Grewal *et al.*, 2001, 2003b). To dejstvo je zelo pomembno, saj se biotično zatiranje polža, kljub tega da ta ne umre takoj, začne že takoj po vstopu ogorčic vanj.

5 GOSTITELJSKE VRSTE

Vse dosedanje raziskave (Wilson *et al*., 1993a; Coupland, 1995; Glen *et al*., 1996; Grewal *et al*., 2003b) so potekale v želji, da bi ugotovili, ali lahko ogorčica, ki je že parazitirala njenega gostitelja, ponovno parazitira novega. Na drugi strani so bile izjemno redke raziskave ugotavljanja, ali se v neobčutljivih (rezistentnih) polžih ogorčice pojavljajo v nekromičnem razvojnem krogu, oziroma kaj je tisti dejavnik, ki preprečuje uspešnost parazitiranja vrste *P. hermaphrodita* (Wilson in Grewal, 2005) .

Wilson *et al*. (1993a) so dokazali, da je v visokih koncentracijah (1,9 x 10^4/polža) vrsta *P. hermaphrodita* učinkovita pri zatiranju naslednjih vrst polžev: *D. reticulatum, D. panormitanum* (Lessona & Pollonera), *A. silvaticus* Lohmander, *A. distinctus* Mabille, *A. intermedius* Normand, *A. ater, Tandonia budapestensis* (Hazay) in *T. sowerbyi* (Férussac). Raziskava ni pokazala, da bi bilo zatiranje vseh naštetih vrst tudi gospodarno. Grewal *et al*. (2003b) poročajo, da je vrsta *P. hermaphrodita* pri nizki koncentraciji suspenzije ogorčic (300-2700 infektivnih ličink/polža) povzročila signifikantno stopnjo smrtnosti polžev *D. reticulatum, D. leave* (Müller) in *Leidyula floridana* (Leidy), tako v laboratorijskih razmerah, kot tudi v poskusih na prostem. Za nekatere vrste polžev je znano, da so občutljivi na infektivne ličinke ogorčic, medtem ko na njihove druge razvojne stadije niso (Glen *et al*., 1996). To so dokazali pri vrstah *Helix aspersa* (Müller) (Glen *et al*., 1996), *A. lusitanicus* Mabille (Speiser *et al.,* 2001; Grimm, 2002) in *A. hortensis* Férussac (Grewal *et al.,* 2003b). Grewal *et al.* (2003b) zaključujejo, da vstopi ogorčica *P. hermaphrodita* v nekromenični razvojni krog v polžih *A. subfuscus* (Draparnaud) in *Limax maximus* L., če je število infektivnih ličink pri obeh vrstah manjše od 10.

Coupland (1995) je v laboratorijskih poskusih dokazal, da povzroči vrsta *P. hermaphrodita* pri nizki koncentraciji suspenzije (300 DI/polža) smrtnost štirih vrst polžev, ki veljajo za najbolj škodljive v Avstraliji; *Theba pisana* (Müller), *Cernuella virgata* (Da Costa), *Cochlicella acuta* (Müller) in *C. barbara* (L.). Wilson *et al*. (2000) so poskus nadaljevali na prostem in s petkratnim tretiranjem s predpisano koncentracijo prišli do sklepa, da ogorčica *P. hermaphrodita* zadovoljivo deluje le na vrsto *Cepaea hortensis* Müller, ki pa je Coupland (1995) ni vključil v laboratorijski poskus.

6 POVEZAVA PARAZITSKIH OGORČIC POLŽEV Z BAKTERIJAMI IN MEHANIZMI PATOGENOSTI

Malo je znanega o povezavi vrste *P. hermaphrodita* z bakterijami v naravnem okolju. Zaradi podobnosti med EPO in parazitskimi ogorčicami polžev številni znanstveniki zaključujejo, da je rast in razmnoževanje

ogorčic v polžu rezultat njihovega simbiontskega odnosa z bakterijami (Wilson *et al*., 1995ab).

Wilson (2002) je iz dormantnih ličink vrste *P. hermaphrodita* ter kadavrov polžev pridobil več kot 100 bakterijskih izolatov; le trinajstim bakterijam je bilo mogoče določiti vrstno pripadnost Največjo sposobnost namnoževanja so dosegli pri bakterijah *Providencia rettgeri, Moraxella osloensis* in pri dveh izolatih bakterije *Pseudomonas fluorescens*. Vse zgoraj naštete bakterije so bile vključene v t.i. kompleks ogorčica/bakterija, vendar sta se zgolj kombinaciji ogorčice *P. hermaphrodita* z bakterijama *M. osloensis* in *P. fluorescens* izkazali kot patogeni (Wilson *et al.*, 1995b). Nobena od dveh vrst bakterij po 16-urnem namnoževanju v petrijevkah pri 25 °C, brez zastopanosti ogorčice, po vbrizgu v polža *D. reticulatum* ni bila patogena.

Tan in Grewal (2001b) sta odkrila, da je bakterija *M. osloensis* po 48-urnem namnoževanju v petrijevkah virulentna za polža *D. reticulatum*. Študije so pokazale, da pri parazitskih ogorčicah polžev ni značilne specifične simbioze z bakterijami, kot to velja pri EPO. Pomanjkanje bakterijske specifičnosti pri vrsti *P. hermaphrodita* je najverjetneje v povezavi s prepustno kutikulo. Delovanje EPO je namreč usmerjeno predvsem v vstopanje ogorčic skozi naravne odprtine v telo gostitelja, pri čemer je zunanja kutikula nepoškodovana. To EPO omogoča tudi boljše antimikrobno delovanje, saj ni nevarnosti za vdor talnih mikroorganizmov v kadaver. Pri parazitskih ogorčicah polžev je delovanje usmerjeno predvsem na kadaver, kjer je zunanja kutikula mnogo bolj prepustna in s tem je antimikrobni potencial bakterij manjši (Wilson in Grewal, 2005).

Vse nadaljnje raziskave so se usmerile predvsem na bakterijsko-ogorčični kompleks med vrstama *M. osloensis* in *P. hermaphrodita*. Ugotovljeno je bilo, da ima bakterija zelo pomembno vlogo pri stopnji patogenosti ogorčic (Tan in Grewal, 2001b, 2002, 2003). Ogorčice, ki v svojem telesu ne prenašajo bakterij, so v stopnji patogenosti slabše od onih, kjer so bakterije zastopane. Število živih bakterij v ogorčicah je odvisno od starosti infektivnih ličink, saj starejše ogorčice prenašajo manjše število viabilnih celic (Tan in Grewal, 2001b). Tan in Grewal (2002) poročata, da bakterija *M. osloensis* proizvaja toplotno odporen endotoksin - visoko toksično snov za polže. Endotoksin je sestavljen iz lipopolisaharidov. Čisti liposaharidi so za polže letalni, predvsem, če pridejo v hemolimfni sistem; njihova LD_{50} vrednost znaša 48 µg/polža (Tan in Grewal, 2002).

7 PROIZVODNJA IN FORMULACIJA PRIPRAVKOV

Razlog, ki je omogočal prihod vrste *P. hermaphrodita* na trg z biotičnimi pripravki, je v dejstvu, da je tehnologija masovne proizvodnje te vrste skoraj identična tisti pri EPO. Wilson *et al*. (1993b) so dokazali, da je mogoče vrsto *P. hermaphrodita* gojiti na sterilnem gojišču s trdim agarjem (ta temelji na metodi Beddinga [1984]), kot tudi na tekočem gojišču. Donos gojenja ogorčic na kulturi z enim mikroorganizmom je bil 100.000 IL/ml (Wilson *et al.* 1995). Večje število infektivnih ličink v formulaciji pa je mogoče doseči s predhodnim centrifugiranjem (Young *et al.*, 2002). Ogorčice je mogoče shranjevati v različnih tipih vermikulita, pa tudi v polimerskih in glinenih formulacijah. Življenjska doba tako hranjenih ogorčic je nižja kot pri EPO iz rodu *Steinernema*, podobna pa je onim iz rodu *Heterorhabditis*. Pripravke na podlagi parazitskih ogorčic polžev moramo hraniti v hladilniku.

8 DELOVANJE NA NECILJNE ORGANIZME

Malo je znanega o delovanju vrste *P. hermaphrodita* na neciljne organizme. Številne vrste polžev veljajo za rastlinske škodljivce v različnih območjih sveta, vendar pa obstajajo tudi koristne vrste polžev (Kerney in Stubbs, 1980). Zato se poraja vprašanje ali bi lahko imela vrsta *P. hermaphrodita* ob masovni uporabi negativen vpliv na koristne vrste polžev. Wilson *et al*. (2000) je v laboratorijskih razmerah testiral delovanje ogorčice *P. hermaphrodita* na sedem koristnih vrst polžev in ugotovil, da ogorčica »uspešno«, to je neciljno, deluje na polža *C. hortensis* in *Monacha cantiana* (Montagu). Ko pa je poskus ponovil na prostem, takšnega vpliva ni bilo mogoče potrditi. Številne vrste polžev ne živijo v tleh, ampak na rastlinah, zato je pri njih stopnja tveganja napada ogorčice *P. hermaphrodita* manjša (Mengert, 1953).

Za vrsto *P. hermaphrodita* je znano, da ni nevarna za talne žuželke. Tako so Wilson *et al*. (1994) preizkusili to ogorčico pri zatiranju hroščev *Zophobas morio* (F.) in *Tenebrio molitor* L. in dokazali, da omenjeni vrsti nista občutljivi na njen napad. Wilson *et al.* (1993d) pa poročajo, da v laboratorijskih razmerah tudi vrsta *Pterostichus melanarius* (Illiger) pri uporabi visokih koncentracij suspenzije ogorčice *P. hermaphrodita* ni bila občutljiva.

Deževniki so pomemben sestavni del talne favne. Dokazano je bilo, da vrsta *P. hermaphrodita* lahko

parazitira deževnika *Lumbricus terrestris* (L.) (Zaborski *et al*., 2001). Številni nadaljnji poskusi so pokazali, da ogorčice iz rodu *Phasmarhabditis* lahko povzročijo smrt številnih vrst deževnikov. Številni raziskovalci pa so dokazali, da komercialni pripravek z vrsto *P. hermaphrodita* kot aktivno snovjo ni škodljiv za deževnika *L. terrestris* ter *Eisenia fetida* (Savigny) (Wilson *et al*., 1993d; De Nardo *et al*., 2003; Grewal, 2003).

9 ZAKLJUČKI

V Evropi so zastopanost ogorčic iz rodu *Phasmarhabditis* doslej potrdili le v 4 državah; v Avstriji, Franciji, na Madžarskem in v Nemčiji (Fauna Europaea, 2007). Ker pri nas do nedavnega parazitskih ogorčic polžev nismo preučevali, so še vedno na seznamu t.i. tujerodnih organizmov in je njihova uporaba omejena le na laboratorijsko delo.

Trenutno lahko na slovenskem tržišču kupimo sedem pripravkov z limacidnim delovanjem. V Katalogu dovoljenih sredstev za ekološko kmetijstvo (Ozimič et al., 2007) sicer najdemo dva pripravka, a ima vsak od njiju nekatere slabosti, ki dobesedno kličejo po čim prejšnji uvedbi novega pripravka. Pripravek Carakol (aktivna snov metaldehid, 5 %) je namreč okolju neprijazen (strupen za toplokrvne organizme), a je na seznamu zato, ker drugih ustreznejših limacidov pač ni na našem tržišču. Pripravek Feramol (aktivna snov železov [III] fosfat) – drugi od omenjenih dveh pripravkov - pa ima lastnosti okolju prijaznega sredstva, a je njegovo delovanje počasno in večkrat nezadovoljivo.

Morebitna prihodnja uporaba ogorčice *Phasmarhabditis hermaphrodita* – identifikacija ogorčic, najdenih v polžih, nabranih na različnih območjih Slovenije je namreč v teku - bi lahko predstavljala alternativo kemičnim limacidom, saj so polži v zadnjih letih zaradi milih zim in vlažnih poletij vse pomembnejši škodljivci gojenih rastlin pri nas in v številnih drugih državah (Kozowski *et al*., 2006; Grubišić *et al*., 2007).

10 ZAHVALA

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Preučevanje ustreznosti prognostičnega modela SIMLEP za varstvo krompirja pred koloradskim hroščem (*Leptinotarsa decemlineata* [Say], Coleoptera, Chrysomelidae) v Sloveniji

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IZVLEČEK

V obdobju 2007-2008 smo v Ljubljani preučevali ustreznost nemškega prognostičnega modela SIMLEP, katerega uporaba je namenjena varstvu krompirja pred koloradskim hroščem (*Leptinotarsa decemlineata*). Med 14. majem in 6. avgustom 2007 ter med 26. majem in 4. avgustom 2008 smo enkrat tedensko na 25 rastlinah krompirja (5 mest s 5 zaporednimi rastlinami) ugotavljali številčnost jajčnih legel, mladih ličink (L1/L2), starejših ličink (L3/L4) in odraslih osebkov. Model SIMLEP 1, ki je namenjen za regionalno napoved prvega pojava prezimelih hroščev in začetka odlaganja jajčec, se je v obeh letih pokazal za neustreznega, saj je 15 (leto 2007) oziroma 17 (leto 2008) dni prezgodaj napovedal prvi pojav jajčnih legel. Model SIMLEP 3, ki je poljsko specifičen model za napoved pojava različnih razvojnih stadijev koloradskega hrošča, se je pokazal za ustreznega. V obeh letih je namreč zelo natančno napovedal prvi pojav mladih ličink in starejših ličink (v nobenem primeru se napoved od dejanskega stanja ni razlikovala več kot 5 dni), pojav največjega števila jajčnih legel in mladih ličink (razlika med napovedanimi in dejanskimi datumi je bila od 0 do 7 dni). Z morebitno prihodnjo uporabo modela SIMLEP 3 v Sloveniji bo mogoče zagotoviti boljšo učinkovitost in gospodarnost zatiranja koloradskega hrošča, saj omogoča določitev optimalnega časa nanosa insekticidov, s čimer lahko pomembno vplivamo na zmanjšanje odpornosti škodljivca na insekticide.

Ključne besede: SIMLEP, prognoza, koloradski hrošč, *Leptinotarsa decemlineata*, krompir, razvojni stadij, poljski poskus, Nemčija, Slovenija

ABSTRACT

TESTING THE SUITABILITY OF SIMLEP DECISION SUPPORT SYSTEM FOR PROTECTION OF POTATO AGAINST COLORADO POTATO BEETLE (*Leptinotarsa decemlineata* [Say], Coleoptera, Chrysomelidae) IN SLOVENIA

In a period from 2007 to 2008 we studied the suitability of German decision support system SIMLEP, which was elaborated for protection of potato against Colorado potato beetle (*Leptinotarsa decemlineata*). In a field experiment in Ljubljana (Slovenia) we weekly assessed the number of egg clusters, young larvae (L1/L2), old larvae (L3/L4) and adults on 25 plants (5 places with five successive plants). The counting was performed between May 14 and August 6 2007 and between May 26 and August 4 2008. Model SIMLEP 1, which is used for a regional forecasting for the first occurrence of hibernating beetles and the start of egg laying, showed itself in both years as not suitable, while it forecasted the first occurrence of egg clusters 15 (2007) respectively 17 (2008) days too early. Model SIMLEP 3, a field-specific model which forecasts the occurrence of the developmental stages of Colorado potato beetle demonstrated as suitable. Namely, in both years this model very precisely forecasted the first occurrence of young and old larvae (in none of the cases the forecast differed from actual situation for more than 5 days) and also the occurrence of the highest number of egg clusters and young larvae (difference between forecasted and actual situation was from 0 to 7 days). With eventual future use of model SIMLEP 3 in Slovenia, a better effectiveness and economy in controlling Colorado potato beetle will achievable, by enabling us to define the optimum time of

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insecticide application. Model results may contribute to the reduction of pest resistance development to insecticides.

Key words: SIMLEP, decision support system, Colorado potato beetle, *Leptinotarsa decemlineata*, potato, developmental stage, field experiment, Germany, Slovenia

1 UVOD

V Evropi je koloradski hrošč (*Leptinotarsa decemlineata* [Say]) razširjen na vseh območjih pridelovanja krompirja, razen na Irskem in v Veliki Britaniji. Navadno se škodljivec množično pojavlja v suhih in toplih območjih, kjer letno razvije dva rodova (Jörg in Beck, 2000). Če koloradskega hrošča ne zatiramo, lahko povzroči precejšnjo škodo, ki se kaže v manjšem pridelku in slabši kakovosti (manjša velikost gomoljev) (Zehnder et al., 1995). Tudi v Sloveniji se je ta žuželčja vrsta v zadnjih letih, tako kot v številnih drugih evropskih državah (Wachowiak et al., 2006), kar nekajkrat prerazmnožila. Na takšnih območjih se je posledično povečala uporaba insekticidov, na približno dve to tri škropljenja letno, zaradi česar je škodljivec ponekod razvil odpornost (rezistenco) na insekticide (Pruszyñski in Wêgorek, 1991; Jörg, 1998; Jörg et al., 2003; Wegorek et al., 2003; Preiß et al., 2004; Stanković et al., 2004). Pojav odpornosti koloradskega hrošča na insekticide smo ugotovili tudi v Sloveniji (Trdan, še neobj.).

Vzrok za ta pojav strokovnjaki pripisujejo nepravilni aplikaciji, neustreznemu času aplikacije ali neustreznim vremenskim razmeram ob aplikaciji. V številnih zgledih so pridelovalci krompirja s piretroidi škropili pri temperaturi nad 25 °C, ko lahko koloradski hrošč razgradi aktivne snovi v insekticidih. Velikokrat so insekticide uporabljali prepozno, to je bilo takrat, ko je večina osebkov v populacijah škodljivca že dosegla stopnjo starejših ličink (L3 in L4) ali odraslih osebkov prvega rodu. Ti so namreč veliko manj občutljivi na insekticide kot mlade ličinke (L1 in L2) (Jörg, 1998).

Za namen integriranega varstva krompirja pred koloradskim hroščem so na inštituciji ZEPP v kraju Bad Kreuznach (Nemčija) izdelali prognostični model SIMLEP, ki temelji na temperaturnih podatkih in je sestavljen iz dveh modulov: SIMLEP 1 in SIMLEP 3. Prognostični model SIMLEP uporabniku pomaga pri odločitvi za škropljenje ob najbolj ustreznem času. Z njegovo uporabo je mogoče doseči boljši učinek škropljenja in zmanjšati pojav odpornosti, saj je s škropljenjem ob ustreznem času potrebno insekticid uporabiti le enkrat, v najslabšem primeru dvakrat. Namen tega prispevka je predstavitev prognostičnega modela SIMLEP in predstavitev rezultatov preizkušanje njegove ustreznosti za uporabo v Sloveniji.

2 PROGNOSTIČNI MODEL SIMLEP

Model deluje na podlagi simulacije pojava različnih razvojnih stadijev koloradskega hrošča. Sestavljata ga dva modula: SIMLEP 1, ki napoveduje prvi pojav prezimelih hroščev v regiji in SIMLEP 3, ki je točkovno specifičen model za simulacijo nadaljnjega razvoja tega škodljivca na njivah s krompirjem (Roßberg et al., 1999).

2.1 SIMLEP 1

SIMLEP 1 simulira razvoj koloradskega hrošča od prihoda iz tal (kjer je prezimil) do pojava mladih hroščev prvega rodu v izbrani regiji. Rezultati so prikazani glede na fenološki razvoj in relativno številčnost naslednjih razvojnih stadijev: prezimeli hrošči, jajčeca, mlade ličinke (stopnja L1/L2), starejše ličinke (stopnja L3/L4) in mladi hrošči.

SIMLEP 1 je osnovan tako, da simulira razvoj hroščev glede na temperaturne podatke, na podlagi katerih preračunava stopnje razvoja, smrtnost, razmnoževanje in prehode med različnimi razvojnimi stadiji (računanje se začne z določenim številom prezimelih samic). Model ne vključuje obdobja prezimovanja. Kot vhodne podatke zahteva urne vrednosti temperature zraka na višini 2 m od 1. aprila naprej.

Glede na dejanski razvoj škodljivca so izhodni podatki modela:

- datum prvega pojava prezimelih hroščev,
- datum prvega pojava jajčnih legel,
- številčnost jajčnih legel,
- številčnost mladih ličink,
- številčnost starejših ličink,
- datum prvega pojava mladih hroščev (prvega rodu).

V praksi se SIMLEP 1 uporablja za regionalno napoved pojava prvih jajčnih legel. Model so intenzivno testirali v Nemčiji. V 80 % zgledov je model podal časovno ustrezno napoved začetka odlaganja jajčec koloradskega hrošča. Ko SIMLEP 1 opozori na možnost pojava prvih jajčnih legel, se začne načrtno spremljanje (monitoring) škodljivca. Drugi podatki tega modela (številčnost različnih razvojnih stadijev idr.) se ne uporabljajo v namene varstva krompirja. Odločitev mora namreč temeljiti na razvoju hrošča na točno določeni njivi,

prognoza z modelom SIMLEP 1 pa je osnovana na regionalni ravni.
Rezultati pojava prezimelih hroščev pri modelu SIMLEP 1 velikokrat niso zadovoljivi, saj so razlike med napovedanimi in opazovanimi podatki tudi do 30 dni (Jörg *et al*., 2007).

2.2 SIMLEP 3

SIMLEP 3 simulira odnose med populacijo koloradskega hrošča in agrometeorološkimi podatki na specifični, točno določeni lokaciji (parceli), v natančno določenem času. Model simulira razvoj koloradskega hrošča od začetka odlaganja jajčec do pojava starejših ličink in nam poda informacijo o optimalnem času za tretiranje škodljivca.

Model zahteva naslednje vhodne parametre:
- urne vrednosti temperature zraka na višini 2 m od 1. aprila naprej,
- datum prve najdbe jajčnih legel na njivi s krompirjem,
- datum zadnjega ocenjevanja, ko na rastlinah še ni bilo jajčnih legel (v primeru, da ta podatek ni na voljo in se je ocenjevanje začelo prepozno, se v model vstavi datum 1. januar),
- število jajčnih legel (zabeleženih ob prvem opazovanju; predvideno je opazovanje na 25 rastlinah [5 zaporednih rastlin x 5 mestih] na parceli).

Simulacija se začne na dan, ko so bila na izbrani parceli prvič opažena jajčna legla. Na podlagi vstavljenih podatkov in meteoroloških podatkov model SIMLEP 3 izračuna datum začetka odlaganja jajčnih legel. Vsi izračuni in napovedi se nanašajo na ta datum.

Izhodni podatki modela so:
- datum prvega pojava mladih ličink (L1/L2),
- datum prvega pojava starejših ličink (L3/L4),
- obdobje najbolj intenzivnega odlaganja jajčec (= obdobje optimalne ocenitve gostote populacije glede na odločitev za uporabo insekticidov; svarilo približno 6-9 dni pred nanosom insekticida),
- obdobje največjega števila mladih ličink (= optimalno obdobje za nanos insekticida; svarilo približno 4-7 dni pred nanosom insekticida).

Za obdobje največjega števila mladih ličink sta izračunani dve napovedi: predhodna in končna napoved. V večini zgledov sta napovedi identični. V letih, ko temperature močno padejo po predhodni napovedi, pa lahko končna napoved največjega števila mladih ličink nastopi nekoliko pozneje.

V Nemčiji odločitev za aplikacijo insekticidov proti koloradskemu hrošču temelji na številu jajčnih legel (Jörg in Beck, 2000). Ocena je potrebna, ko SIMLEP 3 opozori na obdobje največje gostote jajčec.

Nanos insekticidov za uporabo v konvencionalni pridelavi se mora izvesti tedaj, ko model napove največje število mladih ličink (L1/L2), saj je učinkovitost insekticidov največja ravno v tem obdobju razvoja škodljivca. Bioinsekticidi na podlagi bakterije *Bacillus thuringiensis* so najbolj učinkoviti tedaj, če jih uporabimo ob pojavu prvih mladih ličink (Langenbruch, 1992). Model SIMLEP 3 napoveduje omenjene dneve in pred tem opozarja na njihov pojav, tako, da se lahko pridelovalec pravočasno pripravi na zatiranje škodljivca (Jörg *et al*., 2007)..

3 MATERIALI IN METODE DELA

Poljski poskus je potekal v letih 2007 in 2008 na Laboratorijskem polju Biotehniške fakultete v Ljubljani (46°04' zemljepisne širine, 14°31' zemljepisne dolžine, 300 m nadmorske višine). Na njivi z velikostjo 2,4 ara, na katero smo krompir, cv. Kondor, posadili 11. aprila 2007 in 28. aprila 2008, smo preučevali razvojni krog koloradskega hrošča. V prvem letu raziskave smo krompir med rastno dobo trikrat poškropili s fungicidi, da bi preprečili razvoj krompirjeve plesni (*Phytophthora infestans* (Mont.) de Bary). Nasad smo prvič poškropili s fungicidom 29. maja. Uporabili smo pripravek Ridomil Gold MZ Pepite (aktivna snov mankozeb + metalaksil-M). Drugo škropljenje proti krompirjevi plesni smo izvedli 13. junija s pripravkom Polyram DF (aktivna snov metiram), zadnje škropljenje pa ponovno s pripravkom Ridomil Gold MZ Pepite. V drugem letu raziskave smo krompir pred okužbo s paradižnikovo plesnijo prvič zavarovali šele 26. junija, drugič pa 24. julija. V obeh primerih smo uporabili kombinacijo fungicidov Shirlan 500 SC (aktivna snov fluazinam) in Melody Duo WP 66,8 (aktivna snov iprovalikarb + propineb).

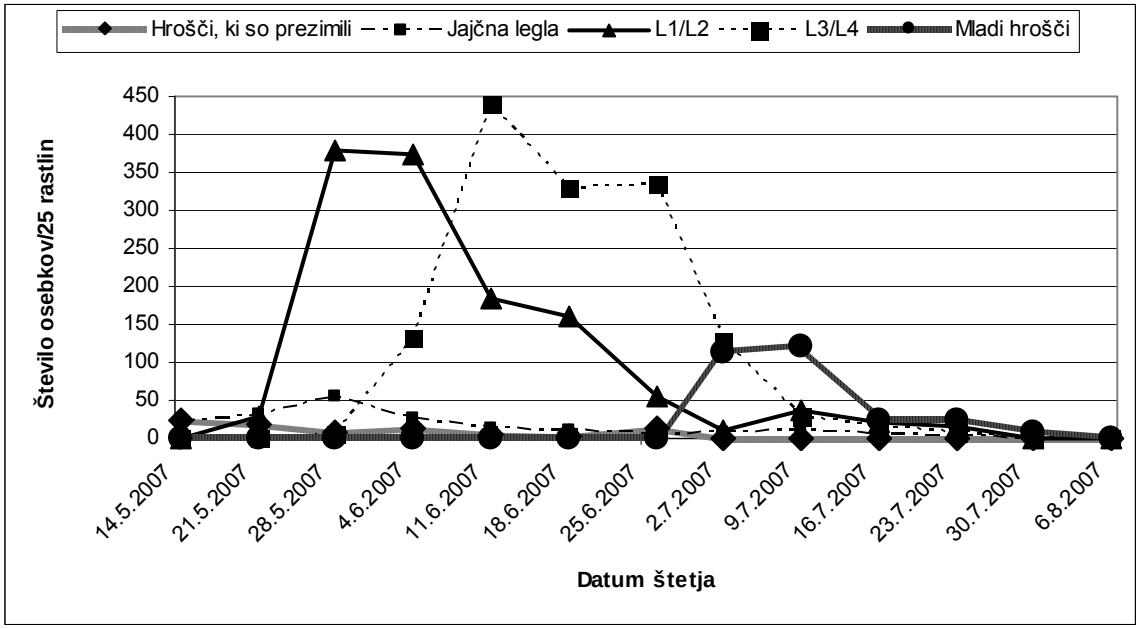
Na parceli smo spremljali pojav prvih (prezimelih) odraslih osebkov, to je njihov spomladanski prihod iz tal, pojav jajčnih legel, mladih ličink (L1/L2), starejših ličink (L3/L4) ter pojav novega (prvega) rodu hroščev. Na parceli smo naključno izbrali pet mest in na vsakem mestu pet zaporednih rastlin krompirja. Na njih smo od dneva, ko smo opazili prve odrasle osebke (14. maj 2007 in 26. maj 2008) do konca pojavljanja škodljivca (6. avgust 2007 in 4. avgust 2008) enkrat tedensko ugotavljali zastopanost različnih razvojnih stadijev škodljivca.

4 REZULTATI

4.1. Leto 2007

Prve prezimele hrošče smo ugotovili ob prvem ocenjevanju, 14.5., in ti so se pojavljali do 25.6. (slika 1). Število hroščev je bilo največje (23 osebkov/25 rastlin) prav ob prvem ocenjevanju, ko smo na spodnji strani krompirjevih listov v povprečju na vsaki rastlini našli tudi po skoraj eno jajčno leglo. Število jajčnih legel je doseglo vrh 28.5. (približno 2 jajčni legli/rastlino), zatem pa se je postopoma zmanjševalo.

Če smo ob prvem ocenjevanju na 25 rastlinah našli le eno mlado ličinko, pa se je njihovo število v obdobju od konca maja do začetka junija približalo 15 osebkom na rastlino. Zatem se je njihovo število zmanjševalo, obenem pa se je povečevalo število starejših ličink, ki so bile najbolj številne ob obdobju od 11.6. do 2.7. Tedaj je bilo njihovo povprečno število na rastlino od 13 do 18. Hrošči 1. rodu so se pojavili v začetku julija, po 30.7. pa jih na rastlinah krompirja nismo več našli, saj je bila cima že suha.



***Slika 1**: Prikaz številčnosti koloradskega hrošča v različnih razvojnih stadijih v poljskem poskusu na Laboratorijskem polju Biotehniške fakultete v Ljubljani leta 2007.*

Prognostični model SIMLEP 1 je za leto 2007 napovedal naslednje datume začetka pojava različnih razvojnih stadijev koloradskega hrošča: za prezimele hrošče in jajčna legla 29.4., za mlade ličinke 11.5., za starejše ličinke 24.5. in za mlade hrošče 19.6 (preglednica 1).

