MAY THE TROPHY EVALUATION VARIABLES BE UTILIZED AS POPULATION INDICES IN CERVIDS: EXAMPLE OF THE RED DEER FROM THE HILLY PART OF THE PANNONIAN PLAIN?

MOGU LI ELEMENTI OCJENE TROFEJA POSLUŽITI KAO POPULACIJSKI INDEKSI U CERVIDA?: PRIMJER NA JELENU OBIČNOM IZ BRDSKOG PODRUČJA PANONSKE NIZINE

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SUMMARY

The most frequently utilized population quality indices in cervids were a fluctuating asymmetry or a branch length in yearlings. Nevertheless, unlike bovids, there has not been a reliable quality index so far that could also be applied at a later age. Therefore, an application reliability testing pertaining to certain elements of trophy measurement for the sake of difference detection between the cohorts was performed on a sample numbering 225 trophies of red deer stags from 11 cohorts. Although each of the nine trophy variables tested has succeeded in finding certain differences, the most reliable are the overall trophy value and circumferences (circumference of coronets, lower beam circumference and upper beam circumference). Since various trophy evaluation systems have been applied in the world, the implementation of the overall trophy value is limited only to the trophies evaluated pursuant to the CIC system. Hence, the most reliable indices are those based upon circumferences.

KEY WORDS: trophy evaluation, antlers, weight of dry antlers, lengths, circumferences, trophy value

INTRODUCTION
UVOD

The corporeal size differences within the identical species are manifested wherever a habitat quality variability, i.e., a population density variability, is present, even on the same locality during a longer annual series (Severinghaus et al. 1950, Rasmussen 1985, Ahrens et al. 1988, Kjelander et al. 2006). Consequently, the selection of a reliable criterion (index) for the sake of a population quality estimation is one of the fundamental preconditions for a high-quality population wildlife management.

In the mid-20th century, Riney (1955) emphasized that a corporeal weight and antler size are quite unreliable indices in the estimation of population condition and proposed the utilization of indices based upon reserve fat (kidney fat index, bone marrow fat index). Nevertheless, the implementation of these indices is relatively complicated, because they may be exclusively applied to the dead animals, i.e., they

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cannot be applied to the fallen stock, for they are not as stable as the teeth, antlers, and horns.

During the second half of the 20th century, the new indices have been developed for the sake of ungulate population monitoring: mandible length (Stubbe and Gleich 1990, Nugent and Frempton 1994, Hewison et al. 1996), hind leg length (Suttie and Mitchell 1983), and horn length (Bunell 1978). Although these indices have deficiencies as well, their advantage lies in a fact that they are less dependent on a head age. Hereby, one should emphasize two crucial benefits of a practical implementation of horn length as a population quality criterion: the horns are easily accessible for an analysis because they are a hunting trophy (1), and it is easy to estimate an individual's age on them (2). A fact that the horns, in certain species, are sported exclusively by the stags is a shortcoming, so the method is not applicable to the hinds as well.

In cervids, the selection of a practical population index is a bit more complex. Should the cervid species that do not sport the antlers be exempted (*Hydropotes inermis*, *Moschus* spp.), the antlers are generally sported by the stags. An exemption to it is the reindeer *(Rangifer tarandus)*, in which the antlers are sported by the hinds as well, but their antlers are of smaller dimensions (Lincoln 1992). Commonly, the antlers represent a hunting trophy, so a wildlife management focus is shifted to the production of that derivative in most countries. Therefore, it was expected that the cervid population indices should have been developed exactly on the basis of certain antler variables. However, the antler growth and shedding are connected with certain cycles, mostly the annual ones, so the recent antler dimensions are connected with a specific season (Mysterud et al. 2005, Landete-Castillejos et al. 2010). On the other hand, an age estimation in cervids is not that simple as in bovids. In spite of that, it has been proven so far that certain antler variables may be used as the population indices. These variables are as follows: branch length in yearlings (Schmidt et al. 2001, Gaspar-López et al. 2008), branch perimeter (Rasmussen 1985), or an asymmetry (Solberg and Saether 1993, Pélabon and van Breukelen 1998, Putman et al. 2000, Mateos et al. 2008, Martínez Salmeron 2014).

The red deer *(Cervus elaphus)* antler (trophy) evaluation methods are described in three trophy evaluation systems: CIC (Hromas et al. 2008), SCI (https://safariclub.org/wp-content/uploads/2020/05/SCI-Measuring-Manual-Sept-2019.pdf), and Rowland Ward (https://rowlandward.org/wp-content/uploads/2021/01/Measuring-Handbook.pdf), about which a database is maintained in each of the systems, while the hunting trophy evaluation is a legal obligation in certain countries (e.g., in Croatia, Anon. 2008). Antler evaluation has a relatively long tradition in Central Europe (Krapinec et al. 2009), but a question is recently being raised of whether the evaluation fundament is exclusively a subject of hunting tournaments or the measured variables may be used for a population quality estimation. Therefore, this paper's objective is to examine whether a trophy strength may be utilized as a population index.

MATERIAL AND METHODS
MATERIJAL I METODE

The research was conducted on the red deer trophies from the State hunting ground "Garjevica", which is located in the central part of Croatia's Pannonian region, in the eastern part of Moslavačka Gora (Fig. 1), at the altitudes from 125 to 488 m. According to Köppen, the Hunting ground belongs to the Cfbx climate type (Seletković and Katušin 1992). It is a moderately warm pluvial climate, there is no dry period, precipitations are equally distributed throughout a year, and the driest part of the year coincides with a cold season. There is a furcate auxiliary precipitation maximum of the warm part of the year, splitting in a maximum in the spring (May) and in the late summer (July or August), and there is a drier period between them. The temperature of the coldest month ranges above –3 °C. The summers are cool, with an average temperature of the warmest month ranging below 22 °C.

Garjevica has an area amounting to 14 305 ha. According to the data of CORINE Land Cover 2000—Croatia, the forests constitute 80% (11 441 ha) of the hunting ground area. The shares of other land use types are as follows: arable lands 9% (1 331 ha), grasslands (mostly meadows) 7% (957 ha), and built-on lands 1% (137 ha). The forest stand shares in view of structural classifications are as follows: even-aged
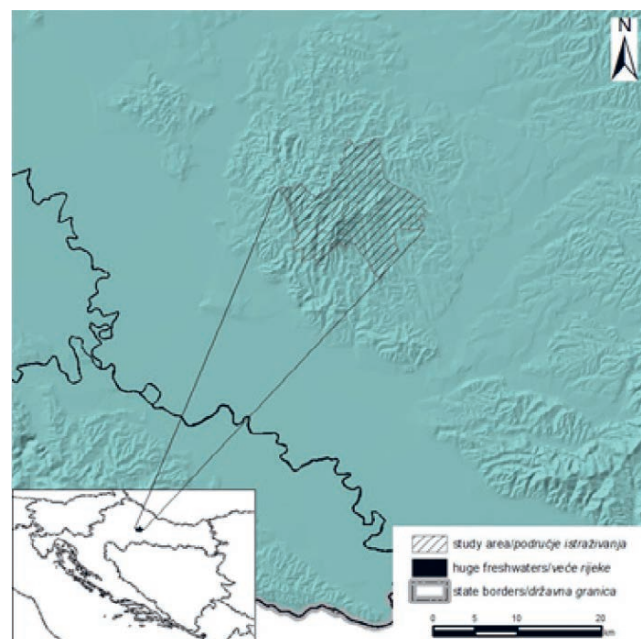

Figure 1. Situation of study area in Croatia and according to relief

seed stands of European beech (*Fagus sylvatica*) constitute 46% of forests, even-aged seed stands of sessile oak (*Quercus petraea*) have a 30-percent share, and even-aged seed stands of the European hornbeam (*Carpinus betulus*) have a six-percent share. The forest stands of pedunculate oak (*Quercus robur*), black locust (*Robinia pseudoacacia*), and conifer cultures are represented in a lower percentage (http://gis.hrsume.hr/hrsume/wms, http://gis.hrsume.hr/privsume/wms). A water share on the Hunting ground amounts to only 0.5% and there are no major watercourses on the Hunting ground, so the watercourses principally have a torrential character.

On the researched area, an intensive big game management started at the beginning of the 1980s. A state-owned forest management company operated the hunting ground at that time, and a 4,000-hectare fenced area was erected on the hunting ground for the purpose of an intensive breeding of the red deer, fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*) and the European mouflon (*Ovis gmelini musimon*). Each species was bred in a separate, detached breeding site area. Ninety-eight percent of the area were comprised of the forest stands (Anon. 1981). During the first decennium, the game was fed by a concentrated feed in the quantity of 541 t per annum. An average annual relative big-game harvest quota (expressed in respect of the hunting areas) on the entire Hunting ground (the fenced and the open-air part) amounted as follows: the red deer – 0.6 head per 100 ha, the European mouflon – 0.3 head per 100 ha, the roe deer – 0.3 head per 100 ha and the wild boar – 2.6 head per 100 ha. Generally, nutrition reinforcements and red deer harvesting during that period were too low, so a major damage was inflicted on the forest stands, and the harvest was significantly intensified up to the commencement of the 1990s (Brna et al. 1996).

A private company has managed the Hunting ground since 1992, having continued a combined big-game breeding (the free nature and fenced hunting ground). This period may be divided in two stages. The first stage lasted from 1992 to 1995 and represented a phase of a lesser-intensified management. During that phase, the same level of nutrition reinforcement was retained, and the cervine animals were released in the fenced part twice, 23 head in 1993 (20 hinds and 3 stags) and five stags in 1994. The heads were from Hungary. The fences of various types and heights were erected around the hunting ground and inside of it. As a rule, the fences are selective, signifying that certain wildlife species (the red deer and mouflon) may jump over them at certain sections, while they prevent the other wildlife species (fallow deer, roe deer and wild boar) from exiting the fenced part. In the 1992-1994 period, 11 tons of hay, 212 tons of coarse fodder (maize silage, haylage, and fruit), and 574 tons of concentrated feed were averagely annually brought on the Garjevica. A grassland area melioration was performed during that phase and clover–grass mixtures were sown. A relative annual harvest quota in this phase amounted to as follows: the red deer – 0.6 head per 100 ha, the fallow deer – 0.1 head per 100 ha, the roe deer – 0.3 head per 100 ha, the European mouflon – 0.4 head per 100 ha and the wild boar – 3.2 head per 100 ha.

The second stage lasted from 1995 to 2004 and represented a phase of intensive management. During that phase, the additional 140 t of compound feed were annually brought, concerning the existent feedstuff quantities demonstrated for the 1992–1994 period. A relative annual hunting bag in that phase amounted to as follows: the red deer – 1.5 head per 100 ha, the fallow deer – 0.3 head per 100 ha, the roe deer – 0.6 head per 100 ha, the European mouflon – 0.7 head per 100 ha and the wild boar – 7.2 head per 100 ha.

