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Health status of red deer and roe deer in Gorski kotar, Croatia

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ABSTRACT

To determine the general health status of the main prey species of wolf (*Canis lupus*) and lynx (*Lynx lynx*), we examined 66 cervids (41 red deer - *Cervus elaphus* and 25 roe deer - *Capreolus capreolus*), shot in two hunting areas of Gorski kotar during the hunting season in 2007. We collected a total of 687 organ samples of shot deer, where 472 samples belonged to red deer and 215 samples to roe deer. Analyses were performed for various parasite invasions, non-specific bacterial infections and for three specific bacteria. In five (12.2%) samples of red deer and seven (17.1%) roe deer, we determined the presence of *Streptococcus* sp. Specific tests for *Mycobacterium* sp., *Brucella* sp. and *Leptospira* sp. were all negative. The prevalence of *Dictyocaulus* spp., *Ostertagia* spp. and *Elaphostrongylus cervi* in red deer was 29.3%, 17.1% and 14.6%, respectively. The prevalence of C*habertia ovina*, O*stertagia* spp. and *Trichostrongylus* spp. in roe deer was 36.0%, 24.0% and 20.0%, respectively. The estimated number of red deer and roe deer in the hunting areas Smrekova Draga (182 km^2) and Bjelolasica (303 km^2) in the management year 2007-2008 were 430 and 290 respectively, with densities of 236 and 148 individuals per 100 km^2. The low prevalence of parasite invasions and the absence of serious bacterial infections were the consequences of low ungulate densities, and the presence of large carnivores - predators that quickly eliminate animals weakened by disease.

Key words: red deer, C*ervus elaphus,* roe deer, C*apreolus capreolus*, parasites, bacteria, Croatia

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Introduction

Parasites and bacteria are an integral part of any natural ecosystem and communities. Every ecosystem needs saprophytes, while pathogens play important role in system stability (SINCLAIR et al., 2006). From the epidemiological viewpoint, wild animals act as a reservoir and permanent source from which domestic animals and humans may be infected and invaded (CORNER, 2006). Knowing the rate at which parasitary and bacterial pathogens are present in the ecosystem helps in understanding the system dynamics and is necessary for estimating the degree of threat for health of humans and domestic animals. Of particular importance could be infections by *Brucella* sp., *Leptospira* sp. and *Mycobacterium* sp.

Long term control programs in Western and Central Europe have almost eradicated *Mycobacterium bovis* in domestic cattle, but the documented rather high prevalence of the bacteria in wild boars (MACHACKOVA et al., 2003) wild red deer, roe deer and foxes (ZANELLA et al., 2008) and captive (zoo) animals (PAVLIK et al., 2005) is a cause for concern. Occasional occurrences of tuberculosis in domestic (CVETNIĆ et al., 2007b; CVETNIĆ et al., 2009a), wild zoo animals (PATE et al., 2006) and humans (CVETNIĆ et al., 2007a) in Croatia and neighboring countries, indicated that *Mycobacterium* sp. was present in the environment (ŠPIČIĆ et al., 2010a) i.e. in wild animals, but the prevalence of this bacterial complex in red deer and roe deer from Croatia was unknown.

A low prevalence of *Brucella* sp. was found in North American wildlife (McCORQUODALE and DIGIACOMO, 1985), while studies in Europe (BERGAGNA et al., 2009; FERROGLIO et al., 1998) found *Brucella* sp. in alpine ibex and wild boar in Italy and in various wild animals in the Czech Republic (HUBALEK et al., 1993). Extensive surveys of the prevalence of *Brucella* sp. infections in domestic animals from Croatia revealed that the occurrence of infection is satisfactorily low (ŠPIČIĆ et al., 2010b). However, earlier surveys of brucellosis in domestic pigs and wild boars (CVETNIĆ et al., 2009b), revealed that *B. suis* biovar 2 is present in 1% of domestic pigs and in 7.5% of wild boars. This ratio is even higher (13.5% in domestic vs. 22.6% in wild) in areas where domestic pigs are kept in the forest most of the year (CVETNIĆ et al., 2003). Serological surveys of deer populations in North America (McCORQUODALE and DIGIACOMO, 1985) and some areas of Brazil (MATHIAS et al., 1999) revealed that deer are not the source of *Brucella* infections, but may be infected if they are sympatric with bisons, cattle or sheep (RIDLER et al., 2000). Infections and brucellosis may occur if the density of deer is high, as on deer farms (HER et al., 2010). There were no previous surveys of the prevalence of *Brucella* sp. in deer from Croatia.

