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BARK STRIPPING DAMAGE BY RED DEER (*Cervus elaphus* L.) IN THE FENCED REARING CENTRE "LOMNIČKA REKA"

Abstract: Bark stripping damage is a serious problem in some forest hunting grounds in Serbia. This study aimed at assessing the incidence and intensity of bark stripping by red deer in the fenced rearing centre "Lomnička Reka" (Mt. Veliki Jastrebac, central Serbia). The data were collected by detailed surveying of the entire rearing centre over spring and autumn 2008, 2009 and 2010. Our results show that, in spring and summer, it is exclusively broadleaf tree species that are bark stripped by red deer, mainly beech (86.3% or 536 trees) and hornbeam (10.1% or 63 trees). The incidence and intensity of bark stripping were the highest in the diameter class of 20-39.9 *cm*. Damaged trees were identified in all parts of the rearing centre, at all aspects and at different slopes. Beech bark was stripped over the period May-August, with the focus in June or July.

Key words: red deer, beech, bark stripping, reintroduction, Serbia

ШТЕТА ЗБОГ ГУЉЕЊА КОРЕ КОЈУ НАНОСИ ЈЕЛЕН (*Cervus elaphus* L.) У ОГРАЂЕНОМ УЗГАЈАЛИШТУ „ЛОМНИЧКА РЕКА"

Извод: Штета због гуљења коре је озбиљан проблем у неким шумским ловиштима Србије. Циљ истраживања је био да се утврди опсег и интензитет гуљења коре које узрокује јеленска дивљач у ограђеном узгајалишту „Ломничка река" (планина Велики Јастребац, централна Србија). Подаци су колектирани

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детаљним прегледом целог узгајалишта у пролеће и јесен 2008., 2009. и 2010. године. Ови резултати показују да јеленска дивљач у пролеће и лето искључиво гули кору лишћарских врста дрвећа, углавном букве (86,3% или 536 стабала) и граба (10,1% или 63 стабла). Опсег и интензитет гуљења коре су највећи у дебљинској класи од 20-39,9 *cm*. Оштећена стабла су утврђена у свим деловима узгајалишта, на свим експозицијама и различитом нагибу терена. Кора букве је гуљена у периоду мај-август, са тежиштем гуљења у јуну или јулу.

Кључне речи: јелен, буква, гуљење коре, реинтродукција, Србија

1. INTRODUCTION

Red deer (*Cervus elaphus* L.) regularly strips bark of forest trees in many parts of Europe, e.g. Slovenia (Jerina *et al*., 2008), Austria (Vospernik, 2006), Czech Republic (Čermák *et al*., 2004), Slovakia (Rajský *et al*., 2008), Great Britain (Gill *et al*., 2000), Germany (Kiffner *et al*., 2007) and France (Saint-Andrieux *et al*., 2009). Bark stripping damage caused by red deer was identified also in some forest hunting grounds in Serbia, mainly in small fenced areas (game rearing centres) and in fenced parts of hunting grounds (Gačić *et al*., 2006, 2008, Gačić, Danilović, 2009).

Many hypotheses have been proposed aiming at the explanation of the reasons why ungulates remove the tree bark, e.g. the demand for high quantities of mineral substances contained in the bark, the difference in nutritive value between the twigs and the bark, as well as the lack of high-quality food (McIntyre, 1972 cit. after Miquelle, Van Ballenberghe, 1989). Generally, there are two basic hypotheses which try to explain the bark stripping damage (Gill, 1992, Verheyden *et al*., 2006, Saint-Andrieux *et al*., 2009): 1) the value of bark as food; and 2) the use of bark for digestion improvement, to establish the balance in the rumen (maintenance of pH level), or to provide protection from parasites.

By the end of the nineties of the 20th century, by the action of PE "Srbijašume", red deer was reintroduced to the forest complexes in Serbia, south of the Sava and the Danube, to the following localities: "Lomnička Reka" on Mt. Veliki Jastrebac (1997), "Miloševa Voda" on Mt. Sokolovica (1997), "Kumovac" on Mt. Cer (1998), "Valmište" on the fringe of the Vlasina plateau (2000), and also "Bukovik" near Sokobanja (2005).