Table 1 Sample size, age and mean values (±SE) of trophy variables according to the cohorts
Tablica 1 Veličina uzorka, dob i prosječne vrijednosti (±SE) elemenata ocjene trofeja prema kohortama

COHORTS/ *KOHORTE*	n	age (years)	Weight of dry antlers (kg) – *Masa rogovlja (kg)*	Main beam length (cm) – *Duljina grane (cm)*	Length of brow tines (cm) – *Duljina nadočnjaka (cm)*	Length of tray tines (cm) – *Duljina srednjaka (cm)*	Circumference of coronets (cm) – *Opseg vijenca (cm)*	Lower circumference of beam (cm) – *Donji opseg (cm)*	Upper circumference of beam (cm) – *Gornji opseg (cm)*	Number of tines – *Broj parožaka*	Trophy value (CIC points) – *Trofejna vrijednost (CIC točke)*
1986	17	6-12	7,4±0,6	99,8±3,0	37±1,9	35,5±1,3	23,7±0,7	28,5±0,8	26,3±0,9	13±0,6	185,4±6,0
1988	14	4-10	7,1±0,8	94,6±5,5	34,1±2,7	32±2,1	23,8±1,0	27,1±1,2	25,7±1,3	12,4±0,5	177,0±9,0
1989	15	4-10	8,2±0,7	105,1±3,3	35,7±1,8	36,1±2,2	25,1±0,6	29,2±0,9	27,2±0,9	12,7±0,7	191,9±6,6
1990	12	3-10	6,5±1,1	90,2±6,2	31,9±3,0	29,8±3,7	23,1±1,4	26,3±2,1	24,5±2,1	12,4±1,2	167,2±15,1
1991	20	3-9	7,4±0,6	98,6±2,9	34,8±1,6	33,3±2,3	23,5±0,7	28,3±1,4	26±1,1	12,3±0,5	180,8±7,3
1992	19	3-8	7,8±0,5	100,4±2,5	34,7±1,2	33,5±1,9	24,6±0,7	28,5±0,9	26,5±0,8	12,6±0,7	185,1±6,0
1993	19	3-8	8,1±0,5	98,4±2,3	36,8±1,2	35,9±2,4	24,7±0,5	29,4±0,7	27,9±0,8	13,7±0,6	188,6±5,0
1994	27	3-7	7,5±0,5	98,5±2,8	36,2±1,4	34,8±1,4	24,6±0,7	27,9±0,7	26,4±0,9	12,6±0,6	181,9±6,1
1995	27	2-6	6,1±0,4	89,9±3,0	33,1±1,4	31,7±1,2	22±0,7	26,1±0,7	24,5±0,8	11±0,5	164,1±6,0
1996	27	2-5	5,9±0,5	88,3±3,3	30,1±1,5	31,1±1,3	22,2±0,6	25,3±0,7	23,4±0,8	11,1±0,6	161,2±6,2
1997	28	2-4	4,9±0,3	83,1±2,3	28,9±1,3	30,1±1,3	21±0,5	24,2±0,6	22±0,7	9,9±0,4	149,5±4,9

Table 2 Comparison of cohorts for dry antler weight (signs in bold indicate significant differences; „i"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)
Tablica 2 Usporedba kohorti za masu rogovlja (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike „i"=interakcija, odn. primjenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – KOHORTE	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	**1986<1988** **g: F= 8,37; p<0,05**	–									1
1989	1986=1989 g: F= 2,72; p=0,11	1988=1989 g: F= 3,5; p=0,07	–								0
1990	**1986<1990** **g: F= 9,43; p<0,01**	1988=1990 g: F= 0,62; p=0,44	1989=1990 g: F= 1,27; p=0,27	–							1
1991	**1986<1991** **g: F= 11,31; p<0,01**	1988=1991 g: F= 3,35; p=0,08	1989=1991 g: F= 0,07; p=0,79	1990=1991 g: F= 1,2; p=0,28	–						1
1992	**1986<1992** **g: F= 15,82; p<0,001**	**1988<1992** **g: F= 7,23; p<0,05**	1989=1992 g: F= 0,06; p=0,81	1990=1992 g: F= 2,86; p=0,10	1991=1992 g: F= 0,38; p=0,54	–					2
1993	**1986<1993** **g: F= 33,37; p<0,00001**	**1988<1993** **g: F= 23,28; p<0,001**	**1989<1993** **g: F= 5,32; p<0,05**	**1990<1993** **g: F= 8,67; p<0,01**	**1991<1993** **g: F= 5,51; p<0,05**	1992=1993 g: F= 0,01; p=0,93	–				5
1994	**1986<1994** **g: F= 42,10; p<0,00001**	**1988<1994** **g: F= 24,47; p<0,0001**	**1989<1994** **(age>5)** **g: F= 1,21; p=0,28** **i: F=4,51; p<0,05**	**1990<1994** **g: F= 6,5; p<0,05**	1991=1994 g: F= 0,96; p=0,33	1992=1994 g: F= 2,67; p=0,11	1993=1994 g: F= 2,52; p=0,12	–			4
1995	**1986<1995** **g: F= 51,43; p<0,00001**	**1988<1995** **g: F= 36,73; p<0,00001**	**1989<1995** **(age>5)** **g: F= 1,9; p=0,18** **i: F=7,64; p<0,01**	**1990<1995** **g: F= 11,5; p<0,01**	**1991<1995** **(age>4)** **g: F= 1,55; p=0,22** **i: F=4,84; p<0,05**	**1992<1995** **(age>5)** **g: F= 4,25; p<0,05** **i: F=7,13; p<0,05**	1993=1995 g: F= 3,98; p=0,053	1994=1995 g: F= 0,004; p=0,95	–		6
1996	**1986<1996** **(age>1)** **g: F= 0,49; p=0,49** **i: F=10,9; p<0,01**	**1988<1996** **(age>2)** **g: F= 0,05; p=0,94** **i: F=10,64; p<0,01**	**1989<1996** **(age>4)** **g: F= 6,21; p<0,05** **i: F=17,86; p<0,0001**	**1990<1996** **(age>3)** **g: F= 1,35; p=0,25** **i: F=8,58; p<0,01**	**1991<1996** **(age>4)** **g: F= 38,09; p<0,0001** **i: F=13,47; p<0,001**	**1992<1996** **(age>4)** **g: F= 11,36; p<0,01** **i: F=17,64; p<0,001**	**1993<1996** **(age>5)** **g: F= 10,53; p<0,01** **i: F=12,3; p<0,01**	**1994<1996** **(age>4)** **g: F= 2,15; p=0,15** **i: F=4,94; p<0,05**	1995=1996 g: F= 3,35; p=0,07	–	8
1997	**1986<1997** **g: F= 26,81; p<0,00001**	**1988<1997** **g: F= 19,03; p<0,00001**	1989=1997 (srnn) g: F= 1,93; p=0,17 i: F=4,52; p<0,05	**1990<1997** **g: F= 5,94; p<0,05**	1991=1997 g: F= 1,57; p=0,22	1992=1997 (srnn) g: F= 3,99; p=0,052 i: F=4,35; p<0,05	1993=1997 g: F= 3,85; p=0,056	1994=1997 g: F= 0,004; p=0,84	1995=1997 g: F= 0,003; p=0,85	1996=1997 g: F= 2,05; p=0,16	3
Sign. Diff.	9	6	4	5	3	2	1	1	0	0	31

COHORTS – KOHORTE

In the 1992–2001 period, 294 stags over one year of age were shot. The antlers were processed so that a trophy may be completely evaluated pursuant to the CIC methods. In addition to a trophy, the mandibles were also processed. The age of the head shot was estimated by the number of dental cementum deposits on the first lower molar (M_1) according to the Almasan and Rieck's method (Almăsan and Rieck 1970) under a Leica Wild M28 binocular microscope, at a 6.3 to 50x magnification). A deer's age in years was subtracted from the year of shooting, so that a head's calving year, i.e., a cohort was obtained that way. Only the cohorts that were represented by more than four head, with an age range of at least three years, were taken into analysis. Therefore, a part of the cohorts was dropped out of the analysis, and 11 cohorts entered the analysis: 1986, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996 and 1997, i.e., a total of 225 trophies.

Pursuant to the CIC rules, the following was measured on the trophies (antlers variables): main beam length, length of brow tines, length of tray tines, circumference of coronets, lower beam circumference (circumference of beam between brow and tray tine), upper beam circumference (circumference of beam between the tray tine and the crown), weight of dry antlers, inside spread, number of tines, qualitative elements (antler colour, pearling, tine tops, bay tines, crowns, and deductions) and trophy value (Hromas et al. 2008).

A distribution normality testing was performed by the Kolmogorov–Smirnov and the Shapiro–Wilk tests. According to these tests, there is no significant difference in data distribution in relation to normality. Comparison of the antler variables was performed by analysis of covariance (ANCOVA), with age as a covariate to control for age-related variation in antler size and cohorts as groups (categorical factors). In case of manifestation of an interaction between equivalence lines, for the calculation of significant difference intervals between the trends, Potthoff's modification of the Johnson–Neyman method was applied (White 2003; Kim 2010).

Testing among cohorts was performed for each of 9 trophy variables (main beam length, length of brow tines, length of tray tines, circumference of coronets, lower beam circumference, upper beam circumference, weight of dry antlers, number of tines and trophy value among 11 cohorts which values according to the cohorts are given in table 1.

A number of groups and subgroups was determined according to the number of significant difference cases between the mutual comparisons of cohorts for each trophy variable (ANCOVA or Johnson–Neyman method). The groups were classified according to the number of significant differences per column, and the subgroups were classified according to the number of significant differences per

row in tables 1 to 9. For example, concerning the antler mass, the number of significant differences per column amounted to 0, 1, 2, 3, 4, 5, 6 and 9 (table 2). Eight groups were obtained that way (table 11). The number of significant differences per row served to rank a variable magnitude within a group. The 1995, 1996, and 1997 cohorts, for example, have not demonstrated a statistically significant mutual difference (the number of significant differences per columns amounted to 0), but various differences were detected between the rows. Thus, the 1997 cohort had a significantly higher antler mass in 3 cases, the 1995 cohort in 6 cases, and the 1996 cohort in 8 cases. Regarding the antler mass variable, all three cohorts are affiliated with the strongest group (Group 1), but the 1996 cohort is the strongest one within the group, followed by the 1995 cohort and ultimately by the 1997 cohort.

Data analysis was performed in Statistica 13.5.0.17 program package (TIBCO Software, 2018).