Different serovars of *Leptospira* sp. are present in different species of wild animals all over the world, with a prevalence of two to ten times higher than the prevalence of *Brucella* sp. or *Mycobacterium* sp. Different serovars of *Leptospira* spp. were documented

in Croatia in brown bear (*Ursus arctos*), (MODRIĆ and HUBER, 1993; SLAVICA et al., 2010), red foxes (*Vulpes vulpes*), (MILAS et al., 2006) red deer, roe deer, wild boars, bears and red foxes (SLAVICA et al., 2008). These studies confirmed that in the lowland parts of Croatia leptospirosis is constantly present in wild animals, while it is sporadic in mountainous areas of Croatia.

Large lungworm - *Dictyocaulus* spp., tissue worm - *Elaphostrongylus cervi* and *Ostertagia* spp. appear to be important parasites and a health problem only on red deer farms in New Zealand (MASON, 1994). Transmission of large lungworm from red deer to cattle is possible in experimental conditions (BIENIOSCHEK et al., 1996). Red deer show a significant negative correlation between indices of health condition (kidney fat index, dressed carcass weight and larder weight) and intensity of *Ostertagia* spp. infection (IRVINE et al., 2006), i.e. in that state they are susceptible to infections and predation. There were no studies of the prevalence of those parasites in red deer and roe deer populations in Croatia. Studies of the occurrence of pathogens in wild animals in Croatia have been focused on diseases which are important for the health of people or domestic animals, but there are very few studies investigating the presence of other possible bacterial infections and parasite invasion which could be detrimental for the health of cervids.

Our aim was to determine the prevalence of major bacterial and parasitic diseases which could persist in red deer and roe deer populations in Gorski kotar. The rate at which bacterial diseases and parasite invasions occur in cervid populations could be an indicator of ecosystem balance. On the one hand is the health status of deer on deer farms, with maximal deer density and potential for the occurrence of diseases, and on the other hand deer populations existing in a complex ecosystem dominated by highly productive forests, three species of ungulates (red deer, roe deer and wild boar and three species of large carnivores (brown bear - *Ursus arctos*, grey wolf - *Canis lupus* and Eurasian lynx -*Lynx lynx*) preying and scavenging on them.

Materials and methods

The study was conducted in the Gorski kotar region, which is situated in the narrowest part of the Dinarids in Croatia (Fig. 1) from 14°22'30" to 15°15'00" east, and from 45°07'30" to 45°37'30" north. The biogeographic features of the study area have been described by KUSAK et al. (2009). The samples were collected in two hunting areas managed by the Croatian Forests Enterprise (Hrvatske šume). The sizes of those study sites were 182 km^2 (Smrekova Draga) and 303 km^2 (Bjelolasica), totaling in 485 km^2. The estimated number of red deer and roe deer in the hunting areas Smrekova Draga (182 km^2) and Bjelolasica (303 km^2) in the management year 2007-2008 were 430 and 290 respectively, with densities of 236 and 148 individuals per 100 km^2. Smrekova Draga has 14 feeding sites for deer (one per 13 km^2), and Bjelolasica has 24 deer feeding sites (one

per 12.6 km^2). The amount of supplementary food annually offered to ungulates at those feeding sites is 139 600 kg and 125 400 kg respectively. Free range farming of sheep, goats or cattle, is almost non exisent in Gorski kotar (KUSAK and OKOVIĆ, 2010).