Model SIMLEP 1 je prvi pojav jajčnih legel napovedal za 29.4., medtem ko smo jajčna legla na listih krompirja dejansko ugotovili šele 14.5. (preglednica 2). Model je bil torej 15 dni prezgoden. Rezultati prvega pojava jajčec z uporabo modela SIMLEP 1 niso bili zadovoljivi, saj je bila razlika med napovedanimi in opazovanimi podatki prevelika.

***Preglednica 1**: Simulacija (napoved) dnevov prvega pojava različnih razvojnih stadijev koloradskega hrošča z modelom SIMLEP 1 v letu 2007.*

Razvojni stadij	Datum prvega pojava
Hrošči, ki so prezimili	29.4.
jajčna legla	29.4.
ličinke L1/L2	11.5.
ličinke L3/L4	24.5.
mladi hrošči	19.6.

***Preglednica 2**: Prikaz vhodnih (meteoroloških) podatkov v model SIMLEP 1, simulacija modela in odstopanje dneva napovedi od dejanskega pojava jajčnih legel na njivi v letu 2007.*

Meteorološka postaja	Ocenitev pred prvim pojavom jajčnih legel	Prvi pojav jajčnih legel na parceli	Simulacija SIMLEP 1	Dnevi (pojav prvega pojava jajčnih legel – napoved)
Ljubljana	1.1.	14.5.	29.4.	15

***Preglednica 3**: Prikaz dejanskih in z modelom SIMLEP 3 napovedanih datumov pojava mladih (L1/L2) in starejših (L3/L4) ličink ter odstopanja med njimi v letu 2007.*

Meteo-rološka postaja	Prvi pojav L1/L2 na njivi	Napoved prvega pojava L1/L2	Dnevi (prvi pojav L1/L2 – napoved)	Prvi pojav L3/L4 na njivi	Napoved prvega pojava L3/L4	Dnevi (prvi pojav L3/L4 – napoved)
Ljubljana	14.5.	16.5.	-2	28.5.	24.5.	4

Z uporabo modela SIMLEP 3 smo zelo natančno napovedali prvi pojav mladih ličink (L1/L2), saj je bila napoved le 2 dni prepozna (preglednica 3). Rezultati napovedi prvega pojava starejših ličink (L3/L4) so bili dobri, saj je model predvidel prvi pojav L3 in L4 ličink 4 dni prezgodaj.

Model SIMLEP 3 je dobro do zelo dobro ocenil čas začetka in konca pojava največjega števila jajčnih legel in mladih ličink (preglednici 4 in 5). Dejanski podatki kažejo na pojav največjega števila jajčnih legel med 25.5. in 31.5., medtem ko je model napovedal čas med 20.5. in 28.5. (preglednici 5 in 6). Največje število mladih ličink smo na njivi ugotovili v obdobju od 27.5. do 7.6., medtem ko je model napovedal čas od 24.5. in 31.5.

Odstotek jajčnih legel se je od 21.5. do 28.5. vsak naslednji dan povečal za 6 %, v dneh od 28.5. do 4.6. pa se je vsak naslednji dan zmanjšal za 7,5 %. Odstotek največjega števila mladih ličink se je od 21.5. do 28.5. vsak dan naslednji povečal za 13,2 %, od 4.6. do 11.6. pa se je vsak naslednji dan zmanjšal za 7,3 %.

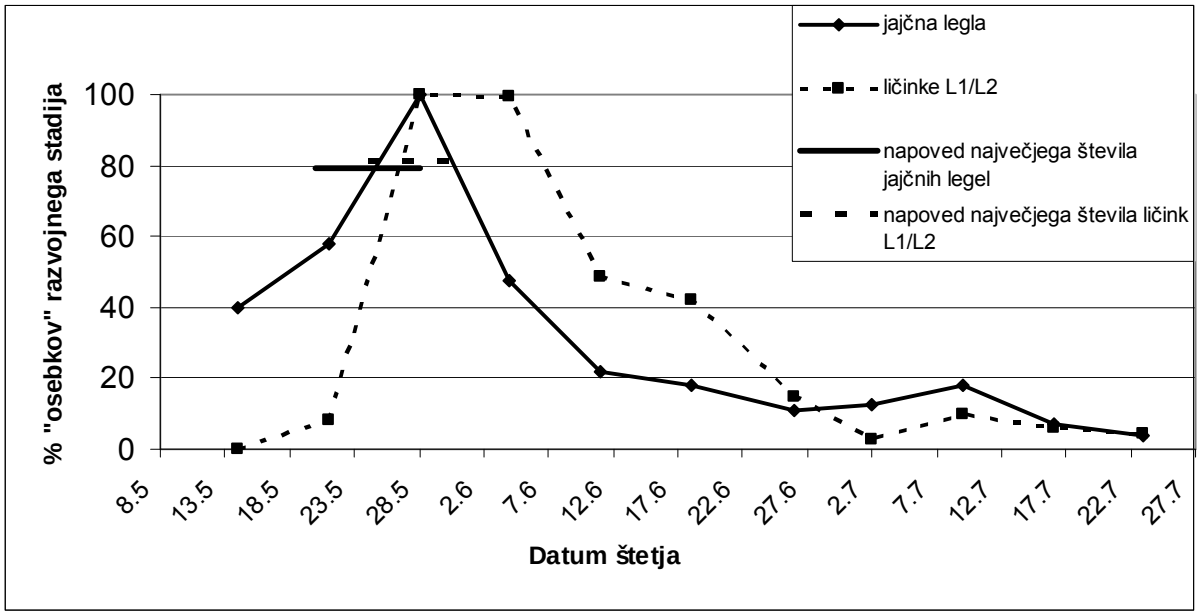
Model SIMLEP 3 je napovedal prvi pojav mladih ličink za 16.5., prvi pojav starejših ličink pa za 24.5. (sliki 3 in 4). Zgornja vodoravna črta na sliki 4 prikazuje čas odločanja za tretiranje koloradskega hrošča z insekticidi (čas namenjen izbiri ustreznega škropiva idr., ki je v našem primeru od 20.5. do 28.5), srednja črta (prva napoved) in spodnja črta (zadnja napoved) pa napovedujeta obdobji z največjo številčnostjo mladih in starejših ličink, ki sta hkrati najustreznejša termina za uporabo insekticidov. V našem primeru traja to obdobje od 24.5. do 31.5.

4.2. Leto 2008

V drugem letu poskusa smo ob prvem ocenjevanju, 26. maja, na 25 rastlinah krompirja ugotovili 19 odraslih hroščev in 14 jajčnih legel. Hrošči so se pojavljali do 28. julija (slika 5). Prvi rod hroščev se je pojavil 7.7., ko je bilo na 25 pregledanih rastlinah 113 odraslih osebkov. Največ jajčnih legel smo ugotovili ob drugem pregledu krompirja, 2.6., ko smo na 25 rastlinah našli 57 jajčnih legel. Mlade ličinke so se množično pojavljale v začetku junija, v tednu od 2.6. do 9.6. se je njihovo število povečalo za 5-krat; na 25 rastlinah jih je bilo 2.6. 124, 9.6. pa kar 595. Število starejših ličink na enakem številu rastlin je bilo 16.6. 465, to pa je bilo več kot 9-krat večje kot 9.6., ki smo jih našteli 49 ličink. Po 16.6. se je število starejših ličink precej zmanjšalo.

***Preglednica 4**: Prikaz dejanskih in napovedanih datumov (začetnih in končnih) največjega števila jajčnih legel in mladih ličink z modelom SIMLEP 3 v letu 2007.*

	Rezultat - štetje		Napoved	
	začetni datum	končni datum	začetni datum	končni datum
največje število jajčnih legel	25.5.	31.5.	20.5.	28.5.
največje število ličink L1/L2	27.5.	7.6.	24.5.	31.5.

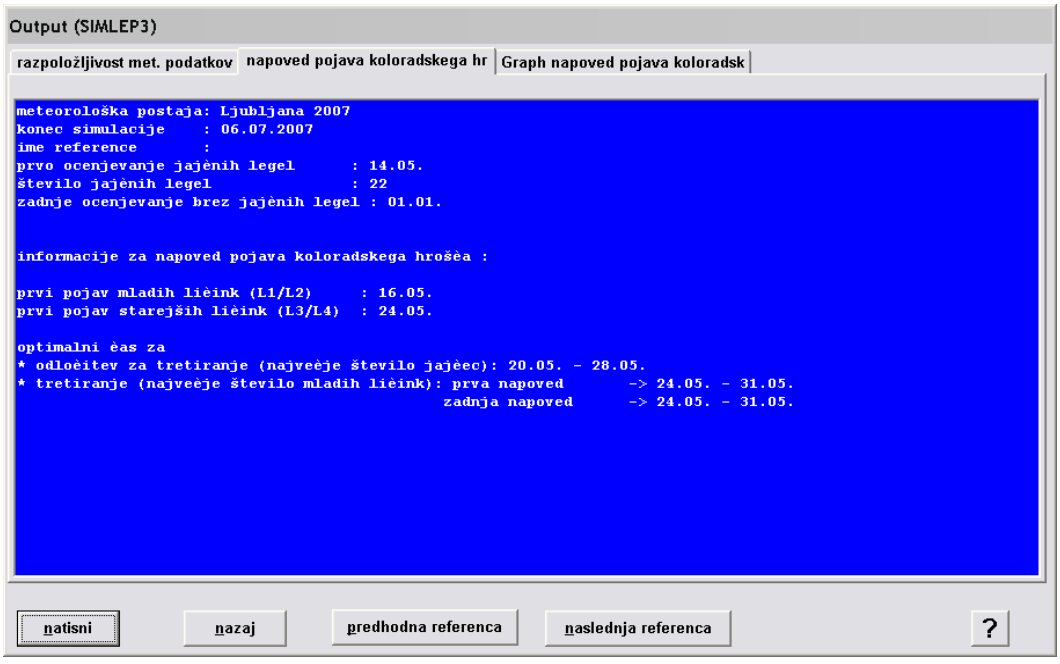


***Slika 2**: Prikaz napovedi največjega števila jajčnih legel in mladih ličink z modelom SIMLEP 3 v letu 2007.*

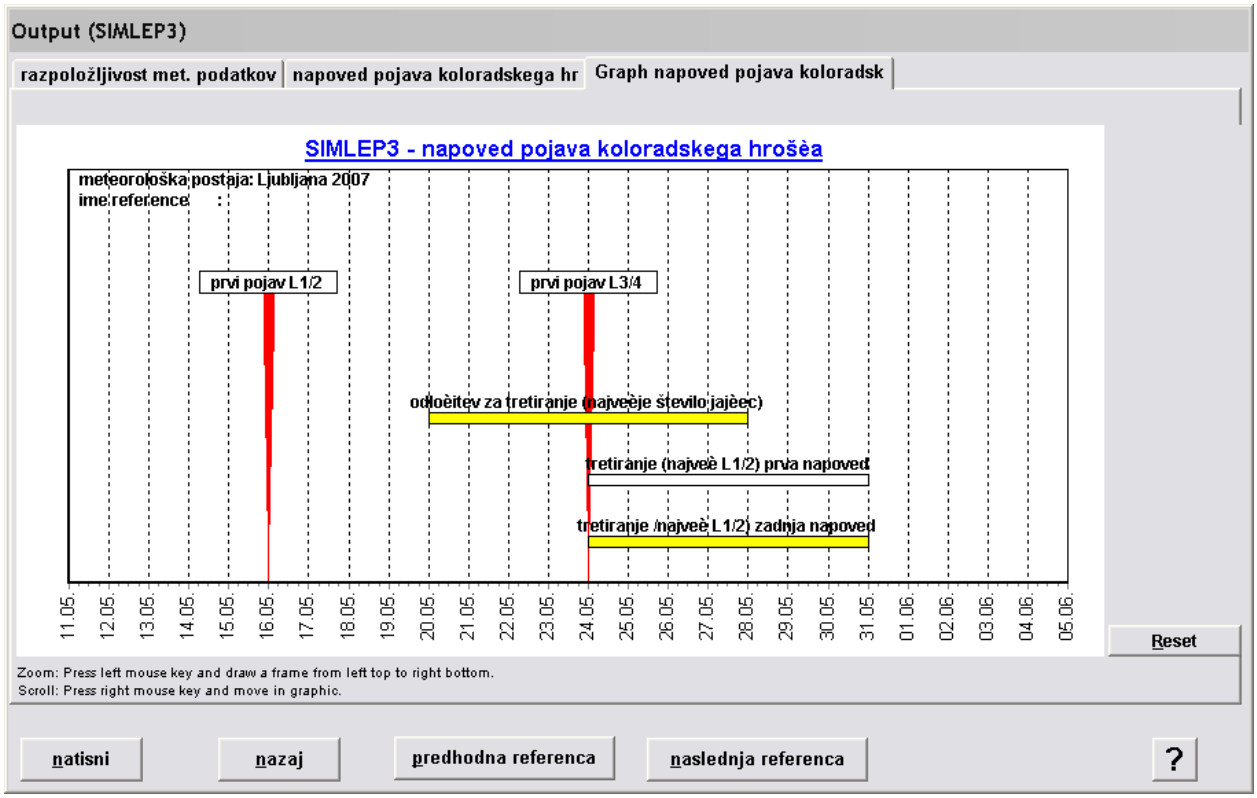
***Preglednica 5**: Ocena natančnosti napovedi datuma pojava največjega števila jajčnih legel in mladih ličink z modelom SIMLEP 3 v letu 2007.*

	Ocenitev - napoved		Ocenitev - napoved	
	začetni datum	končni datum	začetni datum	končni datum
največje število jajčnih legel	5	(o)	3	(+)
največje število ličink L1/2	3	(+)	7	(o)

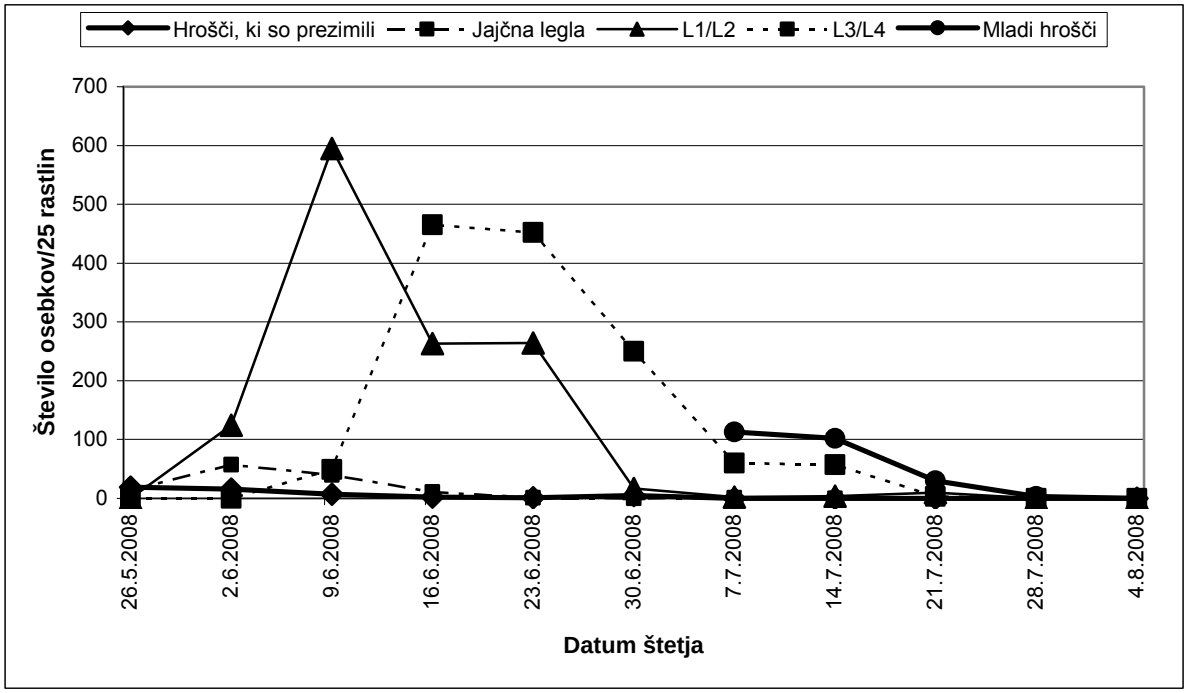
Legenda natančnosti napovedi: (+) zelo dobra [od 0 do ≤ 4 dni], (o) dobra [od 4 do ≤ 7 dni], (-) slaba [nad 7 dni]



***Slika 3**: Računalniški prikaz vhodnih in izhodnih podatkov modela SIMLEP 3 v letu 2007.*



***Slika 4**: Grafični prikaz napovedanega prvega pojava mladih in starejših ličink koloradskega hrošča z modelom SIMLEP 3 na Laboratorijskem polju Biotehniške fakultete v Ljubljani v letu 2007 z napovedjo obdobij za optimalni čas tretiranja z insekticidi.*



***Slika 5**: Prikaz številčnosti koloradskega hrošča v različnih razvojnih stadijih v poljskem poskusu na Laboratorijskem polju Biotehniške fakultete v Ljubljani leta 2008.*

Prognostični model SIMLEP 1 je za leto 2008 napovedal naslednje datume začetka pojava različnih razvojnih stadijev koloradskega hrošča: za prezimele hrošče 4.5., za jajčna legla 9.5., za mlade ličinke 20.5.2008, za starejše ličinke 1.6.2008 in za mlade hrošče 25.6.2008 (preglednica 6).

Model SIMLEP 1 je prvi pojav jajčnih legel napovedal za 9.5., medtem ko smo jih na listih krompirja dejansko ugotovili šele 26.5. (preglednica 7). Model je bil 17 dni prezgoden. Rezultati prvega pojava jajčec z uporabo modela SIMLEP 1 niso bili zadovoljivi, saj je bila razlika med napovedanimi in opazovanimi podatki prevelika.

Z modelom SIMLEP 3 smo natančno napovedali prvi pojav mladih ličink in starejših ličink (preglednica 8). V obeh primerih je model pojav ličink napovedal 5 dni prezgodaj.

***Preglednica 6**: Simulacija (napoved) dnevov prvega pojava različnih razvojnih stadijev koloradskega hrošča z modelom SIMLEP 1 v letu 2008.*

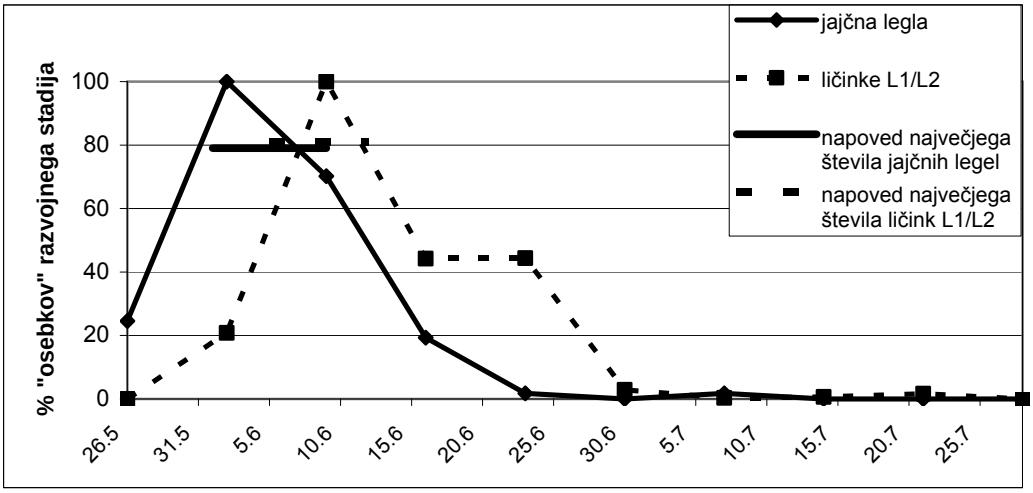
Razvojni stadij	Datum prvega pojava
Hrošči, ki so prezimieli	4.5.
jajčna legla	9.5.
ličinke L1/L2	20.5.
ličinke L3/L4	1.6.
mladi hrošči	25.6.

***Preglednica 7**: Prikaz vhodnih (meteoroloških) podatkov v model SIMLEP 1, simulacija modela in odstopanje dneva napovedi od dejanskega pojava jajčnih legel na njivi v letu 2008.*

Meteorološka postaja	Ocenitev pred prvim pojavom jajčnih legel	Prvi pojav jajčnih legel na parceli	Simulacija SIMLEP1	Dnevi (pojav prvega pojava jajčnih legel – napoved))
Ljubljana	1.1.	26.5.	9.5.	17

***Preglednica 8**: Prikaz dejanskih in z modelom SIMLEP 3 napovedanih datumov pojava mladih (L1/L2) in starejših (L3/L4) ličink ter odstopanja med njimi v letu 2008.*

Meteo-rološka postaja	Prvi pojav L1/L2 na njivi	Napoved prvega pojava L1/L2	Dnevi (prvi pojav L1/L2 – napoved)	Prvi pojav L3/L4 na njivi	Napoved prvega pojava L3/L4	Dnevi (prvi pojav L3/L4 – napoved)
Ljubljana	2.6.	28.5.	5	9.6.	4.6.	5



***Slika 6**: Prikaz napovedanega največjega števila izleženih jajčnih legel in mladih ličink z modelom SIMLEP 3 v letu 2008.*

***Preglednica 9**: Prikaz dejanskih in napovedanih datumov (začetnih ter končnih) največjega števila jajčnih legel in mladih ličink po modelu SIMLEP 3 v letu 2008.*

	Rezultat - štetje		Napoved	
	začetni datum	končni datum	začetni datum	končni datum
največje število jajčnih legel	1.6.	7.6.	1.6.	9.6.
največje število ličink L1/2	8.6.	12.6.	5.6.	12.6.

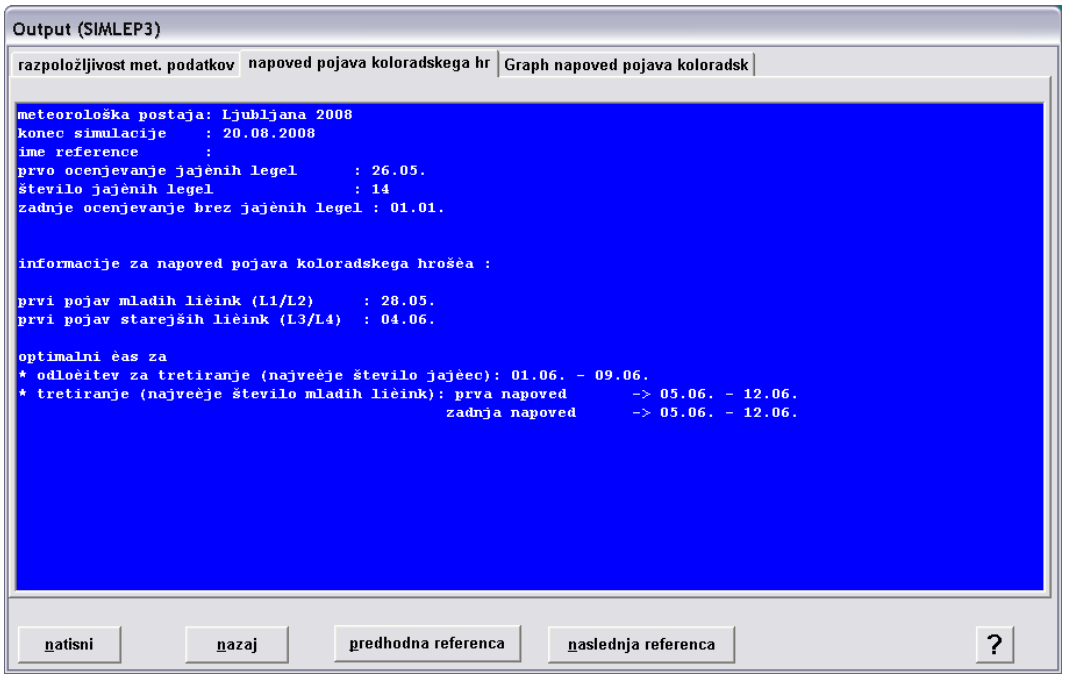
***Preglednica 10**: Ocena natančnosti napovedi dnevov pojava največjega števila jajčnih legel in mladih ličink z modelom SIMLEP 3 v letu 2008.*

	Ocenitev - napoved		Ocenitev - napoved	
	začetni datum	končni datum	začetni datum	končni datum
največje število jajčnih legel	0	(+)	-2	(+)
največje število ličink L1/2	3	(+)	0	(+)

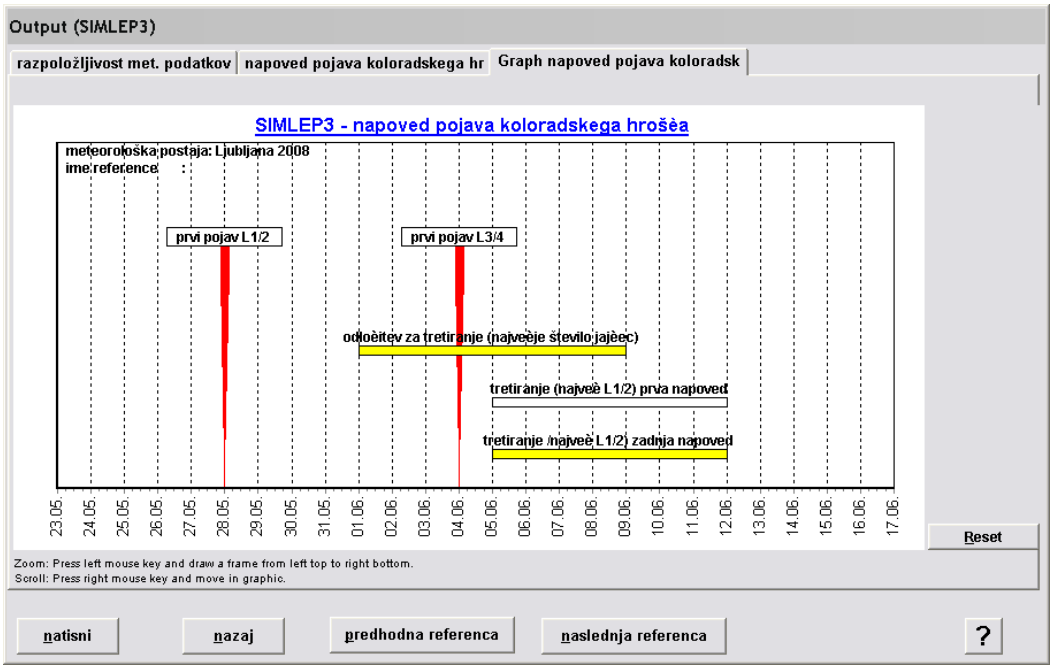
Legenda natančnosti napovedi: (+) zelo dobra [od 0 do ≤ 4 dni], (o) dobra [od 4 do ≤ 7 dni], (-) slaba [nad 7 dni]

Model SIMLEP 3 je zelo dobro ocenil čas začetka in konca pojava največjega števila jajčnih legel in mladih ličink (preglednici 9 in 10). Dejanski podatki kažejo na pojav največjega števila jajčnih legel med 1.6. in 7.6., medtem ko je model napovedal čas med 1.6. in 9.6. Največje število mladih ličink smo na njivi ugotovili v obdobju od 8.6. do 12.6., medtem ko je model za ta pojav napovedal čas med 5.6. in 12.6.

Odstotek jajčnih legel se je od 26.5. do 2.6. vsak naslednji dan povečal za 10,8 %, v dneh od 2.6. do 9.6. pa se je vsak dan zmanjšal za 4,3%. Odstotek največjega števila mladih ličink se je od 2.6. do 9.6. vsak naslednji dan povečal za 11,3 %, od 9.6. do 16.6. pa se je vsak naslednji dan zmanjšal za 8,0 %.



***Slika 7**: Računalniški prikaz vhodnih in izhodnih podatkov modela SIMLEP 3 v letu 2008.*



***Slika 8**: Grafični prikaz napovedanega prvega pojava mladih in starejših ličink koloradskega hrošča z modelom SIMLEP 3 na Laboratorijskem polju Biotehniške fakultete v Ljubljani v letu 2008 z napovedjo obdobij za optimalni čas tretiranja z insekticidi.*

Model SIMLEP 3 je prvi pojav mladih ličink napovedal za 28.5., prvi pojav starejših ličink pa za 4.6. (sliki 7 in 8). Zgornja vodoravna črta na sliki 8 prikazuje čas odločanja za tretiranje koloradskega hrošča z insekticidi (čas namenjen izbiri ustreznega škropiva idr., ki je v omenjenem primeru od 1.6. do 9.6.), srednja črta (prva napoved) in spodnja črta (zadnja napoved), ki označujeta obdobje od 5.6. do 12.6., pa napovedujeta obdobji z največjo številčnostjo mladih in starejših ličink in sta hkrati najustreznejša termina za uporabo insekticidov.

5 RAZPRAVA Z ZAKLJUČKI

Model SIMLEP 1 v obeh letih raziskave ni zadovoljivo napovedal prvega pojava različnih razvojnih stadijev koloradskega hrošča. Razlike med napovedanimi in dejanskimi podatki so bile precejšnje: v letu 2007 je namreč ta model pojav jajčnih legel napovedal 15 dni prezgodaj, v letu 2008 pa 17 dni prezgodaj. Ker se je ta model tudi v našem preliminarnem poskusu v letu 2006 izkazal za premalo natančnega (33 dni prezgodnja napoved prvega pojava jajčnih legel) (Kert, 2007) sklepamo, da v razmerah osrednje Slovenije njegova uporaba ni priporočljiva. Ena od možnosti za njegovo premalo natančno napoved je lahko tudi v morebitnem dejstvu, da so se prva jajčna legla na preučevani parceli in tudi v širšem območju raziskave pojavila teden ali celo več dni prej, model pa je namenjen za regionalno napoved.

Zelo dobre rezultate pa smo z uporabo modela SIMLEP 3 tako v letu 2007 kot tudi v letu 2008 dobili pri napovedi prvega pojava mladih ličink; v letu 2007 je bila ta 2 dni prepozna, v letu 2008 pa 5 dni prezgodnja. Prvi pojav starejših ličink je isti model v prvem letu raziskave napovedal le 4 dni prezgodaj, v drugem letu raziskave pa 5 dni prezgodaj.