In the fenced rearing centre "Lomnička Reka", bark stripping damage was detected soon after red deer reintroduction, on 846 trees or 7 tree species, among which the most endangered species were beech (60%) and spruce (36%) (Gačić *et al*., 2006). Subsequent investigations showed that beech bark was removed by red deer only in the rearing centre "Lomnička Reka", especially in maturing and mature stands, which is explained by a pronounced deficiency in pasture areas (2.5 *ha*), but also by the fact that there was no ground vegetation in these stands (Gačić *et al*., 2008). For this reason, the measures were proposed aiming at the damage elimination or significant reduction. The most important

are: harmonisation of the Special Forest Management Plan with the Hunting Plan; establishment of areas under green forage (pastures and meadows), which should be protected (fenced) against wild boar; and the improvement of the existing pasture quality (Gačić, Danilović, 2009, Tomić *et al*., 2009, 2010). The efficiency of the above measures was verified and confirmed in spring and summer 2009, when there was a significantly lower number of damaged trees (*n*=41) compared to spring and summer 2008 (*n*=481) (Gačić *et al*., 2011).

This study aimed at assessing the incidence and intensity of bark stripping by red deer in the fenced rearing centre "Lomnička Reka".

2. MATERIAL AND METHOD

The study area is the game rearing centre "Lomnička Reka" (Figure 2), in the central part of Mt. Veliki Jastrebac (MU "Lomnička Reka"), at the altitude of 530-890 *m*. The area of the fenced rearing centre is 381 *ha*, of which the greatest part is under forest cover (364 ha or 95.5%), and meadows occupy 2.5 *ha* (0.7%). It was established in 1996 by fencing the initial area (≈8.0 *ha*), which was populated by the initial stock of 20 calves (14 ♂ and 6 ♀) (in 1997), followed by three red deer males and a pregnant hind (in 1998). The relief of the rearing centre is broken by frequent alteration of streams, so the slopes are the main terrain features. The bedrock consists of granite. Terrain aspects are predominantly north-west, west and south-west. Mean annual air temperature is 11.5°*C*, and mean annual precipitation is 650 *mm*.

Regular forest inventory in MU "Lomnička Reka" was performed during 2005, and the information on the forest state was taken from the Special Forest Management Plan. High stands account for 64.6% of the total forest area in the rearing centre, and artificial coniferous stands occupy 35.4%. Well-preserved forests occupy 97.3% of the area, and mixed forests 71.7%. The number of tree species identified in the rearing centre is more than 20 tree species, among which beech (*Fagus moesiaca*) is the most dominant in the total volume, followed by spruce (*Picea abies*), Scots pine and Austrian pine (*Pinus sylvestris* and *Pinus nigra*), sessile oak (*Quercus petraea*), birch (*Betula pendula*), Douglas fir (*Pseudotsuga menziesii*), European fir (*Abies alba*), Weymouth pine (*Pinus strobus*), and aspen (*Populus tremula*). The dominant forest categories are high even-aged forests of beech (143 *ha*) and beech and sessile oak (70 *ha*), then high all-aged forests of fir and beech (20 *ha*), and artificially established stands of spruce and Scots pine with naturally regenerated beech (60 *ha*, and 26 *ha* respectively).

Game species reared in the fenced rearing centre are red deer and wild boar. The planned density of red deer "breeding herd" was 50 individuals (13 individuals per 100 *ha*), and 100 wild boars. Spring densities of red deer and wild boar during the study period was lower than the planned density (48 red deer each in 2008 and 2009, and 45 individuals in 2010; 96 wild boars in 2008, 80 wild boars in 2009, and 83 in 2010). The game

diet was analysed based on the data obtained from the professional service of FE "Rasina" - Kruševac (data on production, purchase and consumption of food and medication).

The data were collected by detailed surveying of the entire rearing centre during spring and autumn 2008, 2009 and 2010 (between June 26th and July 2nd, i.e. between November 3rd and 15th). In the subsequent analyses, the data from the first period were marked as spring stripping (April -June), and the data from the second period were denoted as summer stripping (July-Sept). It was only the trees with new wounds (removed bark) on the stems that were recorded and measured each year. The incidence and duration of spring and summer bark stripping were recorded over five subsequent years: 2007 (Feb 20th, April 21st, July 9th and Dec 10th), 2008 (Feb 26th, May 30th, July 7th, Nov 3rd and Dec 8th), 2009 (April 18th, May 7th, May 21st, June 29th and July 9th), 2010 (May 31st) and 2011 (June 25th and Aug 17th).