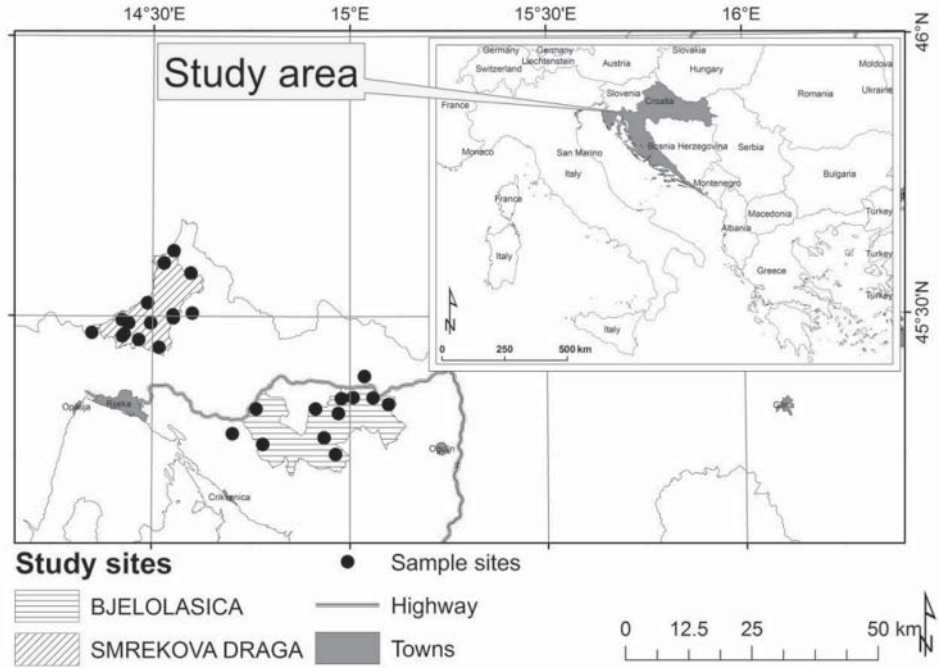

Fig. 1. Study areas in Croatia and sites where samples from shot deer were collected during hunting seasons for roe deer and red deer in 2007. More than one animal was shot at each site, and a few were shot outside the two study sites.

All animals were shot during the regular hunting season for red deer (Sept.- Dec.) and roe deer (May -Aug.) in 2007. Necropsies were performed and samples were collected at the shooting site and were transported to the laboratory in coolers on the same day. On site necropsy included an external examination of the general condition of the animal and the presence of any old injuries. During the necropsy, samples of the following organs and organ systems were collected: blood, gastrointestinal tract, diaphragm muscle, heart, kidney tissue, liver tissue, lungs tissue, lymphatic nodes, masseter muscle, other muscle tissue, skin, spleen tissue, tongue, and the uterus. Samples were separately stored for bacteriological and parasitological tests. Bacteriological testing included general bacteriological examination and additional testing for the three most important specific bacterial infections. Deer age was determined by the cementum layers of the incisors (GASAWAY et al., 1978).

The determination of any *Mycobacterium* spp. in the collected lymph nodes was performed by homogenization, decontamination and concentration of the material. Prepared material was inoculated on four Löwenstein - Jensen slants (two of them supplemented with glycerol) and one Stonebrink slant, which were checked for growth once a week for eight weeks (KENT and KUBICA, 1985).

To determine any *Brucella* spp. infection, we used several grams of tissue (testis, uterus, or lymph node) which were homogenized and inoculated on blood agar, Brucella agar (Brucella medium base, Oxoid CM0169, Oxoid Ltd, Basingstoke, UK), and Farrell's selective growth medium. Inoculated plates were incubated at 37 °C in normal atmospheric conditions with the addition of 10% CO_2. Colony growth was checked daily and was usually observed after 2-4 days. Colonies were identified based on morphology (small, translucent, convex, smooth), their ability to grow in a 10% CO_2 atmosphere, H_2S production, and growth on media supplemented with 20 µg/mL of thionin and basic fuchsine (ALTON et al., 1988).

The determination of *Leptospira* spp. was performed by inoculating samples from kidney tissue on a liquid medium at the temperature of 29 ± 1 °C during 13 weeks and by determination based on colony morphology (ELLIS, 1986).