RESULTS
REZULTATI

The results of ANCOVA and Johnson–Neyman method have demonstrated that the number of differences identified between the cohorts varies (tables 2 to 10) in view of a variable (indicator). Most significant differences between the cohorts are possible to be detected by a trophy value (35 out of 55, 64%), upper beam circumference (35 differences, 64%), circumference of coronets (34 differences, 62%), weight of dry antlers (31 out of 55, 56%) and by lower beam circumference (30 out of 55, 55%). Slightly lesser differences are possible to be detected by length variables. A minimum of difference was detected by the length of tray tines (15 out 55, 27%), slightly more by a length of the beam and length of the brow tine (29 out of 55, 53%), while the number of differences detected was minimal by the number of tines – only 16 (29%).

Most comparisons (351 out of 495) were made by a common covariance analysis, whereby a significant difference between the cohorts was found in 142 cases. In 144 out of 495 comparisons, an interaction was manifested, out of which a significant difference was found in 113 cases. Additionally, a number of interaction cases were increasing along with the number of differences found. In three variables (of main beam length, number of tines, and overall trophy value), more significant differences were found in the interaction comparisons (18, 10, and 21) than in the cases when there is no interaction (11, seven, and 15, respectively).

An interaction phenomenon means that there is no significant difference between two cohorts from or up to certain age, and then a significant difference appears or disappears

Table 3 Comparison of cohorts for main beam length (signs in bold indicate significant differences; „i" = interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)

Tablica 3 Usporedba kohorti za duljina grane (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „i" = interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – *KOHORTE*	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	1986=1988 g: F= 1,69; p=0,20										0

1989	**1986<1989**
	g: F= 4,66;
	p<0,05
		1988=1989 (srnn)
		g: F= 5,48;
		p<0,05
		i: F=4,47;
		p<0,05
			—								1

1990	1986=1990 g: F= 0,32; p=0,581	1988=1990 g: F= 1,1; p=0,31	1989=1990 g: F= 3,84; p=0,06	—							0
1991	**1986<1991** **g: F= 6,7;** **p<0,05**	**1988<1991** **(age<6)** **g: F= 4,97;** **p<0,01** **i: F=27,95;** **p<0,00001**	1989=1991 g: F= 0,04; p=0,85	1990=1991 g: F= 3,33; p=0,08	—						2
1992	**1986<1992** **(age<3)** **g: F= 15,27;** **p<0,001**	**1988<1992** **(age<5)** **g: F= 9,67;** **p<0,05** **i: F=27,95;** **p<0,00001**	1989=1992 g: F= 0,09; p=0,76	**1990<1992** **g: F= 8,36;** **p<0,01**	1991=1992 g: F= 0,01; p=0,94	—					3
1993	**1986<1993** **g: F= 12,04;** **p<0,01**	**1988<1993** **g: F= 14,51;** **p<0,001**	1989=1993 g: F= 0,20; p=0,66	**1990<1993** **g: F= 11,72;** **p<0,01**	1991=1993 g: F= 0,07; p=0,795	1992=1993 g: F= 0,06; p=0,82	—				3
1994	**1986<1994** **g: F= 23,31;** **p<0,0001**	1988=1994 g: F= 2,55; p=0,12	**1989<1994** **(age>6)** **g: F= 1,45;** **p=0,24** **i: F=27,54;** **p<0,00001**	**1990<1994** **g: F= 14,22;** **p<0,001**	**1991<1994** **(age>6)** **g: F= 2,72;** **p=0,11** **i: F=26,61;** **p<0,00001**	**1992=1994 (srnn)** **g: F= 3,24;** **p=0,08** **i: F=31,38;** **p<0,00001**	1993=1994 g: F= 2,90; p=0,10	—			4
1995	**1986<1995** **(age>3)** **g: F= 0,88;** **p=0,35** **i: F=13,92;** **p<0,001**	1988=1995 g: F= 0,87; p=0,36	**1989<1995** **(age>4)** **g: F= 6,47;** **p<0,05** **i: F=49,20;** **p<0,00001**	**1990<1995** **(age>3)** **g: F= 0,19;** **p=0,66** **i: F=73,03;** **p<0,0001**	**1991<1995** **(age>4)** **g: F= 10,52;** **p<0,01** **i: F=44,61;** **p<0,00001**	**1992<1995** **(age>5)** **g: F= 12,81;** **p<0,0001** **i: F=57,14;** **p<0,00001**	**1993<1995** **(age>5)** **g: F= 10,53;** **p<0,01** **i: F=12,3;** **p<0,00001**	1994=1995 g: F= 1,49; p=0,23	—		6

	1986<1996 (age>3)	1988<1996 (age>2)	1989<1996 (age>4)	1990<1996 (age>3)	1991<1996 (age>4)	1992<1996 (age>4)	1993<1996 (age>5)	1994<1996 (age>4)	1995=1996	
1996	g: F= 4,15; p<0,05 i: F=25,59; p<0,0001	g: F= 0,05; p=0,94 i: F=54,41; p<0,00001	g: F= 13,05; p<0,001 i: F=53,66; p<0,00001	g: F= 3,77; p=0,06 i: F=75,43; p<0,00001	g: F= 19,46; p<0,0001 i: F=49,22; p<0,00001	g: F= 23,21; p<0,0001 i: F=62,15; p<0,00001	g: F= 17,41; p<0,001 i: F=49,98; p<0,00001	g: F= 6,39; p<0,05 i: F=61,42; p<0,00001	g: F= 2,84; p=0,10	8
1997	1986<1997 g: F= 6,57; p<0,05	1988=1997 g: F= 1,52; p=0,23	1989=1997 (srnn) g: F= 2,38; p=0,137 i: F=17,11; p<0,0001	1990<1997 g: F= 10,10; p<0,01	1991=1997 (srnn) g: F= 4,09; p<0,05 i: F=16,89; p<0,0001	1992=1997 (srnn) g: F= 4,79; p<0,05 i: F=19,25; p<0,00001	1993=1997 (srnn) g: F= 4,14; p<0,05 i: F=13,10; p<0,00001	1994=1997 g: F= 1,18; p=0,68	1995=1997 g: F= 0,47; p=0,50 / 1996=1997 g: F= 3,95; p=0,052	2
Sign. Diff.	8	4	3	6	3	2	2	1	0 / 0	29

Table 4 Comparison of cohorts for length of brow tines (signs in bold indicate significant differences; „i"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)
Tablica 4 Usporedba kohorti za duljinu nadočnjaka (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „i"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – KOHORTE	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	1986=1988 g: F= 0,09; p=0,77	–									0
1989	1986=1989 g: F= 3,09; p=0,090	1988=1989 g: F= 1,54; p=0,23	–								0
1990	1986=1990 g: F= 0,90; p=0,35	1988=1990 g: F= 0,22; p=0,64	1989=1990 g: F= 1,3; p=0,27	–							0
1991	1986=1991 g: F= 3,00; p=0,09	1988=1991 g: F= 2,41; p=0,13	1989=1991 g: F= 0,01; p=0,92	1990=1991 g: F= 2,30; p=0,14	–						0
1992	1986<1992 (age<6) g: F= 8,09; p<0,01 i: F=21,49; p<0,00001	1988=1992 g: F= 2,16; p=0,15	1989=1992 g: F= 0,31; p=0,58	1990=1992 g: F= 1,33; p=0,26	1991=1992 g: F= 0,24; p=0,63	–					1
1993	1986<1993 g: F= 19,91; p<0,0001	1988<1993 g: F= 12,88; p<0,01	1989<1993 g: F= 8,74; p<0,01	1990<1993 g: F= 12,95; p<0,01	1991<1993 g: F= 4,69; p<0,05	1992<1993 g: F= 5,93; p<0,05	–				6
1994	1986<1994 g: F= 18,61; p<0,0001	1988<1994 g: F= 12,90; p<0,001	1989<1994 g: F= 9,43; p<0,01	1990<1994 g: F= 9,68; p<0,01	1991=1994 g: F= 0,27; p=0,61	1992<1994 g: F= 4,35; p<0,05	1993=1994 g: F= 0,51; p=0,48	–			5

	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	
1995	1986<1995 (age>3) g: F= 25,51; p<0,0001	1988<1995 (age>3) g: F= 17,75; p<0,01	1989<1995 (age>4) g: F= 0,74; p=0,40; i: F=16,98; p<0,00001	1990<1995 g: F= 16,33; p<0,001	1991<1995 (age>4) g: F= 1,45; p=0,24; i: F=18,55; p<0,00001	1992<1995 (age>5) g: F= 3,42; p=0,07; i: F=20,41; p<0,00001	1993=1995 g: F= 1,89; p=0,18	1994=1995 g: F= 0,38; p=0,54		—	6
1996	1986<1996 (age>3) g: F= 0,000; p=1,00; i: F=46,11; p<0,00001	1988<1996 (age>3) g: F= 0,16; p=0,69; i: F=29,40; p<0,00001	1989<1996 (age>5) g: F= 5,62; p<0,05; i: F=26,96; p<0,00001	1990<1996 (age>4) g: F= 1,92; p=0,17; i: F=46,02; p<0,00001	1991<1996 (age>5) g: F= 8,65; p<0,01; i: F=27,80; p<0,00001	1992<1996 (age>5) g: F= 15,2; p<0,01; i: F=34,19; p<0,00001	1993<1996 (age>6) g: F= 10,07; p<0,01; i: F=34,96; p<0,00001	1994<1996 (age>8) g: F= 5,38; p<0,05; i: F=33,10; p<0,00001	1995=1996 g: F= 3,62; p=0,06		8
1997	1986<1997 g: F= 11,02; p<0,01	1988<1997 g: F= 7,58; p<0,01	1989=1997 g: F= 1,00; p=0,32	1990<1997 g: F= 6,58; p<0,05	1991=1997 g: F= 1,76; p=0,19	1992=1997 (srnn) g: F= 3,60; p=0,06; i: F=10,31; p<0,001	1993=1997 g: F= 2,18; p=0,15	1994=1997 g: F= 0,67; p=0,42	1995=1997 g: F= 0,10; p=0,76	1996=1997 g: F= 1,77; p=0,19	3
Sign. Diff.	6	5	4	5	3	4	1	1	0	0	29

subsequent to certain age. As Jumić (2003) established a 10-year culmination of the red-deer trophy value for this Hunting ground, the differences between the cohorts in case of an interaction manifestation should be observed in an age range of one to 10 years. Therefore, it is mostly about a phenomenon that the cohorts, notwithstanding a variable, display no difference at an early age, but it becomes significant later. The most frequent differences are manifested at a transition from the juvenile to the mid-aged deer (aged 3 to 5 years). When it comes to the weight of dry antlers, however, the 1996 cohort has a significantly higher weight of dry antlers than the 1986 cohort as soon as after the yearling age (table 2; g[1]: F= 0,49; p=0,49; i[2]: F=10,9; p<0,01).