Bark stripping incidence is presented by the number of damaged trees in the entire rearing centre area. Bark stripping intensity is presented by the size of wounds on individual trees. It is grouped into four categories based on the data reported by Mountford (1997, 2006) and Kuiters *et al*. (2006): 1=limited damage (bark removed at the root swelling); 2=moderate (10-50% of the bark removed); 3=severe (bark removed on >50% of the stem); 4=very severe (ring-barked). The terrain slopes on which the damaged trees occurred were measured by the instrument Vertex 3 (ultrasonic altimeter). Based on the diameter at breast height (DBH), damaged trees were grouped into the following diameter classes: ≤19.9; 20-39.9; 40-59.9; 60-79.9 and ≥80 *cm*. The damaged trees spatial position within the game rearing centre was assessed by the device Magellan Mobile Mapper 6. Statistical analysis was performed using software package Statistica 8. The impact of tree diameter (DBH) and terrain slope on bark stripping intensity was tested using the one-way analysis of variance. The correlation of tree species and bark stripping intensity was tested by Chi-square test.

3. RESULTS

Bark stripping incidence in the fenced rearing centre "Lomnička Reka" is presented in Table 1. The greatest number of damaged trees was detected in spring 2008 (n=463), and the smallest in summer 2009 (n=11). Bark stripping intensity, which is expressed by wound sizes on individual trees, was significantly higher in spring, when there were 192 ring-barked trees ($\bar{x}$=32.0 *cm*, *min-max*=5.0-60.0 *cm*), which accounts for 30.9% of the total number of stem damaged trees. Bark stripping wounds on the trees in the severe and very severe categories (3 and 4) range from the ground level ($\bar{x}$=4.0 *cm*) to the height of 2.6 *m* ($\bar{x}$=178.0 *cm*). Red deer very often remove tree bark over several years (several times). It was found that 10.8% of new wounds were inflicted on the trees already damaged in the severe and very severe categories.

Diameter structure of damaged trees per study years (2008-2010) and damage categories (1-4) are presented in Figure 1. Bark stripping incidence and intensity are

Table 1. Incidence and intensity of bark stripping by red deer
Табела 1. Опсег и интензитет гуљења коре које је узроковала јеленска дивљач

Season Годишње доба	Year Година	Stem damage category Степен оштећења стабла				Total Укупно	
		Limited Слаб (1)	Moderate Умерен (2)	Severe Јак (3)	Very severe Врло јак (4)		
Spring Пролеће	2008	152	60	77	174	463	544
	2009	8	6	11	5	30	
	2010	9	11	18	13	51	
Summer Лето	2008	11	6	1	-	18	77
	2009	2	3	4	2	11	
	2010	23	6	10	9	48	

the highest in the category of medium-diameter trees (20-39.9 *cm*). This diameter class accounts for 48.8% of the total number of stem damaged trees, of which 137 trees are ring-barked, which is 67.5% of the total number of trees in the very severe stem damage category.

Table 2 presents the incidence of bark stripping per tree species. Red deer in spring and summer exclusively remove the bark of broadleaf tree species, primarily beech, and also hornbeam. Beech accounts for 86.3% of the total number of damaged trees, i.e. 536 trees, and hornbeam accounts for 10.1%, i.e. 63 trees. Chi-square test ($\chi 2$) shows that there is a correlation between damage category and tree species ($p<0.001$), and based on the

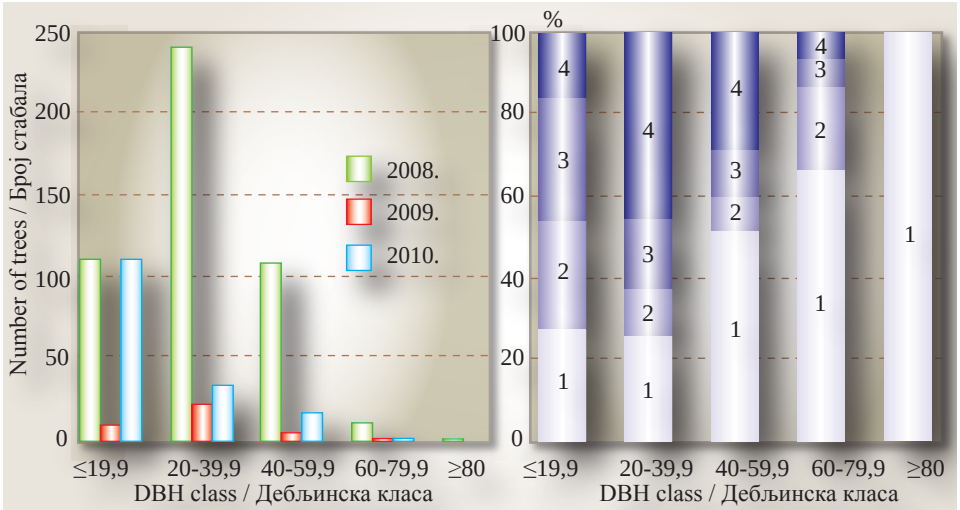

Figure 1. Diametter class distribution of damaged trees per yaer and stem damage catefory
Слика 1. Дистрибуција оштећених стабала по годинама и степену оштећења стабла
Legend/Легенда: 1-Limited/Слаб, 2-Moderate/Умерен, 3-Severe/Јак, 4-Very severe/Врло јак