Parasitological examination was performed to detect the presence of any parasite invasion. Samples were examined for the presence of parasite eggs, larvae or adult parasites in collected organ samples by the use of standard methods of flotation in McMaster chambers (ECKERT, 2000). For separation of endoparasites from internal organs, we used rinsing and sedimentation (KURTZER, 2000). Parasite identification was based on morphological characteristics (shape and structure of shell) and measurements (KAUFMANN, 1996).

The determined frequencies of pathogen occurrences were statistically analyzed by the program STATISTICA (ANONYM., 2004).

Results

We examined 66 different cervids (41 red deer and 25 roe deer), shot in two hunting areas during the hunting seasons in the period from 15.05.2007 to 26.12.2007 (225 days). This represented 9.2% of the estimated number of deer in the Smrekova Draga and Bjelolasica hunting areas (KUSAK, 2008). The prevalence in numbers of shot males was significantly higher for both species. Of 25 shot roe deer only two were females, while 23 were males (χ^2(1df) = 17.000, P<0.001). In the red deer hunting bag, the difference was not so drastic (29 males and 12 females), but still highly significant (χ^2(1df) = 7.049, P<0.001). The age of the shot red deer ranged between 0.5 and 11 years (mean = 4.9, SD = 3.24) and for roe deer between 2 and 8 (mean = 4.9, SD = 1.59) years. We collected a

total of 687 samples of shot deer, where 472 samples were of red deer, and 215 samples were of roe deer.

All samples of both deer species were negative for *Brucella* sp., *Leptospira* sp. and *Mycobacterium* sp. Eleven (26.8%) samples of red deer and 16 (64.0%) samples of roe deer were unreliable for the *Mycobacterium* sp. test. Accordingly, the sample size for this test was lower. In five (12.2%) samples of red deer and seven (17.1%) roe deer, we determined the presence of *Streptococcus* sp. There were no significant differences (χ^2-test, 1DF) in occurrences of *Streptococcus* sp. infections between red deer and roe deer.

Table 1. The prevalence of potential parasites (tested for) found in red deer and roe deer from Bjelolasica and Smrekova Draga areas in Gorski kotar during 2007 and differences in occurrences between species of deer tested by χ^2-test

	Red deer (n = 41)		Roe deer (n = 25)		χ^2-test (1DF)	
Parasite	N positive	Prevalence %	N positive	Prevalence %	χ^2	p
Cephenemyia stimulator	N/A	N/A	3	12	N/A	N/A
Chabertia ovina	0	0	9	36	12.33	0.000
Dictyocaulus sp.	12	29.3	0	0	6.69	0.010
Eimeria sp.	1	2.4	0	0	0.60	0.437
Elaphostrongylus cervi	6	14.6	N/A	N/A	N/A	N/A
Haemonchus contortus	0	0	4	16	6.00	0.014
Lipoptena cervi	1	2.4	0	0	0.60	0.437
Nematodirus filicollis	0	0	2	8	3.13	0.077
Nematodirus sp.	0	0	3	12	4.59	0.032
Oesophagostomum sp.	3	7.3	1	4	0.27	0.060
Ostertagia circumcincta	1	2.4	1	4	0.12	0.728
Ostertagia ostertagi	0	0	2	8	3.13	0.077
Ostertagia sp.	7	17.1	6	24	0.31	0.577
Ostertagia trifurcata	1	2.4	2	8	1.00	0.318
Protostrongylus sp.	1	2.4	0	0	0.60	0.437
Trichostrongylus sp.	3	7.3	5	20	1.79	0.180
Trichostrongylus vitrinus	1	2.4	1	4	0.12	0.728
Trichuris sp.	1	2.4	0	0	0.60	0.437