Zelo dobre rezultate smo z uporabo modela SIMLEP 3 dobili pri napovedi pojava največjega števila jajčnih legel in mladih ličink. V letu 2008 se je namreč napovedani interval tega obdobja pokrival z intervalom dejanskega pojava na polju. V letu 2007 je bila ocena natančnosti napovedanega intervala, pridobljenega z omenjenim modelom, dobra do zelo dobra in se je od dejanskih dnevov razlikovala od 3 do 7 dni. V letu 2008 je bila ocena natančnosti napovedanega intervala celo zelo dobra, saj se je od dejanskih dnevov razlikovala od 0 do 3 dni. Za model SIMLEP 3 zato ocenjujemo, da lahko dovolj natančno napove najpomembnejše

razvojne stadije koloradskega hrošča in s tem ustrezen čas aplikacije insekticidov tudi v Sloveniji.

Model SIMLEP, ki ima korenine v nekdanji Nemški demokratični republiki (Kurth, 1984; Spaar in Ebert, 1985), je bil doselj preizkušan v več evropskih državah; v Nemčiji, Avstriji, Italiji in na Poljskem. V približno 90 % poskusov je model SIMLEP 3 natančno napovedal obdobje največjega odlaganja jajčec in pojav mladih ličink, ki sta najustreznejši obdobji za poljsko ocenjevanje in aplikacijo insekticidov. V kmetijsko prakso je bil doslej uveden v Nemčiji, Avstriji in na vzhodu Poljske (Jörg *et al*., 2007).

Uporaba modela SIMLEP 3 je pomembna zaradi izboljševanja učinkovitosti zatiranja koloradskega hrošča. Z njegovo uporabo je namreč mogoče ločeno zatirati koloradskega hrošča in krompirjevo plesen (*Phytophthora infestans* [Mont.] de Bary). Pred tem so insekticide in fungicide na rastline večkrat nanašali hkrati, s tem modelom pa je mogoče insekticide za potrebe zatiranja koloradskega hrošča uporabiti že prej (10-14 dni pred aplikacijo fungicidov).

Učinkovitost delovanja konvencionalnih in biotičnih insekticidov je s takšno aplikacijo veliko večja, saj se jih nanaša v času pojava najbolj občutljivega razvojnega stadija škodljivca - mladih ličink (Wojtowicz in Jörg, 2006). Na ta način bodo kmetje smotrneje uporabljali insekticide, njihova učinkovitost pa bo večja. Velika prednost uporabe modela SIMLEP 3 je tudi natančnost napovedi, saj se z njim zmanjša potreba po večkratnem pregledovanju njiv, kar vpliva na bolj gospodarno pridelavo krompirja. Optimalni čas aplikacije insekticidov in ustrezna odločitev o vrsti pripravka in njegovem nanosu ob ustreznem času lahko tudi pomembno vpliva na zmanjšanje odpornosti koloradskega hrošča na insekticide. Ker so nekatere populacije omenjenega škodljivca pridobile odpornost na insekticide tudi v Sloveniji (Trdan, še neobj.), uporaba okoljsko sprejemljivejših insekticidnih pripravkov za njegovo zatiranje (Trdan et al., 2007) pa je pri nas še v povojih, smo prepričani, da tudi uporaba modela SIMLEP 3 lahko pomembno pripomore k učinkovitejšemu in gospodarnejšemu zatiranju škodljivca na krompirju.

6 ZAHVALA

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Die Waldungen der Herrschaft Gornji grad in ihrer althergebrachten Wirtschaftsweise und fehlgeschlagene Versuche zur Einführung der rationellen Forstökonomie im Übergang aus dem 18. ins 19. Jahrhundert

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AUSZUG

Die Herrschaft Gornji grad (Oberburg), seit 1462 im Eigentum des Bistums von Ljubljana, hatte durch Jahrhunderte sehr ausgedehnte Waldungen und Pachtweideflächen, in denen auf althergebrachte Weise mit Servituts- oder auf andere Weise erworbenen Rechten ihrer Untertanen, mit Plenterabstockung, meistens ohne An- und Ausweisung des Holzes den Untertanen, mit Ausweitung der Weideflächen zuungunsten der Wälder und auch auf andere Weise, wennauch nicht absichtlich zugunsten der Untertanen gewirtschaftet wurde. Zur Erhöhung der Rentabilität der Wälder wurde fremdländisches forstlich ausgebildetes Personal angestellt, welches neue Methoden der Forstbewirtschaftung, nach den Prinzipien der "Deutschen Forstschule" einführen sollte. Dieses Personal sollte so bald und soviel als möglich die alt hergebrachten Methoden verändern. Diesem Ansinnen widersetzten sich die Untertanen, denen es gelang, fast alle forstliche Neuerungen zu verhindern. Alle Verfahren der Untertanen waren aber nach der gültigen Forstordnung strafbar. Die Herrschaftsverwaltung war aber in dieser Zeit gleichzeitig auch noch Staatsbehörde, der die Verwaltungs-, Justiz-, Polizei- und Rekrutierungsaufgaben oblagen. Die Feudalordnung war damals schon schwächlich und so konnte die Herrschaftsverwaltung nicht so streng die Anzeigen ihres Forstpersonals gegen die Untertanen über die Forst- und Weideübertretungen (Exzesse) ahnden und Prozesse führen bzw. so streng die Vorschriften durchführen, um die Untertanen nicht noch mehr in Aufregung zu bringen.

Zweck dieser Abhandlung ist die Beschreibung der erwähnten Waldungen mit ihren äuβerst verworrenen Verhältnissen mit den Untertanen und Darstellung der Probleme, die mit der Einführung der rationalen Forstökonomie verbunden waren.

ABSTRACT

THE FORESTS OF THE GORNJI GRAD ESTATE IN A TRADIONAL WAY OF HUSBANDRY AND UNSUCCESFUL TRIALS OF INTRODUCTION A RATIONAL FOREST MANAGEMENT IN THE PERIOD OF TRANSITION FROM THE EIGHTEENTH TO NINETEENTH CENTURY

The estate Gornji grad, since 1462 in the ownership in the diocese of Ljubljana, owned for centuries large forests and leasehold pastures. They were managed in a traditional way with the servitude or otherwise acquired rights of the bondsmen, applying selected felling of the trees, mostly without allocation to the bondsmen or by increasing the acreage of the pasture on the expense of that of the forests as well as in many other ways. All this finally resulted, although unintentionally, in the benefit of the bondsmen. To increase the productiveness of the forests, administration staff from abroad was employed, whose expertise should introduce new forest management based on the principles of "the German forest school". The methods of the forest management should be changed as much as possible, but the bondsmen raised against all such solutions and they hindered mostly very effectively every realization of these innovations. All these measures were punishable according to the laws valid in that time in the region, the direction of the estate being at the same time also administrative, juridical, police and recruiting authority. The feudal order was already pretty weak in that time and so the estate authorities could not exhibit the expected strictness and expediousness in the processing the denunciations of the forest management staff dealing with forests and pasture excesses. They could not afford to upset the bondsmen even more.

The aim of this treatise is the description of the mentioned forests and their management together with extremely complicated relations between the authorities and the

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bondsmen as well the problems arising at the introduction of the rational forest economy.

IZVLEČEK

GOZDOVI GOSPOSTVA GORNJI GRAD Z GOSPODARJENJEM NA TRADICIONALNI NAČIN IN NEUSPEŠNI POSKUSI ZA UVEDBO RACIONALNEGA GOZDARJENJA NA PREHODU IZ 18. V 19. STOLETJE

Gospostvo Gornji grad, od 1462 v lasti Ljubljanske škofije, je imelo skozi stoletja obsežne gozdove in zakupne pašnike, na katerih je gospodarilo na tradicionalni način, s servitutnimi ali z drugače pridobljenimi pravicami njihovih podložnikov, s prebiralno sečnjo večinoma brez odkazila podložnikom, s širjenjem pašnikov v škodo gozdov in na druge načine, kar se je vse izteklo, čeprav ne namenoma, v prid podložnikov. Za povečanje donosnosti gozdov so zaposlili tuje gozdarsko šolano osebje, ki naj bi uvedlo nove metode gospodarjenja z gozdovi po načelih "Nemške gozdarske šole". To osebje naj bi, kolikor mogoče, spremenilo metode gospodarjenja z gozdovi. Toda temu so se zoperstavili podložniki, ki so večinoma uspešno preprečili vse gozdne novotarije. Vsi postopki podložnikov pa so bili po veljavnem gozdnem redu kaznivi. Uprava gospostva je bila v tem času hkrati državna oblast, ki je imela upravne, sodne, policijske in naborne funkcije. Fevdalni red pa je bil tedaj že dokaj šibek in tako uprava gospostva ni mogla prav ostro obravnati ovadb gozdarskega osebja glede gozdnih in pašniških prestopkov (ekscesov) in voditi sodne procese oz. izvajati predpise, da ne bi podložnike še bolj razburila.

Namen te razprave je opis omenjenih gozdov in gozdnega gospodarstva z njihovimi skrajno zapletenimi odnosi s podložniki in prikaz problemov, povezanih z uvedbo racionalne gozdne ekonomije.

EINFÜHRUNG

Die Herrschaft Gornji grad (Oberburg), seit 1462 im Eigentum des Bistums von Ljubljana, hatte durch Jahrhunderte sehr ausgedehnte Waldungen und Pachtweideflächen, in denen auf althergebrachte Weise mit Servituts- oder auf andere Weise erworbenen Rechten ihrer Untertanen, mit Plenterabstockung, meistens ohne An- und Ausweisung des Holzes den Untertanen, mit Ausweitung der Weideflächen zuungunsten der Wälder und auch auf andere Weise, wennauch nicht absichtlich zugunsten der Untertanen gewirtschaftet wurde. 1785 übergab der damalige Bischof Janez Karl Graf Herberstein die Herrschaft Gornji grad in die Verwaltung des Steirischen Religionsfonds, technisch aber der Innerösterreichischen Staatsgüteradministration in Graz. Diese verwaltete sie ebenso wie andere Staats- bzw. Religionsfondsherrschaften. Zur Bewirtschaftung ausgedehnter Waldungen und Erhöhung ihrer Rentabilität wurden in Gornji grad fremdländische ausgebildete Forstleute angestellt, die natürlich die dortherrschaftliche Forstwirtschaft nach Grundsätzen der damaligen "Deutschen Forstschule" mit neuen Methoden der Forstbewirtschaftung möglichst schnell umkrempeln wollten.

Dagegen stellten sich die Untertanen zur Wehr und vereitelten meistens erfolgreich fast alle herrschaftliche forstliche Neuerungen. Auch das Wirtschafts- und Verwaltungsamt der Herrschaft, das damals noch allgemeine Verwaltungs-, Justiz-, Polizei- und Werbbezirksaufgaben innehatte, konnte wegen ersichtlicher Schwächen der Feudalordnung die vorkommenden Forst- und Weidexzeße nicht so streng ahnden, wie die Forstbeamten es durch Anzeigen und auf andere Weise durchsetzen wollten. Der Beschreibung der erwähnten Waldungen mit ihren äusserst verworrenen Untertansverhältnissen und der Einführung der "rationellen" Forstökonomie ist die vorliegende Abhandlung gewidmet.

UMRISS DER GESCHICHTE DER HERRSCHAFT GORNJI GRAD

Hier soll die Geschichte der Herrschaft hauptsächlich nach Pirchegger (1962)[1] kurz vorgestellt werden. Das ganze obere Gebiet der Savinja (Sann) ostwärts bis Paška vas (Packdorf) war Eigen (Alod) des Hochfreien Diebald von Chager und seiner Frau Truta. Sie übergaben es 1140 dem Patriarchen von Oglej (Aquileia) und stifteten mit ihm in "Obremburch" (Gornji grad) ein Benediktinerkloster. Es bekam fast 500 Holden (Untertanen) mit Weib und Kind, Wälder mit Rodungsrecht, Jagd und Fischerei. Dem Patriarchen fielen die Burg, zwei Dienstmannen mit ihren Besitze sowie 10 Huben, ferner bei hundert Ministerialen mit ihren Besitze zu; sie sollten das Recht der Standesgenossen von Oglej erhalten. Der Patriarch widmete dem Kloster zwei Teile des Zehents innerhalb der Pfarren Gornji grad - die bisher Diebald von Chager als Lehen innegehabt - und Braslovče (Fraßlau). 1147 und 1158 bestätigten die römischen Kaiser und deutschen Könige Konrad III. und Friedrich I. die

[1] Pirchegger, Hans: Die Untersteiermark in der Geschichte ihrer Herrschaften und Gülten, Städte und Märkte. Buchreihe der Südostdeutschen Historischen Kommission, Band 10. München, 1962, 195-199.

Gründung des Stifts und nahmen es in des Reiches Schutz.

Nach der Gründungsurkunde erhielt Oglej, wie ausgeführt, die Feste Gornji grad mit Zugehör und die ritterliche Mannschaft des Chagers. Weil es bei 100 Ministerialen beiderlei Geschlechts waren, so liegt der Schluß nahe, daß sie nicht nur in Gornji grad selbst saßen, sondern im ganzen Bereiche der Herrschaft, die sich vielleicht mit den Pfarren deckte, daher noch den Bezirk Mozirje (Praßberg) einschloß und bis Dobrovlje (Dobroll) und bis zur Mündung des Flußes Paka reichte. Der Patriarch besaß ja als Lehensherr später auch die Herrschaften Mozirje (Prassberg) und Vrbovec (Altenburg). Deshalb wollte Patriarch Berthold 1237 in Gornji grad ein Suffraganbistum errichten, was aber wohl wegen der folgenden politischen Wirren nicht gelang.

1243 wird in einer Patriarchenurkunde das "alte" Schloß Gornji grad (*antiquum castrum*) erwähnt, gelegen ob dem Bach Dreta (Drietbach), jedenfalls auf dem Hügel Gradišče, wo noch um 1820 Mauerreste sichtbar waren. Aber wo stand 1243 das "neue" Schloß? Es wird niemals besonders genannt. Das Burgamt Gornji grad besaßen seit Beginn des 14. Jahrhunderts die Ritter von Vrbovec (Altenburg), die von 1315 an dem Kloster wiederholt Güter verkauften und 1349 (1350) ihre Anteile an der Feste Gornji grad sowie ihren Besitz oberhalb Celje (Cilli) den Grafen von Celje um 800 Mark Pfennige, mit Gericht, Maut, Jagd, Fischwaid, einen Anteil an Markt Rečica (Rietz), 57 ½ Huben, mehrere Mühlen, Zehenten sowie je zwei Dienstmannen zu Lešje (Hasel), einem Hof bei Rečica in Savinjska dolina (Sanntal), und auf dem Breg (Rain), ebenso einem Hof bei Gornji grad, veräußerten. Die Güter erstreckten sich von Rečica bis St. Peter in Savinjska dolina (Sanntal) in 34 genannten Orten, sie waren nicht Amtslehen von Gornji grad sondern Privatbesitz der Adligen von Vrbovec; ob Lehen oder Eigen ist nicht bekannt. Nun wurden die Grafen von Celje vom Patriarchen mit der Feste Gornji grad belehnt, das letztemal 1425.

Die Erbvogtei über den Besitz des Patriarchen und des Klosters stand Leopold von Konjice (Gonobitz) zu (als Lehen vom Landesfürsten?), 1230 verpfändete er sie dem Kloster um 100 Mark Pfennige; Liutpold VI. bestimmte damals, daß nur der Herr von Konjice und seine Erben sie rücklösen dürften. Das muß geschehen sein, denn 1284 überließ Amelrich der Späte sie seinem Vatersbruder Leopold von Konjice und der dürfte die Erbvogtei vor 1286 dem Grafen Ulrich von Vovbre (Heunburg) in Kärnten übergeben haben; dieser wollte sie so lange kostenlos versehen, bis er die dem Kloster zugefügten Schäden ersetzt hätte. Daneben gab es auch Teilvögte, so Gebhard von Lemberg bei Šmarje (Langenberg, wohl zu Žovnek - Sannegg gehörig), er versprach kurz vor 1235 gegen eine Entschädigung die Vogtei über das in der Krajina (Mark) im jetzigen Kozjansko und in Gornji grad gelegene Klostergut kostenlos zu führen. Sein gleichnamiger Enkel verwüstete dagegen 20 Jahre später das Klostergut, tötete zwei Holden und verstümmelte einige; was der Anlass dazu war, ist nicht bekannt. 1255 kam ein Ausgleich zustande.

Um Stopnik (Heggenberg) bei Vransko (Franz) war 1257 Otto von Kunšperk (Königsberg, Burg über heutiger Bistrica ob Sotli) Teilvogt, sein Nachkomme Friedrich versetzte die Vogtei 1313 dem Kloster. Als Herdegen von Ptuj (Pettau) 1328 Stopnik erworben hatte, wurde er Vogt daselbst. Im Gerichte Mozirje besaßen die Grafen von Vovbre die Vogtei. 1241 versprach Graf Wilhelm, gegen eine Entschädigung auf sie zu verzichten und von den Klosterleuten nur bestimmte Abgaben einheben zu wollen. Teilvogt war auch Friedrich von Ptuj, er sandte 1288 seine Rechte dem Herzog Albrecht für Graf Ulrich von Vovbre. Demnach war der Herzog Hauptvogt. Die Wirren des nun folgenden Adelsaufstandes und des Krieges der Habsburger gegen die Kärntner Meinhardiner trafen die Herrschaft Gornji grad schwer, weil sie von den Grafen von Vovbre bekämpft wurde. Nach Erlöschen dieses Grafengeschlechts erbten die Grafen von Pfannberg die Vogtei, verkauften sie aber 1337 den Freien von Žovnek.

Nachdem die Grafen von Celje (ehemalige Freien von Žovnek) zehn Jahre später auch die Herrschaft Vrbovec erworben hatten, waren sie die Herren im oberen Sanntale - nur Stopnik war eine größere Exklave - und beherrschten damit die wichtigsten Straßen nach Ljubljana und Dunaj (Wien). Die Habsburger sahen das ungern. Römischer Kaiser und deutscher König, Rudolf IV., der Stifter (1358-1365), bewog den Abt, 1361 in Oberburg einkehrend, den Landesfürst als rechten Erbvogt anzunehmen; alle früheren Verschreibungen an die Grafen von Celje seien ungültig, als "bezwungen und genötigt", denn Vogtei und Gericht gehörten zur Herrschaft Österreich. Aber die Grafen blieben die Herren des Stiftes und 1372 bat der Abt den Kaiser, die Erbvogtei den Grafen zu bestätigen. das geschah auch, weil sie das Kloster - nach dem Berichte des Abtes - "aus großer und verderblicher Schuld und Schaden gebracht" haben.

Nach dem Aussterben der Grafen von Celje 1456 ging die Herrschaft und Vogtei an den Landesfürst über; Kaiser Friedrich III. bestätigte dem Kloster 1458 die alten Freiheiten, ließ es aber gleichwohl, als er 1461 das Bistum Ljubljana errichtete, diesem durch den Papst als Tafelgut ausweisen (1463). Zehn Jahre später wurde das Kloster aufgelöst und dort ein Kollegium von

Weltpriestern errichtet; die Bischöfe residierten hier sehr oft bis zur Zeit Kaiser Josefs II. (1780-1790), daher erhielten die Stiftsgebäude und die Kirche starke Mauerwehr (1517); nach 1750 erfolgte Neubau.

Ältestes Stiftungsgut waren die Ämter Solčava und Luče, beide gleich den Pfarren, sowie Ljubno, dem Teile der Pfarre zwischen Savinja und Ljubnica (Laufnitzbach) zugehörten. Herzog Ulrich von Kärnten ließ im Jahre 1268 auf Beschwerden des Abtes die Grenze des Klostergutes und des herzöglichen Besitzes in Kärnten durch Hermann von Stopnik, Gundakar von Turn und Burggraf Hermann von Gornji grad feststellen. Das war nun überall die Wasserscheide zwischen Planina Zavratnik (*Retroporta*) an der Raduha, Olševa und Losekše (jetzt noch als Hofname Ložekar bekannt), am Übergang nach Železna kapla (Eisenkappel). Die Beschwerden galten ungenannten Übergriffen. Otto von Rechberg, der 1262 und 1268 bezeugt ist, hatte, wie seine Onkel Otto und Wulfing 1298 aussagten, sein Eigengut in Solčava dem Kärntner Kloster Dobrla ves (Eberndorf) aufgegeben. Noch 1335 beschwerte sich der Abt beim Patriarchen, das Kloster Dobrla ves habe zehn seinem Kloster gehörige Huben zu Solčava unter der Olševa widerrechtlich inne. Sonst war der Klosterbesitz in diesem Hochgebirgsgebiet geschlossen. Wahrscheinlich waren die Rodungen vom Norden her schneller erfolgt als vom Osten, denn der Fahrweg nach Solčava war damals bei der Igla (*Retro Portam*, Zavratnik) unterbrochen.

Nach dem Urbar von 1426 zerfiel der Klosterbesitz in 13 Ämter: Tirosek, An der Savinja, An der Dreta, Ljubno, Luče, Solčava, Braslovče, Volog, in der Mark bei Lemberg (Šmarje), Št. Ilj, Poreber in Krain sowie Kosiza und Arteza in Friaul. Das Amt Tirosek ensprach der Westhälfte der Pfarre Gornji grad bis zum Markte, der damals Ror hieβ. Hier ging die Straβe nach Krain durch, hier stand das Schloβ des Patriarchen - später der Grafen von Celje - und hier gab es viel Lehengut. Weniger geschloßen waren die Ämter an der Savinja, von Suha bei Ljubno bis unter Mozirje reichend, das an der Dreta, die Ämter von Volog, Braslovče und Št. Ilj. Außer diesem geschlossenen Besitz lebten die Untertanen der Herrschaft Gornji grad, sei es als dörfliche Enklave, sei es als einzelne Bauern in den Territorien anderer Dominien in der unteren Savinjska dolina, in Šaleška dolina, aber auch an den Hügeln von Ponikva, Št. Andraž und Št. Ilj. Außer diesen Besitzungen, die territorialmäßig mit dem Hauptsitz der Herrschaft in Gornji grad verbunden waren, lebten die Untertanen dieser Herrschaft in der ganzen Krajina östlich bis zum Fluß Sotla, sowie in Zasavje bis zum Fluß Save: in Pilštanj (Peilenstein), Žusem (Süßenheim), Podčetrtek (Windisch Landsberg), Podsreda (Hörberg), in Sv. Peter pod Svetimi gorami (Königsberg) sowie über Griže (Greis) und Sv. Pavel bei Prebold (Pragwald) bis Trbovlje (Trifail). Für diese außer der Gornja Savinjska und Zadrečka dolina lebende Untertanen bestand das Savinjaamt in Braslovče und Amt für Šaleška dolina in Št. Ilj bei Velenje (Wöllan). Diesem Amt oblagen auch die Pfarrhöfe von Solčava über Mozirje bis Podčetrtek und Trbovlje, die in ihrem Bereich im Namen der Herrschaft Gornji grad die Verwaltung über diese Untertanen durchführten. Wie das Kloster das "Amt in der March" bei Lemberg erworben hat, ist nicht bekannt (wahrscheinlich durch die Freien von Žovnek?). Weil in den angeführten Ortschaften keine größeren Waldungen bestanden, wird man sie aus unseren Erörterungen auslassen. Nach dem Steuerbuch von 1517 betrug die Gült der bischöflichen Herrschaft Gornji grad 877, die des Stiftes Rein bei Gradec (Graz) zum Vergleich, z. B. 1.320 Pfund.

Im Jahre 1543 gehörten der Herrschaft Gornji grad die Märkte Gornji grad, Ljubno, die Ämter Tirosek mit 97½ Huben (darunter viele "zunichte", also öde) und 9 Weingärten; an der Dreta: 127½ Huben und 71 Weingärten; An der Savinja: 97 und zwei halbe Huben, 114 Weingärten, dazu im Markt Rečica 22 Huben, 14 Hofstätten, 3 "Häuslein" und 19 Weingärten; im Amt Ljubno 85 Huben, 19 Weingärten; im Amt Luče 115 Huben, 3 Weingärten; im Amt Solčava 40 Huben; im Amt Braslovče 59½ Huben, 7 Weingärten: im Amt Brezje (Pirk unter Celje), wahrscheinlich nordwestlich von St. Georgen und östlich von Teharje (Tüchern) 27 Huben, 7 Weingärten. Zusammen: 343 ganze, 4 halbe Huben, 14 Hofstätter, 3 Häusler und 213 Weingärten.

Der Bischof von Ljubljana, Janez Karl Graf Herberstein, gab einige Jahre vor seinem Tod die Herrschaft Gornji grad in die Verwaltung der Innerösterreichischen Staatsgüteradministration in Gratz, bzw. dem Steirischen Religionsfonds. Als die Diözesanregulierung 1786 die Diözese Ljubljana auf das Land Krain beschränkt hatte, sollte die bischöfliche Herrschaft Gornji grad, in Steiermark gelegen, mit der ehemaligen Zisterzinserherrschaft Stična (Sittich), in Krain gelegen, vertauscht werden. Deswegen wurde die Herrschaft von Gornji grad fälschlicherweise (weil es nach wie vor im Eigentum des Bistums von Ljubljana war) vom Steirischen Religionsfond als Religions-fonds-, bzw. Staatsherrschaft angesehen und verwaltet. In diesem Status verblieb sie bis zum Jahre 1807 als sie der damalige Erzbischof Michael Baron Brigido zurückerhielt. Zum Tausch der Herrschaften Gornji grad und Stična ist es nämlich nicht gekommen. Von 1809 bis 1814 war die Herrschaft Gornji grad aus unklaren Gründen wieder in der Staatsverwaltung, danach bis 1941 im Eigentum des Bistums von Ljubljana. Zur Zeit schwebt ein unvollendetes Denationalisierung-sverfahren, nach welchem das Erzbistum von Ljubljana die Wälder der ehemaligen Herrschaft Gornji grad zum

grössten Teil schon, sie aber zur Gänze zurück erhalten sollte.

Die Herrschaft besaβ um 1820 9 Ämter. Das Amt Gornji grad, Tirosek oder Nova Štifta (erwähnt schon 1426), umfasste folgende Dörfer Nova Štifta, Črnivec (Černelec) mit Volovljek, Bezgovje, Šmiklavž mit Mačkin kot, Štajngrob, Slemene, Kriška vas, Slatina, Čeplje und Sv. Primož bzw. Florijanska gora); das Amt Dreta umfasste das Dretatal mit den Ortschaften Kropa, Bočna, Otok, Delce, Šmartno, Št. Jošt, Slape, Volog, Marinec, Gornje und Spodnje Kraše, Potok, Kokarje und einzelne Untertanen in Lačja vas, auf Čreta, Dobletina, Podhom, Spodnje und Zgornje Pobrežje sowie Ternovec; das Amt Savinja umfasste die Märkte Ljubno und Rečica, sowie Ortschaften Juvanje, Okonina, Grušovlje, Šentjanž, Varpolje, Vimpasle, Spodnja Rečica, Prihova, Meliše, Radmirje, Gornje Radmirje und Ljubno;[2] das Amt Luče (genannt schon 1426) umfasste Ortschaften Krnice, Rogačnik, Podvolovljek an der Lučnica, Podveža, Raduha, Skrile, Konjiški vrh und Ljubečka ves; das Amt Solčava (genannt schon 1426) umfasste die ganze Pfarre desselben Namens, mit den Grenzen Igla - an der Savinja hinauf bis unter Raduha - Olševa - Citrija - Sv. Duh - Ložeške Alpe (an diesen Namen erinnert jetzt nur noch der Hofname Ložekar) - Matkov kot - unter Kočna - Logarska dolina. Auf der rechten Seite der Savinja gehörten diesem Amt die Huben in Bela und in Robanov kot; Braslovče und Št. Ilj, zusammen also 1125 (1156?)[3] untertänige Häuser, das freie Landgericht (seit 1470), die hohe und niedere Jagd sowie die Fischerei im Landgerichtsbezirke, die niedere Mitjagd in den Pfarren Mozirje und Braslovče, Patronat und Vogtei über 130 Kirchen und ein ausgedehntes Zehentrecht. Ablösung bei der Grundentlastung (nach dem Jahre 1848) betrug 209.484 Gulden.

Die Herrschaft besaß neben dem üblichen Patrimonialgericht auch privilegiertes Landgericht; ihr Verwalter durfte als geprüfter Richter also auch zugestellte Verbrecher richten. In der behandelten Zeit hatte er jedoch kein *jus gladii* (er durfte kein Todesurteil fällen). In den Fällen die in die Kompetenz des Landgerichtes fielen verhörte er unmittelbar den Verbrecher und sandte das Protokoll darüber dem k. k. Blutrichter in demViertl von Celje, der sich danach nach Gornji grad verfügte und den Prozess durchführte. Danach wurden die Prozessakten zum Sterischen Landrecht nach Gradec geschickt, das als Spruchgericht fungierte. Danach wurde das Urteil zurück an das Landesgericht geschickt und vom Richter kundgemacht. Zur Sicherheit der Delinquenten verfügte die Herrschaft über fünf Arrestkammern. Das Bestehen eines Landgerichts, bei der Herrschaft Gornji grad, das im Grunde hauptsächlich Strafgericht war, ist bedeutend, da nach Meinung der Forstbeamten einige Forstexzeße als größere Verbrechen eingestuft und vor diesem Landgericht verhandelt werden müßten. Wie aus der Tabelle 4 ersichtlich, wurden aber diese Exzeβe vor dem Patrimonialgericht oder eher im Verwaltungsweg verhandelt und (oder nicht) bestraft.

Weil die später dem Bistum von Ljubljana gehörigen Herrschaften Rudenek (Rudenegg) und Vrbovec (Altenburg) gegen Ende des 18. Jahrhunderts extra verwaltet wurden und ihre Wälder in den Gutsbeschreibungen beider Herrschaften enthalten sind, so wird auf ihre Besitzgeschichte hier nicht eingegangen.