Table 2. Species composition and number of damaged trees in the fenced rearing centre
Табела 2. Састав врста и број оштећених стабала у ограђеном узгајалишту

Tree species Врста дрвећа	Year / Година					
	2008		2009		2010	
	Spring Пролеће	Summer Лето	Spring Пролеће	Summer Лето	Spring Пролеће	Summer Лето
Deciduous species / Лишћарске врсте						
Fagus moesiaca (K. Maly) Czecz	417	18	25	9	25	42
Carpinus betulus L.	25	-	4	2	26	6
Acer pseudoplatanus L.	2	-	-	-	-	-
Quercus petraea (Matt.) Liebl.	1	-	-	-	-	-
Quercus cerris L.	1	-	-	-	-	-
Prunus avium L.	-	-	1	-	-	-
Corylus colurna L.	1	-	-	-	-	-
OML (Other species)	13	-	-	-	-	-
Coniferous species / Четинарске врсте						
Picea abies (L.) Karst	1	-	-	-	-	
Abies alba Mill.	1	-	-	-	-	-
Pinus nigra Arnold	1	-	-	-	-	-
Total / Укупно	463	18	30	11	51	48

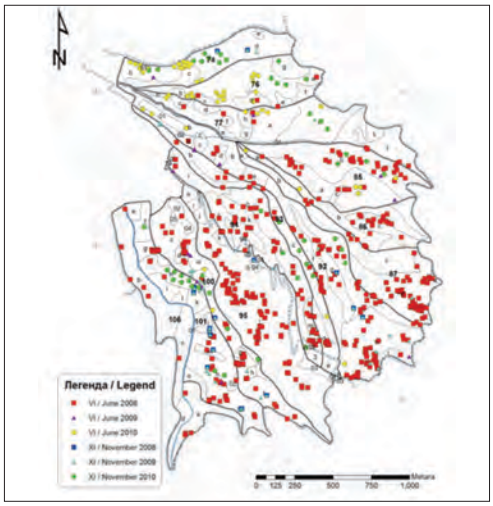

Figure 2. Spatial distribution of damaged trees in the fenced rearing centre "Lomnička reka"

Слика 2. Просторна расподела оштећених стабала у ограђеном узгајалишту „Ломничка река"

value of the coefficient of contingency (0.212), it can be concluded that the correlation is not strong.

Beech bark stripping intensity depends on the tree sizes. One-way analysis of variance of beech diameter at breast height (DBH) and the factor "damage category" shows that there are significant differences in the intensity of bark stripping, i.e. that red deer selectively remove beech bark (p<0.001). Mean diameter of beech trees ($\bar{x}$=SE) in very severe damage category (33.5±0.7 *cm*; n=186) and limited damage category (36.5±1.2 *cm*; n=187) is significantly higher than that of the trees in moderate (28.2±1.8 *cm*; n=68) and severe damage categories (28.4±1.3 *cm*; n=95). During the study period (2007-2010), bark stripping of

Table 3. Type and quantity of food consumed in the fenced rearing centre (Evidence Forest estate "Rasina" - Kruševac)

Табела 3. Врста и количина утрошене хране у ограђеном узгајалишту (евиденција шумског газдинства „Расина" - Крушевац)