In 27 cases, upon a calculation of Potthoff's modification of the Johnson–Neyman method (Kim 2010), it was impossible to calculate an age at which a significant difference between certain cohorts sets on due to the case of square root of a negative number's. In tables 2 to 10, these cases are demarcated as "srnn", and occurred: in 6 cases for main beam length (table 3), in 5 cases for circumference of coronets (table 6) and trophy value (table 10), in 4 cases for the number of tines (table 9), in 2 cases for the weight of dry antlers (table 2), lower (table 7) and upper beam circumference (table 8). In only one case upon a calculation of Potthoff's modification of the Johnson–Neyman method square root of a negative number occurred for the length of brow (table 4) and tray tines (table 5). Consequently, one may say that, in such cases, there is no significant difference between the cohorts in the one-to-10-year age span observed irrespective of significant "p" values.

In three cases, the differences are significant as early as at a later age, exceeding a 10-year economic maturity. They are recorded for the factors of lower beam circumference (table 7; 1989<1990; age>11 years; g: F= 5,41; p<0,05; i: F=23,77; p<0,00001), number of tines (table 9; 1992<1997; age>15 years; g: F= 5,88; p<0,05; i: F=9,41; p<0,001) and trophy value (table 10; 1989<1990; (age>13 years; g: F= 5,30; p<0,05; i: F=29,83; p<0,00001). Thus, these differences may be considered insignificant.

It is interesting that, in eight cases, the significant differences are manifested up to a juvenile-head age group, and they disappear subsequently. Such differences are recorded in several variables: main beam length (table 3; the cohorts of 1988 and 1991; age<6 years; g: F= 4,97; p<0,01; i: F=4,75; p<0,05; the cohorts of 1988 and 1992; age<5 years; g: F= 9,67; p<0,05; i: F=27,95; p<0,00001), length of brow tines (table 4; the cohorts of 1986 and 1992; g: F= 8,09; p<0,01; i: F=21,49; p<0,00001), circumference of coronets (table 6; the cohorts of 1986 and 1989; age<8 years; g: F= 9,45; p<0,01; i: F=24,31; p<0,00001 and the cohorts of 1988 and 1989; age<5 years; g: F= 10,90; p<0,01; i: F=31,03; p<0,00001), lower beam circumference (table 7; the

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[1] "g" = group

[2] „i"=interaction (Johnson–Neyman method is applied)

Table 5 Comparison of cohorts for length of tray tines (signs in bold indicate significant differences; „I"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)

Tablica 5 Usporedba kohorti za duljinu srednjaka (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „I"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – *KOHORTE*	COHORTS – *KOHORTE*										Sign. Diff.
	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	
1988	1986=1988 g: F= 3,38; p=0,08										0
1989	1986=1989 g: F= 0,23; p=0,64	1988=1989 g: F= 1,24; p=0,28	–								0
1990	1986=1990 g: F= 2,99; p=0,10	1988=1990 g: F= 0,02; p=0,88	1988=1990 g: F= 1,39; p=0,25	–							0
1991	1986=1991 g: F= 0,90; p=0,35	1988=1991 g: F= 0,33; p=0,57	1989=1991 g: F= 0,24; p=0,63	1990=1991 g: F= 0,58; p=0,45	–						0
1992	1986=1992 g: F= 0,55; p=0,47	1988=1992 g: F= 1,07; p=0,31	1989=1992 g: F= 0,04; p=0,84	1990=1992 g: F= 1,41; p=0,25	1991=1992 g: F= 0,13; p=0,72	–					0
1993	1986=1993 g: F= 0,96; p=0,34	**1988<1993 g: F= 9,04; p<0,05**	1989=1993 g: F= 0,32; p=0,58	**1990<1993 g: F= 5,23; p<0,05**	1991=1993 g: F= 0,03; p=0,88	1992=1993 g: F= 0,22; p=0,65	–				2
1994	**1986<1994 (age>6) g: F= 2,04; p=0,16 i: F=12,53; p<0,0001**	**1988<1994 g: F= 17,95; p<0,001**	**1989<1994 g: F= 4,85; p<0,05**	**1990<1994 g: F= 8,68; p<0,01**	1991=1994 g: F= 0,01; p=0,92	1992=1994 g: F= 0,34; p=0,56	1993=1994 g: F= 0,01; p=0,91	–			4
1995	**1986<1995 (age>6) g: F= 1,58; p=0,22 i: F=10,70; p<0,001**	**1988<1995 g: F= 18,31; p<0,001**	1989=1995 g: F= 0,24; p=0,63	**1990<1995 g: F= 13,02; p<0,001**	**1991<1995 g: F= 4,36; p<0,05**	1992=1995 g: F= 0,06; p=0,81	1993=1995 g: F= 0,18; p=0,68	1994=1995 g: F= 0,25; p=0,62	–		4
1996	**1986<1996 (age>7) g: F= 1,98; p=0,17 i: F=8,34; p<0,001**	**1988<1996 g: F= 13,20; p<0,001**	1989=1996 g: F= 0,57; p=0,45	**1990<1996 g: F= 10,48; p<0,01**	1991=1996 g: F= 0,02; p=0,90	1992=1996 g: F= 0,36; p=0,55	1993=1996 g: F= 0,01; p=0,93	1994=1996 g: F= 0,001; p=0,98	1995=1996 g: F= 0,28; p=0,60	–	3
1997	1986=1997 (srnn) g: F= 1,81; p=0,19 i: F=6,13; p<0,01	**1988<1997 g: F= 11,07; p<0,01**	1989=1997 g: F= 0,53; p=0,47	**1990<1997 g: F= 10,85; p<0,01**	1991=1997 g: F= 0,02; p=0,90	1992=1997 g: F= 0,33; p=0,57	1993=1997 g: F= 0,01; p=0,94	1994=1997 g: F= 0,001; p=0,97	1995=1997 g: F= 0,25; p=0,62	1996=1997 g: F= 0,001; p=0,99	2
Sign. Diff.	3	5	1	5	1	0	0	0	0	0	15

Table 6 Comparison of cohorts for circumference of coronets (signs in bold indicate significant differences; „i"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)
Tablica 6 Usporedba kohorti za opseg vijenca (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „i"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – KOHORTE	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	**1986<1988** g: F= 21,68; p<0,0001	–									1
1989	**1986<1989** (age<8) g: F= 9,45; p<0,01 i: F=24,31; p<0,00001	**1988<1989** (age<5) **1988>1989** (age>10) g: F= 10,90; p<0,01 i: F=31,03; p<0,00001	–								1
1990	**1986<1990** g: F= 22,41; p<0,0001	**1988<1990** g: F= 4,59; p<0,05	**1989<1990** (age>10) g: F= 5,04; p<0,05; i: F=26,38; p<0,00001	–							3
1991	**1986<1991** g: F= 12,85; p<0,01	1988=1991 g: F= 2,11; p=0,15	1989=1991 g: F= 1,17; p=0,29	1990=1991 g: F= 1,69; p=0,21	–						1
1992	**1986<1992** g: F= 25,73; p<0,00001	**1988<1992** g: F= 9,45; p<0,01	1989=1992 g: F= 0,23; p=0,65	1990=1992 g: F= 3,71; p=0,07	1991=1992 g: F= 0,44; p=0,51	–					2
1993	**1986<1993** g: F= 38,51; p<0,00001	**1988<1993** g: F= 24,11; p<0,001	1989=1993 g: F= 0,0003; p=0,99	**1990<1993** g: F= 8,56; p<0,01	**1991<1993** g: F= 8,60; p<0,01	1992=1993 g: F= 0,23; p=0,63	–				4
1994	**1986<1994** g: F= 45,05; p<0,00001	**1988<1994** g: F= 27,10; p<0,0001	**1989<1994** (age>6) g: F= 3,53; p=0,07; i: F=20,72; p<0,00001	**1990<1994** g: F= 8,17; p<0,01	**1991<1994** (age>5) g: F= 1,14; p=0,29; i: F=25,82; p<0,00001	**1992<1994** (age>6) g: F= 2,62; p=0,11; i: F=23,37; p<0,00001	1993=1994 g: F= 3,73; p=0,06	–			6
1995	**1986<1995** g: F= 28,14; p<0,00001	**1988<1995** g: F= 20,52; p<0,0001	**1989<1995** (age>6) g: F= 4,75; p<0,05; i: F=19,43; p<0,0001	**1990<1995** g: F= 6,72; p<0,05	**1991<1995** (age>5) g: F= 1,71; p=0,20; i: F=24,85; p<0,00001	1992=1995 (srnn) g: F= 3,67; p=0,06; i: F=22,16; p<0,0001	1993=1995 (srnn) g: F= 4,98; p<0,05; i: F=20,3816; p<0,00001	1994=1995 g: F= 0,01; p=0,92	–		5

1996	1986<1996 (age>2) g: F= 0,18; p=0,67; i: F=58,03; p<0,00001	1988<1996 (age>2) g: F= 0,32; p=0,58; i: F=65,53; p<0,00001	1989<1996 (age>5) g: F= 8,81; p<0,01; i: F=28,14; p<0,00001	1990<1996 (age>5) g: F= 0,35; p=0,56; i: F=54,52; p<0,00001	1991<1996 (age>4) g: F= 3,86; p=0,06; i: F=33,66; p<0,00001	1992<1996 (age>5) g: F= 6,93; p<0,05; i: F=30,51; p<0,00001	1993<1996 (age>6) g: F= 9,14; p<0,01; i: F=29,12; p<0,00001	1994=1996 g: F= 0,34; p=0,56	1995=1996 g: F= 0,30; p=0,59	–	7
1997	1986<1997 g: F= 22,36; p<0,0001	1988<1997 g: F= 19,87; p<0,0001	1989<1997 (age>6) g: F= 5,41; p<0,05; i: F=14,31; p<0,0001	1990<1997 g: F= 7,11; p<0,05	1991=1997 (srnn) g: F= 1,80; p=0,19; i: F=20,80; p<0,00001	1992=1997 (srnn) g: F= 3,92; p=0,054; i: F=17,48; p<0,00001	1993=1997 (srnn) g: F= 5,62; p<0,05; i: F=14,62; p<0,0001	1994=1997 g: F= 0,01; p=0,91	1995=1997 g: F= 0,001; p=0,98	1996=1997 g: F= 0,27; p=0,60	4
Sign. Diff.	10	7	5	5	4	2	1	0	0	0	34

cohorts of 1988 and 1989; age<5 years; g: F= 8,18; p<0,01; i: F=23,78; p<0,00001 and the cohorts of 1993 and 1997; age<3 years; g: F= 7,68; p<0,01; i: F=12,85; p<0,0001) and upper beam circumference (table 8; the cohorts of 1988 and 1989; age<5 years; g: F= 6,12; p<0,05; i: F=18,01; p<0,0001). A significant difference found in the upper beam circumference between the 1993 and the 1997 cohort is present, however, only in the stags aged one and two years, not at a later age, and it was considered to be insignificant. Still, such differences generally signify the errors in the execution of breeding hunt, i.e., the average or over-average trophy stags were eliminated from the population in "weaker" cohorts.