Nach der Klosteraufhebung in den Jahren 1782 bis 1786 durch den Kaiser Josef II. gingen in die Staatsverwaltung bzw. die Innerösterreichische Staatsgüteradministration in Gradec zahlreiche ehemalige Klosterherrschaften und Güter über. Die Renten dieser Herrschaften verminderten sich aber sehr stark unter der staatlichen Verwaltung, im Vergleich zum vorigen Stand, als sie meistens noch durch Klosterangehörige bewirtschaftet wurden. Das war vollkommen unerwartet und mißlich, da ja der Staat bzw. die Landesreligionsfonds aus den Erträgnisen dieser Herrschaften ihre vom Staat vorgeschrieben Ausgaben, vor allem für die eingeführte Pfarregulierung, decken sollten. Warum der damalige Bischof von Ljubljana Janez Karl Graf von Herberstein die Bistumsherrschaft Gornji grad in die obige Verwaltung übergab, ist nicht bekannt. Wahrscheinlich wollte er sich mit den Wirtschaftsfragen nicht befassen. Es ist aber bekannt, dass er die verbrieften Rechte dieser Herrschaft sehr streng vertrat. Bei den Verhandlungen über Umwandlung der Naturalrobot in Geldgaben (Robotreluizionsverhandlungen), die in der Zeit von 1783 bis 1786 liefen entstand ein Robotreluizions-kontrakt. Den unterschrieb Herberstein, mit Vorbehalt zweier Paragraphen, die für die Herrschaft ungünstig ausfielen. Diese Kontrakte für grössere Herrschaften unterschrieb als höchste Instanz auch der Kaiser. Bei der Unterschrift des erwähnten Kontrakts von Gornji grad erklärte der Kaiser den Vorbehalt von Herberstein als null und nichtig.

Unter den damaligen Wirtschaftsfachleuten, in den Hof- und Landesämtern entfachte sich wegen der schlechten Erträgnisse der Herrschaften in der Verwaltug der Staatgüteraministration eine lebhafte Diskussion, wie man die Erträgnise dieser Herrschaften steigern könnte, und ob die Herrschaften in eigener Regie oder in Pacht

[2] Baš, Franjo: K zgodovini Gornjegrajskega. Časopis za zgodovino in narodopisje 33 (1938), 1-16. (Weiterhin Baš, 1938).

[3] Krajevni leksikon Dravske banovine. Ljubljana, 1937, stran 166.

betrieben oder sogar früher oder später veräußert werden sollen. Für den letzten Fall, also Verkauf und Lizitationsangebot mußten aber die Herrschaften und Güter mit allen ihren Vermögenswerten, Gerechtsamen und Verbindlichkeiten genau beschrieben werden. Deshalb wurde am 4. April 1802 von Erzherzog Karl, nach Genehmigung durch den Kaiser, allen Wirtschaftsämtern der Herrschaften auferlegt, eine Güterbeschreibung zu verfassen.[4] Für die Herrschaft Gornji grad kam der Verkauf, solange sie im Eigentum des Bistums von Ljubljana war, bzw. bis zum beabsichtigten Tausch mit der ehemaligen Zisterzienserherrschaft Stična, natürlich nicht in Frage, aber weil sie eben der Staatsgüterverwaltung oblag, musste für sie auch eine Güterbeschreibung erstellt werden. Daraufhin wurde von dem Wirtschaftsamt der Herrschaft Gornji grad entsprechende Güterbeschreibung verfasst, worin ein grosses Kapitel die Waldungen behandelt.[5] Anhand der allgemeinen Beschreibung der Herrschaft (also nicht nur der Waldungen) hat Franjo Baš 1938 eine allgemeine Abhandlung veröffentlicht,[6] worin einige Absätze mit interessanten Angaben auch den Wäldern gewidmet sind. Die vorliegende Abhandlung wird die eingangs erwähnte Forstproblematik, wie schon bei einigen Herrschaften der Untersteiermark,[7] in einer wald- bzw. forstmässig weit interessanteren Herrschaft, wie die von Gornji grad ist, erörtern. In dem Kapitel Gozdarstvo (Der Waldbau) in der voluminösen Gospodarska in družbena zgodovina Slovencev. Zgodovina agrarnih panog. 1. zvezek Agrarno gospodarstvo (Wirtschafts- und Gesellschaftsgeschichte der Slowenen. Die Geschichte der Agrarsparten. 1. Band Agrarwirtschaft, ist diese Problematik nur ansatzweise angeschnitten.[8]

[4] NŠAL (Erzbischöfliches Archiv Ljubljana), Fond Bischöfliches Archiv, Serie Gornji grad A, Sign. Fasc. 104, Inhalt Schriften. Historische Gutsbeschreibung der Religions Fonds Herrschaft Oberburg in Steiermark, Cillier Kreises. Darin ist enthalten die Instruktion zu der von allen Wirtschaftsämtern abzufassenden historischen Güterbeschreibung.

[5] Wie vorige Fußnote. Die Historische Gutsbeschreibung der Religions Fonds Herrschaft Oberburg enthält ein grosses Kapitel Historische Beschreibung über die Forste und Waldungen der k. k. Staatsherrschaft Oberburg, welche auf allerhöchsten Befehl Sr. Majestät, dann Sr. königl. Hoheit Erzherzog Carl erhoben worden im Jahr 1802. Im weiteren Historische Waldungsbeschreibung. Weil das Heft mit dieser Beschreibung nicht durchgängig foliiert ist, und weil die Thematik an mehreren Stellen angeschnitten wird, können bei weiterer Erörterung nicht bei allen Abschnitten Seitenzahlen angegeben werden.

[6] Baš, 1938, 1-16.

[7] Maček, Jože: O gospodarjenju z gozdovi na državni gospoščini v Konjicah na prehodu iz 18. v 19. stoletje. Gozd. vestn. XXXV (1977) 4, 141-149.

Id.: Gospodarjenje z gozdovi na državnih gospoščinah v Sloveniji v 18. stoletju. In: Pomen zgodovinske perspektive v gozdarstvu. Gozdarski študijski dnevi 1985, BF VTOZD za gozdarstvo, Ljubljana 1985, str. 75-87.

Id.:Gospodarjenje z gozdovi na državni gospoščini Jurklošter na prehodu iz 18. v 19. stoletje. Gozd. vestn. 44 (1985) 10, 379-384 in ZbBF 45 (1985) 215-224.

Id.: O gospodarjenju z gozdovi na državni gospoščini Studenice na prehodu iz 18. v 19. stoletje. Gozd. vestn. 44 (1985) 10, 347-350 in ZBBF 45 (1985) 225-231.

Id.: O gospodarjenju z gozdovi na državni gospoščini Štanof na prehodu iz 18. v 19. stoletje. Gozd. vestn. 44 (1986) 17-8, 291-293 in ZBBF 45 (1985) 233-237.

Id.: O gospodarjenju z gozdovi na državni gospoščini Marenberg (Radlje) na prehodu iz 18. v 19. stoletje. Gozd. vestn. 44 (1986) 1, 6-9 in ZBBF 45 (1985) 239-244.

Id.: Die Wälder der Herrschaften Žiče und Frajštanj und ihre Bewirtschaftung im Übergang vom 18. ins 19. Jahrhundert. *Acta agriculturae slovenica,* 89-1 (2007),189-206.

[8] Gospodarska in družbena zgodovina Slovencev. Zgodovina agrarnih panog. 1. zvezek Agrarno gospodarstvo, Ljubljana 1970, 417-463.

DIE WIRTSCHAFTLICHE VERFASSUNG DER HERRSCHAFT GORNJI GRAD UND IHRER WÄLDER

Diese Herrschaft war im Grunde eine klassische Grundherrschaft mit über tausend Untertanen (Grundholden) mit über 200 Bergrechtlern, berechtigt zum Bezug von vielen verschiedenen Untertans-giebigkeiten. Ihre eigene (dominikale) landwirt-schaftliche Gründe hielten sich in Massen; sie besass nämlich 42 Joch Äcker, 75 Joch Wiesen und 11 Joch Teiche. Wegen der für die Landwirtschaft nicht sehr günstigen Naturverhältnisse und der bekannten Nachteile des Wirtschaftens in eigener Regie waren die erwähnten Gründe in die Pacht übergeben. Für slowenische Verhältnisse überdurchschnittlich groß, 11.064 Joch, waren aber die eigentümlichen Flächen von Weiden (wobei es sich im grossen Ausmass um Alpen handelte), und von Wäldern, 9.645 Joch. Die Flächenangaben, besonders über Waldungen, Viehweiden und Alpen, beruhen auf eigenen geometrischen Messungen, die der erste herrschaftliche Forstmeister Alois Schweska auf Veranlassung des Grazer Guberniums und der dortigen Staatsgüteradministration in den Jahren 1792-1794 durchführte, um die regelmässige Forstregie und ordentlicheVerpachtung der landwirtschaftlichen Gründe zu ermöglichen. Später wurden die Wälder erneut vermessen, wobei 10.735 Joch ermittelt wurden. Die Wälder wurden zum Teil generell abgeschätzt und in Schläge eingeteilt. Z. B. wurden Reviere Petelinjek in 83, in Ravniče in 90, in Podlog 55, in Kuhinek 80 in Globače dann Mali Tovsti vrh in 100 Schläge, jedoch nur in den Mappen, nicht aber auf dem Terrain, eingeteilt.[9]

Die Herrschaft Gornji grad wurde unter fürstbischöflicher Verwaltung hauptsächlich als ansehnliche, jedoch nicht auch alle wirtschaftliche Möglichkeiten erschöpfende, Rentenquelle für das Bistum angesehen. Das könnte eigentlich nur durch sehr strenge Anforderungen an die Untertanen, und durch Überwachung ihres Wirtschaftsgebarens, besonders in den Wäldern, erreicht werden. Diese Möglichkeiten konnte aber die Herrschaft nicht ausschöpfen. Dafür gab es zwei wesentliche Gründe. Die Herrschaft konnte als kirchliche Institution, dem alten Spruch gemäß, daß es sich unter krummen Stab leichter leben lässt, mit ihren Untertanen bei Einforderung aller möglichen Gaben und Herrenforderungen nicht so streng verfahren als ähnliche Privatherrschaften, die es aber in der oberen Savinjska dolina gegen Ausklang des Mittelalters und in der Neuzeit gar nicht mehr gab. Andererseits spürte die Herrschaft sehr wohl, daß sich die feudale Gesellschaftsordnung ihrem Ende nähert und sie sich noch in stärkere Auseinandersetzungen mit ihren Untertanen, hauptsächlich über ihre Nutzung der herrschaftlichen Wälder und Weiden, wie sie seit jeher bestanden, nicht einlassen konnte. Das sollte sich ziemlich wesentlich nach der Übergabe der Herrschaft in die Verwaltung der Innerösterreichischen Staatsgüteradministration in Graz, bzw. dem Steirischen Religionsfond ändern. Auch die bischöfliche Herrschaft Gornji grad sollte gleich wie die anderen Religionsfondsherrschaften verwaltet werden. Die früher praktizierten Rücksichten gegenüber den Untertanen sollten nach dem Willen der Forstbeamten (wenigstens was die Wald- und Weideproblematik betrifft) nicht noch weiter erhalten werden. Der Herrschaftsverwalter, der auch alle Staatsbefugnisse im Bereich der Herrschaft wahrnahm, nahm aus Not eine breitere und mildere Sicht auf bestehende Probleme. Diese Sicht konnten oder eher wollten sich fremdländische Forstbeamte, die hier angestellt wurden, nicht aneignen. Daraus entstanden Streitereien, Anzeigen, Ahndungen, gerichtliche Prozesse, Bestrafungen (u. a. auch mit Leibesstrafen), die die Atmosphäre zwischen den Untertanen und der Herrschaft sehr stark vergifteten. Die meisten Anzeigen wurden aber überhaupt nicht wahrgenommen und schon gar nicht weiter verhandelt.[10]

Die Herrschaft hatte wenige landwirtschaftliche Gründe, auf denen Bewirtschaftung in eigener Regie rentabel wäre, deshalb wurden sie verpachtet. Weideflächen waren zwar ziemlich ansehnlich, sie waren aber auch mit ansehnlichen rechtlich ausgewiesenen, noch mehr aber durch Gewohnheitsrecht erworbenen Servitutsrechten behaftet. Die Abgrenzung, zwischen den, mit diesen Rechten belasteten und unbelasteten Flächen, war äusserst schwierig, wenn nicht gar unmöglich, so kam auch die Weide in eigener Regie nicht in Frage, und so wurden diese Flächen ebenfalls verpachtet. Die Herrschaft strebte im Einklang mit den Forstbeamten an, die Weiden, die sie alle in Pacht überließ, langsam in die Wälder umzuwandeln. Dem widersetzten sich aber die Untertanen besonders in bergigen Gegenden. Die Haupteinkommensquelle der Herrschaft waren die Zehente von den eigenen und auch fremden Untertanen, dann der Zehent- und Bergrechtswein von ihren Bergholden und noch einige weniger bedeutende Untertanengaben. Die finanziellen Einnahmen aus dem reinen Waldbau waren aber sehr gering bis fast belanglos.

Die Hauptursache für die Auseinandersetzungen zwischen der Herrschaft und ihren Untertanen war,

[9] Historische Waldungsbeschreibung 126 und 127 r + v, Forst et Holz Befunds Tabelle.

[10] Wie vorige Fußnote.

neben der leidlichen Weidenfrage, die Nutzung der herrschaftlichen Wälder. Bei der Verneinung der Rechte zur Brenn-, Bau- und Zeugholzgewinnung in den herrschaftlichen Wäldern beriefen sich die Forstbeamten ständig auf die eigenen und Zulehenswaldungen der Untertanen, woraus sie ihren Bedarf an Holz decken sollten. Das war natürlich nur eine Ausrede, denn die Begehrung des Holzes aus den erwähnten Waldungen war wohlerworbenes Gewohnheitsrecht. Zu welcher Zeit die Untertanen "eigene" Waldungen ins rechtliche Eigentum erwarben, müsste näher untersucht werden, es kann aber berechtigt angenommen werden, dass dies gleichzeitig mit der Umwandlung der früheren Mietgründe in kaufrechtliche Huben geschah, wahrscheinlich in der ersten Hälfte des 18. Jahrhunderts. Die Abschaffung der Mietgründe und ihre Umwandlung in kaufrechtliche Gründe war nähmlich ein bedeutendes Anliegen im Rahmen der Bauernbefreiung, die im absolutistischen Zeitalter vom Staat sehr befördert wurde und dem sich die Herrschaftseigentümer, also die Bischöfe von Ljubljana, nicht recht widersetzen konnten.

Die Herrschaft Gornji grad hatte ansehnliche Waldungen (Tabelle 1),[11] wohl die grössten in dem damaligen unteren Teil des Landes Steiermark, von denen aber entsprechender Ertrag nicht erwirtschaftet wurde. In früheren Zeiten konnte auf den geldlichen Ertrag der Wälder in allgemeinen kein grosser Bedacht gelegt werden, weil der geldliche Holzverkauf noch sehr gering war und die Waldbestände als Vorrat des Holzes für den Bedarf der Herrschaft und der meisten Untertanen, und als Standort des Wildes für damals sehr bedeutende Jagdzwecke angesehen wurden. Ob das auch auf die behandelte Herrschaft zutraf, ist nicht bekannt und müßte untersucht werden. Die Flosserei ist nämlich schon im Jahre 1606 bezeugt. Damals gab es offenbar schon starke Auseinandersetzungen zwischen der Herrschaft und den Untertanen, was daraus ersichtlich ist, daß die Herrschaft bei den Verhandlungen mit den Untertanen der Bischof Tomaž Hren höchstselbst vertrat. In der Urkunde die darüber verfasst wurde, und die in den nächsten zwei Jahrhunderten für die Belange der Herrschaft bedeutende Rolle spielen sollte, steht nähmlich auch der Satz: "....nicht allein ihren eigenen Notdurften sondern auch zur Verkaufung andern ferner dem abwärts nach dem Wasser zu schwemmen...".[12] Also im Jahre 1606 wurde, wie durch diese Urkunde bezeugt, die Flösserei schon betrieben, vielleicht auch schon Ende des 16 Jahrhunderts. Diese Angabe über die Flösserei wird hier erstmals veröffentlicht. Natürlich weiß man aber über den Umfang der damaligen Flößerei zur Zeit nichts. Im 18. Jahrhundert kam aber in dem nadelholzreichen Gebiet der Herrschaft Gornji grad die Flößerei in Schwung und deshalb wurde Nadelholz am Stock wertvolles Handelsgut. Andere industrielle Holznutzung war in diesem Gebiet zunächst ohne Belang.

Die damalige Herrschaftsverwaltung beharrte aber noch ziemlich lange an alter Doktrin, wonach der Waldbau nicht als eine eigene Wirtschaftssparte mit eigener Wirtschaftsrechnung angesehen, sondern als Aushilfe für andere Wirtschaftszweige sowohl der eigenen Herrschaft als ihrer Untertanen dienen sollte. Dazu war sie nicht wegen des Wohlwollens gegenüber den Untertanen geneigt, sondern weil sie die unausweichlichen Auseinandersetzungen mit ihnen wegen der Servitutsrechte an Wald und Weiden, die vielen nicht bereinigten Grenzkonflikte zwischen den Wald- und Weidegründen und ebenso unklaren, oder wenigstens nicht angenommenen Landesgrenzen zwischen Steiermark, Kärnten und Krain, scheute.

Wie bei anderen Herrschaften wurde auch in Gornji grad die Bewirtschaftung der herrschaftlichen und Untertansgründe bis in die neunziger Jahre des 18. Jahrhunderts einheitlich betrieben, es gab nur eine allgemeine Wirtschaft (Landwirtschaft) in die sowohl landwirtschaftliche Gründe, Weiden und Wälder einbezogen wurden. Weil von den Wäldern wegen mangelnder käuflichen Nachfrage nach Holz, kaum erwähnenswerte geldliche Einnahmen, ausgenommen die eher seltenen Jahre in denen Buchen und Eichen fruchteten und Schweinemast in den Wäldern möglich war, in die herrschaftliche Kasse einflossen, wurden die Wälder praktisch als eine sehr bedeutende Hilfspertinenz der allgemeinen Wirtschaft angesehen. Im 18. Jahrhundert begann sich aber die käufliche Nachfrage nach Holz in den Wäldern, wo Städte und Märkte, sowie entstehende Manufakturen nicht allzuweit enfernt lagen, oder günstige Transportmöglichkeiten für die Beförderung des Holzes oder seiner Produkte in entferntere Regionen bestanden, zu heben. Der Zweig des Waldbaus bzw. der Holznutzung innerhalb der Herrschaft begann sich zu verselbständigen, seiner Hilfsfunktionen für die Landwirtschaft wollte er loswerden, und so wie in Gornji grad innerhalb der Herrschaft, sogar ein Forstamt, also eine Art Behörde, zu gründen. Die Auseinandersetzungen mit den früheren Forstnutzern, deren echte oder vermeintliche Rechte hierbei beschnitten werden sollen, waren unausweichlich.

[11] Historische Waldungsbeschreibung 126 v bis 127 v und Forst et Holz Befunds Tabelle.

[12] Historische Waldungsbeschreibung: Zu wissen nachdem sich der Ehrenwert und.....Oberburg 6ten April 1606.

Tabelle 1 *Die Forstreviere der Herrschaft Gornji grad mit ihren Flächenmaßen, der Holzgattung, den Servitutsrechten und damaliger Benutzungsart*

Fortsreviere	Fläche		Holzgattung	Servitutsrechte und Lasten	Damalige Benutzungsart	Anmerkungen
	Joch	□ Klafter				
Krašica - Kokarca - Kurji vrh	565		Buche,. Nadelholz	siehe Fußnote [13]	siehe Fußnote [14]	siehe Fußnote [15]
Mala Peč	282		detto			
Pod Vologo ??	25	540	detto			
Nad Kokarjem, Šentjanžem, Krašami, in Pustim Poljem	381	1310	gut			
Buschplätze und Blößen	50					
Mostne	139	414	detto			
detto, 2. Teil	25	1196	Stockbuche			
Blöße	7	320				
Tovsti vrh	169	1123	vermischt			
Pretkovca I. Teil	150		detto	frei		
Pretkovca II. Teil	82	1321	Buchen	frei		
Štrukljeve peči	37	1559	detto	frei	Noch nicht gehörig eröffnet	
Blöße	34	910				
Stradovnik	238	430	vermischt	muß frei bleiben	Nadelholzverkauf	
Gemisch	38		detto			
Ivje I. Teil	200		detto	Dörfer Bočna, Delce und Otok haben Behölzungsanspruch auf 160 W. Kl.	Detto	
Ausgelichtet	28	240				
Pod Belo pečjo -Bočki graben	292	800	Buchen			
Erjavka	13	1300	detto	Bočna und noch ein Dorf beanspruchen die Entnahme der Streu ohne Grund und Recht	Stämme, geeignet zur Flosserei	
Vrh Smolnika	90		vermischt			
Nad Kropo	22		detto			

[13] Die Untertanen der Ortschaften Kraše, Pusto Polje, Kokarje, Lačja vas, Pobrežje, Varpolje, Šentjanž in Spodnja Rečica beanspruchen wegen der Reichung des koplevnik das Behölzungsrecht, das um 642 W. Kl. betragen dürfte. Darüber lagen aber keine Beweise vor.

[14] Aus diesen beträchtlichen Revieren werden derzeit etwa 100 Nadelholzplöcke und Stämme und seit 2 Jahren auch Klafterholz abgestockt, wozu 80 fl ausgegeben wurden. Dieses Unternehmen wurde eingestellt, da das Laubholz nicht abgesetzt werden konnte.

[15] Die angesprochenen Servitutsrechte müßen gründhaltig untersucht werden, wobei auf eine von dem Fürsten Thomas, Bischofen zu Laibach etc. etc. 6. April 1606 bestehende gutachtliche Urkunde, dann auf den Flächeninhalt der bestehenden Hub- und Communwaldungen das Augenmerk gerichtet werden muß, als vermög besagten sub C angehefteten Schriftstück (hier nicht wiedergegeben), die in Colonne XIII benannten Gemeinden eigentlich gar kein Recht, sondern nur die Begnadigung gegen Anmeldung, Ausweisung dann Bezahlung einer Gebühr, wessen Zuteil ihres eigenen Hub- und Communwaldstandes für sich haben, so werden durch den besagten Vorgang nicht allein der gesammte Anspruch geschmächtet, sondern auch die Begnadigung auf den Hub- und Communbesitz hinsehend behauptet werden dürfte. Nach einem dann ferner ...(unleserlich) von dem jährlichen Natural Ertrag per 3814 W. Kl. der vorbenannte Servitutsanspruch mit 642 W. Kl. abgezogen würde, so bleibt jedoch noch zur freien Disposition und Speculation bei Grašica und Kokarca 3172 W. Kl. Die weiteren Berechnungen müßen wegen Unleserlichkeit ausgelaßen werden.

Blöße	21					Zur Kultur geeignet
Petelinjek	300	600	Nadelholz	siehe Fußnote [16]	Verkauf von Stämmen und Sagplöcken	siehe Fußnote [17]
Detto	59		Detto			
Item et Pod Medvedjakom	46	70	Detto			
Ravniče	150		Detto			
Kuhinek	90		vermischt	frei	Reservatrevier	
Item	30		Detto	siehe Fußnote [18]	siehe Fußnote [19]	
Globače I. Teil	267	840	Detto			
Detto, II. Teil	134		Gestrüpp			
Detto, samt Mali vrh	212		Nadelholz	frei		
Item	60	640				
Poškovsko ??	150		vermischt			
Item	50		Detto			
Detto	33	800		Untertanen zu Nova štifta 50 Kl. Servitute	?buche wie im Stranski Revier derzeit ohne	siehe Fußnote [20]
Tovsti vrh	38		Nadelholz			
Detto	10					
Javorje pri Kokarju	15	280	Stockbuche	ohne	'buche wie im Stranski Revier derzeit ohne	
prope Jespa na Menini	48	600	Nadelholz		Zu herrschaftlichen Gebäuden und Deputaten	siehe Fußnote [21]
Prekerštajn	10	150	Eichlinge			
Detto	12	455	Fichten	ohne		
Detto	4	800	Birkengestr.	ohne		
Detto	5	1200	Eichlinge	ohne		
Tičjek		1000	Eichen	ohnr		
Detto	4	600	Eichlinge	ohne		
Kožlak	5	1120	vermischt	ohne		
Jakobcov vrh	28	190	Nadelholz	ohne	Bedarf der Grundpächter	siehe Fußnote [22]
Gradišče	47	1200	Nadelholz			
Hom, I. Teil	133	1280	Detto	Servitute der Untertanen zu Pusto polje	Stamm-, Bretter und Brückenholzverkauf	siehe Fußnote [23]
Hom, II. Teil	120		Detto			
Trbolca	18	260	Detto	frei	Detto	
Detto	35	690	Detto			siehe Fußnote [24]

[16] Aus diesen zwei Revieren haben die Bürger des Marktes Gornji grad bisher 180 (?Klafter) Beholzung gezogen. Wie zu Vrh Smolnika.

[17] Diese wichtigen in der Nähe der Herrschaft liegenden Reviere verdienen alle Aufmerksamkeit und müßten daher nicht allein von den überstandenen Stämmen gereinigt und soviel immer möglich regelmäßig abgeholzt, ihre Blößen durch künstliche Hilfe in Kulturstand gesetzt werden, auch nach aufwärts in die verpachteten Viehweiden um 300 Joch ....(unleserlich), an der krainersichen Grenze aber das strittige Terrain mit 726 ? W.. Kl.(die Zahlen sind nicht klar!) zu Excentrierung der Viehweide berichtigt werden.

[18] Außer einiger Stämme zu Zaun und Schindeln, welche (unleserlich) abgeholzt werden muß.

[19] Wird seit 3(?) Jahren durch Geding(Akkord)arbeiter zum industriellen Nutzen abgestockt und ein Ertrag erzielt (teilweise unleserlich) und wird solchergestalt fortgesetzt.

[20] Muß wie Kozica Revier bedacht werden, der dermalen der Kalkerzeugung dient, dann aber die gereinigte Fläche zum Bauholz verwendet werden.

[21] Bei diesen Eichenrevieren muß so mehr auf Kultur und Schonung das strengste und sorgfältigste Augenmerk gerichtet werden als außer diesen nahe der Herrschaft liegenden Erdfläche keine andere zur Eichenkultur geeignet besteht.

[22] Die sehr nachteilige Verbindlichkeit an die Pächter muß aufgelöst und auf Schonung gedacht werden.

[23] Dieses wichtige Revier muß von gebrandmarkten Setzlingen gereinigt dann aber ohne weiteren Verzug in in Schonung und Kultur gelegt werden.

V Bregih	12	205		nicht leserlich	Derzeit nichts	Muß in 6 Jahren in Kultur gesetzt werden
Polamank, Pfarre Luče	10	1200	vermischt	ohnr		
Detto	17	800	Fichten	ohne	Stamm-, Blockabgabe	siehe Fußnote [25]
Detto	75	1200	vermischt			
Brezovje	17	800	Nadelholz	ohne	Stamm-, Blockholzabgabe	
Detto	35			ohne		
Rogac (Rogatec)	35		Fichten	ohne	Stamm-, Blockholzabgabe	Die Blößen und Brandstätten sind zu kultivieren
Detto	90		vermischt	ohne	Detto	Detto
Detto Banatska	232	299	Nadelholz	ohnr		siehe Fußnote [26]
Sopote	5		Fichten	ohnr		
Detto	20	252	vermischt	ohne	Detto	siehe Fußnote [27]
Šentlenarški les	58	500	Detto	ohne	Bisher ohne Weiden	siehe Fußnote [28]
V Slemeh	5	150	Nadelholz	ohne	Detto	
Nad Osojnikom ??	6	176	Nadelholz	ohne	Detto	
Bukovec	350		vermischt			
Mala Planina, strittig	243		vermischt		Seit 2 jahren Brennholzverkauf	siehe Fußnote [29]
Detto	243	490				
Na Pripoteh	110		Nadelholz			
Detto	142	800	Anflug			
Na Ravneh nad Naveršnikom	422	800	Nadelholz	ohne	Detto	siehe Fußnote [30]
Detto, Brandstätte	170					
Kačjek	154	170	vermischt	Dorf Luče 120 Klafter, Bauholz Solčava	Sehr wenig Verkauf in der Zeit	
Mala Ojstrica, Solčava	180	400	Detto		ohne	siehe Fußnote [31]
Graohat in pod Čreso	125		Detto			
Pod Rožnim vrhom	112		Nadelholz	ohne	Derzeit nichts verkauft	Müßen durchschn. jährlich 50 Stämme verkauft werden
Raduha in Suhadol	178	900	Detto	ohne	Detto	siehe Fußnote [32]
Suhadole, Sedelce ??	463	68	Detto	ohne	Detto	Wird 1802 der mögliche Verkehr angefangen
Repenševskova planina ??	8	350	Detto	ohne	Wieder ohne Nutzen	

[24] Die Blößen müßen sogleich in Schonung und Kultur gelegt werden.
[25] Muß binnen 3 Jahren nach Auslauf der Pachtzeit eine Fläche von 31 Joch 550 □ Klafter von Weide in Waldstand erklärt und sowohl auf Schonung als Kultur gedrungen werden, somehr als durch Halterfeuer eine beträchtliche Strecke geschwendet worden ist.
[26] Ist rückgelöset und unter Bedingnissen streckenweise Schonung und Kultur in Pachtung.
[27] Die neue Brandstätte zur Kultur.
[28] Muß mittelst Ausführungswege in Nutzungsstand gebracht werden.
[29] Die bisher durch den Grenzstreit gehemmte Benutzung kann durch Errichtung einer Nagelschmiede ungemein erweitert werden, wozu ein ohnehin erforderlicher Weg von Ljubno bis Luče und Sv. Anton bereits angefangen ist, wo sodann alles bisher unanbringliche Buchenholz auch aus dem Revier Jakobcov vrh versilbert werden kann.
[30] Die durch zügellose Hirtenfeuer nebst anderer Blößen müßen in Schonung und Kultur gelegt und die Schwendereien der Hirten empfindsam geahndet werden.
[31] Muß unter anderen der Servitutsanspruch berichtigt und bestimmt werden.
[32] Muß mittels eines Ausfuhrweges bis zur Savinja Benutzung gesichert werden.