We determined ten different parasites to the species level, while nine others were determined to genus level. Of 19 parasite groups, six were found in both deer species, six only in red deer and six only in roe deer, while one (*Trichinella* sp.) was not found in any of the two examined deer species. The occurrences of five parasites common for both deer species were significantly different (Table 1) between the two deer species. The

most common parasite in roe deer was *Chabertia ovina*, which was found in nine (36.0%) animals, but it was not found in any red deer, and this difference was significant (χ^2(1DF) = 12.33, P = 0.0004). The second most common for both deer species was *Ostertagia* sp., found in six (24.0%) roe deer and seven (17.1%) red deer, with no significant difference in occurrences. In two (8.0%) roe deer but in none of the red deer, we determined *Ostertagia ostertagi,* while *Ostertagia trifurcata* was also found in two (8.0%) roe deer and in one (4.0%) red deer. The third species of the same genus, *Ostertagia circumcincta* was found in one roe deer and in one red deer. *Trichostrongylus* sp. was found in five (20.0%) roe deer and in three (7.3%) red deer. Additionally, *Trichostrongylus vitrinus* was determined in one (4%) roe deer and in one (2.4%) red deer. *Haemonchus contortus* was found in four (16.0%) roe deer but not in any of the red deer. This difference was significant (χ^2(1DF) = 6.00, P = 0.0143). *Cephenemyia stimulator* was found in three (12%) roe deer. *Nematodirus filicollis* was found in two (8%) roe deer but in no red deer, while *Oesophagostomum* sp. was found in one (4%) roe deer and in three (7.3%) red deer. *Trichostrongylus vitrinus* was found in one (4%) roe deer and in one red deer. *Dictyocaulus* sp. was found only in red deer (n = 12) and in no roe deer, which difference was significant (χ^2(1DF) = 6.69, P = 0.0097). *Elaphostrongylus cervi* was found in six (14.6%) red deer. There was one (2.4%) occurrence each of *Eimeria* sp., *Lipoptena cervi, Protostrongylus* sp. *Trichuris* sp. in red deer and no occurrences in roe deer.

Discussion

Our samples included 9.2% of the estimated number of deer in the study area. The density of deer in our study area (148.5/100km^2, (KUSAK, 2008)) was rather low, compared to some other habitats (MELIS et al., 2009) with similar climate and plant productivity. In spite of this, we believe that because of the uneven habitat use of deer (KUSAK, 2008), which tend to concentrate close to feeding sites, locally high densities of deer are created, which are then more prone to transmission of diseases that may exist in the populations. Our sample was biased towards male deer and because of this, we could not check for differences in disease occurrences between genders. Not a single case of *Leptospira* spp. was found which is in accordance with previous findings (SLAVICA et al., 2008). It seems that this disease is rare or nonexistent in deer living on karst in Croatia. Occurrences of *Leptospira* sp. antibodies of various serovars have been found in bears which live in the same area (MODRIĆ and HUBER, 1993; SLAVICA et al., 2010), but for some reason, deer do not become infected very often. Bears, as omnivorous animals, are more likely to be in contact with rodents, which are considered to be the primary reservoir of leptospiral infections (ADLER et al., 2002). The reason for the absence of infection by *Brucella* sp. is most likely due to the low density of cattle and sheep in the area, when brucellosis does not have enough hosts to maintain persistence in the area.

Infections with *M. paratuberculosis* are increasing in wild animals worldwide, including red deer and roe deer (DEUTZ et al., 2005; KOPECNA et al., 2008). Deer in Gorski kotar, particularly in the two study areas, are fed at permanent feeding sites. It is known that wild animals may be infected with *M. paratuberculosis* if the hygiene of the food provided is inadequate (DEUTZ et al., 2005), but it seems this was not the case with the examined deer. Streptococcus infections were most common in the examined deer, which is not surprising since *Streptococcus* sp. are ubiquitous bacteria and part of the normal micro-flora.