As the age represents a categorical predictor to each variable analysed, it is impossible to apply the usual statistical methods such as a discriminant analysis or a PCA for the sake of a cohort group separation. In view of a grouping method applied, it is possible to separate various numbers of cohort groups (table 11), from four (length of tray tines and the number of tines) to eight (weight of dry antlers), depending on a variable. The cohorts do not exhibit a statistically significant difference within the same group, and in most cases the successive cohorts in a sequence belong to different groups. The exemptions are recorded in the weight of dry antlers (table 2; 1986<1988; g: F=8,37; p<0,05), circumference of coronets (table 6; 1986<1988; g: F=21,68; p<0,0001), and upper beam circumference (table 8; 1986<1988; g: F=4,60; p<0,05).

Irrespective of the number of groups obtained and a variable utilized as a quality indicator, the cohorts of 1995, 1996, and 1997 may be isolated as the "superior" ones, comprising the first group of the three examined variables (weight of dry antlers, main beam lengths, length of brow tines and the upper beam circumference). In the variables of the length of tray tines, circumference of coronets, and trophy value, the 1994 cohort also comes along as a member of the first group. This cohort is interesting due to a fact that it does not exhibit a significant difference regarding the 1995 and 1997 cohorts most frequently, but it is significantly weaker than the 1996 cohort in the variables of the main beam length and upper beam circumference, so it comprises a separate Group 2 concerning these two variables. With regard to the tine number variable, the 1993 cohort (but not the 1994 one) also joins the aforementioned "superior" cohorts, whereas it also comprises the first group with the "superior" cohorts and the cohorts of 1992 and 1994 in the length of tray tines.

The cohorts from the 1980s and the 1990 cohort generally comprise a sequence back, so it may be said that they pertain to the "worse cohorts," out of which the 1986 cohort should definitely be isolated, as it has significantly lower values in most variables. The mediocre cohorts would be the ones of 1991 and 1992. The number of qualitative groups succeeded to be recognized by each individual variable varies from 5 to 8.

Since the number of groups is based upon the number of established significant differences, the more differences are found, the higher a variable usability should be. Nonetheless, 8 groups were obtained through weight of dry antlers, which, in principle, are not significantly mutually different. A small number of groups obtained by the implementation of the length of tray tines and the number of tines has not succeeded in isolating the best cohorts clearly, so some mediocre cohorts (1992 and 1993) were also placed in the "best" category. Consequently, an overall

Table 7 Comparison of cohorts for lower beam circumference (signs in bold indicate significant differences; „I"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)
Tablica 7 Usporedba kohorti za donji opseg (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „I"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – KOHORTE	COHORTS – KOHORTE										Sign. Diff.
	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	
1988	1986=1988; g: F=1,89; p=0,18	–									0
1989	1986=1989; g: F=1,70; p=0,20	**1988<1989 (age<5) g: F=8,18; p<0,01 i: F=23,78; p<0,00001**	–								1
1990	1986=1990; g: F=0,91; p=0,35	1988=1990 g: F=0,07; p=0,80	**1989<1990 (age>11) g: F=5,41; p<0,05; i: F=23,77; p<0,00001**	–							1
1991	**1986<1991 g: F=7,39; p<0,05**	**1988<1991 g: F=6,35; p<0,05**	1989=1991 g: F=2,16; p=0,15	1990=1991 g: F=0,21; p=0,65	–						2
1992	**1986<1992 g: F=9,36; p<0,01**	**1988<1992 g: F=11,45; p<0,01**	1989=1992 g: F=0,61; p=0,44	1990=1992 g: F=3,24; p=0,08	1991=1992 g: F=1,02 p=0,32	–					2
1993	**1986<1993 g: F=12,69; p<0,01**	**1988<1993 g: F=22,65; p<0,001**	**1989<1993 g: F=4,21; p<0,05**	**1990<1993 g: F=9,91; p<0,01**	1991=1993 g: F=3,47; p=0,07	1992=1993 g: F=1,51; p=0,23	–				4
1994	**1986<1994 g: F=18,06; p<0,001**	**1988<1994 g: F=26,87; p<0,0001**	**1989<1994 (age>6) g: F=2,54; p=0,12; i: F=20,01; p<0,00001**	**1990<1994 g: F=7,40; p<0,05**	1991=1994 g: F=0,25; p=0,62	1992=1994 g: F=0,63; p=0,43	1993=1994 g: F=2,78; p=0,10	–			4
1995	**1986<1995 (age>4) g: F=0,05; p=0,83; i: F=30,79; p<0,00001**	**1988<1995 g: F=36,36; p<0,0001**	**1989<1995 (age>5) g: F=3,84; p=0,06; i: F=23,45; p<0,00001**	**1990<1995 g: F=16,82; p<0,01**	**1991<1995 g: F=5,64; p<0,05;**	1992=1995 g: F=1,24; p=0,27	1993=1995 (srnn) g: F=5,94; p<0,05; i: F=19,38; p<0,00001	1994=1995 g: F=0,07; p=0,80	–		5

	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	
1996	1986<1996 (age>4) g: F= 0,97; p=0,33; i: F=37,26; p<0,00001	1988<1996 g: F= 36,49; p<0,0001	1989<1996 (age>5) g: F= 8,05; p<0,01; i: F=28,08; p<0,00001	1990<1996 g: F= 15,30; p<0,01	1991<1996 g: F= 4,45; p<0,05;	1992<1996 (age>5) g: F= 3,95; p=0,053; i: F=32,72; p<0,00001	1993<1996 (age>8) g: F= 9,14; p<0,01; i: F=29,12; p<0,00001	1994=1996 g: F= 1,44; p=0,24	1995=1996 g: F= 1,12; p=0,30	–	7
1997	1986<1997 (age>4) g: F= 0,51; p=0,48; i: F=22,15; p<0,00001	1988<1997 g: F= 22,04; p<0,0001	1989<1997 (age>5) g: F= 5,52; p<0,05; i: F=16,01; p<0,0001	1990<1997 g: F= 12,25; p<0,01	1991=1997 g: F= 0,02; p=0,88;	1992=1997 (srnn) g: F= 2,56; p=0,12; i: F=21,24; p<0,00001	1993>1997[1] (age<3) g: F= 7,68; p<0,01; i: F=12,85; p<0,0001	1994=1997 g: F= 0,78; p=0,38	1995=1997 g: F= 0,52; p=0,47	1996=1997 g: F= 0,05; p=0,83	4
Sign. Diff.	7	8	6	5	2	1	1	0	0	0	30

[1]Test result is interpreted as „insignificant difference" because the difference is refered to stags *at the age of 1 and 2 years./Rezultat testa je interpretiran kao „nesignifkantna razlika" jer se razlika odnosi samo na jelene u dobi od 1 i 2 godine.*

trophy value, as well as the circumferences (coronets, lower and upper beam), may be utilized as an estimation indicator in the future, for they have managed to isolate the same cohorts—1994, 1995, 1996 and 1997—as the more high-quality ones.

DISCUSSION
RASPRAVA

A cohort represents a group of individuals in a population calved (hatched) within the same calving (hatching) period. There are two basic cohort effects or variabilities: an abundance effect and a quality effect (Gaillard et al. 2003). An abundance effect is manifested by a calf share that has survived the first year of life and recruits a population (Gaillard et al. 1997, Forchhammer et al. 2001), whereas a quality effect represents a long-term impact that may generate the phenotypic and genotypic differences in the condition component between the cohorts (Kruuk et al. 1999, Hik and Carey 2000). According to Gaillard et al. (2000, 2003), the ways of life namely depend on a habitat conditions that had prevailed from the moment at which an individual has come into the world (and even on the conditions during its mother's gestation) up to the moment at which they have started to enter the adult life phase. If these conditions were better, then the ways of life of an individual will also be better, i.e., an individual has a major predisposition by comparison with those peers who grew up in the worse life conditions. Simplified, individuals from the better cohorts will have larger corporeal dimensions, will earlier enter an adult phase, will have better chances for survival, will be in a breeding phase longer and will also have a more numerous progeny.

The most frequently used indicators concerning the ways of life among the cohorts were physical growth, corporeal mass of adult individuals, an average reproduction success, the age in which a head enters into reproduction, adult head survival and yearling survival (Gaillard et al. 2003). The antlers and horns, however, are one of the most visible examples of sexual selection, since they have been developed as a result of an intensive competition between the stags during mating (Clutton-Brock et al. 1980, Coltman et al. 2001). This mating competition is a key factor in the evolution and morphology of those male artiodactyls which demonstrate a high level of polygamy. Hereby, sexual dimorphism, manifested in a body (Weckerly, 1998) and antler size (Clutton-Brock et al. 1980, Caro et al. 2003), also increases along with a polygamy degree, but it actually pertains to a relative resource allocation, i.e., to an incorporation of environmental resources (forage and water) into the antlers, horns, corporeal size or just in the individual organs. Since the stags are fighting for a hind during a relatively short mating season, the quality lies in a close dependency on a fighting capability, i.e., on a corporeal size and age. In other words, the antlers and horns do not only play a role of weapon, but they are also a signal, i.e., a sign of readiness (Goss 1983).