Dimnikova Dolina ??	79	130	Detto	ohne		siehe Fußnote [33]
Kolarica, Hlipovc				ohne		
Schwendplatz	24			ohne	siehe Fußnote [34]	siehe Fußnote [35]
Pod Komnom	40			ohne	Holzverkauf und Versuch nittelst Geding	
Kolarica	136		vermischt	ohne		
Detto	24		Nadelholz	ohne		
Detto	361	80	Detto	ohne		
Smrekovec. Koriti pod Ostrim vrhom	48		Detto	frei	Vom Stammverkauf bisher nichts	
Bukovec, Pfarre Luče	134	1318	vermischt	frei		
Šibje, Bela, Pfarre Luče	1190	600	Nadelholz	frei	Detto	
Zusammen	10735	1434		siehe Fußnote [36]	siehe Fußnote [37]	siehe Fußnote [38]

Abkürzungen: m. = meistens, t. = teilweise, W. Kl. = Wiener Klafter

[33] Muß auf Verdrängung der Weide und Benutzung des Holzes fürgedacht werden.

[34] Unbedeutender Stammholzverkauf und Versuch der Nutzung mittels der Geding(akkord)arbeiter.

[35] Der durch 30 alle Jahre mögliche Ertrag blos von Schnittblöcken pr. 27.037 fl 43 xr á 901 fl 14 xr ist möglich zu erreichen, als das auf nicht auf ein Mittel zur Ausbringlichkeit und Verkehr fürgedacht werden sollte. In dieser Absicht werden also ab 1.000 Current Klafter 200 Stosskisten á 2 fl 30 xr mit 500 fl, ab 1000 Klafter aber Bachräumung mit Schleusen mit 700 fl erforderlich, wo sodann nicht allein obige Summe, sondern jährlich auch noch zu einer Nagelfabrik das Buchenholz um jährlich 100-200 fl in Verkehr gesetzt werden kann.

[36] Die Berichtigung der Servitute muß um so eifriger mit den Grenzen betrieben werden, als ohne diesen Vorgang nicht allein die Forsteinrichtung erschwert und die Benutzung der ausgebrannten Flächen in Revieren, dann nicht minder die Kultur und Schonung ins unendliche (unleserlich) auf das Eigentum gestärkt werden müßte, sondern auch der vorsätzlichen nicht gehörig Genüge geleistet werden könnte.

[37] Verschiedene ökonomische und Sicherheitsregeln haben es bereits so weit gebracht, daß im Jahre 1802 40 bis 50 Holzknechte auf Geding(Akkord) arbeiten, wodurch so wie im Jahr 1801 800-900 fl nun 1800 fl lediglich industrieller Nutzen ohne die Forst Taxe erworben werden wird.

[38] Muß auch noch der Brennholzverkauf eingeleitet werden. Ist von Weid- in den Waldstand erhoben, dann Ausfuhrsweg herzustellen und bewilligt werden. Vorderhand summarisch und durchschnittsmäßige Ertrag von Bau- und Schnittblöcken ist zwar ohne Zweifel, jedoch aber nur als dann erreichbar, wann die Forstwirtschaft so wie bereits seit zwei Jahren angefangen, dergestalt betrieben wird, daß nicht allein alle nach mehreren Jahren auf den höchsten Stand gesteigert und Hindernisse beseitigt, sondern auch die erforderlichen Hilfsmittel nicht mehr entzogen, vielmehr aber der Unterstützung nach Maßgabe der Umstände beschlossen und erlaßen werden, welche Begünstigung um so mehr erwartet werden sollte, als sich keine Spekulation kehren läßt, welche nicht im Stande ist zu ihrer Begründung einen *Fundus instructi* erforderlich haben möchte, wogegen sich die hierortige Forstwirtschaft bisher teils durch Opfer des Forstrevieralters, teils durch langsame Zuflüße, teils aber durch fremde Ansätze von 260 fl (unleserlich) nun auf 3000 bis 4000 fl reiner Ertrag durchkämpfen mußte.

Durch das Territorium der Herrschaft Gornji grad fliessen zwei Flüsse Dreta und Savinja, die sich zur Flößerei eignen. Die Einwohner dieser Gegend sahen in der Flößerei eine Möglichkeit, das Holz, das damals noch reichhaltig vorhanden war, in entferntere Gebiete zu befördern, zu verkaufen und sich damit ihre Lebenslage aufzubessern. Die Waldungen der Herrschaft Gornji grad wurden schon sehr früh, wie erwähnt, schon im 17. Jahrhundert, aber wahrscheinlich in geringen Umfang in die Geldwirtschaft einbezogen. In der Mitte des 18. Jahrhunderts hatte die Flößerei an der Savinja, mit welcher Nadelholz aus den erwähnten Waldungen nach Kroatien und noch weiter nach Osten befördert wurde, einen größeren Umfang. Die Flöße mussten in Radeče, am krainischen Ufer der Save, anlegen, um dort die Flußbenutzungsgebühr zu bezahlen. In den entsprechenden Warentarif-verzeichnissen aus den Jahren 1749 (wiederholt in 1755) und 1782 sind die Floße aus Savinjska dolina (Sanntal) angeführt. Das ist ein sicheres Zeugnis dafür, dass erwähnte Flößerei einen entsprechenden Umfang erreichte und so in diesen Tarifverzeichnissen aufgeführt wurde.[39] Angelos Baš schreibt auch, daß die Flößerei seit der Mitte des 18. Jahrhunderts die Haupterwerbsquelle der Einwohner unter Ljubno und Gornji grad, war.

In dieser Situation kam die Idee einer besseren Ausnutzung der Wälder unter dem Motto der rationellen Forstwirtschaft auf. Diese konnten natürlich nur fremdländische Forstbeamte einführen. Wegen der ansehnlichen Waldungen der Herrschaft Gornji grad, wurde auf Veranlassung der Innerösterreichischen Staatsgüteradministration bzw. des Grazer Guberniums hier 1793 der erste, an höherer Forstschule ausgebildete fremdländische Forstmeister, Alois Schweska, angestellt. Dieser erkannte sofort nach seiner Anstellung in Gornji grad, daß die Waldverhältnisse hier nicht im geringsten der Doktrin der deutschen Forstschule entsprachen, nach Nutzung der Wälder, die vollkommen getrennt von den Bedürfnissen der hiesigen Untertanen wären, mit möglichster Verdrängung der erworbenen Wald- und Weideservitutsrechte, der anderen erworbenen Gewohnheitsrechte, bis zu verschiedenen Waldbaumassnahmen z. B. der Anweisung und Ausweisung der bewilligten Holzkontingente, die sich bisher die Untertanen selbst auswählen konnten, der Abschaffung des bis dahin üblichen Plenterschlags und der Einführung der Kahlschläge u. v. a. Es ging einfach darum, die Bauern mit ihren Rechten aus den Wäldern und Weiden zu verdrängen.[40] Das wurde in dieser Zeit vor allem in deutschen Ländern versucht, in slowenischen Gebieten wurde das, m. W. zuerst auf der Herrschaft Gornji grad versucht. In früheren Zeiten führte der Herrschaftsverwalter, einheitlich alle Wirtschafts-zweige, darunter auch den Waldbau mit Hilfe einiger heimischer bäuerlicher, waldbaulich nicht geschulten Holzknechte durch, die später von den Forstbeamten als betrügerisch verschmäht wurden. Sie setzten auch ihre Entlassung durch. Die Wirtschaftsführung der herrschaftlichen Wälder ging seit der Anstellung der Forstbeamten auf zwei Gleisen, einerseits durch den Herrschaftsverwalter, andererseits durch die Forstbeamten. Ein wirklicher Nachteil bei diesen Waldungen war auch die fehlende geometrische Ausmessung, die der erwähnte Forstmeister in den nächsten drei Jahren nach seiner Anstellung wenigstens teilweise durchführte.

Nach der Versetzung des Forstmeisters Schweska, kam nach Gornji grad Forstmeister Johann Löffler, dem es mit Hilfe der Landestelle (Gubernium) gelang, ein von dem herrschaftlichen Verwaltungs- bzw. Wirtschaftsamt weitgehend unabhängiges Forstamt mit ausgebildetem Forstpersonal zu errichten.

Im folgenden soll der schlechte Zustand der herrschaftlichen Waldungen von Gornji grad anhand der Schilderungen der dortigen Forstbeamten in der Güter- bzw. Waldbeschreibung erörtert werden. Weil es den Forstbeamten daran gelegen sein mußte, die Verhältnisse möglichst düster zu beschreiben, um ihre vermeintlichen oder wahren Erfolge im helleren Licht erscheinen zu lassen, ist es wahrscheinlich, daß die Waldzustände in dieser Herrschaft nicht so schlecht waren, wie sie in der Niederschrift der Waldbeschreibung erscheinen. Weil sich aber die Förster als treue Staatsbeamte fühlten, obwohl sie das nicht waren, muss man aus ihrer josephinischen Beamtendoktrin heraus annehmen, dass sie die Waldzustände doch einigermassen getreu wiedergegeben haben.

Der Holzbestand in den Waldstrecken war nicht gleichen Alters, sondern durch vorzeitige, nach der Doktrin der Deutschen Forstschule forstwidrige Abholzungen und willkührliche zügellose Aushebungen altersmässig sehr vermischt. In einem Schlag befanden sich Bäume von 10, 30, 50, 70, 90, 120, 140 und sogar 160 Jahren. Mit Sprungschlägen und Aushebung wurden die überständigen Stämme ausgehauen, mehr als ökonomisch rätlich war. Daran war, wie schon oben,

[39] Baš, Angelos: Savinjski splavarji. Ljubljana, 1974, 32, 37.

[40] Radkau, Joachim: Natur und Macht. Eine Weltgeschichte der Umwelt. München: C. H. Beck, 2000, 236-283, besonders 243.

und noch öfter erwähnt wird, das herrschafliche Verwaltungsamt schuld. Besonders in entfernteren Gegenden konnte das allzugeringe, als auch das allzudicke (von 36 bis 42 Zoll) Stammholz wegen beträchtlicher Ausbringungskosten auf Erdriesen entweder gar nicht, oder um abwürdigende Preise in Verkehr gebracht werden.

Äusserst verworren, mit Gegensätzlichkeiten und Emotionen behaftet waren in der Herrschaft Gornji grad die Behölzungsrechte der Untertanen in den herrschaftlichen Waldungen, die man üblicherweise Holzservitutsrechte nennt, diesen Ausdruck aber der Forstmeister Löffler, der die Historische Beschreibung verfasste, fast peinlich vermied. Diese Rechte waren auch deshalb sehr schwer zu eruieren, weil die Untertanen bei der Umwandlung der Miet- in kaufrechtliche Huben eigene und Zulehenswaldungen erwarben, sowie Holzgenuß in den gemeinschaftlichen Waldungen bestätigt bekamen. Die Herrschaft, besonders aber ihr Forstamt berief sich ständig auf diese Waldungen, wenn die Untertanen ihre Ansprüche auf Behölzigungsrecht in den herrschaftlichen Waldungen stellten, obwohl sie dazu keine rechtlichen Grundlagen hatte. Zusätzlich sollte es bei dieser ersten Waldzuteilung den Untertanen so vorgegangen sein, dass diese niedere Waldungen erhielten, die Herrschaft aber die Hochwaldungen behielt. Aus diesen sollten die Untertanen vollkommen verdrängt werden, was im Zusammenhang mit den dort bestehenden Weiderechten auf den heftigsten Widerstand der Untertanen stiess.

In der Tabelle 1 sind in Revieren[41] diese Dörfer ausgewiesen, die das Behölzungsrecht und die Art desselben, wie bisher genossen, ersichtlich. Dieser Holzgenuss ist aber in den herrschaftlichen Waldungen, nach Ansicht der herrschaftlichen Förster, besonders für die Untertanen der Dörfer Bočna, Nova vas, Volog, Delce und Šmartno etc. keineswegs rechtlich gegründet oder realisiert, sondern sind diese vielmehr ausdrücklich auf ihre Hub-, Zulehens- und Gemeindebehölzungen angewiesen und nur in Rücksicht der zerfallenen Hub-, und Gemeindewaldstandes, nach der Überzeugung von der Dürftigkeit, bei allfälliger Anmerkung und gegen Bezahlung einer rechtmässigen Gebühr in Anbetracht des Bedarfs nach Zeit und Umständen begnehmigt, niemals aber in unauflösbares Recht versetzt worden. Diesfällige Selbstüberzeugung, dass nähmlich jene Untertanen welche selbst hinreichend Hub-, Zulehens- oder Genussrecht an der Gemeindewaldung besitzen, mit diesen Scheinansprüchen nicht wohl zu einem realisierten Behölzungsrecht gelangen möchten, führte solche auf den Gedanken, die Abreichung des sogenannten aus Buchweizen, Hirsen, Händeln und Haarzehling bestehenden koplevnik als eine Giebigkeit für das Brennholzrecht anzugeben. Die Gabe von koplevnik wird im Kapitel über die Auseinandersetzung der Herrschaft mit den Untertanen näher besprochen.[42]
In den herrschaftlichen Waldungen war auch der Holzdiebstahl sehr verbreitet Es handelte sich hierbei meistens um den Unfug, dass die Käufer neben den gekauften auch eine stattliche Anzahl von Stämmen entfremdeten. Es gab aber auch Fälle wo Bäume ohne irgendeinen, auch vermeintlichen Rechtsanspruch abgestockt wurden.

Im folgenden sollen die natürlichen und von den Menschen verursachten Zustände der zur Herrschaft Gornji grad eigentümlich gehörigen Waldungen beschrieben werden, die Untertanenwaldungen sind also hier nicht inbegriffen. In der Herrschaft gab es nämlich zwei Arten von Waldungen, herrschaftliche und Untertanenwaldungen. Die letzteren wurden den Untertanen anlässlich der Verkaufrechtung ihrer Miethuben mit den Mietgründen zugeteilt. Sie bekamen ihre Anteile am Niederwald in den niederen Lagen, die Herrschaft behielt sich den Hochwald in den höheren Lagen. Weil auch die Weidegründe meistens im Gebirge mit angrenzenden Hochwäldern lagen, gab diese Konstellation Anlass für ständige Streitereien mit den Untertanen wegen der Erweiterung der Weideflächen zum Schaden der Wälder einerseits und zu Schäden in den Wäldern wegen des eingetriebenen Untertanenviehs.

Die Waldungen lagen alle in abwechselnd weniger oder mehr steilen Gebirgen und waren den schlechten Wirkungen von Wildbächen einigermassen ausgesetzt. Nur lediglich eine, meistens zur Wiesmahd benutzte und zur Eichen- oder Erlenkultur geeignete 7 Joch messende Blösse bei Revier Kamen, an der Grenze, war der Überschwemmung ausgesetzt, welche so wie bereits im Jahr 1797 an einem Ort geschehen, mit Durchschnittskanälen vermieden werden könnte.[43]

In diesen Waldungen konnten seit neun Jahren sicher in 400 bis 500 Joch Brände, nicht natürlichen Ursprungs, angenommen werden. Diese wurden teils durch nachbarliches Gereut- oder Erdbrennen, oder durch Feuer, welche zur Erweiterung der verpachteten Viehweiden vorsätzlich von den Viehhaltern angelegt wurden, verursacht. Die diesfalls bezichtigten Exzedenten wurden zwar gehörigen Orts angezeigt, aber bis 1802 oder noch gar nicht verhandelt, oder nicht fleissig genug bestraft. Zur Erweiterung der

[41] Herrn Mag. Vid Preložnik, Univ. Dipl. Forstingenieur von der Forstanstalt Sloweniens, Zweigstelle in Nazarje, bedanke ich mich herzlich für die Durchsicht der in der Tabelle angeführten slowenischen Namen.

[42] Historische Waldungsbeschreibung, 132 v bis 135 r.

[43] Historische Waldungsbeschreibung, 130 v.

Weidestrecken wurden nicht allein die jung und alten Stämme von den Weidepächtern zur Abdörrung geringelt und geschwendet, sondern ganze Strecken durch Feuer abgeblösst, und hierdurch sogar beträchtliche Hauptwaldungen in Gefahr gesetzt. So wäre es notwendig, dass künftig die an die Waldungen angrenzende Alpen und Viehweiden überhaupt nicht in Pacht, sondern nur um einen Zins von der Anzahl des aufzutreibenden Viehs, welche von dem Forstamtpersonal alljährlich festzusetzen und zu revidieren wäre, vergeben würden. Die Übertretungen müssten strengstens bestraft werden. Die Strafen sollten aber in Stamm- und Kulturstax (Bezahlung nach den forstamtlichen Holzverkaufsbedingnissen), dann Leibesbusse und Verbot des weiteren Weidgenusses bestimmt werden.[44]

Die Hirtenfeuer wurden von Seite des Forstpersonals zu keiner Zeit in freien Gelände, sondern nur in Hütten und vom Wald genug entfernten, mit Steinen und Erdkamm umfangenen Plätzen, gestattet. Danach hielten sich aber die Viehhalter nicht. An mehreren Orten wurden derlei Hirtenfeuerstätten wahrgenommen, wovon aber die Viehhalter beim Herannahen eines Forstbeamten flohen.[45]

Wenn dem Forstamtspersonal ein Waldbrand bekannt, oder gelegentlich der Forstbesuche ansichtig wurde, so wurden sofort, sei es Tag oder Nacht, die erforderlichen Arbeitskräfte aufgenommen, die Nachbarn zur Hilfe gerufen, dann mit Hauen und Krampen an der Grenze des Brandes die Erde aufgeworfen, Steine vorgelegt und die hohen Grenzbäume gegen den Feuerplatz gefällt. In der waldbrandfreien Grenze wurde die Erde aufgeworfen und alles dürre Holz entfernt, die Glut durch Aufwerfung der Erde, wo aber möglich auch mit Wasser gedämmt, wobei noch ferner in Gegenden, allwo Wasser vorhanden ist, mit Feuerspritzen vorgegangen wurde. Wobei musste es jedoch traurig berühren, dass die Nachbarn bei einem solchen Brande nicht einmal natürliche mitleidige Teilnehmer, noch weniger aber vorschrifts- und pflichtmässige Gehilfen waren. Hierin zeichneten sich besonders jene aus, welche sich in der Gegend befanden, wo der Brand an Viehweiden grenzte. Diese ersahen in einem solchen Unglücksfall des Brandes für sich ein Glücksfall bzw. Möglichkeit zur Weideerweiterung. Gegen solche Moral und Sittenlosigkeit wetterten stark die Forstleute und forderten die strengsten Massregeln; besonders von den Gemeinderichtern sollten an ihnen unterstehende Gemeindeinsassen Aufträge erlassen werden, worin diese zur Rettung und Hilfe aufgefordert würden. Die Saumseligen sollten zu Bestrafung, die Gutgesinnten und Tätigen aber zur Belohnung angezeigt werden.[46]

Die abgebrannten Plätze mussten bisher dem Schicksal der Entblössung oder allenfalls dem irregulären natürlichen Samenanflug überlassen werden. Die Gründe dafür waren, wie schon erwähnt, der zügellose Viehauftrieb, wiederholter Brand und ständig unterbliebene Bestrafung dieser Exzeβe. Deshalb waren alle Mühe und Kosten vergebens und verloren. Weiter hat man Erfahrung, dass in dieser Gegend Waldbaumsamen trotz der Bemühung des Forstpersonals nicht aufzubringen waren. Die Bewilligung einer beträchtlichen Summe, im Durchschnitt aller Jahre um 200 bis 280 fl, für die Anschaffung des Samens wäre bei vorgewesenen Kriegszeiten so weniger zu erreichen gewesen, als man z. B. zu nützlichen Holzverkaufsgeschäften von dem Verwaltungsamte keinen Vorschuss von 400 bis 800 fl bewilligt bekommen konnte. Aus diesen Gründen konnte man also leider bisher die enormen Blössen nur mit Wehmuth und Mitleid betrachten, und auf andere Zeitumstände und höhere Unterstützung hoffen.[47]

Das Tabakrauchen in den Wäldern wurde nach den Forstordnungen streng geahndet. Bisher wurde in dieser Herrschaft, mit Rücksicht auf das Ärarialinteresse, das Rauchen nur mit offenen Pfeifen gänzlich verboten, das Rauchen der, mit einem Deckel versehenen, Pfeifen aber zugelassen. Das Ausklopfen der brennenden Pfeifen oder der warmen Asche war aber gänzlich verboten.[48]

In den Wäldern wurden verschiedene Beschädigungen der Bäume vorgenommen. Die meiste Schändung und Schwendung der Bäume tätigten die Alpenpächter und deren Viehhirten, um hierdurch die Weidestrecken über die ausgewiesenen Grenzen zu erweitern. Nach erwirkter Abdorrung wurde das Feuer angelegt, der allen Pflanzenwuchs verzehrte, bisweilen gar zum Einbruch des Brandes in die Hochwaldungen und Schonungsstrecken führte. Das heimliche Beklopfen der Bäume ist hier kaum verbreitet, da die Übertreter ihren Zweck durch Umringeln leichter erreichen und dazu frech genug sind. Das Anschneiden zur Harzgewinnung wird teils von Halterburschen, teils von Vagabunden, desto mehr von denen aus Krain durchgeführt. Die in den Wald Veža gewalttätig aus Krain vordringenden Untertanen verarbeiten die Stämme zu Schindeln. In Ermangelung höherer Maßregeln und wegen der nicht durchgeführten Landesgrenzenberichtigung werden diese Holzexzeβe für den Wald sehr nachteilig betrieben. Über diesfalls geschehene Anzeigen ist noch

[44] Historische Waldungsbeschreibung, 131 r.

[45] Historische Waldungsbeschreibung, 131 v.

[46] Historische Waldungsbeschreibung, 132 r.

[47] Historische Waldungsbeschreibung, 132 r bis 132 v.

[48] Historische Waldungsbeschreibung, 131 r bis 131 v.

keine Ahndung und Bestrafung in Ausführung gebracht worden.

Der mit Krašica in Zusammenhang stehende Revier Kokarca gab einen traurigen Anblick, welche Folgen die Vermehrung der Keuschler ("bettelhafte Urbars Nummern") bzw. Schwarzhafnern nach sich ziehe. Diese hatten für ihr Vieh zuwenig Wiesmahd oder Äcker zum Anbau von Futterpflanzen. Diese Keuschler fielen bei verlängertem Winter und trockenen Sommer gleich Raupen oder Juni-(Brach)käfer über die Laubholzäste und Gipfel her, um ihrer Futternot zu begegnen. Sie hauten, natürlich ohne Erlaubnis, junge Buchen im besten Wachstum ab und zogen sie nach Hause. Endlich aber brannten sie auch den Wald ab, um Gereut zu gewinnen. Dieser Vorgang wurde zur Zeit der Verfassung der Güterbeschreibung wegen strengerer Aufsicht nicht mehr so massiv wie früher betrieben.[49]

Um die Verschwendung der Holzmasse zu verhindern, wurde empfohlen zu hohe Stuppen und Schaftgipfel nicht zu belassen; letztere besonders auch um die Borkenkäfer und andere schädlichen Forstinsekten nicht zu fördern. In den Bedingnissen war vorgeschrieben, dass an bequemen Orten kein Stock über 6, an anderen 8 und an dritten und beschwerlichen nur 12, höchstens 14 Zoll aus der Erde ragen dürfen; das wurde bei allen Abstockungen so ziemlich befolgt. Die Aushebung der Stuppen, Stümpfen und Waldstöcken war bisher in dieser Gegend nicht üblich und konnte bisher nicht eingeführt werden, da die Stamm- und Klafterholzpreise noch immer so mäßig sind, daß die Aushebung der Stuppen sich nicht lohnen würde. Zusätzlich kam noch, daß die meisten Reviere in solch beschwerlichen Lagen liegen, daß es sich sogar nicht lohnte 4 bis 5 Zoll dicke Äste in Benutzung zu bringen. Es wurde auch erfolglos versucht in der Ebene bestehende Kiefer- und Lerchenstuppen zu Öl und Theerbrennen zu verarbeiten.[50]

Das Grasschneiden, das in einigen anderen Herrschaftswaldungen verbreitet war, wäre nur in drei kleinen Eichenschonungsrevieren tunlich; in diesen aber vermög ihrer Lage auf natürliche Bedingungen gesehen werden mußte, und weil außerdem aus Zulassung dieser Nutzung mehr andere Nachteile zu erwarten wären, so wurde bisher hiervon keine Anwendung gemacht.[51]

Der Abnahme der Streu aus den Wäldern wurde eigentlich wenig Aufmerksamkeit gewidmet. Das im Herbst abfallende Laub von Eichenbäumen wurde bisher meistens in drei Eichenschonungen, Prekerštajn, Tičjek in Kožlak von den armen Inwohnern des Marktes Gornji grad altherkömlich heimlich geharkt und in Rückenkörben (Köschen) nach Hause getragen und zur Streu verwendet. In denen im Gebirg bestehenden Buchenrevieren wurde das abfallende Laub wegen beschwerlicher Ausbringlichkeit, nicht zur Streu verwendet, folglich das Laub dem Wald als Dünger belassen. Es wird die Möglichkeit erwähnt, dass Buchenlaub zu Gerberlohe verwendet werden könnte. Davon wurde kein Gebrauch gemacht, sondern dazu die ungleich mehr Mühe erforderliche Fichtenrinde vorgezogen. Das im heutigen slowenischen Gebiet irgendwo Buchenlaub zur Gerberlohe verwendet würde, ist nicht bekannt. Da in hiesiger Gegend wenig junge Eichenwaldungen, woraus eine Rinde zu Gerberlohe gezogen werden könnte, bestehen, so ist diesfällige Benutzungsart eine seltene Sache, wird aber gleichwohl im Kreis Maribor (Marburg) nebst Sammlung von Knoppern mehr betrieben.[52]

Schleichwege, welche teils von den krainischen Landhändlern, teils von anderen Schwärzern und Kontrabantisten begangen wurden, bestanden in der Pfarre Luče in dem Alpenrevier Veža im Ausmaß von 486 Joch, die mit dem Lande Krain strittig sind, dann zweitens unter dem Revier Thön Bukovec ??, allwo sich der Weg über die Waldungen der Religions-fondsherrschaft Vrbovec hinter Markt Rečica und Mozirje gegen Šoštanj zieht. Diesen Weg wird das Forstamtspersonal so lange nicht sperren können, bis die Grenze mit dem Land Krain berichtigt und der gefährliche Kontrabandzug nicht durch höhere Macht gesteuert wird.[53]

Vagabunden, welche meistens aus Deserteurs und ausgewichenen Rekruten bestehen, welche Harz und Pech sammeln, dann Potasche brennen, und unter Begünstigung der Händler Holz entfremden, wurden meistenteils zur Zeit einer militärischen Stellung in Wäldern verzeichnet, die aber das Forstamtspersonal nicht verfolgen kann, da sie meistens mit Schlag-, Stech- und Schießgewehren ausgerüstet sind; die Forstbeamten aber so lange die herrschaftlichen Jagden verpachtet sind, mit keinem Schutzgewehr versehen waren. Einzeln stehende, möglicherweise verdächtige Häuser befanden sich, wie schon erwähnt, lediglich in Revier Hom. In diesen wären aus damaligen Verhältnissen die Visitationen um so mehr fruchtlos sein, als jede Aufmerksamkeit auf Vagabunden oder gar Anzeige sowohl der Beamten als Untertanen mit

[49] Historische Waldungsbeschreibung, 139 r.

[50] Historische Waldungsbeschreibung, 138 v bis 139 r.

[51] Historische Waldungsbeschreibung, 139 v.

[52] Historische Waldungsbeschreibung 139 v, 140 r.

[53] Historische Waldungsbeschreibung, 141 r.

Mord und Brand bedroht wird, und wirklich auch solche traurige Fälle vorgekommen sind.[54]

Auch bei der Schweinemast in den herrschaftlichen Wäldern ging es nicht ohne Auseinandersetzungen mit den Untertanen. Auch bei der Jagd, die verpachtet war, zeigten sich viele Mängel, auf die die Forstbeamten aufmerksam machten und sie in Eigenregie überführen wollten. Die Herrschaft Gornji grad hatte in ihren Gebiet die gesamte Jagd, zusammen mit den Herrschaften Rudenek und Vrbovec nur die niedere Jagd (jedoch auch mit Netzen) in der Gegend um Mozirje, Paka und Braslovče. Interessant sind die Arten der damals verbreiteten Jagdtiere und ihr Lebensraum. Die Steinadler und Gemsen siedelten im Gebiet von Luče und Solčava (jährlich wurden durchschnittlich 12-18 Gemsen abgeschossen. Bären und Wölfe (von beiden jährlich abgeschossen 4-6) siedelten im Gebiet von Solčava, Luče, Ljubno, Nova Štifta und Gornji grad und drangen von dort bis nach Rečica und Šmartno. Die Hirsche (abgeschossene 5-6) und Luchse lebten in den Alpen nördlich über Solčava, Luče, Ljubno und Rečica sowie auf der Alpe Menina. Sporadisch drangen Bären, Luchse, Wölfe und Hirsche auch in die niederen Lagen um Sv. Frančišek und Radmirje. Bei den Rehen decken sich die Angaben nicht. Nach einer Angabe sollten die Rehen selten sein (...Rehen welche derzeit in diesherrschaftlichen Forstrevieren keinen steten Aufenthalt haben...), nach einer anderen Angabe aber wurden doch einige Rehe erlegt.
Vom anderen Wild wurden bis 30 Füchse, 40 bis 60 Hasen, 4 bis 6 Auerhähne, dann 12 bis 20 Schnepfen, Reb- und Haselhühner, 20 bis 30 wilde Enten, und so proportional von anderen Wild mehr oder weniger erlegt. Im Zusammenhang mit der Jagd mußte die Herrschaft von Gornji grad 100 geräucherte Forellen anderen Herrschaften (Novo Celje 30, Podčetrtek 20, Bizeljsko 20, Žusem 10, Kozje 10 und Planina 10 Stück) reichen. Diese Gaben wurden von den Boten, die dafür täglich 20 Kreuzer bekamen, abgeliefert. Das war sogenannte Sperbersteuer, ein Überbleibsel der mittelaterlichen Jagd mit den Sperbern. Die Herrschaften mit den Hochalpengründen, wo die Sperber lebten, mußten die Herrschaften in den niederen Lagen, wo es keine Vögel dieser Art gab, versorgen. Wegen Veränderung der Jagdtechnik wurde diese Art von Jagd aufgegeben und anstatt von einem Sperber mußten 10 geräucherte Forellen an die genannten Herrschaften abgeliefert werden.[55]

Die Fischerei, die im Jahre 1793 für 12 Jahre verpachtet wurde, zeigte ungefähr dasselbe Bild, daß bis in die neuere Zeit galt. In den Flüßen Savinja und Dreta mit ihren Nebenflüßen (wo die Herrschaft Gornji grad Fischereirechte genoß) lebten Forellen, Weißfische, in der Savinja unter Ljubno auch Huchen. Ausnahme war bei der Jagd von Fischottern, die sie einst mit dem Kloster von Gornji grad teilte, nach der Säkularisation aber mit der Herrschaft von Žiče. Außerdem teilte die Herrschaft Gornji grad innerhalb der Grenzen seines und des Marktes Ljubno die Fischereirechte je zur Hälfte. Gegen Ende des 18. Jahrhunderts als die Herrschaft die Fischerei in Pacht übergab, begann sich das Fischreichtum wegen der Überfischung durch die Pächter zu mindern. Auch die Herrschaftsteiche sind in Verfall geraten. Die meisten Teiche wurden in damaliger Zeit als Wiesen verpachtet. Nur in den Teichen von Cimpernik und Fedran in Bočna züchtete die Herrschaft noch Karpfen.