Year Година	Type of food Врста хранива	Month / Месец						∑
		IV	V	VI	VII	VIII	IX	*kg*
2008	Maize (corn) / Кукуруз (зрно)	-	400	600	1,800	2,000	800	5,600
	Maize (corncob) Кукуруз (клип)	2,400	1,800	1,500	-	-	1,200	6,900
	Maize (ground) Кукуруз (млевен)	250	150	150	400	200	150	1,300
	Green forage / Зелена храна	1,500	3,000	4,000	3,500	2,000	-	14,000
	Sugar beet / Шећерна репа	-	-	500	500	500	-	1,500
	Hay / Сено	90	50	30	40	80	130	420
	Clover / Детелина	-	-	210	210	-	-	420
	Cattle flour / Сточно брашно	200	300	250	250	250	500	1,750
	Cattle solt / Сточна со	20	25	23	30	33	28	159
2009	Maize (corn) / Кукуруз (зрно)	200	3,500	5,880	4,155	2,550	3,570	19,855
	Maize (corncob) Кукуруз (клип)	1,900	-	-	-	-	-	1,900
	Maize (ground) Кукуруз (млевен)	-	320	-	-	-	-	320
	Green forage / Зелена храна	-	2,400	3,000	3,000	1,800	-	10,200
	Sugar beet / Шећерна репа	550	530	820	2,250	850	400	5,400
	Hay / Сено	600	280	-	-	20	10	910
	Clover / Детелина	-	25	102	165	150	78	520
	Bran / Мекиње	560	60	680	210	900	420	2,830
	Concentrate / Концентрат	1,000	-	730	275	325	-	2,330
	Cattle solt / Сточна со	30	30	25	30	30	40	185
2010	Maize (corn) / Кукуруз (зрно)	3,170	4,050	4,440	3,040	400	-	15,100
	Maize (corncob) / Кукуруз (клип)	-	-	-	-	-	-	-
	Maize (ground) / Кукуруз (млевен)	100	-	-	-	-	-	100
	Green forage / Зелена храна	-	-	2,400	2,400	2,400	-	7,200
	Sugar beet pulp pellets Суви резанци шећерне репе	1,375	950	900	975	950	850	6,000
	Hay / Сено	250	50	-	-	500	80	880
	Bran / Мекиње	140	450	510	420	390	300	2,210
	Concentrate / Концентрат	-	-	60	220	400	400	1,080
	Wheat / Пшеница	-	-	-	-	1,400	1,620	3,020
	Barley / Јечам	-	-	-	-	-	1,640	1,640
	Cattle solt / Сточна со	10	70	-	125	50	60	315

beech trees started by the end of May, and reached the maximum already in June or July. The first beech trees with new stem wounds (removed bark) were detected on June 9th 2007, May 30th 2008, May 21st 2009 and May 31st 2010. There were no beech trees with new stem wounds during the period November-April.

Figure 2 presents the spatial distribution of damaged trees in the fenced rearing centre. The damage caused by bark stripping is non-uniformly distributed throughout the rearing centre area (mainly by groups), on all aspects and different terrain slopes. There were no significant differences (p=0.388) between the terrain slopes and the damage categories. Damaged trees occur, inter alia, on the ridge, near the feeding places, salt lick places and near the meadow, as well as along forest roads and streams.

The data on spring and summer nutrition in the fenced rearing centre are presented in Table 3. Maize and green forage are dominant in the total quantity of consumed food, followed by sugar beet (whole or pulp pellets), bran, concentrate, wheat and barley. The highest quantity of maize was consumed in 2009 (altogether 9,700 *kg* in May and June), which coincides with the lowest incidence of bark stripping damage (30 trees in spring). Conversely, the lowest amount of maize was consumed in 2008 (altogether 4,600 *kg* in May and June), when the largest incidence of damage was recorded (463 trees in spring). The presented data point to the dependence between the consumed food and the incidence of bark stripping damage. This dependence is not readily determined, because the cutting of damaged beech trees in the fenced rearing centre started in 2008 (74d, 76a, g, 77a, i, j, k), and clear cutting of Weymouth pine was performed at two sites (74c, 95k - total 3.60 *ha*), which caused significant changes in nutrition conditions in the fenced rearing centre.

4. DISCUSSION

Selective bark stripping is a widely distributed and well known phenomenon, characterising numerous species of ungulates and rodents. The species in the deer family (Cervidae) selectively strip the bark of forest trees, and the tolerance of each tree species to bark removal is different, causing the reduction in the percentage of species whose bark is frequently removed and which is not resistant to bark removal, and vice versa (Ando et al., 2004).

Bark stripping damage by red deer in forest plantations and stands has become an increasing problem in Serbia, especially in the smaller fenced areas (game rearing centres) and fenced parts of hunting grounds (Gačić *et al*., 2006, 2008, Gačić, Danilović, 2009). In the rearing centres "Lomnička Reka" (Veliki Jastrebac) and "Miloševa Voda" (Sokolovica), the most endangered tree species are those with smooth bark, such as spruce and hornbeam. Beech is at risk only in the rearing centre "Lomnička Reka". Also, depending on the age, the trees of the following species are at risk: Sycamore maple, Norway maple, White ash, Elm, Hazel, Wild cherry, Douglas fir and European fir. Conversely, red deer does not remove the bark of Austrian pine and Scots pine, Weymouth pine,

Birch, Sessile oak and Turkey oak. However, it was found that coniferous bark is mainly damaged during winter and autumn, and that bark stripping incidence and intensity depend greatly on the stand age.