The prevalence of *Chabertia ovina* in roe deer from Gorski kotar was ten times higher (36% vs 3%) than in Sweden (AGUIRRE et al., 1999), but was on the lower end of the prevalence found in some regions of the former Czechoslovakia, where the prevalence in different regions varied from 33.1% to 77% (VETYŠKA, 1980). A possible explanation is the reciprocal difference in the density (MELIS et al., 2009) of roe deer between northern Europe and Central Europe, plus the effect of concentrations of animals at feeding sites. *C. ovina* was found in bison, bighorn sheep, mule deer, white-tail deer, cattle and sheep, but not in red deer and moose from North America (HOBERG et al., 2001). *C. ovina* is not present in red deer in New Zealand, in spite of the fact that it occurs in sheep in the same country (McKENNA, 2009), so we can assume that red deer are not appropriate hosts for this parasite, while roe deer are. On the contrary, we only found nematodes of the genus *Dictyocaulus* spp. in red deer and not in roe deer. This indicates the nonexistence of *D. capreolus* in Gorski kotar which can live in roe deer and moose, but not in red deer, which however may host *D. eckerti* (DIVINA et al., 2002). The same species (*D. eckerti*) was also found in red deer from Vojvodina with a prevalence of 59.4% (LEPOJEV et al., 1999), but with a 15.8% admixture of *D. viviparus*, which is absent in red deer in Sweden (DIVINA et al., 2002) but is usual in cattle. The hybridization of large lung-worm species is likely to happen, as proven in fallow deer from Sweden (DIVINA et al., 2002), so only by the use of molecular methods could one tell which species or hybrid live in our red deer. *Dictyocaulus sp* was the most common (29.3%) parasite found in red deer from Gorski kotar. The same parasite is the most common in red deer in New Zealand (MASON, 1994), North Rhine-Westfalia with a prevalence of 81.6% (REHBEIN et al., 2002), while in Sweden the overall prevalence of *Dictyocaulus* spp. in four species of deer is 12.2% (DIVINA et al., 2002). A similar rate (12% to 14%) of large lung-worm invasion is found in elk from Wyoming and Montana (RHYAN et al., 1997). The prevalence of large lung-worm in Gorski kotar was similar to that occurring in low density, natural populations and not like that in intensively managed, wolf free populations in New Zealand, Germany and the Panonnian lowland.

At least ten different species of *Ostertagia* spp. are known to exist in the abomasus of various wild and domestic ruminants (McKENNA, 2009). Three species of this *Trichostrongilid* were determined in both species of studied deer from Gorski kotar, with

the exception of *O. ostertagii*,which was found in roe deer only and not in red deer. The rates of occurrence of all *Ostertagia* spp. in red deer and roe deer from Gorski kotar (24.3% and 44% respectively) were similar to occurrences in deer populations from North America (PRESTWOOD et al., 1976). The opposite situation was found in dense reindeer population on Svarbald (BYE and HALVORSEN, 1983), where all deer had some species of O*stertagia,* and in Scandinavia where the parasite is exchanged between intensively managed reindeer, sheep and cattle (HRABOK et al., 2006).

Protostrongilid *Elaphostrongylus cervi* can invade many wild and domestic ruminants from Europe, North America and New Zealand including red deer (VALCARCEL et al., 2004). *E. cervi* was originally found only in Eurasian countries, but has been translocated together with red deer to other parts of the world, in spite of preventive efforts (GAJADHAR et al., 1994). *E. cervi* was found in red deer from Gorski kotar at a rate lower than in red deer from Italy (14.6% vs. 41%), (MORANDI et al., 2006), but higher than in red deer from central Spain (7%, VALCARCEL et al., 2004).

Haemonchus contortus is considered as one of most pathogenic nemathods of ruminants, particularly of goats and sheep in warm and wet climates, but was recently discovered in northern Europe (PETER and CHANDRAWATHANI, 2005). *H. contortus* was found only in roe deer from Gorski kotar, but it can invade red deer as well (McKENNA, 2009). The current distribution of roe deer in Croatia (KUSAK and KRAPINEC, 2010) does not overlap with sheep and goat farming (KUSAK and OKOVIĆ, 2010). The idea of providing natural prey (presumably by natural spreading of roe deer) for wolves in Dalmatia may introduce additional problems (source of *H. contortus*) for sheep and goat farmers in Dalmatia.