[54] Historische Waldungsbeschreibung, 141 r bis 141 v.
[55] Baš, 1938, 4-5.

DIE AUSEINANDERSETZUNGEN DER HERRSCHAFT (DES FORSTAMTS) MIT DEN UNTERTANEN UND VERSUCHE ZUR EINFÜHRUNG DER FORSTORDNUNG UND RATIONELLER FORSTMASSNAHMEN

Forstmaβnahmen

Mit dem neuen Forstmeister, der 1796 angestellt wurde, verschärften sich die Auseinandersetzungen mit den Untertanen bezüglich der Wald- und Weidenutzung, da diese bei ihren bisherigen relativen Freiheiten in Wald und Weide verbleiben und davon sehr wenig oder überhaupt nicht abrücken wollten. Die Forstbeamten klagten, dass das Verwaltungsamt, das dem ersten Forstmeister noch vorgesetzt, und dieser also weisungsgebunden war, aus Mangel an festen Forstgrundsätzen an der Plenterschlagweise (die stark mit der einzuführenden An- und Ausweisung der Holzkontingente an die Untertanen, gegen ihre bisherige freie Auswahl der Stämme verbunden war) festhielt und keiner schlagweisen Abholzung beipflichtete, sondern so mehr nur nach vorurteilsvollen Sitte der sich anfangs gegen alle Neuerungen stützenden Gegendbewohner für Auslichtung gestimmt war. So kam es in relativ grossen Umfang zu Übertretungen der neuen Vorschriften, welche die Forstbeamten einfach als Forstexzeβe bewerteten und davon dem herrschaftlichen Verwaltungsamt, als Verwaltungs- und Justizbehörde laufend Anzeigen erstatteten. Das Verwaltungsamt, dass sich in offene, möglicherweise turbulente Auseinandersetzungen mit den eigenen Untertanen nicht verwickeln konnte und wollte, behandelte die Anzeigen sehr schleppend oder gar nicht. Das Verwaltungsamt als politische Behörde spürte sehr wohl, dass sich die feudale Gesellschaftsordnung seinem Ende nähert, und dass die Landes- und Staatsmacht auch keine schärfere Mittel, ausser den nicht bindenden Mahnungen, besass, um in die Forststreitigkeiten in Gornji grad einzugreifen. Auch die Landesstelle in Graz, die laufend vom Forstamt von den Übertretungen in Gornji grad benachrichtigt wurde, verhielt sich relativ zurückhaltend, was wahrscheinlich davon herrührte, dass bei dieser Stelle lange Zeit kein forstliches Referat bestand, und die Eingaben des hiesigen Forstamts meistens überhaupt nicht beantwortet wurden. Ständige Gegensätze der Untertanen mit der Herrschaft, besonders aber noch ihre Streitereien mit dem Forstamt ersetzten nach Baš[56] das heutige politische Leben mit seinen Auseinandersetzungen in diesem Gebiet. So zog sich ein Schwebezustand bei den Forstauseinandersetzungen in Gornji grad sicher bis 1802 hin, mit grosser Wahrscheinlichkeit aber noch einige Jahrzehnte nach der Grundentlastung (1848), als schliesslich die sogenannte Separierung der Wälder, bei welcher sowohl die Servituts- als auch Weide- und sonstige Rechte durch Vergleich anerkannt, den Untertanen dafür einige, meist schlechte Forstflächen zuerkannt, und damit schlussendlich die Nutzungsrechte der Untertanen an herschaftlichen Waldungen und Weiden abgeschafft wurden.

In den Jahren 1795 und 1796 wurde die erste Forstmassnahme durchgeführt. Auf einigen Schlägen wurde versuchsweise mit dem Kahlschlag begonnen, in berechtigter Erwartung der Neubesamung durch natürlichen Anflug. Diese Forstmaβnahme gestaltete sich aber als abschreckbar dadurch, dass so wie z. B. in Revier Hom und Terbolca geschehen, bei Ablösung eines Schlags und ohne Rücksicht auf den Anflug des Samens und Verbot durch die Forstbeamte sogleich und unverdränglich fortsetzend, von den Untertanen alle Gattungen Vieh in Schonungen zur Weide getrieben und also besonders durch Schafe und Ziegenvieh, die Geschosse der Pflänzchen zum zweiten oder dritten mal verbissen, durch Pferd und Rindvieh aber ab- oder eingetreten worden sind. Der Versuch schlug also fehl. Daher musste die schlagweise Abholzung in geführten Revieren, um nicht traurige Blössen zu vermehren, bis zu anhoffend strengen Maβregeln gegen Forstexzeβe, auf spätere Zeiten verschoben werden.

In etwa derselben Zeit wurden weitere Versuche mit dem Säen der Samen und Setzen der Setzlinge auf den Blössen durchgeführt. Hier kamen aber die Forstleute mit den Untertanen in Streit, da diese die erwähnten Blössen für die Weide ihres Viehs beanspruchten. Diese Ansprüche wurden aber von den Förstern nicht anerkannt. Im April 1796 wurden also a) im Revier Prekerštajn 5 Joch 150 □ Klafter mit Lerchensamen, b) in Terbolca 8 Joch 600 □ Klafter, c) in Kuhinek 9 Joch mit Fichtensamen, im Jahr 1797 d) im Revier Mali vrh 10 Joch mit Tannen- und Fichtensamen, e) im Revier Hom 7 Joch mit Lerchen- und Kiefernsamen, f) im Jahr 1798 unter Kuhinek 3 Joch mit Buchensamen, g) im Jahr 1797 im Revier Hom 400, h) in Prekerštajn 300, dann im Jahr 1801 i) unter Kuhinek 300, k) in Hom 300, l) auf der Dominikalweide Terbovš 300 Eichensetzlinge auf Blössen besät oder versetzt.

Weil aber durch die Forstpolizei, obwohl rechtzeitig über die folgenden Forstexszeβe benachrichtigt, aus verschiedenen Vorwänden und Gründen durch mehrere Jahre keine Ahndung vorgenommen hatte, so hatten auch diese Versuche von a) bis f) traurigen Ausgang erlitten. Die Versuche von a) bis inclusive f) wurden mehrmalig von Pferden, Horn-, Schaf- und Ziegenvieh zum Teil bei der Aufkeimung zertreten und zum Teil dergestalt öfter abgefressen worden, dass man die Mühe

[56] Baš, 1938, 13.

und Kosten wie ganz umsonst angelegt ansehen kann. Weiter ereignete sich bei g) das Schicksal, dass sich 25 Untertanen von Pusto Polje und Križ am 13. April des darauffolgenden Jahres auf die Verwaltungsamtskanzlei mit dem Begehren verfügten, dass nicht allein die auf der Blösse gesetzten Eichlinge durch die noch auf der Kulturstrecke beschäftigten Arbeiter ausgerauft, sondern, dass auch der zur Allienierung eines Wassergrabens nützlich angebrachte Kanal wegen angeblichen Weiderechts demoliert werden sollen, in welcher Stimmung sie sich auch sämtlich bei dem damals erkrankten Forstmeister mit aufrührerischen Drohung, und mit dem noch beigesetzten ausserordentlichen Begehren eingefunden, dass ihnen die Weide mit aller Gattung Vieh sogleich anerkannt werden sollte, welchen folgend dann nach und nach alle Stämmchen auf verschiedene Weise und dergestalt ausgetilgt worden, dass dann im 1800 und 1801 hievon nur noch die Spur ihres Standortes wahrgenommen werden konnte, worüber ungeachtet an das Verwaltungsamt in Sachen entflossenen hohen Gubernialauftrags vom 5. August 1797 und umsomehr anderer wiederholten Aufträge bis zur Stunde noch keine Amtshandlung bewusst ist, welches die Folge hatte, dass auch die sub k) berührten Eichlinge meistens jenen sub l) aber alle abermals boshaft mutwillig geschändet und ausgerauft worden sind, bei welch so bemerkten Umständen also, bis zur Erfolgung einer höheren Unterstützung und nachdrucksamen Einschärfung der Forstpolizeiassistenz, jede Unternehmung fruchtlos, und jede Auslage verloren sein würden.[57] Zu dieser Aufruhr der Untertanen hat auch ein anderer Vorfall verholfen.

Das herrschaftliche Verwaltungsamt hat am 17. März 1797 eine von dem Forstamte auf einer mit Borkenkäfern befallenen Strecke, die früher durch öfteres Astschneiden devastiert war, zur Abstockung freigegeben, im Jahre 1798 sollten die Stämme nach Vorgabe desselben Amtes als Brennholz verwendet werden. Dafür setzte sich auch der steirische Gubernialrat und Staatsgüteradministrator Ignatz von Peball ein. Die Stämme und Stangen wurden also abgestockt. Eine Interessentengruppe wollte aber die Stämme ohne Einvernehmen des Forstamtes für anderweitige Verwendung kaufen. Es kam zur öffentlichen Abwürdigung des Forstpersonals. Wie auch in vielen anderen Fällen traute sich das Verwaltungsamt nicht dem scharfen Vorgehen, welches das Forstamt gegen die Untertanen verlangte, Folge zu leisten und die vielen Anzeigen über verschiedene Forstzwischenfälle zur Verhandlung zu bringen. Die Feudalordnung war zu dieser Zeit schon ziemlich in Verfall begriffen, und die Grundherrschaften auf slowenischen Gebiet mussten sich dieser Tendenz wohl nicht gerne fügen um Aufruhr und Revolten zu vermeiden. Die fremdländischen Forstbeamten konnten sich aber mit den hiesigen Verhältnissen nicht anfreunden, deshalb kam es oft zu sehr scharfen Zwischenfällen. Aus diesem Grund war auch das Verhältnis zwischen dem herrschaftlichen Verwaltungsamt, das zu dieser Zeit auch staatliche Verwaltungs- vor allem aber Justizaufgaben innehatte, und dem Forstamt, das erst vor einigen Jahren errichtet wurde, sehr gespannt.

Um aber jedoch die für das zukünftige Wohl und die regelmässige Forstwirtschaft bedeutende schlagweise Abstockung doch an einigen Orten durchsetzen, und denen ortsansässigen Gegnern mit Eindruck begegnen zu können, so wurden im Jahr 1797 mit Bewilligung der hohen Landesstelle (Gubernium) zu Gratz durch aufgenommene Holzknechte in 4 Revieren Schläge erstmals und da wo man des natürlichen Windanflugs gewiss war, alles Oberwuchs samt dem unter der Beschattung an Gipfeln beschränkten Stangenholz abgestockt, welches Unternehmen zwar sowohl für die Methode, als auch für die Forsterträgniserhöhung in Festsetzung einer neuen Proportionalstammtaxe den besten Erfolg versprach. Doch diese Unternehmung scheiterte offenbar durch Trotz der Untertanen. In der Historischen Beschreibung der Wälder der Herrschaft Gornji grad steht, dass dieses Unternehmen "für den unter unvergesslich durch volle 5 Jahre erlittenen Verfolgungen, und unausgesetzter Gegenwirkung bedrungenen Forstmeister ein Vermögensverlust von 1.000 fl zum Erfolg hatte."[58]

Um was für Verfolgungen und Gegenwirkung es sich handelte, ist nicht beschrieben, es ging aber wohl wieder um den Vieheintrieb in die Kahlschläge und die üblichen Feindseligkeiten der Untertanen gegen das Forstpersonal. Es kann aber auch ernste Auseinandersetzungen zwischen dem Herrschafts-verwalter und dem Forstmeister als Chef des Forstamts gegeben haben. Der erste war nähmlich verbunden ein entsprechendes Erträgnis als Herrschaftsrente zu erwirtschaften und konnte kaum den, schliesslich doch verlustreichen Experimenten des Forstmeisters, zustimmen.

Trotz der miβratenen Versuche der Besamung der Kahlschläge trachtete aber das Forstamt in den nächsten Jahren, wo immer thunlich, teils beim Verkauf auf dem Stocke und bei der Ausbringung und teils durch aufgenommene Holzknechte auf schlagweiser Abstockung auf eigene Rechnung, auf seinen Forstgrundsätzen standhaft zu beharren. Um nicht mit vielen Einzelkäufern verhandeln zu müssen, hatte man 1799 das Holz an eine einzige Partei bzw. an eine Kompagnie abgegeben. Bei diesen Verkäufen wurde

[57] Historische Waldungbeschreibung, 129 v bis 130 v.

[58] Historische Waldungsbeschreibung, 1802, S. 129 r.

versucht die Abschätzung, Ausweisung, Bemerkung und Vermerkung der klassifizierten Qualität und Quantität einzuführen, und schliesslich die Rentabilität zu berechnen, worüber die technischen Einzelheiten eingehend beschrieben sind, die aber hier ausser acht gelassen werden müssen.

Behölzungsrechte

Wie schon erwähnt, war die Frage der Behölzungsrechte der Untertanen in den herrschaftlichen Wäldern äusserst schwierig, weil hierbei zwei total entgegengesetzte Anschauungen gegeneinander stiessen. Abgesehen vom Gewohnheitsrecht begründeten die Untertanen ihre Behölzungsrechte auch auf die Giebigkeit des koplevnik, die sie regelmässig entrichteten. Für die Behölzungsrechte im Wald Javorje reichten koplevnik die Ortschaften Kokarje und Dobletina; für solche Rechte im Wald Krašica das Dorf Šmartno; im Wald Na Kokarci die Orte Šentjanž und Pusto Polje; in den Wäldern Pretkovca, Pod Koriti und auf Travnik aber das Dorf Volog. Das Dorf Bočna (Tabelle 2) hatte anhand der Reichung von koplevnik in den

Tabelle 2 *Auszug aus dem Ausweis jener Bürger und Untertanen die in den Jahren 1797-1801 Holz für Zäune und Schindeln bezogen haben*

Ortschaft	Anzahl der zum Holz Berechtigten	Holzbezug insgesamt	
		Stämme	Klafter
Markt Gornji grad	91	796	571,75
Gemeinde Kobre	5	9	-
Gemeinde Bočna	33	217	74
Gemeinde Šmartno	17	48	5
Gornje Kraše	7	30	21
Spodnje Kraše	14	82	14
Potok	3	18	11,50
Križ	15	40	7
Šmiklavž	11	16	-
Štajngrab und Nova Štifta	19	61	32
Gemeinde Luče	36	347	121,50
Pobrežje	5	24	10,50
Solčava	23	270	111,50
Lačja vas	3	21	19
Pocsoba	4	17	20
Suha ?	9	43	16
Pusto Polje	10	99	54
Šentjanž	9	50	20,33
Arpoladorf	9	54	28,50

Berghängen pod Ivjem und im Wald V Bregih das Recht zum Fällen des Hartholzes und Entnahme des Weichholzes für Zäune. Einfach auf dem Gewohnheitsrecht begründeten die nötige Entnahme des Holzes in dem Wald Kačjek die Dörfler von Luče und der Markt Gornji grad in dem Wald Petelinjek. Es soll hier hinzugefügt werden, dass das Dorf Solčava ihr Recht zum Fällen von Bau- und Brennholz im Wald Veža auf der Leistung von Jagdrobot und der Abgabe von Wildpret an die Herrschaft in Gornji grad begründete.[59]

Dass die Untertanen aus den erwähnten Dörfern in der Zeit, die die Wälderbeschreibung umfasste, den koplevnik entrichteten ist aus der derselben Tabelle ersichtlich. Das in der Tabelle 3 als Mass angegebene Kastenschaff war das übliche Mass bei der Herrschaft Gornji grad. Nach der österreichischen Masserei waren das 53 102/128 Metzen Heiden (Buchweizen) und 100 25/128 Metzen Hirse.

[59] Baš, 1938, 6.

Tabelle 3 *Die Reichung von koplevnik als Berechtigung zur Holznutzung in den Wäldern der Herrschaft Gornji grad*

Pfarre	Ortschaft	Reichungs-verpflichte-tete (Anzahl)	Zu entrichten		
			Heide	Hirse	Haarz.
			Kastenschaff		Stück
Gornji grad	Šmartno ob Dreti	23	24,50	39,50	63
Gornji grad	Bočna	38	15	56	122
Rečica	Homec	5	1,25	8,50	8
Rečica	Zgornje Pobrežje	10	15	16	27
Rečica	Spodnje Pobrežje	7	16	15	27
Rečica	Trnovec	7	6	9	16
Rečica	Dobletina*	9	4	14	30
Rečica	Kokarje**	11	9	18	36
Rečica	Lačja vas***	10	10	12	28
Rečica	Potok****	1		1	2
Rečica	Spodnje Kraše	9	11	13	28
Rečica	Verde	7	4,50	12	27
Rečica	Šentjanž	7	15,75	1,75	
Rečica	Pusto Polje*****	12		21	42
Rečica	Spodnja Rečica	6	3,50		2
Zusammen		162	127,5	237,5	449

Abkürzung: Haarz. = Haarzähling

* Die Ortschaft Dobletina musste noch 7 Hendl reichen.
** Die Ortschaft Kokarje musste noch 9 Hendl reichen.
*** Die Ortschaft Lačja vas musste noch 9 ½ Hendl reichen.
**** Die Ortschaft Potok nusste noch ½ Hendl reichen.
***** Die Ortschaft Pusto Polje musste noch 9 ½ Hendl reichen.

Die Ansprüche die die Untertanen aus der Abgabe von koplevnik zogen, waren aus der Sicht der Herrschaft um so weniger annehmbar und gegründet, als die Giebigkeit unter diesen Namen zu verschiedenen Rechtstiteln geleistet wurde.

a) Von einigen fremden Untertanen, welche vorhin ein Behölzungsrecht an dasiger Herrschaft genossen, dann entgegen;
b) Von einigen Untertanen an fremden Dominien, z. B. Gut Brdce bei Mozirje, ohne dort ein Behölzungsrecht zu geniessen, und so an mehreren Dominien, als z. B. bei den Untertanen der Religionsfondsherrschaft Studenice, die koplevnik an die Herrschaft Rače und umgekehrt die Untertanen von Rače an die Herrschaft Studenice als Abgabe leisteten ohne einen bestimmten Gegengenuβ zu haben, ausser wenn man hinter dieser Gabe vielleicht wirtschaftsamtlichen und landesgerichtlichen Schutz vermutet, der aber in angeführten Fällen nicht wahrscheinlich war;
c) Ist die unter dem Titel koplevnik vorkommende Giebigkeit eigentlich eine Art verglichener Getreidezehend von Sommerfrüchten, welcher sonst Sackzehend oder Blutzehend genannt wird, welches unter anderem aus der Benennung Haarzähling zu entnehmen ist, keineswegs aber für das Behölzungrecht abgegeben worden ist;
d) Konnte es in der Macht eines Bischofs, als Nutzniesser der Herschaft, zwar gewesen sein, dass er mit seinem zeitlichen Genuβ eines Gutsertrags, so lange er dazu berechtigt war, disponieren konnte, einen oder anderen Ertrag verschenken, vertauschen, oder um geringe Bezahlung zu verkaufen. Keineswegs durfte er aber die Rechte des liegenden Guts, oder an Grund und Boden haftende Einkommen, Servitutsrechte etc. schmälern, oder durch schlechte Verwaltung vernachlässigen und auf letzte Weise den nächsten Successor oder gar den Staat als Eigentümer (das betraf die Herrschaft Gornji grad nicht) zu beeinträchtigen;
e) Würde es ganz der Billigkeit widerstreben, wenn die Herrschaft bei der Bemessung des Holzgenuβes aus ihren Waldungen auf den vorherigen Hub-, Zulehens- oder Gemeindewaldbesitz der angeblichen Holzberechtigten kein Augenmerk richten und jenen Untertanen, die Holz im Überfluβ

haben und ihn deswegen auch verkaufen können, und den minder oder gar nicht mit Waldbesitz versehenen Untertanen, gleiche Rechte oder aus milder Nachsicht zufliessende Genüße anerkennen würde. Die Herrschaft bzw. das Forstamt schliesst zwar nicht aus, dass auf Grund eines vorliegenden Rechts, oder auf allerhöchste Bewilligung oder nach Maßgabe des Bedürfnisses *in natura* den Untertanen Holzgenuß erlaubt oder mittels Excentierung (Separierung) eine angemessene Waldstrecke zugemittelt werde. Jedoch sollten vorher in den Untertanen- und Gemeinde-waldungen kostspielige Forstmaß-nahmen, wie geometrische Flächenausmessung, Beobachtung, Taxierung und Erhebung des jetzt bestehenden und in Zukunft bei guter Forstwirtschaft zu erwartenden Holzbestandes, die Bestimmung der Abholzungsperiode, usw. durchgeführt werden. Endlich sollte nach diesen Berechnungen der mindere oder höhere Holzbedarf der einzelnen Untertanen ausgemittelt werden. Diese Forderungen des Forstamtes waren von den Untertanen nicht zu erfüllen, sie wurden in dem behandelten Zeitraum auch in den herrschaftlichen Waldungen bei weitem nicht erfüllt. So kann mit Recht gesagt werden, dass sie auf eine allgemeine Nichterfüllung des Behölzungsrechtes hinausliefen, wozu der Herrschaft jegliche rechtliche Grundlage fehlte. Die Behölzungsrechte konnten nicht an Vorbesitz der Waldungen gebunden werden. Aus dem oben Angeführten sollte nach der Ansicht der Herrschaft zu ersehen sein,

f) Dass die Untertanen eigentlich gar kein auf Urkunden oder Giebigkeiten gegründetes Behölzungsrecht besassen. Wohl aber geschah es, dass solche aus bischöflicher Nachsicht und resp. Personalgnaden gegen Anmeldung, Ausweisung und Bezahlung einer Gebühr zum eigenen *consumo* das Brennholz, und in dürftigsten Fällen auch Bauholz aus herrschaftlichen Waldungen erhielten.
g) Daraus kann aber nie ein (obwohl ungegründetes) Recht gefolgert werden.
h) Weil sich die freie Forstnutzung der Untertanen auf kein bestimmtes Holz*quantum* beschränkte, gereichte sie besonders bei Ermangelung gehöriger Forstaufsicht zum grössten Nachteil des Waldstandes. Die Ermittlung des berechtigten Holz*quantums* könnte nur nach oben beschriebenen Massnahmen geschehen. Das war aber nicht durchzuführen und wurde auch kaum versucht. Deshalb wollte das Forstamt wenigstens die An- und Ausweisung des Holzes durchsetzen;
k) Diese wurden aber von den Untertanen seit neun Jahren stets verweigert, und unter dem Vorgeben abgelehnt, dass sie durch diesfällige Folgsamkeit den Verlust ihres vermeintlichen Rechts eingehen würden. Sie wollten dann weiter nur junges, leicht ausbringliches Holz abstocken. Gegen diesen Unfug sind zwar bereits seit den letzten 5 Jahren sowohl forstamtliche Ausweisungsvorladungen, als auch Anzeigen über Übertreter und erhobene Exzeße erlassen. Trotzdem ist aber zur Ausweisung nie eine Partei erschienen. Nicht minder sind die Exzeße von Seiten des Bezirkskommissariats Gornji grad bis 1802 meistens unverhandelt geblieben, vermutlich aus der Ursache weil auch die Servitutsrechte noch nicht gehörig berichtigt worden sind. Auch hier kann man die von den Untertanen beteuerte und offenbar von amtlicher Seite angenommene Verbindung oder gar Gleichsetzung der Behölzungsrechte mit den Servitutsrechten ersehen.
l) In der Waldungsbeschreibung sollte auch angegeben werden, wieviel in jedem der letzten neun Jahren von jeder Holzart jedem Holzberechtigten, in der erwähnten Beschreibung meistens Holzbegünstigte genannt, verabfolgt wurden. Darüber konnte nichts angegeben werden, da zur Zeit des ersten Forstmeisters Schweska teils keine Ausweisungen erzielt, von dem neu errichtetem Forstamt aber nur von Jahren 1797 bis 1801 die wenigsten Untertanen und Käufer zur Ausweisung bewogen werden konnten, worüber in den Archivalien ein Ausweis besteht, der aber hier nicht wiedergegeben werden kann.
m) Natürlich musste auch die Frage beantwortet werden ob das Behölzungsrecht abgeschafft oder abgelöst werden könnte. Das Forstamt bezweifelte stark, dass dieses vorgebliche, zwar ungegründete Behölzungsrecht ganz abgeschafft oder abgelöst werden könnte. Einerseits standen dagegen die Bedürfnisse der Untertanen, anderseits aber die Verjährung.
n) Daraus ist ersichtlich, dass sich die Herrschaft doch bewogen fühlte die Frage der Behölzungsrechte der Untertanen auf irgendeine Weise, wie sich herausstellte, vor allem durch Abtretung eines Teils ihrer eigenen Wälder an diese (Separierung), zu lösen. Hierbei entstand die Frage wieviel Joch abzutretenden Waldes, wieviel Geld, oder abzugebende Klafter Holz dazu erforderlich wären. Darauf konnte ebenfalls keine Antwort gegeben werden. Das Forstamt forderte wegen Verlässlichkeit der Berechnungen wieder die oben erwähnten Forstmassnahmen und Erhebungen, die Holzerzeugung in den Hub-, Zulehens- und Gemeindewaldungen und daraus ermittelte nötige Zugabe aus den herrschaftlichen Waldungen.

Allerdings hat das Forstamt in den vorigen Jahren mit einem Versuch der Excentierung (Separierung) angefangen, hierbei im geringen Umfang die oben erwähnten Massnahmen und Erhebungen berücksichtigt. Es zeigte sich aber, dass die vorhin

gedachte Ausgleichung und die Rücksicht auf den Forstbesitz und Waldstand als ein unauflösbarer Gegenstand zu betrachten ist. Es wurde ermittelt, dass zur Separierung erforderliche Waldfläche um 950 Joch betrüge, und konnte wenigstens 180 Joch Wald in Ersparung gebracht werden. Wie es zu dieser Ersparung käme ist nicht klar ersichtlich.[60]

Holzdiebstahl

Der Holzdiebstahl hatte nach Aussage glaubwürdiger Männer in Vorjahren einen solchen Grad erreicht, dass jener Käufer, welcher zum Beispiel 20 Stämme erkaufte, dazu eben so viele oder noch mehr entfremdet hatte. Um diese Sitten- und Zügellosigkeit zu beschränken und zu verhindern, wurden vor zehn Jahren dem vorgewesenen Waldförster, der hier danach zum Forstmeister befördert wurde, zwei Forstbediente zugegeben und die täuschende Aufsicht der unkundig trügerischen bäuerischen Forstknechte aufgelassen. Danach wurde im Jahre 1796 ein ordentliches Forstamt errichtet und ihm im Jahre 1800 der dritte Förster von höchsten Ort bewilligt. Dessen ungeachtet stand aber fest, dass so lange die Veräusserungen des Holzes in den Revieren auf dem Stocke geschehen, abwechselnd von einem oder anderen Käufer 5 bis 10 und 50 Stämme, unbemerkt zur Entfremdung abgestockt, noch mehr aber von ledigen Burschen, Keuschlern, Deserteuren und Vagabunden, öfters an gebotenen Feiertagen und anderen freien Tagen, bei Tag- oder Mondlicht und wo nicht anders möglich bei stürmischer Witterung, abgestockt wurden. Die hoffnungsvollsten Laubhölzer von 7 bis 10 Zoll wurden von den angeblichen Holzberechtigten zu Brennholz schändlich ausgehoben.

Zur Abwendung und Verdrängung der Holzdiebstähle wurden im Jahr 1797 Bedingnisse zum Verkauf des Holzes bekannt gemacht und von den Käufern anerkannt. Darin wurden einfache Forsttaxen (Holzpreise) für Holz verschiedener Gattungen vorgeschrieben. Nach diesen Verkaufsbedingnissen war für jeden unerlaubt und unbemerkt abgestockten Stamm die doppelte Forsttaxe festgesetzt. Der Grund dazu war, dass damit die betrügerischen Käufer bestraft, und ihre Sitten- und Zügellosigkeit in gewisse Schranken gewiesen werden sollte. Die treuen Käufer sollten aber mit der einfachen Forsttaxe zur Erwerbung des Holzes für ihren, wie man damals sagte, Industrialnutzen stimuliert werden.

Was die Erhebung der Excesse und Bestrafung der Holzdiebstähle betrifft, so war durch mehrere Jahre unentschieden, ob die Erhebung bei der Grundherrschaft, wohin der Untertan dienstbar, oder bei dem Dominium, welcher den Wald besitzt, oder aber von dem politischen Bezirkskommissariate aufgenommen und sogleich selbst aburteilt, oder dem betreffenden Kreisamt zur Revision und Bestätigung vorgelegt werden sollte. Die Folge dieses Kompetenzwirrwars war, das geraume Zeit entweder gar keine Verhandlungen durchgeführt, oder wenn welche erfolgten, in Ermangelung eines Maβstabs oder Systems allerdings nicht der Absicht angemessen bestraft, und auf solche Weise die Zahl aller auf 300, der noch unverhandelten Fälle auf über 200 angewachsen ist. Andernteils werden aber die Frevler durch Ermangelung zeitlicher Bestrafung leichtsinnig und gleichgültig gemacht, und durch Erhärtung diesfälliger Leidenschaft in immer mehr ausgedehnte Exzeβe verwickelt. Der Waldstand wurde dabei stark beschädigt und die Forstpolizei, statt notwendigerweise erhoben, wurde nicht allein abgewürdigt, sondern sogar gehasst, verabscheut und bedroht. Das Forstamts-personal wurde unter Leib- und Lebensgefahr verfolgt. Die Tabelle 4 zeigt bestrafte Waldexzeβe.