The animals that strip bark of beech trees are: Red deer *Cervus elaphus* (Ueckermann, 1960, Rheinberger, Suter, 2006, Gačić *et al*., 2006, 2008, Saint-Andrieux *et al*., 2009), horse *Equus caballus* (Kuiters *et al*., 2006) and American grey squirrel *Sciurus carolinensis* (Mountford, 1997, 2006). Our results show that in the rearing centre "Lomnička Reka" during spring and summer, Red deer exclusively removed the bark from broadleaf species, primarily beech and hornbeam (86.3% i.e. 10.1% respectively of the total number of damaged trees). Similarly, in the National Park "Veluwezoom" (the Netherlands), it was found that horses most frequently removed bark from broadleaf species, first of all beech, Mountain ash, Sweet chestnut and Hornbeam (Kuiters *et al*., 2006).

The beech bark stripping incidence and intensity depends on the tree sizes. Our results show that Red deer in the rearing centre "Lomnička Reka" most often removed bark from medium-diameter trees (20-39.9 *cm*), wherefore 48.8% of the total number of damaged trees belong to this diameter class, of which 137 trees were ring-barked. Also, according to Kuiters *et al*. (2006), horses show preference to smaller diameter classes (<40 *cm*), especially the trees with smooth bark. This is explained by the fact that bark structure changes with the increased tree age, as in most tree species bark becomes thicker and much more difficult to detach (Gill, 1992).

Beech is at risk of bark stripping during a long time interval, between the ages of 15 and 50 years, and even later on (Ueckermann, 1960). This author reports that beech, as opposed to other tree species is at risk exclusively in spring and summer (between May 20th and Aug 31st, with the focus in July). Saint-Andrieux *et al*. (2009) report that red deer removed beech bark during May-August, with the focus in June or July. Also, our results show that red deer in the rearing centre "Lomnička Reka" started beech bark stripping by the end of May, with the maximum in June or July. Also, previous investigations in this rearing centre (Gačić *et al*., 2006, 2008, Gačić, Danilović, 2009), as well as our study results (Figure 1), confirmed that beech trees in the small fenced areas, even at higher ages (>70 years), could be greatly endangered and damaged by bark stripping.

Some authors (Akashi, Terazawa, 2005) report that the probability of damage by Sika deer (*Cervus nippon*) to some coniferous species (*Larix kaempferi* and *Abies sachalinensis*) decreased with the increase in diameter at breast height. Sika deer removes bark of *Clethra barbinervis* and *Ilex geniculata*, but avoids the species *Fagus crenata* and *Acer shirasawanum* (Ando *et al*., 2003). These authors report that forest tree bark stripping caused by Sika deer was not related to the content of crude proteins, carbohydrates and mineral elements (Ca, Mg, Na, K). However, later researches (Ando *et al*., 2004) show that nutritive value of the bark is lower compared to bamboo (*Sasa nipponica*) foliage, which has high contents of crude proteins and hemicellulose in summer, but an inadequate ratio of mineral elements. This indicates that Sika deer consume bark to establish

the favourable ratio of digestible nutrients in summer and/or to achieve the adequate ratio of mineral elements.

The factors that affect beech bark stripping by red deer were studied in detail in France (Saint-Andrieux *et al*., 2009). These authors report that beech bark contains more water and carbohydrates, and less macro-elements in late spring and summer than during autumn and winter. Bark is more easily detached in summer than during the dormancy period (autumn and winter), which is in correlation with the stripping frequency. It is also reported that both damaged and undamaged beech trees have evidently similar bark chemical composition, which indicates that the trees for bark stripping are randomly selected. Also, the results of our study in the rearing centre "Lomnička Reka" (Figure 2) show that the bark stripping damage was non-uniformly distributed throughout the rearing centre (mainly by groups), at all exposures and at different slope angles.

The fact that horse *Equus caballus* prefers the bark of beech and several other species (Mountain ash and Sweet chestnut) is not explained by the bark mineral composition (Kuiters *et al*., 2006). These authors report that the content of mineral elements in beech bark does not differ significantly from that in other tree species (Mountain ash, Sweet chestnut, Aspen, Common oak and Scots pine). Also, the content of mineral elements in beech bark is almost independent on diameter classes. Therefore, if we want to explain why horses prefer beech bark stripping and select the thinner diameter classes, it can be concluded that, regarding stripping capacity, the bark physical characteristics (diameter and hardness) are much more important than the bark chemical composition. This is confirmed by the results reported by other authors (Saint-Andrieux *et al*., 2009), which report that mechanical properties of bark, especially as it is easily detachable, can stimulate red deer to remove beech bark in summer. In contrast, selective bark stripping of juvenile trees caused by voles (species in the family *Cricetidae*) is explained by the significant differences in the bark chemical composition (Heroldová *et al*., 2009). It is reported that broadleaf bark (Mountain ash and beech) is much more attractive to the voles than coniferous bark (spruce), thanks to the higher content of nutrients (fats and crude proteins) and a low content of fibres.