Table 8 Comparison of cohorts for upper beam circumference (signs in bold indicate significant differences; „i"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)
Tablica 8 Usporedba kohorti za gornji opseg (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „i"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – KOHORTE	COHORTS – KOHORTE										Sign. Diff.
	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	
1988	**1986<1988 g: F= 4,60; p<0,05**	–									1
1989	1986=1989 g: F= 1,54; p=0,23	**1988<1989 (age<5) g: F= 6,12; p<0,05 i: F=18,01; p<0,0001**	–								1
1990	**1986<1990 g: F= 4,82; p<0,05**	1988=1990 g: F= 0,06; p=0,81	1989=1990 (srnn) g: F= 4,41; p<0,05; i: F=17,01; p<0,00001	–							1
1991	**1986<1991 g: F= 8,98; p<0,01**	1988=1991 g: F= 1,79; p=0,19	1989=1991 g: F= 1,20; p=0,28	1990=1991 g: F= 1,29; p=0,27	–						1
1992	**1986<1992 g: F= 8,98; p<0,01**	**1988<1992 g: F= 5,36; p<0,05**	1989=1992 g: F= 0,05; p=0,83	1990=1992 g: F= 2,44; p=0,13	1991=1992 g: F= 1,12 p=0,30	–					2
1993	**1986<1993 g: F= 22,84; p<0,0001**	**1988<1993 g: F= 19,27; p<0,001**	1989=1993 g: F= 0,11; p=0,74	**1990<1993 g: F= 12,42; p<0,01**	**1991<1993 g: F= 7,51; p<0,01**	**1992<1993 g: F= 4,66; p<0,05**	–				5
1994	**1986<1994 g: F= 20,56; p<0,0001**	**1988<1994 g: F= 14,28; p<0,001**	**1989<1994 (age>7) g: F= 1,47; p=0,23; i: F=11,86; p<0,001**	**1990<1994 g: F= 7,46; p<0,05**	1991=1994 g: F= 0,02; p=0,89	1992=1994 g: F= 1,41; p=0,24	1993=1994 g: F= 2,44; p=0,13	–			4
1995	**1986<1995 g: F= 28,33; p<0,00001;**	**1988<1995 g: F= 26,13; p<0,0001**	**1989<1995 (age>5) g: F= 3,13; p=0,09; i: F=18,43; p<0,00001**	**1990<1995 g: F= 16,52; p<0,001**	**1991<1995 g: F= 6,44; p<0,05;**	**1992<1995 (age>5) g: F= 3,20; p=0,08; i: F=21,12; p<0,00001**	**1993<1995 g: F= 4,67; p<0,05;**	1994=1995 g: F= 0,07; p=0,79	–		7

											Total
1996	1986<1996 (age>3) g: F= 0,92; p=0,34; i: F=64,31; p<0,00001	1988<1996 (age>3) g: F= 0,19; p=0,67; i: F=63,62; p<0,00001	1989<1996 (age>5) g: F= 12,72; p<0,001; i: F=34,12; p<0,00001	1990<1996 (age>3) g: F= 0,59; p=0,45; i: F=52,42; p<0,00001	1991<1996 (age>4) g: F= 4,91; p<0,05; i: F=37,05; p<0,00001	1992<1996 (age>5) g: F= 14,42; p<0,001; i: F=37,37; p<0,00001	1993<1996 g: F= 15,08; p<0,0001;	1994<1996 (age>5) g: F= 3,79; p=0,06; i: F=36,21; p<0,00001	1995=1996 g: F= 1,16; p=0,29	–	8
1997	1986<1997 g: F= 30,98; p<0,00001	1988<1997 g: F= 13,11; p<0,001	1989<1997 (age>7) g: F= 4,78; p<0,05; i: F=11,90; p<0,0001	1990<1997 g: F= 8,73; p<0,01	1991=1997 g: F= 1,04; p=0,31;	1992=1997 (srnn) g: F= 5,10; p<0,05; i: F=14,28; p<0,0001	1993<1996 g: F= 6,46; p<0,05;	1994=1997 g: F= 0,71; p=0,41	1995=1997 g: F= 0,54; p=0,47	1996=1997 g: F= 1,33; p=0,25	5
Sign. Diff.	9	7	4	5	3	3	3	1	0	0	35

Thus, the development of antlers (and horns) represents the second cohort component—a qualitative one.

A question is being raised, however, of which antler variable may be a reliable indicator of differences between the red deer cohorts. In bovids, a horn length was manifested as a reliable index, especially in the wild sheep, Ovis spp. (e.g., Bunnell 1978, Hik and Carey 2000, Festa-Bianchet et al. 2004, Loehr et al. 2007, Hengeveld and Festa-Bianchet 2011).

The research results in this paper indicate that it might be a trophy value. It might be so, however, only if one compares the cohorts evaluated in an identical trophy evaluation system, because the evaluation procedures differ (CIC, SCI, and Rowland Ward). According to Mysterud et al. (2005), a tine number may also be a cohort quality indicator, being positively connected with the meteorological conditions (snow intensity) during hibernal months—the lower the snow depth, the higher the number of tines during a summer following that winter. Nonetheless, this index is not utilizable in the juvenile head age class (e.g., aged two to five years), for the number of tines is then still relatively small (and is, as a rule, increased on the crown, whereas the first three tines (brow, bay and tray tines) are relatively permanent (Raesfeld and Reulecke 1988). The implementation of weight of dry antlers has a disadvantage of its own, because it is only measured in the CIC evaluation system, but a skull processing method upon evaluation is not standardized, since a skull may be weighed freshly processed, dry, and complete, with a smaller or larger maxilla part dissected. A skull dissection type thereby entails certain deductions (Hromas et al. 2008). Additionally, since the antler mass measurement has two components—a branch mass and a skull mass—, it is difficultly applicable to the branches shed. The length variables are also unfavorable, because the fractures of the brow and of the tray tines, or the fractures of a main beam, may occur. It therefore appears that circumferences may be the most adequate variables. According to Ullrey (1982) and Rasmussen (1985), a variability in the white-tailed deer *(Odocoileus virginianus)* feedstuff quality has been manifested solely in a branch diameter modification, while the other antler variables have remained unchanged. What is more, a white-tailed deer's trophy quality is possible to be predicted by a branch diameter as early as in the yearling age (Severinghaus et al. 1950). Besides, a circuferences share in the overall trophy value averagely amounts to 42.4% even in the CIC evaluation system (Paljug 2018), comprising almost a half of the grade.

Contrary to North American–Scandinavian approach of wild ungulate management, in the Central European approach, supplemental feeding is practiced (Adamič 1990). Therefore a cohort effect should be reduced. However, this impact is occasionally even comprehended contrarily by the researchers, as a compensation growth may occur in certain species. It is a phenomenon in which the populations in worse habitat conditions, despite an initial slower antler or horn growth, may compensate the shortcoming at a later age during a lifetime (see Rughetti and Festa-Bianchet 2010). Certain scientists (e.g., Sibbald et al. 1993) quote that a compensation growth in the red deer

Table 9 Comparison of cohorts for number of tines (signs in bold indicate significant differences; „i"=interaction i.e. Johnson–Neyman method is applied; srnn = square root of negative number)

Tablica 9 Usporedba kohorti za broj parožaka (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „i"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – *KOHORTE*	COHORTS – *KOHORTE* 1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	1986=1988 g: F= 1,26; p=0,27	–									0
1989	1986=1989 g: F= 0,82; p=0,37	1988=1989 g: F= 0,02; p=0,97	–								0
1990	**1986<1990 g: F= 4,67; p<0,05**	1988=1990 g: F= 1,47; p=0,24	1989=1990 g: F= 1,01; p=0,33	–							1
1991	1986=1991 g: F= 1,30; p=0,26	1988=1991 g: F= 0,0003; p=0,99	1989=1991 g: F= 0,001; p=0,97	1990=1991 g: F= 1,94; p=0,17	–						0
1992	1986=1992 g: F= 1,02; p=0,32	1988=1992 g: F= 0,03 p=0,87	1989=1992 g: F= 0,05; p=0,83	1990=1992 g: F= 1,46; p=0,24	1991=1992 g: F= 0,03 p=0,85	–					0
1993	**1986<1993 g: F= 9,70; p<0,001**	**1988<1993 g: F= 7,20; p<0,05**	**1989<1993 g: F= 4,98; p<0,05**	1990=1993 g: F= 1,13; p=0,30	**1991<1993 g: F= 6,24; p<0,05**	1992=1993 g: F= 0,01; p=0,93	–				4
1994	**1986<1994 g: F= 5,44; p<0,05**	1988=1994 g: F= 0,21; p=0,65	1989=1994 g: F= 0,20; p=0,66	1990=1994 g: F= 0,37; p=0,55	1991=1994 g: F= 0,31; p=0,60	1992=1994 g: F= 0,39; p=0,54	1993=1994 g: F= 0,24; p=0,63	–			1
1995	**1986<1995 g: F= 6,41; p<0,05;**	1988=1995 (srnn) g: F= 1,65; p=0,21; i: F=12,19; p<0,0001	1989=1995 g: F= 1,19; p=0,28	1990=1995 g: F= 0,05; p=0,83	1991=1995 g: F= 2,12; p=0,15;	1992=1995 g: F= 1,74; p=0,19	1993=1995 g: F= 1,27; p=0,27	1994=1995 g: F= 0,30; p=0,59	–		1
1996	**1986<1996 (age>4) g: F= 0,96; p=0,33; i: F=22,99; p<0,00001**	**1988<1996 (age>5) g: F= 6,48; p<0,05; i: F=21,71; p<0,0001**	**1989<1996 (age>5) g: F= 4,53; p<0,05; i: F=14,58; p<0,001**	**1990<1996 (age>5) g: F= 1,50; p=0,23; i: F=27,24; p<0,00001**	**1991<1996 (age>5) g: F= 8,06; p<0,01; i: F=19,69; p<0,00001**	**1992<1996 (age>5) g: F= 5,71; p<0,05; i: F=12,61; p<0,0001**	1993=1996 (srnn) g: F= 4,70; p<0,05; i: F=15,46; p<0,00001	1994=1996 (srnn) g: F= 2,96; p=0,10; i: F=15,87; p<0,00001	1995=1996 g: F= 2,78; p=0,10	–	6
1997	**1986<1997 (age>4) g: F= 1,01; p=0,32; i: F=20,79; p<0,00001**	**1988<1997 (age>5) g: F= 8,06; p<0,05; i: F=19,13; p<0,0001**	**1989<1997 (age>6) g: F= 4,96; p<0,05; i: F=11,36; p<0,001**	1990=1997 g: F= 1,51; p=0,23	**1991<1997 (age>5) g: F= 8,80; p<0,01; i: F=16,32; p<0,00001**	**1992<1997[1] (age>15) g: F= 5,88; p<0,05; i: F=9,41; p<0,001**	1993=1997 (srnn) g: F= 5,05; p<0,05; i: F=12,14; p<0,0001	1994=1997 g: F= 2,85; p=0,10	1995=1997 g: F= 2,76; p=0,10	1996=1997 g: F= 0,02; p=0,90	3
Sign. Diff.	6	1	3	1	3	1	0	1	0	0	16

[1]Test result is interpreted as „insignificant difference" because the difference is refered to stags older of 15 years (management is directed to maximal age of 12 years)./*Rezultat testa je interpretiran kao „nesignifikantna razlika" jer se razlika odnosi samo na jelene starije od 15 godina, što premašuje gospodarsku starost jelena od 12 godina.*

Table 10 Comparison of cohorts for trophy value (signs in bold indicate significant differences; „I"=interaction i.e. Johnson–Neyman method is applied srnn = square root of negative number)
Tablica 10 Usporedba kohorti za trofejnu vrijednost (znakovi otisnuti masnim slovima ukazuju na statistički značajne razlike; „I"=interakcija, odn. primijenjena je Johnson–Neyman metoda; srnn = korijen iz negativnog broja)