[60] Historische Waldungsbeschreibung, 133 r bis 135 r.

Tabelle 4 *Übersicht der bestraften Waldexzeße*

Verursacher des Waldexzesses	Wohnort	Begangener Waldfrevel	Waldrevier	Verursachter Schaden		Zuerkannte Leibesstrafe	Geldstrafe		Anmerkungen
				fl	xr		fl	xr	
Nik. Krek	ob Terbolca	Weide 7 St. Hornvieh	Terbolca	1		6 Tage Eisen			Wegen Kulturskosten Ersatz erörtert.
Tomaž Kropovšek		Schlagen von 4 Fichten	Gradišče	1	36	1 Tag Arrest wegen keiner Ausweisung			
Prim. Primožnik & Compagnon		15 Buchen abgestockt	Petelinjek	5		Durch Urteil Bez. Komm. nachgesehen			
Detto		5 Fichten abgestockt	Petelinjek		3	Detto			
Jos. Lesič *vulgo* Vouk		Bäume abgestockt und mit Absicht verdorben	Hom	13	43	Kreisamt 2 Tage Arrest			Ist während der Verhandlung gestorben.
Jurij Šubert		2 Buchen verdorben	Hom			Verwaltungs-Amt 1 Tag Arbeit		6	
Sim. Verhoč		20 Stämme abgestockt	Krašica	5	20	Detto 2 Tage Arbeit	5	20	Holzfuhr gemässigt.
Peter Kasimind		30 Stämme abgestockt	Krašica	21	30	30 Tage Arbeit	26	30	Ist aus bekannten Gründen überspannt und Strafe unausführbar.
Janez Kovač		4 Stämme abgestockt	Hom	3	31	Verwaltungsamt			Anmerkung nicht lesbar.
Janez Herman		29 junge Eichen	Petelinjek	2	10	Detto 4 Tage Arbeit	2	50	Detto
Jos. Peistner	prope Gornji grad	1 Klafter Buchenholz	Kuhinek		20	2 Tage Arbeit		40	Wegen Devastierung junger Buchen angemessen.
Anton Podmilšek und 4 Comp.		83 Nadelholz-Stämme	Kačjek	23	31	Verwaltungamt 3 Tage Arbeit	26	31	
Jos. Rojnik & Jurij Veršnik		32 Detto	Polamank	25	36	3 Tage Arbeit	26	6	
Mart. Požnik	Štajngrub	15 Detto	Globače	15		1 Tag Arbeit	34	19	
Jos. Petrič	Piršek	8 Detto	Petelinjek	8	41	Kreisamt 2 Tage Arbeit			
Jurij Markovšek		7 Detto	Podverše	5	36	Mündlich verhandelt, keine Strafe erteilt.			
Andrej Sprah	Bočna	11 Sagplöcke	Petelinjek	5	30	4 Tag Arbeit ohne Essen			
Simon Podlesnik & V. Tratnik		Weide von 41 Schafen und 10 Ziegen	Golobač	61		Kreisamt, jeden 2. Tag in Eisen zu arbeiten			
Jernej Obersnik	Fara Solčava	Abholzung für 730 Platten?	im eigenen Hubwald			Verweis			Zum Rekurs geeignet.
Gašper Pečovnik	Fara Luče	Schändung 229 junger Fichten	Detto			Kreisamt 24 Std. Arrest			Derlei Strafen gereichen kein Beispiel.
Jernej Ermm. Inwohner bei Schatt		Abstock. 4 Nadelstämmen	Hom	4		1 Tag Arrest			Detto.

Abkürzungen: Bezirkskommissariat Gornji grad = Bez. Komm., Verwaltungsamt Urteil Gornji grad = Verwaltungsamt, Kreisamtsurteil = Kreisamt

Aus der Tabelle 4 ist ersichtlich, das die meisten Waldexzeße doch ansehnlich, einige aber fast vernachlässigbar sind. Die Strafen fielen im Vergleich mit der damaligen Strafpraxis mild aus. Natürlich waren aber Leibestrafen für den Beginn des 19. Jahrhunderts veraltet. Bei so milden Strafen bestand keine Gefahr, dass der Forstpolizei die Geschäfte ausgingen.

Der Verdacht der Diebstähle deren Täter nicht entdeckt wurden, fiel auf einige Flößer, die von ledigen Burschen, Inwohnern und Vagabunden das gestohlene Holz aufkauften. Auch erlaubten die Flößer die Transportierung des gestohlenen Holzes auf ihren Flößen, damit sie die üblichen Floßknechts-entlöhnungen vermindern konnten. Gegen diese Gebrechen wurde bisher von Seite der Bezirksbehörden die Ahndung nicht eindrucksvoll genug betrieben, jedoch gab es in letzter Zeit einige Bemühungen, so dass auch Resultate erwartet werden konnten.

Zur Verminderung der außerordentlich in Schwung geratenen Holzdiebstählen, die meistens an jungen in besten Wuchs bestehenden Nadelbäumen begangen wurden, wurden bereits im Jahre 1797 in eigener Regie Abstockung und Transportierung bis an den Fluβufer auf den Verkaufsplatz, durch eigene Holzknechte, als Drohungsmittel gegen die Holzdiebe einzuleiten versucht. Dieses Unternehmen brachte aber dem dermaligen Forstmeister bei einer außerordentlichen Anzahl von Gegnern und bei Ermanglung erforderlicher Unterstützung durch das Verwaltungsamt eine groβe Schlappe, der Herrschaft aber einen beträchtlichen Vermögensverlust.

Deshalb wurde diese Unternehmung, auβer dem zur Kreisstadt Celje gelieferten Bauholz in den nächsten zwei Jahren, eingestellt. Danach wurde der Holzverkauf auf dem Stocke, jedoch unter den besonderen Bedingnissen, die aber hier nicht wiedergegeben werden können, fortgeführt.

Mit den vorgeschrieben Bedingnissen wurden aber offenbar die Holzexzeße nicht vermindert oder gar abgestellt. So wurde in Jahr 1800 abermals versucht, das Holz in eigener Regie zu schlagen und zu transportieren. Es wurden hierzu hierortige Leute angeheuert. Diese aber zeigten grosse Nachlässigkeiten, so wurde dieser Versuch mit heimischen Leuten fallen gelassen. Dieses Verhalten kann leicht aus dem äuβerst angespannten Verhältnis der Bevölkerung gegenüber der Herrschaft bzw. dem Forstamt erklärt werden. Im Jahre 1801 wurde der Versuch, jedoch durch fremde, aus dem Venetianischen Gebiet angeheuerte Geding(Akkord)arbeiter fortgesetzt. Diese führten in zwei Revieren alle Arbeiten inclusive Ausbringung durch. Über diese zwei Versuche gibt es keine detaillierte Angaben. Jedoch halfen sie dazu, dass die Herrschaft Gornji grad von diesem Jahr an, als Käufer am Stock nur Leute mit gutem Ruf zuliess. Denen lohnte sich der Holzkauf nach vorgeschriebener Forsttaxe, auch ohne irgendwelche verbotene Entfremdung zusätzlicher Stämme. Nach einer einzigen, nach unserer Meinung fragwürdigen Angabe, sollte das Unternehmen des Holzkaufes am Stock bei einer Auslage von 100 fl einen Gewinn von 41,8 Prozent einbringen. Mit solchen guten Beispielen wollte die Herrschaft der Raubsucht der unteren Volkschichten in ihren Wäldern entgegentreten.

Jeder Übertreter sollte nach den Bedingnissen für die Entfremdung des Holzes fürs erste mal neben einer angemessenen öffentlichen Arbeitsstrafe die doppelte Forsttaxe bezahlen, bei jungen Stämmen zusätzlich noch ein Pflanzgeld von 6 Kreuzer je Stamm für die Entschädigung der Forstrenten, und jedem Forstbeamten das Diätgeld entrichten. Bei der zweiten und weiteren Übertretungen sollte jedesmal ein *duplum* mehr in einen zu errichtenden Straf- und Belohnungsfond entrichtet werden. Um dann weiter derlei Forstfrevel verläβlich auf den Grund zu kommen, die Sittlichkeit aber hierbei zu befördern so war es notwendig auf die Durchführung der Vorschriften der Höchsten Waldordnung mit allem Eifer zu drängen. Sowohl die Flößer, Sagmeister und Holzknechte sollten in Zunftpflicht gezogen, und die diesfälligen Übertreter sollten schärfstens geahndet und öffentlich bestraft werden. Besonders aber sollte der Auftrag erlassen werden, dass die Flößer ohne ein von dem Verkäufer vorzuzeigendes forstamtliches Zertifikat, von Niemand Holz zu kaufen, die Sägemeister aber ohne solches Niemand Schnittwaren zu bereiten, endlich und ebenso auch weiter die Flößer ohne Assignationsschein über die Flößprodukte keinen Transport abzuführen berechtigt sein sollte, worauf die Wasser-, Brücken- und Grenzmautämter zur Aufmerksamkeit zu verhalten sein würden. Um aber in einer jeden Provinz und Gegend sowohl die Sittlichkeit als bei der Nachwelt und folgenden Generation mehrere Aufmerksamkeit, Liebe, Schonung und Pflege für den Waldstand einzuprägen und zu erzielen, so war es notwendig, dass so wie für die wirklichen Hauswirte schon geschehen, für die Jugendlichen ein Forstökonomischer Katechismus im belebenden Ton entworfen, in mehrerern Nationalsprachen in Druck in hohen Auflagen gebracht und verteilt wird. In den Normal- und Trivialschulen, sollte über den Waldbau unterrichtet werden und bei diesem Fach den besten Schülern eine Auszeichnung überreicht werden.[61]

[61] Historische Waldungsbeschreibung, 135 r bis 137 v.

Weideexzeβe

In den Waldungen wurde eigentlich kein Vieh gehütet, sondern es besteht der noch größere Unfug, das von den Untertanen zu Križ, Pusto Polje, Meliše und Slatinec in das Schonungsrevier Hom und Gradišče unter dem Titel eines Weiderechts sowohl Pferde als Horn-, Schaf und Ziegenvieh, sehr oft ohne einen Hirten, sich selbst überlassen eingetrieben, und erster Gattung Vieh sogar wider die Gesetze darin über Nacht weiden belassen, hierbei aber auβer dem Winter gar keine Zeit oder Schonung des Samenanflugs beobachtet. Es wurde auch keine Anzahl des eingetriebenen Viehs bestimmt. Weidebefugnis wurde, seit Forstaufsicht bestand, niemals erteilt, sondern es wurden derlei Auftritte öfter zur Ahndung angezeigt, jedoch aber erst im vorigen Jahr die Ahndung und Bestrafung auf Veranlassung eines Visitationsauftrags, dann in Beobachtung der Schonungsvorschriften, jedoch mit solcher Modifikation angefangen, dass leider ähnliche Exzeβe neuerdings wieder festgestellt wurden. Dieses nähmliche Vorgehen ging von den höchsten Alpenweiden hinunter und von den unteren Weiden hinauf, von den Huben- in die herrschaftlichen Waldungen, zum Ruin des sich oft hoffnungsvoll zeigenden Anschlags. Wie erwähnt, wurde bisher keine Weidebefugnis erteilt noch ein Weiderecht erwiesen. Der Viehauftrieb geschah ohne Rücksicht auf Zeit und Anzahl des Viehs teils aus Mangel der Aufsicht, teils in Ermangelung einer beispielmässigen Ahndung. Wie groβ die eingetriebene Herde war, konnte niemals ermittelt werden, es konnte nur die Zahl des Viehs, welches in Schonungen und Waldungen gefunden und worüber die Anzeige zur Ahndung erstattet worden, ist angegeben werden. Die Untertanen haben in herrschaftlichen Waldungen keine Wiesen, wohl aber bestehen in dem Revier Hom ein kümmerlicher Rustikal- und ein Keuschengrund zum offenbaren Schaden dieses wichtigen Reservatreviers. Diese beiden Gründe sollen samt der Rustikalkontribuzion und einer Dominikalgabe mit den herrschaftlichen Botengründen vertauscht werden. Eigenmächtige und heimliche Rodungen wurden vorhin von den schon erwähnten Hafnerkeuschlern in Revir Krašica und Kokarca unternommen, welche aber zur zeit der Waldungsbeschreibung wegen strenger Beobachtung verhindert wurden.

Schweinemast und Jagd

Auch bei der Schweinemast, die in den Jahren als Buchen und Eichen fruchteten einigermassen bedeutend war, ging es nicht ohne Auseinandersetzungen mit den Untertanen. Hier ein Beispiel. In den Eichen- und Buchenwaldungen Kokarca, Krašica, Pretkovca, Stradovnik, Ivje und Graben wurde im Jahr 1797 eine halbe Buchekerfrucht wahrgenommen, und eine Verlautbarung erlassen, dass die Mastinteressenten das zum Auftrieb vorgesehene Borstenvieh von dem Forstamte zu beschreiben lassen hätten. Obwohl in den besagten Revieren Niemand ein Weiderecht besass, so konnte man jedoch von dem Forstamte verlangte Beschreiben des Borstviehs um so weniger erreichen und zur Ordnung gelangen, als diesmal von dem Verwaltungsamte keine Assistenz geleistet wurde. Das sollte sich in den nächsten Jahren ändern, da die Excendierung (Separierung) der Behölzungstrecken erreicht werden sollte.

Auch die Jagd, bzw. deren Nutzung wollte das Forstamt anders regeln. Die hohe und niedere Jagd sowie die Fischerei war seit dem 1. November 1794 auf 11½ Jahre, also bis 1805 an die benachbarten Pfarrer verpachtet. Diese Art von Pacht hatte aber erhebliche Mängel. Nach bisheriger Erfahrung wurde nach dem Tode oder Versetzung eines oder anderen dieser Geistlichen der betreffende Jagddistrikt an den Nachfolger, an einen Beamten oder auch an irgendwelchen Untertanen vertragsmässig in Administration überlassen. Die Geistlichen waren aber in ihrem Amt sehr beschäftigt, oder bejahrt, oder wie öfters der Fall mit solchen Körperübeln behaftet, dass sie selbst persönlich die Jagd nicht pflegend, wegen der Kostspieligkeit sich aber keinen besonderen Jäger halten konnten. Als Folge wurde die Jagd ebenso vorschriftswidrig betrieben, als wenn sie an mehrere Untertanen verpachtet, zum Nachteil der Landwirtschaft in Huth und Pirsch überlassen würde. So jagten in sieben Pfarren 40 bis 50 solche Jäger, wovon die meisten entweder aus Mangel an Begriffen von der Jagd und Wildordnung, oder aus verschiedenen anderen Gründen weder Begattungs- noch Brut-, noch Pirschzeit beobachten wollten. Es wurde das erste Tier, das dem Jäger vorkam, geschossen. Es wurde geschossen um ein Wildpret zur geheimen Entschädigung zu erhalten. Das Wild wurde durch das Getöse über die Grenze verscheucht. Die verderbliche Habsucht war verbreitet. Das Hauptjagdwild bestand in Hirschen und Rehen, welche derzeit in diesherrschaftlichen Forstrevieren wegen Beunruhigung durch die in den Waldungen vagirenden Schafherden keinen steten Aufenthalt haben, sondern nur bisweilen über Kärntens- und Krainsgrenze herüber setzen, wogegen Gemse in den Pfarren Solčava und Luče, Hasen, Stein- und Edelmarder, Füchse, Bären, Wölfe, Auer-, Rebhühner, wilde Enten und noch andere geringere Tiere, als in hierortigen Waldungen autochton lebende Wildtiere zu betrachten waren.

Die eigene Jagdregie hätte den Vorteil, dass in den an der Landesgrenze gelegenen Hochwaldungen Hirsche und Rehe herangezogen und dort zur verhältnissmässigen Nachzucht geschont werden könnten. Bei der Fischerei war der Hauptunfug die Ausraubung des Fischbestands zu Ende der Pachtzeit; bei eigener Regie konnten an mehreren Orten die alt bestehenden Huchen (Sulzen) erneuert werden.

Der Pachtschilling von der Fischerei betrug jährlich 188 fl in neun Jahren also 1.694 fl, von der Jagd aber jährlich 63 fl, in neun Jahren also 570 fl. Bei der Jagd konnten also keine Schussgelder, Fangtaxen oder Wildpret verlangt werden. Der Ertrag von der Jagd in eigener Regie, könnte nach Auflösung der Pacht und Entfernen der Raubschützen, die meistens auch an Waldexzeβen beteiligt sind, jährlich auf 200 bis 300 fl und mehr angehoben werden. Im Durchschnitt aller Jahre wurden nämlich 5 bis 6 Hirsche, 2 Schmultiere und Spissen, ebenso viele und noch mehr Rehe, 12 bis 18 Jungen, 6 Bären, eben so viel Wölfe, bis 30 Füchse, 40 bis 60 Hasen, 4 bis 6 Auerhähne, dann 12 bis 20 Schnepfen, Reb- und Haselhühner, 20 bis 30 wilde Enten, und so proportional von anderen Wild mehr oder weniger erlegt. Soviel Wild könnte auch in Zukunft zu Pirsch bestimmt und erwartet werden.

Das Forstamtspersonal war sehr an der Jagd in eigener Regie interessiert, da es dann in der Dienstzeit bei sich Schuβwaffen führen dürfte, die ihm, solange die Jagd verpachtet, nicht gestattet war. Es unterlag aber keinem Zweifel, dass die eigene Jagdregie bei ohnehin bestehenden Forstamtspersonal sowohl einen betrachtlich höheren Ertrag liefern, als auch zur besseren Jagd- und Waldordnungung führen könnte, da das Forstamtspersonal bei seiner ständigen Forstaufsicht, nebenbei auch die Jagdbelange bestreiten könnte. In Kärnten wurde bereits bei einigen Staatsherrschaften die Jagd in eigene Regie übernommen und dies vom höchsten Ort bewilligt worden ist.[62]

POVZETEK

GOZDOVI GOSPOSTVA GORNJI GRAD Z GOSPODARJENJEM NA TRADICIONALNI NAČIN IN NEUSPEŠNI POSKUSI ZA UVEDBO RACIONALNEGA GOZDARJENJA NA PREHODU IZ 18. V 19. STOLETJE

Gospostvo Gornji grad je bilo od 1462 v lasti Ljubljanske škofije. Imelo je skozi stoletja obširne gozdove s katerimi je gospodarilo v lastni režiji in pašnike, ki jih je dajalo v zakup svojim podložnikom. Z gozdovi je gospodarilo na tradicionalni način s servitutnimi ali z zastaranjem pridobljenimi pravicami podložnikov, s prebiralno sečnjo, s podiranjem drevja brez odkazila, s širjenjem pašnikov na škodo gozdov in tudi sicer z (nehotenim) gospodarjenjem v prid podložnikov. Leta 1785 je tedanji ljubljanski škof Janez Karl grof Herberstein predal omenjeno gospostvo v upravo Štajerskega verskega sklada oz. tehnično v upravo Notranjeavstrijske administracije državnih posestev v Gradcu. Ta je gornjegrajsko škofijsko gospostvo upravljala enako kakor druga državna ali verskoskladna posestva. Za ta posestva je bila predpisana obsežna "inventura" - izčrpen popis vseh nepremičnin, premičnin, pravic in obveznosti. V tem popisu gospostva Gornji grad so izčrpno opisani tudi gornjegrajski gozdovi. Čeprav je imela Ljubljanska škofija na Gornjegrajskem še dve gospostvi Vrbovec in Rudenek, ti nista bili zajeti v obravnavanem popisu.

Za uvedbo racionalnih metod gozdarjenja po "nemški gozdni šoli", ki naj bi vrgle večji gospodarski donos kot dotlej, sta bila zapovrstjo nastavljena tuja (češki in nemški) gozdarja, ki naj bi staro tradicionalno gozdarjenje kar se da hitro odpravila in uvedla novo. Seveda jima je bilo tukajšnje tradicionalno gozdarjenje popolnoma tuje. Proti novotarijam pa so se izredno ostro v bran postavili gornjegrajski podložniki, ki so že prve poskuse v kali zatrli. Podložniki so namreč zelo dobro vedeli, da gredo vse novotarije v omejevanje njihovih dosedanjih pravno in z zastaranjem pridobljenih pravic. Zato sta oba vodilna gozdarja in pozneje še drugo gozdarsko osebje proti podložnikom nastopali zelo strogo. Gornjegrajskemu upravnemu uradu kot oblastni instanci so prijavili množico njihovih prekrškov, izstavili nekaj sto ovadb; o vseh prestopkih so poročali tudi Notranjeavstrijskemu guberniju v Gradcu. Upravnik vsega gornjegrajskega gospostva, ki je bilo hkrati gospodarsko podjetje in upravna, sodna, policijska in naborna oblast, je bil hkrati gospodarstvenik in izprašan sodnik. Bil je gozdarskim novotarijam načelno naklonjen, vendar je moral v tedanjem času, ko je fevdalni red že prehajal v zaton, kot predstavnik oblasti in omenjene administracije državnih posestev skrbeti, da se stalno tleča nasprotja med gospostvom in podložniki ne bi še bolj razmahnila. Zato je od velikega števila ovadb bilo obravnavanih le malo, kar gozdarskemu osebju seveda ni ustrezalo. Gozdarji so vse dotlej običajne postopke v gozdovih in na pašnikih kot so podiranje drevja brez odkazila, krajo drevja nasploh in ob prodaji na panju, obsekavanje drevja za vejnik, grabljenje stelje, sekanje drevja ob meji s pašniki, da so te lahko širili, pašo živine in svinj v gozdovih brez soglasja itd. šteli za hude prestopke. Servitutne pravice in zastaralne pravice so bile na gospostvu nerazrešljivo zapletene. Meje med gospostvenimi in podložniškimi zemljišči niso bile urejene. Meje med štajersko deželo, kjer je ležalo gospostvo in Kranjsko in Koroško niso bile natančno določene. Pri tem ni šlo za nekaj arov, ampak za nekaj sto hektarov.

Gozdarji so osporavali pravico podložnikov do oskrbe z lesom iz gospostvenih gozdov in so zahtevali, da se ti prvenstveno oskrbujejo iz svojih gozdov in iz skupnih (gmajnskih) gozdov (ki pa jih na tem območju ni bilo veliko), in če bi se tam ne mogli, bi šele imeli pravico do neke skromne oskrbe iz gospostvenih gozdov. Ta

[62] Historische Waldungsbeschreibung, 142 v bis 144 r.

pogoj pa nikjer ni bil zapisan. Taka presoja tudi ni bila izvedljiva, ker niti vsi gospostveni gozdovi, kaj šele podložniški in skupni niso bili geodetsko izmerjeni, niti ni bila v njih ocenjena lesna zaloga. Separacije gozdov - dodelitve določene površine gozdov kot nadomestila za servitutne pravice podložnikov v njih, tako rekoč niso načenjali. Pri pašnikih so zahtevali, da se odpravi zakup in uvede vsakoletna prijava števila živine za določeni pašnik. O številu bi seveda odločali gozdni uradniki. Vseh problemov, ki so vzniknili ob teh novotarijah v tem povzetku sploh ne moremo obravnavati.

Pač pa je bila zelo upravičena kritika gozdarjev nad predajo lova in ribolova v zakup, ker so bili dohodki gospostva od njega bistveno prenizki in je tak način šel tudi v škodo staleža divjadi in rib. Predlagali so gospodarjenje v lastni režiji, ki bi bilo bistveno bolj donosno. Lovsko čuvajstvo pa bi gozdarsko osebje lahko opravljalo hkrati s svojimi obhodi terena. Tak sistem so uvajala tudi nekatera gospostva na Koroškem.

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The introduction of decorative bulbs in Slovenia

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ABSTRACT

This paper presens a comparative study of the introduction of the tulip in Slovenia and in Europe. The method is based on the investigation of archival material, provincial chronicles, and descriptive accounts. The goal of the research is to establish as precisely as possible the structure and form of gardens where decorative bulbs were planted, the habits of the owners of such gardens, and their relationships with each other. The second part of the research paper will present a comparison of the types of tulips found in Slovenian and foreign gardens in the 17th century. At the centre of the research project is the assortment of tulips from the park at Castle Lisičje, the first and most extensive collection of tulips in Slovenia dating from the mid-17th century. On the basis of comparisons with contemporaneous foreign tulip collections, we evaluated the collections in terms of the origin of various types and provide a description of prevailing social and economic factors. On the basis of the evaluation of this collection, it is possible to strongly support the hypothesis that the introduction of decorative bulbs (and particularly tulips) in Slovenia did not lag far behind the rest of Europe.

Key words: Landscape architecture, history, decorative bulbs, tulip, introduction

IZVLEČEK

INTRODUKCIJA OKRASNIH ČEBULNIC NA SLOVENSKO OZEMLJE

V prispevku je predstavljena raziskava o introdukciji tulipana na slovensko ozemlje in umestitev slovenske introdukcije v evropski okvir. Raziskava temelji na proučevanju arhivskega gradiva in deželnih kronik z namenom opredeliti strukturo in obliko prvih nasadov okrasnih čebulnic, kje in kdo jih je gojil, ter povezave med lastniki vrtov. V drugem delu raziskave je izdelana primerjava med domačimi in tujimi sortimenti tulipanov iz 17. stoletja. Kot najpomembnejši je predstavljen sortiment tulipanov iz parka gradu Lisičje (prva in najobsežnejša kolekcija tulipanov v sredini 17. stoletja na Slovenskem). Izdelan je bil popis sort tulipanov iz tega vrta. Na podlagi primerjave s tujimi sočasnimi zbirkami tulipanov je bila popisana zbirka ovrednotena glede na poreklo oz. izvor sort, sodobnost in ekonomski vidik. Na podlagi omenjenega vrednotenja zbirke je moč potrditi uvodoma postavljeno hipotezo, da introdukcija okrasnih čebulnic (tulipanov) na slovensko ozemlje časovno ni bila v zaostanku glede na ostale evropske dežele.

Ključne besede: krajinska arhitektura, zgodovina, okrasne čebulnice, tulipani, introdukcija

1 INTRODUCTION

Definition of Theme

From their first introduction in Slovenia until the present, decorative bulbs have been popular above all because of the visual appearance of the flower. However, their value has not always rested on appearance alone. In the 16th and 17th centuries, possession of such bulbs indicated a certain social status. By the end of the 17th century, the perceived financial value of decorative bulbs led to an economic surge that ended with the market euphoria known as tulip mania (Garber, 2000; Chancellor, 1999). Facts about the introduction, expansion, and economic significance of decorative bulbs in the world, or more specifically in Western Europe, are well known (Missel, 2008; Moggach, 1999; Pavord, 1999; Proctor, 1998), while their early introduction into Slovenian territory is much less researched.

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2 MATERIAL AND WORK METHOD

In terms of assortment, dissemination, and economic value, tulips, among all the decorative bulbs, played a special role in both Europe and Slovenia. Because of the many impacts, not least social, of the introduction of the tulip in Europe (tulip mania), this research paper focuses particularly on this type of bulb.

As a result of the recent discovery of new material, extensive new research has been done using primary source data (accessible archival data). This paper presents a comparative study of the introduction of the tulip in Slovenia and in Europe based on this new data. The first part of the research analyses the social factors that created conditions for the introduction of tulips and other decorative bulbs in Slovenia as well as their dissemination and use. This paper will answer the following research questions:

- what were the reasons underlying the introduction of decorative bulbs in Slovenia,
- when, how, and in what quantity did decorative bulbs arrive in Slovenia,
- who first introduced decorative bulbs in Slovenia and where.

The work method is based on the investigation of archival material (the Franciscan cadastral register, the main book of names, probate lists of nobility, estate records, collections of plans and manuscripts) and on the investigation of provincial chronicles and descriptive accounts (for example, the chronicles of Valvasor and Vischer). The goal of the research is to establish as precisely as possible the structure and form of gardens where decorative bulbs were planted, the habits of the owners of such gardens, and their relationships with each other.

The second part of the research paper presents a comparison of the types of tulips found in Slovenian and foreign gardens in the 17th century. Some of the same data used in the first part of the study (inventories of plant types in the first gardens and collections of decorative bulbs in individual parks in Slovenia – Lisičje, Castle Brdo pri Kranju, Dol pri Ljubljani) will be supplemented in the second part by the inventories of similar collections in Western Europe (in the Netherlands, Germany, Italy, and France). The majority of data for Slovenia was found among the archival material of manor houses and in provincial chronicles (Valvasor, 1689, and Vischer, 1681). Data about the extent and structure of decorative bulb collections in Europe were found in Dutch (Wageningen UR Library, Wageningen; Stichting Het Nederlandsch Economisch-Historisch Archief, Amsterdam), American (Norton Simon Museum of Art, Pasadena; ASU Libraries, Arizona State University), and German archives.

At the centre of the research project is the assortment of tulips from the park at Castle Lisičje, the first and most extensive collection of tulips in Slovenia dating from the mid-17th century. An inventory of the types of tulips used in this garden was well documented. On the basis of comparisons with contemporaneous foreign tulip collections, we evaluate the collections in terms of the origin of various types and provide a description of prevailing social and economic factors.

3 RESULTS AND DISCUSSION

2.1 Overview of Historical Sources

In terms of research from archival sources, an important part of the results derive from the discovery of rare entries in various documents.

Western European Sources

Special Collections of Wageningen UR Library

Register van de prijsen der bloemen, zijnde de derde samen-spraeck, tusschen Gaergoed ende Waermond, inhoudende het vervolgh van den op ende ondergangh van flora / [door Adriaen Roman], [1e dr.] - Haerlem : Adriaen Roman, 1637.

Document comprising 24 pages; listed on pages numbered 6, 7, 8, and 9 are 194 various prices for different tulips. The tulip with the highest price was named Audernaede (5,700 guldens), the least expensive was the Rattebeet tulip (30 guldens).