Based on the chemical analysis of meadow and pasture plants, and the chemical analysis of beech and hornbeam bark (Gačić *et al*., 2008), it was found that the plants had almost two times higher energetic value than beech bark (4.51 $MJ \cdot kg^{-1}$ ME) and hornbeam bark (4.72 $MJ \cdot kg^{-1}$ ME). As all animals as a rule show preference to the nutrients which are more digestible and richer in energy, these authors conclude that red deer in the rearing centre "Lomnička Reka" should by all means prefer to consume pasturage than the tree bark, if it was available. In this rearing centre, there is only one meadow (92nd Compartment, Clearing 1) of relatively small area (1.71 *ha*), so the grass is completely consumed by big game already at the beginning of the vegetation period (Tomić *et al*., 2009, 2010). Based on the plant community analysis, this association is *Agrostio-Festucetum valesiacae* Gajić 1961. However, it is reported that poor and valueless species account for the highest percentage (29.4%), whereas the grasses of high and medium quality account for 20.6%, among which are: *Agrostis capillaris* L., *Festuca rubra* L.,

Festuca vallesiacae L., *Poa pratensis* L., *Festuca pratensis* Huds. and *Cynodon dactylon* L. Leguminous species of high quality are *Medicago lupulina* L., *Trifolium repens* L. and *Trifolium pratense* L. In other families, there are 4 useful species, 3 conditionally useful species, 10 poor and valueless species, and two species are harmful and slightly poisonous (*Rubus cesius* L. and *Mentha longifolia* L.). For this reason, it was proposed to improve the quality of this meadow and the few forest clearings, i.e. to establish new areas under green forage, which could satisfy the nutrient requirements of Red deer, which would most likely prevent (or significantly reduce) the bark stripping of beech trees. Also, fertilization was proposed as the main measure for meadow improvement, i.e. the minimal rates of NPK 15:15:15, 300 $kg \cdot ha^{-1}$ in spring, which would be favourable for the good quality leguminous species.

The analysis of game nutrition in the rearing centre "Lomnička Reka", also shows that the lowest quantities of maize were consumed in 2008 (4,600 *kg* in May and June), while almost two times higher quantities were consumed in 2009 (9,700 *kg*), and 2010 (8,490 *kg*). When these data are compared to the number of damaged trees (463, 30 and 51 respectively), it is evident that the higher quantities of consumed food result in the smaller incidence of bark stripping damage. Also, in the meadow of the 92nd Compartment, as well as in some of the existing and new forest clearings (e.g. 74c), the hunting ground user performed the proposed agro-engineering measures - mineral fertilization and seed sowing of suitable species and varieties for hay production and pasturage (Gačić *et al*., 2008, Tomić *et al*., 2009, 2010). Additionally, large-scale felling over several past years (2008-2010), primarily of damaged beech trees, provided considerable amounts of twigs and foliage in the spring, but also opened the canopy in many stands and stimulated the development of shrubs and ground flora. Accordingly, the results of our study confirm the hypothesis that forest tree bark stripping was caused by the deficiency in natural food supply.

5. CONCLUSIONS

The following conclusions were made based on the study in the fenced rearing centre "Lomnička Reka":

- Red deer in spring and summer exclusively remove bark of broadleaf tree species, first of all beech (86.3% or 536 trees), followed by hornbeam (10.1% or 63 trees);
- Bark stripping incidence and intensity are the highest in diameter class of 20-39.9 *cm*, which accounts for 48.8% of the total number of damaged trees. Bark damage of 137 trees is in very severe category (ring-barked);
- Damaged trees are non-uniformly distributed throughout the rearing centre area (mainly by groups), at all aspects and at different slopes;
- Beech bark was stripped in the period May-August, with the focus in June or July;

– Beech trees can at bark stripping risk over a very long time interval (>70 years), especially in smaller fenced areas;
– Our results confirm the hypothesis that forest tree bark stripping is caused by the shortage of natural food;
– In the following period, new areas under green forage (pastures and meadows) should be established and the quality of the existing pasture areas should be improved.