COHORTS – *KOHORTE*	1986	1988	1989	1990	1991	1992	1993	1994	1995	1996	Sign. Diff.
1988	1986=1988 g: F= 0,32; p=0,58	—									0
1989	1986=1989 g: F= 3,80; p=0,06	1988=1989 (srnn) g: F= 5,41; p<0,05; i: F=25,40; p<0,00001	—								0
1990	**1986<1990 g: F= 6,30; p<0,05**	1988=1990 g: F= 0,01; p=0,91	**1989<1990 (age>13) g: F= 5,30; p<0,05; i: F=29,83; p<0,00001**	—							1
1991	**1986<1991 g: F= 9,57; p<0,01**	**1988<1991 g: F= 5,02; p<0,05**	1989=1991 g: F= 0,59; p=0,45	1990=1991 g: F= 3,08; p=0,09	—						2
1992	**1986<1992 g: F= 14,44; p<0,001**	**1988<1992 g: F= 9,29; p<0,01**	1989=1992 g: F= 0,16; p=0,90	1990=1992 g: F= 3,03; p=0,09	1991=1992 g: F= 0,57; p=0,46	—					2
1993	**1986<1993 g: F= 23,09; p<0,0001**	**1988<1993 g: F= 21,38; p<0,0001**	**1989<1993 g: F= 4,80; p<0,05**	**1990<1993 g: F= 11,93; p<0,01**	**1991<1993 g: F= 5,63; p<0,05**	—	—				5
1994	**1986<1994 g: F= 31,27; p<0,0001**	**1988<1994 g: F= 24,43; p<0,0001**	**1989<1994 (age>6) g: F= 2,78; p=0,10; i: F=26,13; p<0,00001**	**1990<1994 g: F= 10,457; p<0,01**	1991=1994 g: F= 0,92; p=0,34	**1992<1994 (srnn) g: F= 3,08; p=0,09; i: F=28,26; p<0,0001**	**1993=1994 (srnn) g: F= 4,84; p<0,05; i: F=24,23; p<0,00001**	—			4
1995	**1986<1995 (age>3) g: F= 0,04; p=0,84; i: F=64,42; p<0,00001**	**1988<1995 (age>3) g: F= 0,16; p=0,69; i: F=60,78; p<0,0001**	**1989<1995 (age>5) g: F= 4,53; p<0,05; i: F=14,58; p<0,001**	**1990<1995 g: F= 20,23; p<0,0001**	**1991<1995 (age>4) g: F= 2,71; p=0,11; i: F=40,31; p<0,00001**	**1992<1995 (age>5) g: F= 6,88; p<0,05; i: F=39,36; p<0,00001**	**1993<1995 (age>6) g: F= 9,38; p<0,001; i: F=34,42; p<0,00001**	1994=1995 g: F= 0,27; p=0,61	—		7

1996	1986<1996 (age>3) g: F= 3,72; p=0,06; i: F=115,70; p<0,00001	1988<1996 (age>3) g: F= 1,42; p=0,24; i: F=101,13; p<0,0001	1989<1996 (age>4) g: F= 17,39; p<0,001; i: F=60,93; p<0,00001	1990<1996 (age>3) g: F= 1,03; p=0,32; i: F=87,67; p<0,00001	1991<1996 (age>4) g: F= 10,52; p<0,01; i: F=57,39; p<0,00001	1992<1996 (age>4) g: F= 19,53; p<0,0001; i: F=60,58; p<0,00001	1993<1996 (age>5) g: F= 22,6853; p<0,0001; i: F=54,85; p<0,00001	1994=1996 (srnn) g: F= 4,46; p<0,05; i: F=73,66; p<0,00001	1995=1996 (srnn) g: F= 3,84; p=0,06; i: F=105,09; p<0,00001		7
1997	1986<1997 (age>3) g: F= 0,39; p=0,54; i: F=40,36; p<0,00001	1988<1997 (age>3) g: F= 0,01; p=0,93; i: F=40,84; p<0,0001	1989<1997 (age>5) g: F= 6,89; p<0,05; i: F=22,77; p<0,00001	1990<1997 g: F= 12,963; p<0,001	1991<1997 (age>5) g: F= 3,64; p=0,06; i: F=28,02; p<0,00001	1992<1997 (age>5) g: F= 7,78; p<0,01; i: F=24,84; p<0,00001	1993<1997 (age>7) g: F= 10,12; p<0,01; i: F=19,94; p<0,00001	1994=1997 g: F= 0,87; p=0,36	1995=1997 g: F= 0,32; p=0,58	1996=1997 g: F= 1,22; p=0,28	7
Sign. Diff.	8	7	5	5	4	3	3	0	0	0	35

Table 11 Ranking of cohorts according to parameters and significant differences of statistical tests
Tablica 11 Poredak kohorti prema parametrima s obzirom na dobivene signifikantne razlike statitičkih testova

NO RB	Weight of dry antlers Masa rogovlja		Main beam length Duljina grane		Length of brow tines Duljina nadočnjaka		Length of tray tines Duljina srednjaka		Circumference of coronets Opseg vijenca		Lower beam circumference Donji opseg		Upper beam circumference Gornji opseg		Number of tines Broj parožaka		Trophy value Trofejna vrijednsot	
	G	C	G	C	G	C	G	C	G	C	G	C	G	C	G	C	G	C
1		1996		1996		1996		1995		1996		1996		1996		1996		1997
2	1[1]	1995	1	1995	1	1995		1994	1	1994	1	1995	1	1995	1	1997	1	1996
3		1997		1997		1997	1	1996		1995		1997	2	1997		1993		1995
4	2	1993	2	1994	2	1993		1997		1997		1994		1994		1995		1994
5		1994	3	1992		1994		1993	2	1993	2	1993	3	1993		1994	2	1993
6	3	1992		1993	3	1991		1992	3	1992	3	1992		1992	2	1992		1992
7	4	1991	4	1991	4	1992	2	1991	4	1991	4	1991	4	1991		1990	3	1991
8	5	1989	5	1989		1989	3	1989	5	1990	5	1990	5	1989		1988	4	1990
9	6	1990		1988	5	1988	4	1986		1989	6	1989	6	1990	3	1991		1989
10	7	1988	6	1990		1990		1990	6	1988	7	1986	7	1988		1989	5	1988
11	8	1986	7	1986	6	1986		1988	7	1986		1988		1986	4	1986	6	1986

G = groups, C = cohorts/G =skupine. C=kohorte

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[1] Number of statistical differences/ Broj statistički značajnih razlika

is considerably limited in the free nature, and nutrition reinforcement does not exert its influence on an increase in natal masses or sexual maturity acceleration. Yet, most results of the research conducted in the Central European conditions speak the contrary. According to Schmidt and Hoi (2002), a variability between the cohorts is by 50% less manifested in red deer populations that are supplementarily fed than in the populations in which the red deer individual are not supplementarily fed, depending on a quantity and quality of nutrition reinforcement. As a result of nutrition reinforcement, a qualitative climate effect is reduced, since wildlife nutrition reinforcement generally contributes to the equalization of environmental conditions which are variable, and it conditions considerable differences in body masss or other way-of-life characteristics between the cohorts in the regions without supplementary feeding. In the long run, it implies that, in the conditions of a supplementary feeding, the oscillations in body mass and antler quality are not conditioned by environmental stresses to such an extent, but they are generally conditioned by genetic predispositions, what alleviates, i.e., reduces, a breeding hunt error. In the Central European approach to the wild artiodactyl management, namely, the unpromising head are eliminated from the population by breeding hunt ("Hege mit der Büchse"), whereas the promising head are spared up to the obtainment of asymptotic trophy values (Raesfeld and Reulecke, 1988). In that respect, it should be expected in our research that major differences are manifested without interactions, i.e., ever since the age of two up to the asymptotic values. A manifestation of interactions signifies the errors in the execution of selection hunt, i.e., that the promising individuals were shot in the younger age categories during the breeding hunt.

Summarizing the results of our research, one may say that the differences in the red-deer management level on the examined Hunting ground were generally confirmed. The cohorts from the commencement of an intensive management (the second half of the 1980s and the beginning of the 1990s) have the lower variable values than the cohorts that came into the world during an intensive management (mid-1990s) and circumferences of antlers can use as a quite valuable indicators.

REFERENCES
LITERATURA

- Adamič, M., 1990: Prehranske značilnosti kot element načrtovanja varstva, gojitve in lova parkljaste divjadi s odudarkom na jelenjadi (*Cervus elaphus* L.). Universa Edvarda Kardelja v Ljubljani – VDO Biotehniška fakulteta, Inštitut za gozdno in lesno gospodarstvo VTOZD za gozdarstvo, Strokovna in znanstvena dela 105, Doktorska disertacija na Univerzi v Beogradu, Ljubljana, 203 pp.

- Ahrens, M., G. Dittrich, H. Sparing, 1988: Untersuchung zur Körperentwicklung beim Damwild. Beiträge zur Jagd- und Wildforschung, 15:7-14.

- Almăsan, A., W. Rieck, 1970: Untersuchungen der Zahnstruktur zur Alterbestimmung beim Rotwild (*Cervus elaphus* L.). Z. Jagdwiss. 16(2):49-55.

- Anon., 1981: Hunting management plan for hunting ground „Garjevica", time span 1981-1991. Lovno gospodarstvo „Garjevica" Kutina, 48 pp. (in Croatian).

- Anon., 1993: Hunting management plan for hunting ground „Garjevica", time span 1st April 1991. – 31st March 2001. Kutina, 210 pp. (in Croatian).

- Anon., 2000: CORINE Land Cover Hrvatska.

- Anon., 2008: Rules on hunting trophy measurement method, hunting trophy form, proposition of hunting trophies evidence and report of measured hunting trophies. Official Gazette, no. 92.

- Brna, J., Đ. Nikolandić, S. Darabuš, 1996: Hunting management plan for hunting ground „Garjevica", time span 1st April 1995. – 31st March 2004. Kutina, 240 pp. (in Croatian).

- Bunnell, F.L., 1978: Horn growth and population quality in Dall sheep. J Wildlife Manage, 42(4):764 – 775.

- Caro, T.M., C.M. Graham, C.J. Stoner, M.M. Flores, 2003: Correlates of horn and antler shape in bovids and cervids. Behav Ecol Sociobiol, 55:32-41.

- Clutton-Brock, T.H., S.D. Albon, P.H. Harvey, 1980: Antlers, body size and breeding group size in Cervidae. Nature, 285:565-567.

- Coltman, D.W., M. Festa-Bianchet, J.T. Jorgenson, C. Strobeck, 2001: Age-dependent sexual selection in bighorn rams. P Roy Soc B-Biol Sci, 269:165-172.

- Enquist, L., 2005: The mistreatment of covariate interaction terms in linear model analyses of behavioural and evolutionary ecology studies. Anim Behav, 70:967–971. doi:10.1016/j.anbehav.2005.01.016

- Festa-Bianchet, M., D. Coltman, L. Turelli, J.T. Jorgenson, 2004: Relative allocation to horn and body growth in bighorn rams varies with resource availability. Behav Ecol, 15:305–312.