Samen-spraeck, tusschen Waermondt ende Gaergoedt, nopende de opkomste ende ondergangh van flora / Adriaen Roman, [1e] dr. - Haerlem : Adriaen Roman, 1637.

Document comprising 24 pages; listed on pages numbered 11, 12, and 13 are 131 types of tulips that were present on the Netherlands market in 1637; quoted on pages numbered 24 and 25 are the prices for selected tulips.

Tweede samen-spraeck tusschen Waermondt ende Gaergoedt, zijnde het vervolgh van den op ende ondergangh van Flora / Adriaen Roman, Haerlem, 1637.

Document comprising 24 pages; enumerated on page 5 are 25 kinds of tulips with their prices.

Lijste van eenighe tulpaen : verkocht aen de meest-biedende op den 5 Februarij 1637 : op de sael van de Nieuwe Schutters Doelen, int bywesen van de E. Heeren Wees-meesteren ende voochden, ghecoomen van Wouter Bartelmiesz. Winckel, in sijn leven casteleyn van de Oude Schutters Doelen tot Alckmaer, [Alckmaer : s.n.], 1637.

This document is one page long. It is a leaflet offering 101 tulips. The prices range between 51 guldens for a

tulip called Ian Gerritz and 4,200 guldens for the Viseroy.
Dood-rolle ende groef-maal van Floortie-Floraas / I. Soet, 1636.
This document is one page long. The author of the text is I. Soet; 139 tulips are listed.

Troost-brief, aen alle bedroefde Bloemmisten, die treuren over 't sterven of 't overlijden van Flora, Goddinne der Floristen.

Document comprising 24 pages. The pages numbered 22, 23, and 24 feature a sales offer for tulips (similar to the document *Listje van eenighe tulpaen*).

There are approximately 43 known books (manuscripts) about tulips. The majority (34) of these emerged from the Netherlands in the first half of the 17th century. Among the most important of these are as follows:

Cos, P. (1637) The Tulip Book
Verzameling van een meenigte tulipaanen, naar het leven geteekend met hunne naamen, en swaarte der bollen, zoo als die publicq verkogt zijn, te Haarlem in den jaare A. 1637, door P. Cos, bloemist te Haarlem. - Haarlem : [s.n.], 1637. - 75 pl.
This book is comprised of sections from a larger collection (Krelage Collection, Wageningen). The manuscript features 54 illustrations of tulips made in gouache, and an appendix with 12 additional illustrations of tulips and 9 watercolours of other plants. The illustrators are Pieter Holsteijn the Younger and Peter Schangen. Most of the names of the tulips are written below the illustration. At some later point, prices and weights were added (weight expressed in 'aasen' which equals 0.048 grams). The prices are comparable to those called at a February 5, 1637 auction in Alkmaaron.

Bijzondere Collecties NEHA,Tulpen, Signatuur Bijzondere Collecties 254, Periode 1630-1639, Stichting Het Nederlandsch Economisch-Historisch Archief, Amsterdam.
Document comprising 116 pages on which are featured the image of various plants. Watercolours of tulips appear on 75 of these pages (29 of which are unnamed). There is a register of names in the appendix.

Slovenian Sources
Provincial chronicles
Valvasor V. 1689. Die Ehre des Herzogthums Krain, 3. Band. Rudolfswerth, J. Krajec: 730 pages. From page 173 to 179, Valvasor describes an extensive collection of exogenous plants in the park of the Castle Lisičje pri Ljubljani. Special emphasis is given to tulips. The following varieties of decorative bulbs appear in the description: anemone (simple, 15 types), double anemone (double, more than 20 types), ranunculus (simple, many types), irises (various types), double white lilies (double, two types), golden lily (also Turkish bouquet), fritillaria (three types), tulips (107 different types).

Vischer G.M. 1971. Topographia Ducatas Stiriae. Ljubljana, 1971, Cankarjeva Založba: 540 pages.

Archival sources
Dol Estate Records, Manuscript Collection, manuscript 203, Archives of the Republic of Slovenia.
Title: Annalen des Gartens zu Lustall für das Jahr 1840
Author: Henrik Freyer

61 pages on which are enumerated all the work and directives for the maintenance of the park as well as a description of the various plants that are grown in the garden. Bulbs from Holland are also featured as are hyacinths (*Hyacinthus*), tulips (*Tulipa*), anemones (*anemone coronaria*), runuculus (*Ranunculus asiaticus*), and various daffodils (*Narcissus*).

Zois Collection, fascicule 19, Archives of the Republic of Slovenia
Contains a list of plants that Karel Zois obtained from the Netherlands (Mellung aus Holland); tulips are among the plants mentioned.

Zois Collection, fascicule 13, Archives of the Republic of Slovenia
Contains garden inventory for the botanical park at Brdo pri Kranju. Information from the years 1792, 1793, 1799, 1834, and 1835 has been preserved.

2.2 The Introduction of Tulips in Europe
Records indicate that tulips were raised in Turkey even before the year 1000 (Time Table for Tulip, 2008). There are poems by Omar Khayyam from the 12th century about the tulip, and a century later poems by Rumi that celebrate the tulip. According to Hall (1940:6), the original name for tulip (*lale*) appears for the first time in Persian literary texts by Omar Khayyam (dated 1123) and Hafiz (dated 1390). This is the word still used for tulip in the Persian and Turkish languages today. During the time of Suleiman II's reign (1522-1566), there was an extraordinary enthusiasm for growing tulips in Turkey. Exotic plants were also of great interest to A.G. Busbequiis (sy. Busbeq), the ambassador of the Austrian Emperor Ferdinand I to the Ottoman Empire. He documented his observations in the 1554 book entitled *The Four Epistles of A.G. Busbequiis* (Missel, 2008). It is clear from his 1554 Constantinople travel journal that he sent or brought back to Vienna with him the first bulbs. However, Hall (1940:6) allows for the possibility that the first introduction of tulips to Vienna came even before

Busbequiis. The first visual image of the tulip can be found in 1561 in a book by C. Gesner. In 1568, we find a Dutch portrait of a tulip in a book by R. Dodoens 'Cruydtboeck' (Herbal). Ten years later the first tulip appears in England and a decade after that, in France (Time Table for Tulip, 2008).

Most botanical types of tulips come from Central Asia, the northern Caucuses, Persia, Turkistan, and Bukhara. The first tulips introduced in Europe came from the *T. gesneriana* group, which, during Busbequiis' time, were cultivated in Turkish gardens. Bailey (1950:215) states that Gesner saw his first tulip in Augsburg in 1559. On the basis of his descriptions of the flower, we can conclude that it came from the *T. gesneriana* group. Not only Bailey (1950:3395), but Hall (1990:94) also suspects that contemporary tulips came from the *T. gesneriana* group. Linnee combines all garden tulips under this name. Tulips in this group include those that Europeans have been growing in their gardens for two hundred years, and before the Europeans, Turks (though more precise data about such tulips is difficult to find). Interest in this type of plant led to the discovery of autochthonous types and caused their near extinction in the natural environment. Some sources claim that the original *T. suaveolons* was discovered in southern Europe, though that it is truly autochthonous to this region has been questioned (it may have spread in the wild after the first foreign introduction). The first records that make reference to tulips brought from Turkey speak of fragrant, early blooming flowers with drooping stems that would seem to be a perfect description of *T. suaveolons*. On the first images (lithographs), we do not see tulips with rounded petals (Pena and Lobel, 1570; Clusius, 1576; Dodoens, 1578; Besler, 1613). Bailey (1950:3394) concludes his thoughts about the original types with the notion that late-blooming tulips came from the *T. gesneriana* group and early-blooming tulips from *T. suaveolons* (Duc van Thol). With the cross-breeding of tulips, the number and variety of tulip types greatly increased. Even before tulip mania, Dutch growers used selection to raise tulips with the pointed and rounded petals which even today are the most treasured feature of the tulip. The wide variety of shape and colour is apparent in Besler's collection of 53 coloured lithographs (Hortus Eystettensis) and the book entitled *Cruydtboeck* in which Matthias de l'Obel describes 41 varieties of tulips.

One person named Carolus Clusius was decisive for the introduction of the tulip into Europe when he planted the first tulip bulb in the Leiden botanical garden in the Netherlands (Time Table for Tulips, 2008). He wrote and published numerous botanical works of which *Historia stirpium per Pannonium* (1583) was important for Slovenia. The work comprises a study of Austrian and Hungarian flora that Clusius researched while managing the construction of the Viennese garden of medicinal plants. He described about 34 variegated early tulips and some later types, all of them being part of the *T. sylvestris* group (Missel, 2008). In 1592, he accepted an invitation to Leiden and took the position of head gardener in the botanical garden. He was assisted in his work by Dirck Outgaerzoon Cluyts, also known by the name Clutius (Hyams, 1961). He cultivated a number of tulips in his garden and carefully kept them to himself. Tulip admirers who didn't want to pay a lot of money for seed material simply stole them from Clusius. By this time, tulips had spread through the Netherlands and the price had risen. Clusius also introduced the tulip to England (around 1577) where they remained in fashion until the beginning of the 18th century when they were supplanted by foreign trees (Bailey, 1950). Matteo Caccini was another important figure for the wider dissemination of the tulip throughout Europe, sending out a variety of tulips (Tulipa saxatilis, Tulipa chrysantha, Tulipa clusiana) as well as pictures of rarer types from his garden (Masson, 1972: 74). Caccini closely collaborated with Francesco Caetani. Caetani's manuscripts published around 1630 refer to parcels of bulbs from Constantinople, Paris, Avignon, Brussels, Amsterdam, Vienna, and Frankfurt. The bulbs were intended for the Cisterna gardens (Masson, 1972: 182). Caccini raised approximately 15,000 tulips and 29,000 anemones in his garden (Schnapper, 1991: 176). It is clear from Caetani's correspondence that he traded samples with various representatives of society (merchants, nobles, and monks). From his correspondence, we are able to follow the names of people with whom he exchanged plants and bulbs (Caccini, Charles d'Arenberg, Acquaviva, Sweerts, and Bartolotti).

As early as 1600, an extensive range of tulips was being cultivated south of Haarlem (Wagenweg, Kleine Houtweg). In 1612, Emanuel Sweerts published the first sales catalogue of tulips. Tulip mania (1626-1637) came soon after. By 1661, approximately 120 different tulips were recorded (Branderberg). But tulip mania was not limited to Europe. Between 1700 and 1730, a similar fever seized Turkey then under the reign of Mohammed Lalizar, a great tulip enthusiast who imported a large quantity of tulips into Turkey from the Netherlands. The high price of tulips and the rich buyers encouraged the publication of a number of high-quality catalogues for which the illustrations were done by well-known artists such as Pieter Holsteijn the Younger, Peter Schangen, and Jacob Marrel (Missel, 2008).

During the 18th century, the fame of tulips slowly faded and hyacinths took their place. During that same century, tulips were introduced to America. (J.B. der

Scoot was one of the first travelling merchants selling decorative bulbs).

2.3 The Introduction of Tulips to Slovenian Lands

The first data about the planting of tulips in Slovenia dates back to 1689 when Valvasor (1689: 174) described the collection of non-indigenous plants at the castle park at Lisičje pri Škofljici in his book *Die Ehre des Herzogthums Krain*. Slovenian lands were under a strong Italian influence during the Renaissance. Builders and artists in Slovenia worked to introduce novelties in structural and garden architecture as well as in plantings. The reasons for the introduction of various plants can be attributed to the imitation of Italian fashion, which also dictated the rising trend of flowering bulbs (Masson, 1972: 180). We also find proof of the connection with Italian cultivators in the Italian names of many types of tulips in the Slovenian lexicon. An analysis of the assortment of tulips in 17th century European collections indicates that tulips came not only from Italy, but also from Germany and the Netherlands. The participation of Slovenian lands in the Spanish-Dutch wars was an important factor in creating a connection between Slovenian lands and the Netherlands in the 16th century. At that time, the Netherlands united with Belgium and parts of northern France to create the so-called Low Countries which were especially known for the cultivation of tulips. We discover in Valvasor's inventory that the owner of Lisičje Castle, Lenart Merharič Fabjanič, served in the military in the Netherlands for twenty-four years. During his years there, he brought home many decorative bulbs. According to statements of Valvasor, his son Lenart (Leonard) Fabjanič gave the castle garden with a second blossoming. Valvasor's pictorial representation of the castle garden is from this period (Valvasor, 1689: 173). That the owner of the tulip collection, Lenard Merharič Fabjanič, was an educated man and fervent botanist is also evident from the testimonies that Valvasor made about his many non-indiginous plants. In addition, Fabjanič's castle contained botanical records by other important writers, above all Clusius, Bauhin, and D. Jacobi Theodor Tabernaemontani in which tulips are divided into groups. Fabjanič also had contact with German lands through the Berlin professor and doctor Henrik Munting. In the Lisičje Castle records, Valvasor stumbled across an extensive inventory of tulips available in Germany that were cultivated by Munting and represent an important source of study of tulip varieties from the 17th century (Valvasor, 1689: 176). The collecting period at Lisičje Castle ended in 1710 with the death of its last owner, Ernest Engelhart, the grandson of Lenart (Leonard) Merharič Fabjanič (Smole, 1982: 257).

Presented below is an inventory of tulips translated from Valvasor's original text. It is necessary to emphasize the complexity that arises from the names of the various bulbs. The author himself warns the reader of this, noting that the same type of tulip may have many names depending on the individual language of the nation from which it came. In 1689, there are 107 types of tulips in the Lisičje collection:

***Table 1**: Presence of tulips from Lisičje in European collections.*

Admiral von Gent	Admiral del mar	Africana
Agata	Amoraglio Deman	Alagrand Groll
Agata marlin	Agata Giocosea	Agata d'Rampar
Amadis	Angles	Apollo
Arateur	Aria	Armida
Assure	Aurora Celeste	Bella Helena
Bella d'Ramar	Brabantea	Bella d'Brussel Costante
Bella d'Brussel	Vagabunda	Bagina
Bauger	Ballada d'Olanda	Blanc Bichot
Beleonberg	Bella Diana	Bella Sylvia
Bellina	Belvedere	Blumashe
Cardinale Costante	Cardinal Vagabondo	Cittadella Cornart
Corno di Cervo	Cistenmoher	Cyrus
Duste	Don Diego	Dulsina
Clairmond	Cesar d' Marans	Doclman
Florida Doman	Gabriel	Gial Holandia
Gial Monde	Grand Duce	Magnifeur
Maller	Ottoman Paragon Costante	Palamedes
Semper Augustus	Tragena	Echomede
Emphemerides	Euphrosyne	Foret
Gial Doman	Grand Duc d'Fiorenz	Gial Blucart
Gial Alagrand	Gial Holandia	Gail Horlat
Giallo Coronato	Gatta Biatana	Giallo Rosso
Jacosa	Liste	Lydias Bizar
Lacle Bleionberge	Marstion Superbe	Monsuest
Marent Starcluit	Molsuich	Meliaris
Orgelosa	Paraches Raiselle	Perfetta
Pussart	Pastor Fido	Piccardo
Portuges	Purpur Foret	Purpurea Bianco Obscura
Pypinis	Romana	Rex
Ratevul	Rottan	Solo Regal
Senateur Sollicitant	Spigelle	Salamelech
Sol	Tornei Delphin	Triumphante
Veste Diana	Vilana	Vice-re d'Ingil-terra
Zystenmacher		

Comparison of Slovenian and European collections of tulips.
Featured in the table below are data about the 107 tulips cultivated at Lisičje Castle that appear in individual European collections.

Vir (zbirka)	leto	poreklo (država, kraj)	zastopanost sort (št.)
Lisičje (sinonimi)	1689	Slovenija (Ljubljana)	107
Elsholstius	1689	Nemčija (Berlin)	23
The Tulip Book P.Cos	1637	Nizozemska Haarlem	14
Bijzondere Collecties NEHA	1628	Nizozemska Amsterdam	7
Register Tulpen der Blumen	1637	Nizozemska Haarlem	4
Lijste van eenighe tulpaen	1637	Nizozemska	4
Floortie-floraas	1636	Nizozemska	5

The particular assortment of tulips from the Lisičje gardens is most similar to Berlin assortments. Both collections (Lisičje and Berlin) overlap over a period of time (of the 107 tulip types cultivated at Lisičje, 23 types appear in the Berlin inventory). We can also find many types of tulips cultivated in Lisičje in various Dutch sales catalogues (34 types). Most come from Haarlem, a region of Amsterdam which was one of the largest tulip centres in Europe.

The table below shows the presence of Lisičje tulips in other European countries. The table shows in which European countries the same types of tulips were cultivated as at Lisičje, what types they were and how often they appeared in individual countries (the number of foreign collections where we have recorded individual tulips types from Lisičje).

***Table 2**: Presence of tulips from Lisičje gardens in contemporaneous European collections (Germany, the Netherlands).*

Sorta (Slovenija, Lisičje)	Nemčija (št.)	Nizozemska (št.)	Skupno (št.)
Barbanson	1	2	3
Bella Helena	1	1	2
Olinda	1	4	5
Blijenburgher	1	4	5
Cornart	1	4	5
Semper Augustus	1	1	2
Giallo Rosso	1	1	2
Jacosa	1	2	3
Giallo Coronato	1	2	3
Lacle Bleionberge	1	2	3
Bella d'Brussel Vagabunda	1	-	1
Bauger	-	1	1
Bella Diana	1	-	1
Bella Sylvia	1	-	1
Belvedere	1	-	1
Cittadella	1	-	1
Cesar d'Marans	-	1	1
Gabriel	1	-	1
Grand duc d'Fiorenz	1	-	1
Molsuich	-	1	1
Portuges	1	-	1
Africana	1		1
Agata	-	1	1
Agata Marlin	-	1	1
Agata d'Rampar	-	1	1
Bella d'Brussel Constance	1	-	1
Spigelle	1	-	1
Admiral de Mann	1	1	2
Veste Diana	1	-	1
skupaj	**23**	**34**	**57**

We can also make conclusions about the origins of specific tulips by their names. In Valvasor's inventory, there are 30 tulips with Italian names (Amoraglio deman, Agata Giocosea, Bellina, Cardinal Vagabondo, Cittadella, Corno di Cervo, Gial monde, Gial Holandia, Gial doman, Giallo coronato, Gatta Biatana, Giallo rosso, Perfetta, Orgelosa...), many with French names (Agata d'Rampar, Clairmond, Cesar d'Marans, Emphemerides, Foret, Grand Duc d'Fiorenz, Marstion Superbe, Meliaris, Triumphante, Pussart, Senateur Sollicitant, Paraches Raiselle...), German names (Admiral von Gent., Bauger, Cistenmoher, Maller, Spigelle, Salamelech, Veste Diana, Zystenmacher...), and most of all Dutch names (Lacle Bleionberge, Monsuest, Marent Starcluit...). Descriptions of collections from that time also allow us to identify the most valuable type of tulips, namely Semper Augustus, the price of which reached astronomical levels on the

European market. In 1624, it was necessary to part with 3,000 guilders for a single bulb (1 guilder = approximately 6 grams of gold). The following list of items should give an idea of what that amount of money could buy at the time: two loads of wheat, four loads of rye, four fate oxen, five swine, twelve sheep, two hogsheads of wine, four barrels of beer, two barrels of butter, a thousand pounds of cheese, one complete bed, one suit of clothes, one silver tankard and one sizeable wagon to haul it all away! How much the owner of Lisičje spent for his collection remains unknown.

In the 17th century, the most highly-regarded tulips were those with multi-coloured blossoms (broken tulips) of which the variegated colour was a result of the introduction of a viral infection rather than a morphological cause. Tulips with single-coloured flowers were considerably less appreciated and therefore less expensive. Analysing the assortment of tulips at the Lisičje Castle gardens, we conclude that it had representatives from the three major groups into which tulips were categorized during the 17th century in accordance with their colour. Prices were also included in some inventories of tulips from the era. Not only were the countries comparable, but the two primary currencies of the time had comparable values (German guldens and Dutch guilders).

If we compare the purchase price of tulips at Lisičje (Valvasor, 1689: 174-175) with those of foreign suppliers, we conclude that they were considerably lower. This is due to the fact that, as a result of the wider cultivation of tulips in the second half of the 17th century, prices had already fallen. Among the most expensive tulips in the Lisičje collection (over 1,000 guldens) were Semper Augustus, Cornart, Brabantea, Giallo Coronato. These were followed by Lacle Bleionberge, Torneo Delphin, Ottoman Paragon Costante, Ballada d'Olanda (between 200 and 600 guldens) and by Perfetta, Aurora Celeste, Bella Sylvia which were the least expensive (under 200 guldens).

4 CONCLUSION

Facts about the introduction, dissemination, and economic significance of decorative bulbs in the world, and more precisely in larger European countries, are well-known (Missel, 2008; Moggach, 1999; Pavord, 1999; Proctor, 1998). In contrast, the early introduction of decorative bulbs in Slovenia is poorly researched. Research was conducted into the first introduction of geofits in Slovenian territory. The principle method of acquiring necessary data is based on the study of domestic archival material, provincial chronicles, and descriptive accounts of the countryside (specifically Valvasor's and Vischer's chronicles) as well as foreign archival sources.

It has been concluded that the first and most extensive collection of tulips on Slovenian territory was in the mid-17th century at the Lisičje Castle park, which contained more than 107 varieties. On the basis of studies of foreign tulip collections, the Slovenian collection is comparable with others, given the origins, contemporaneity, and economic aspects of tulips in the collection.

Of the 107 sorts cultivated in Lisičje, twenty-three kinds were from German lands (mostly from Berlin) and thirty-four were from the Netherlands (Haarlem). There were also many samples in the collection without a known supply source. The origins of these tulips were determined according to their name. In the inventory made by Valvasor, most of these were from Dutch sources, many from French and German sources, and some thirty from Italian sources.

As far as the economic value of the Lisičje gardens derived from the purchase prices of Lisičje tulips (Valvasor, 1689; 174-175) from foreign suppliers, we conclude that the prices were lower when the collection was made. This can be explained by the fact that the increased cultivation of tulips in Slovenia took place in the second half of the 17th century when the price of tulips had already fallen in Europe. Nevertheless, the economic value of the Lisičje gardens was extraordinary given the social circumstances in Slovenia at the time.

They were clearly ties between Slovenia and Dutch, German, and Italian suppliers of tulips. In establishing these links between foreign and Slovenian lands, we note three important factors. In the 16th century, the connection between Slovenian lands and the Netherlands had been enhanced because of the participation of Slovenians in the Spanish-Dutch war. Leonhard Merherič, the owner of Lisičje Castle and the father of the tulip collector Leonhard Merherič Fabjanič, had worked as a mercenary soldier in this war for twenty-four years. He was one of the first to bring tulip bulbs from the Netherlands to Slovenia.

The son of the abovementioned owner of Lisičje castle made contact with German lands through the Berlin professor and doctor Henrik Munting, whose inventory

of tulips was discovered in Lisičje by Valvasor (Valvasor, 1689: 176).

We can assume that the reason for the introduction of bulbs from Italy had to do with following Italian fashion and methods in cultivating flowering bulbs. Indirect evidence of a link to Italian cultivators can be found in the Italian names of many sorts of tulips in Slovenia.

We can explain the size of the tulip collection at Lisičje gardens with the popularity of tulips at the time, the same factors that led to their dissemination throughout Europe and wider access to them in general. On the basis of the evaluation of this collection, it is possible to strongly support the hypothesis that the introduction of decorative bulbs (and particularly tulips) in Slovenian lands did not lag far behind the rest of Europe.

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CONTENT ANALYSIS OF THE PAPERS IN THE ACTA AGRICULTURAE SLOVENICA
VSEBINSKA OBDELAVA PRISPEVKOV V ACTA AGRICULTURAE SLOVENICA let. 93 št. 1

Tomaž BARTOL[a], Karmen STOPAR[b],

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PREDMETNO KAZALO PO DESKRIPTORJIH AGROVOC

[a] Jamnikarjeva 101, SI-1000 Ljubljana, P. O. Box 95
[b] ibid.

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VSEBINSKO KAZALO PO SKUPINAH ZNANJA (PREDMETNIH KATEGORIJAH)

NAVODILA AVTORJEM

Prispevki

Sprejemamo izvirne znanstvene članke, predhodne objave in raziskovalne notice s področja agronomije, hortikulture, rastlinske biotehnologije, raziskave živil rastlinskega izvora, agrarne ekonomike in informatike ter s sorodnih področij v slovenskem, angleškem in nemškem jeziku, znanstveno pregledne članke samo po poprejšnjem dogovoru. Objavljamo prispevke, podane na simpozijih, ki niso bili v celoti objavljeni v zborniku simpozija. Če je prispevek del diplomske naloge, magistrskega ali doktorskega dela, navedemo to in tudi mentorja na dnu prve strani. Navedbe morajo biti v slovenskem in angleškem jeziku.

Pri prispevkih v slovenskem jeziku morajo biti preglednice, grafikoni, slike in priloge dvojezični, povsod je slovenščina na prvem mestu. Naslovi grafikonov in slik so pod njimi. Slike in grafikoni so v besedilu. Priloženi morajo biti tudi jasno označeni izvirniki slik. Na avtorjevo željo jih vračamo, s tem da je želja pisno sporočena ob oddaji gradiva in ponovno v teku 30 dni po izidu. Latinske izraze pišemo ležeče. V slovenščini uporabljamo decimalno vejico, v angleščini decimalno piko. Prispevki v angleščini morajo imeti povzetek v slovenščini in obratno. Prispevki v nemščini morajo imeti tudi povzetka v slovenščini in angleščini.

Prispevki naj bodo strnjeni, kratki, praviloma največ 12 strani. Uporabljamo Microsoft Word 97 (Windows); pisava Times New Roman, velikost strani 16,2 x 23,5 cm, velikost črk besedila 10, v obsežnih preglednicah je lahko 8; izvlečki in metode dela Arial velikost 8, levi in desni rob 2,1 cm, zgornji rob 1,3 cm, spodnji rob 1,6 cm,

Prva stran

Na prvi strani prispevka na desni strani označimo vrsto prispevka v slovenščini in angleščini, sledi naslov prispevka, pod njim avtorji. Ime avtorjev navedemo v polni obliki (ime in priimek). Vsak avtor naj bo označen z indeksom, ki ga navedemo takoj pod avtorji, in vsebuje polni naslov ustanove ter znanstveni in akademski naslov; vse v jeziku prispevka. Navedemo sedež ustanove, kjer avtor dela. Če je raziskava opravljena drugje, avtor navede tudi sedež te inštitucije. Na željo avtorjev bomo navedli naslov elektronske pošte.

Pod naslovi avtorjev je datum prispetja in datum sprejetja prispevka, ki ostaneta odprta. Sledi razumljiv in poveden izvleček z do 250 besedami. Vsebuje namen in metode dela, rezultate, razpravo in sklepe. Sledijo ključne besede.

Izvlečku v jeziku objave sledi naslov in izvleček s ključnimi besedami v drugem jeziku.

Viri

V besedilu navajamo v oklepaju avtorja in leto objave: (priimek, leto). Če sta avtorja dva, pišemo: (priimek in priimek, leto), če je avtorjev več, pišemo: (priimek in sod., leto). Sekundarni vir označimo z "navedeno v" ali "cv.". Seznam virov je na koncu prispevka, neoštevilčen in v abecednem redu. Vire istega avtorja, objavljene v istem letu, razvrstimo kronološko z a, b, c. Primer: 1997a. Navajanje literature naj bo popolno: pri revijah letnik, leto, številka, strani; pri knjigah kraj, založba, leto, strani. Za naslove revij je dovoljena uradna okrajšava, za okrajšanimi besedami naj bodo vedno pike. Navedbo zaključimo s piko. Za primere upoštevajte objave v Zborniku BFUL.

Oddaja

Avtorji prispevke oddajo v dveh izvodih, enega z dvojnim razmakom med vrsticami in največ 35 vrst na strani, in na disketi. Priložijo tudi izjavo s podpisi vseh avtorjev, da avtorske pravice v celoti odstopajo reviji.

Prispevke recenziramo in lektoriramo. Praviloma pošljemo mnenje prvemu avtorju, po želji lahko tudi drugače. Če uredniki ali recenzenti predlagajo spremembe oz. izboljšave, vrne avtor popravljeno besedilo v 10 dneh v dveh izvodih, enega z dvojnim razmakom. Ko prvi avtor vnese še uredniške pripombe, odda popravljeno besedilo v enem izvodu in na disketi ter vrne izvod z uredniškimi popravki.

Prispevke sprejemamo vse leto.

NOTES FOR AUTHORS

Papers

We publish original scientific papers, preliminary communications and research statements on the subject of agronomy, horticulture, plant biotechnology, food technology of foods of plant origin, agricultural economics and informatics; in Slovenian, English and German languages while scientific reviews are published only upon agreement. Reports presented on conferences that were not published entirely in the conference reports can be published. If the paper is a part of diploma thesis, master of science thesis or dissertation, it should be indicated at the bottom of the front page as well as the name of the supervisor. All notes should be written in Slovenian and English language.

Papers in Slovenian language should have tables, graphs, figures and appendices in both languages, Slovenian language being the first. Titles of graphs and figures are below them. Figures and graphs are part of the text. Clearly marked origins of figures should be added; they can be returned if author desires. Latin expressions are written in italics. Decimal coma is used in Slovenian and decimal point in English. Papers in English should contain abstract in Slovenian and *vice versa*. Papers in German should contain abstracts in German, Slovenian and English.

The papers should be condensed, short and usually should not exceed 12 pages. Microsoft Word 97 (Windows) should be used, fonts Times New Roman, paper size 16.2 x 23.5 cm, font size in main text 10; in large tables size 8 could be used, abstracts and material and methods Arial size 8, right and left margin 2.1 cm, upper margin 1.3 cm and lower margin 1.6 cm.

First page

The type of the paper should be indicated on the first page on the right side in Slovenian and English language following by title of the paper and authors. Full names of authors are used (first name and surname). Each name of the author should have been added an index, which is put immediately after the author(s), and contains address of the institution and academic degree of the author, in the language of the paper. The address of the institution in which the author works is indicated. If the research was realised elsewhere, the author should name the headquarters of the institution. E-mail is optional.

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