C. stimulator is a common and the only botfly of roe deer throughout its distribution area with prevalence ranging from 11% up to 90% (KIRALY and EGRI, 2007). The prevalence found in roe deer from Gorski kotar was at the lower end of this range (12%). Developing larvae are situated in the nasal cavity and larynx of the host and they obstruct the flow of air. Such debilitated roe deer become easy prey of wolves and lynx living in Gorski kotar, which then eliminate invaded animals from the population.

The generally low rate of bacterial infection in the studied deer populations was a consequence of habitat conditions (dry karst), low deer densities, the absence of livestock in deer areas and the presence of large carnivores which eliminate deer weakened by disease.

This study brings the first overview of parasite status in deer in Gorski kotar. Earlier studies examined helmintho parasites of wildlife in the Plitvice Lakes National Park (HUBER and ERLICH, 1981) and in the Žumberak mountains (HUBER and ŠTAHAN, 1983), which are both neighboring to Gorski kotar. In the Plitvice lakes NP, a total of 31 helmintho parasitic species were identified from 19 species in wild and domestic

animals, while on Žumberak, five species of nemathodes were found in only 12 roe deer individuals. A finding of at least 18 different parasites in Gorski kotar, in a relatively small sample size may, from the veterinary prospective, appear to be a very bad situation, if we look at deer as a source of disease for domestic animals. However, from the perspective of nature biodiversity and ecology - parasites play important role in ecosystems. They can be stabilizers or destabilizers, depending on factors such as the susceptibility of hosts and the size of the ecosystem. Parasites play a major role at the population and/or specific level, as they do at the individual level (COMBES, 1996). In our situation, it seems that the host -parasite system is stable as a whole, i.e. for all the parasitic species investigated. Extinction of some parasites is contributing to a loss of biodiversity. Such a trend was already recognized in Japan, where the low diversity of the abomasal nematode community of sika deer was regarded as the result of the extinction of some species of nematodes on Hokkaido Island (KITAMURA et al., 1997). The need for a reduction i parasites in wild animals usually appears if they are seen as a threat to livestock. The nonexistence of free range livestock husbandry in Gorski kotar favors parasite biodiversity and host -parasite system stability.

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SAŽETAK

Za određivanje općega zdravstvenoga stanja glavnih vrsta plijena vuka (*Canis lupus*) i risa (*Lynx lynx*), pretraženo je 66 cervida (41 jelen - *Cervus elaphus* i 25 srna - *Capreolus capreolus*), odstrijeljenih u dva lovišta na području Gorskoga kotara tijekom lovne sezone u 2007. godini. Sakupljeno je ukupno 687 uzoraka organa, od čega je 427 bilo od jelena, a 215 od srna. Provedene su pretrage na razne parazitske invazije, nespecifične bakterijske infekcije, te za tri specifične bakterijske infekcije. U pet (12,2%) uzoraka jelena i sedam (17,1%) srna bio je prisutan *Streptococcus* sp. Testovi na *Mycobacterium* sp., *Brucella* sp. i *Leptospira* sp. bili su negativni. Zastupljenost parazita *Dictyocaulus* spp., *Ostertagia* spp. i *Elaphostrongylus cervi* u jelena bila je 29,3%, 17,1%, odnosno 14,6%. Zastupljenost parazita *Chabertia ovina*, *Ostertagia* spp. i *Trichostrongylus* spp. u srna bila je 36,0%, 24,0% odnosno 20,0%. Procijenjeni broj jelena i srna u lovištima Smrekova Draga (182 km^2) i Bjelolasica (303 km^2) u lovnoj godini 2007./2008. bio je 430 odnosno 290, s gustoćama od 236 i 148 jedinki na 100 km^2. Niska zastupljenost parazitarnih invazija i odsutnost ozbiljnijih bakterijskih zaraza, bile su posljedica niske gustoće parnoprstaša i prisutnosti velikih zvijeri - grabežljivaca koji hitro uklanjaju životinje oslabljene bolešću.

Ključne riječi: crveni jelen, *Cervus elaphus*, srna, *Capreolus capreolus*, paraziti, bakterije, Hrvatska