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ШТЕТА ЗБОГ ГУЉЕЊА КОРЕ КОЈУ НАНОСИ ЈЕЛЕН (*Cervus elaphus* L.) У ОГРАЂЕНОМ УЗГАЈАЛИШТУ „ЛОМНИЧКА РЕКА“

Резиме

Подаци су колектирани детаљним прегледом целог узгајалишта у пролеће и јесен 2008., 2009. и 2010. године (између 26. јуна и 2. јула односно између 3. и 15. новембра). У каснијим анализама, подаци из првог периода су означени као пролећно гуљење (април-јун), а подаци из другог периода као летње гуљење (јул-септембар). Сваке године су мерена једино стабла са новим ранама на деблу (уклоњеном кором). Опсег гуљења коре је исказан бројем оштећених стабала на целој површини. Интензитет гуљења коре је исказан величином рана на појединим стаблу и груписан у четири степена (Mountford, 1997, 2006, Kuiters *et al*., 2006): 1 = слаб (кора је гуљена на жилишту); 2 = умерен (10-50% коре уклоњено); 3 = јак (кора је гуљена на >50% дебла); 4 = врло јак (кора је прстенована). Нагиб терена на којем се налазе оштећена стабла мерен је инструментом Vertex 3. У односу на прсни пречник (DBH) оштећена стабла су груписана у следеће дебљинске класе: ≤19,9; 20-39,9; 40-59,9; 60-79,9 и ≥80 *cm*. Положај оштећених стабала утврђен је помоћу уређаја Magellan Mobile Mapper 6. Статистичка анализа је спроведена у софтверском пакету Statistica 8. Утицај пречника стабла (DBH) и нагиба терена на интензитет гуљења коре тестиран је једнофакторском анализом варијансе. Повезаност врсте дрвећа и интензитета гуљења коре тестирана је χ^2-тестом.

Површина узгајалишта „Ломничка река“ је 381 *ha* (530-890 *m* надморске висине), од чега је највећи део под шумом (364 *ha* или 95,5%), док ливаде заузимају 2,5 *ha* (0,7%). Основни подаци су детаљно дати у претходним истраживањима (нпр. Gačić, Danilović, 2009, Gačić *et al*., 2011). Гајене врсте дивљачи су јелен и дивља свиња (13 односно 26 јединки на 100 *ha*). Исхрана гајене дивљачи анализирана је на основу података добијених од корисника ловишта (Евиденција ШГ „Расина“ - Крушевац).

Највећи број оштећених стабала утврђен је у пролеће 2008. год. (*n*=463), а најмањи у лето 2009. год. (*n*=11). Интензитет гуљења коре значајно је већи у пролеће него у лето (табела 1). Опсег и интензитет гуљења коре су највећи у дебљинској класи од 20-39,9 *cm* (слика 1). Ране од гуљења коре на стаблима оштећеним у јаком и врло јаком степену (категорија 3 и 4) крећу се од површине земљишта ($\bar{x}$=4,0 *cm*) до висине 2,6 *m* ($\bar{x}$=178,0 *cm*).

Интензитет гуљења коре букве зависи од величине стабла. Једнофакторска анализа варијансе пречника на прсној висини (DBH) стабала букве са фактором „степен оштећења“ показала је да постоје значајне разлике у интензитету гуљења коре, односно да јеленска дивљач селективно гули кору букве (p<0,001). Средњи пречник стабала букве ($\bar{x}$±SE) оштећених у врло јаком (33,5±0,7 *cm*; *n*=186) и слабом степену (36,5±1,2 cm; n=187) значајно је већи од стабала оштећених у умереном (28,2±1,8 *cm*; *n*=68) и јаком степену (28,4±1,3 *cm*; *n*=95). Ниједно стабло букве са новим ранама на деблу није утврђено у периоду новембар-април. Између нагиба терена при разним степенима оштећења стабла није утврђена значајна разлика (p=0,388).

Најмања количина кукуруза је утрошена у 2008. години (4.600 *kg* у мају и јуну), док су готово двоструко веће количине утрошене у 2009. и 2010. години (9.700 *kg*, односно

8.490 *kg*). Кад се ови подаци упореде са бројем оштећених стабала (463, 30 и 51) очигледно је да већа количина утрошене хране има за резултат мањи обим штете од гуљења коре. Поред тога, на ливади у 92. одељењу, као и на неколико постојећих и нових шумских чистина (нпр. 74c), корисник ловишта је спровео предложене агротехничке мере поправке - ђубрење минералним ђубривима и усејавање семена одговарајућих врста и сорти за спремање сена и испашу. Додатно, обимне сече у неколико претходних година (2008-2010. год.), првенствено оштећених стабала букве, обезбедиле су у пролеће знатну количину избојака и листова, али и утицале да се отвори склоп у многим састојинама и тиме омогући развој жбуња и приземне флоре. Резултати наших истраживања потврђују хипотезу да је гуљење коре шумског дрвећа узроковано недостатком природне хране.