- Forchhammer, M.C., T.H. Clutton-Brock, J. Lindström, S.D. Albon, 2001: Climate and population density induce long-term cohort variation in a northern ungulate. J Anim Ecol, 70:721-729.

- Gaillard, J.-M., A. Loison, C. Toïgo, D. Delorme, G. Van Laere, 2003: Cohort effects and deer population dynamics. Ecoscience, 10(4):412-420.

- Gaillard, J.-M., J.-M. Boutin, D. Delorme, G. Van Laere, P. Duncan, J.D. Lebreton, 1997: Early survival in roe deer: Causes and consequences of cohort variation in two contrasted populations. Oecologia, 112(4):502–513.

- Gaillard, J.-M., M. Festa-Bianchet, D. Delorme, J.T. Jorgenson, 2000: Body mass and individual fitness in female ungulates: bigger is not always better. P Roy Soc Lond B Bio, 267(1442):471-477.

- Gaspar-López E., A.J. García, T. Landete-Castillejos, D. Carrión, J.A. Estévez, L. Gallego, 2008: Growth of the first antler in Iberian red deer *(Cervus elaphus hispanicus)*. Eur J Wildlife Res, 54(1):1–5.

- Goss, R.J., 1983: Deer antlers. Regeneration, function and evolution. Academic Press, New York, 316 pp.

- Hengeveld, P.E., M. Festa-Bianchet, 2011: Harvest Regulations and Artificial Selection on Horn Size in Male Bighorn Sheep. J Wildlife Manage, 75(1):189-197.
- Hewison, A.J.M., J.P. Vincent, E. Bideau, J.M. Angibault, R.J. Putman, 1996: Variation in cohort mandible size as an index of roe deer *(Capreolus capreolus)* densities and population trends. J Zool, 239(3):573-581.
- Hik, D.S., J. Carey, 2000: Cohort variation in horn growth of dall sheep rams in the southwest Yukon, 1969-1999. Biennial Symposium Northern Wild Sheep and Goat Council 12, pp 88-100.
- Hromas, J., J. Feuereisel, K. Maierhofer, 2008: Trophäenbewertung der europäischen Wildarten (aktualisierte Bewertungskriterien). CIC-Kommission „Ausstellungen und Trophäen" – Herausgegeben für den Trophäenbewertundskurs der Internationalen Kommission für Trophäenbewertung in Nasswald vom 30. Mai bis 1. Juni 2008, 135 pp.
- http://gis.hrsume.hr/hrsume/wms
- http://gis.hrsume.hr/privsume/wms
- https://rowlandward.org/wp-content/uploads/2021/01/Measuring-Handbook.pdf
- https://safariclub.org/wp-content/uploads/2020/05/SCI-Measuring-Manual-Sept-2019.pdf
- Jumić, V., 2003: Body and trophy development of red deer (*Cervus elaphus* L.) in the state hunting ground VII/4 "GARJEVICA". Master thesis, University in Zagreb – Faculty of Forestry, Zagreb, 76 pp. (in Croatian).
- Kim, S., 2010: Alternatives to analysis of covariance for heterogeneous regression slopes in educational research. Korean Journal of Teacher Education, 26(1):73-91.
- Kjellander, P., J-M. Gaillard, A.J.M. Hewison, 2006: Density-dependet responses of fawn cohort body mass in two contrasting roe deer populations. Oecologia 146(4):521-530.
- Krapinec, K., M. Grubešić, K. Tomljanović, I. Kovač, 2009: The role of hunting exhibitions and degree of development hunting management of countries with the emphasis on Croatia (in Croatian with English summary). Ekonomska i ekohistorija, 5(5):5-43.
- Kruuk, L.E.B., T.H. Clutton-Brock, E. Rose, F.E. Guinness, 1999: Early determinants of lifetime reproductive success differ between the sexes in red deer. P Roy Soc Lond B Bio, 266(1429):1655-1661.
- Landete-Castillejos, T., J.D. Curey, J.A. Estevez, Y. Fiero, A. Calatayud, F. Ceacero, A.J. Garcia, L. Gallego, 2010: Do drastic weather effects on diet influence changes in chemical composition, mechanical properties and structure in deer antlers? Bone, 47(4):815-825.
- Lincoln, G.A., 1992: Biology of antlers. J Zool, 226(3):517-528.
- Loehr, J., J. Carey, M. Hoefs, J. Suhonen, H. Ylönen, 2007: Horn growth rate and longevity: implications for natural and artificial selection in thinhorn sheep *(Ovis dalli)*. J Evolution Biol 20(2):818-828.
- Martínez Salmerón, D., 2014: Three-dimensional study of the Iberian red deer antler (*Cervus elaphus hispanicus*): application of geometric morphometrics techniques ond other methodologies. PhD Thesis, Universitat de Barcelona. Departament de Biologia Animal, 292 pp.
- Mateos, C., S. Alarocos, J. Carranza, C. Sánchez-Prieto, J. Valencia, 2008: Fluctuating asymmetry of red deer antlers negatively relates to individual condition and proximity to prime age. Anim Behav, 75(5):1629-1640.
- Mysterud, A., E. Meisingset, R. Langvatn, N.G. Yoccoz, N.Ch. Stenseth, 2005: Climate-dependent allocation of resources to secondary sexual traits in red deer. Oikos, 111(2):245 - 252.
- Nugent, G., C. Frampton, 1994: Microgeographical and temporal variation in mandible size within a New Zealand fallow deer *(Dama dama)* population. J Appl Ecol 31(2):253-262.
- Owen, S.V., R.D. Froman, 1998: Uses and Abuses of the Analysis of Covariance. Res Nurs Health, 21(6):557–562.
- Paljug, P., 2018: The importance of trophy evaluation components for finally trophy evaluation of wild ungulates. Bachelor thesis, University in Zagreb, Faculty of Forestry, Zagreb, 33 pp. (in Croatian).
- Pélabon, Ch., L. van Breukelen, 1998: Asymmetry in antler size in roe deer *(Capreolus capreolus)*, an index of individual and population conditions. Oecologia 116(1-2):1-8.
- Putman, R.J., M.S., Sullivan, J. Langbein, 2000: Fluctuating asymmetry in antlers of fallow deer *(Dama dama)*: the relative roles of environmental stress and sexual selection. Biol J the Linn Soc 70(1):27–36.
- Raesfeld, F., K. Reulecke, 1988: Das Rotwild. Verlag Paul Parey, Hamburg und Berlin, 416 pp.
- Rasmussen, G.P., 1985: Antler measurements as an index to physical condition and range quality with respect to white-tailed deer. New York Fish Game J, 32(2): 97-113.
- Riney, T., 1955: Evaluating condition of free-ranging red deer *Cervus elaphus* with special reference to New Zealand. New Zealand Journal of Science and Technology B. General section, 36(5):429-463.
- Rughetti, M., M. Festa-Bianchet, 2010: Compensatory growth limits opportunities for artificial selection in Alpine chamois. J Wildlife Manage, 74(5) 1024–1029. https://doi.org/10.2193/2009-335
- Schmidt, K.T., A. Stien, S.D. Albon, F.E. Guiness, 2001: Antler length of yearling red deer is determined by population density, weather and early life history. Oecologia 127(2):191-197.
- Schmidt, K.T., H. Hoi, 2002: Supplemental feeding reduces natural selection in juvenile red deer. Ecography 25(3):265-272.
- Seletković, Z., Z. Katušin, 1992: Croatian Climate. In: Rauš, Đ., ed. Forests of Croatia, Faculty of Forestry & Croatian Forests, p.f. Zagreb, pp. 13-19. (in Croatian with English summary).
- Severinghaus, C.W., H.F. Maguire, R.A. Cookingham, J.E. Tansk, 1950: Variations by age class in the antler beam diameters of white-tailed deer related to range conditions. Transactions of the 15th North American Wildlife and Natural Resources Conference, 15:551-570.
- Sibbald, A.M., P.D. Fenn, W.G. Kerr, A.S. Loudon, 1993: The influence of birth date on the development of seasonal cycles in red deer hinds *(Cervus elaphus)*. J Zool , 230(4): 593–607.
- Solberg, E.J., B.-E. Sæther, 1993: Fluctuating asymmetry in the antlers of moose *(Alces alces)*: does it signal male quality. P Roy Soc Lond B Bio, 254(13471):251-255.
- Stubbe, Ch., E. Gleich, 1990: Die Unterkieferlänge als Weiser für die Körpergröße des Schalenwildes. Beiträge zu Jagd- und Wildforschung, 17:244-248.
- Suttie, J.M., B. Mitchell, 1983: Jaw length and hind foot length as measures of skeletal development of Red deer (*Cervus elaphus)*. J Zool, 200(3): 431-434.

- TIBCO Software Inc. (2018). Statistica (data analysis software system), version 13. http://tibco.com.
- Ullrey, D.E., 1982: Nutrition and antler development in white-tailed deer. Pages 37-48 in Brown, R.D., ed. Antler development in Cervidae. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, pp. 48-59.
- Weckerly, F.W., 1998: Sexual-size dimorphism: influence of mass and mating system in the most dimorphic mammals. J Mammal 79(1):33-52.
- White, C. R. 2003: Allometric Analysis beyond Heterogeneous Regression Slopes: Use of the Johnson-Neyman Technique in Comparative Biology. Physiol Biochem Zoology, 76(1):135-140.

SAŽETAK

Kod cervida je izbor praktičnog populacijskog indeksa složeniji nego u bovida. Rogovlje nose uglavnom mužjaci (postoje i vrste kod kojih su oba spola šuta) i ono uglavnom predstavlja lovački trofej te je težište lovnog gospodarenja u većini zemalja usmjereno proizvodnji tog derivata. Stoga je i za očekivati da su se populacijski indeksi u cervida trebali razvijati upravo na bazi pojedinih elemenata izmjere trofeja (rogovlja). Za očekivati je kako u uvjetima prihrane cervida ne bi smjelo biti velikih razlika u kohortama neke populacije. No, postavlja se pitanje koji je od populacijskih indeksa dovoljno "osjetljiv" u prepoznavanju razlika.

Budući da ocjenjivanje rogovlja ima relativno dugu tradiciju u srednjoj Europi, u posljednje vrijeme postavlja se pitanje da li je podloga ocjenjivanja isključivo predmet lovačkih nadmetanja ili izmjerene vrijednosti elemenata ocjene trofeja mogu poslužiti za procjenu kvalitete populacije. Stoga je svrha ovoga rada ispitati može li se trofejna snaga upotrijebiti kao populacijski indeks.

Istraživanje je provedeno na trofejima jelena običnog iz državnog lovišta "Garjevica", koje se nalazi u središnjem dijelu panonskog područja Hrvatske u istočnom dijelu Moslavačke gore (Fig. 1)

Za analizu su uzimani podaci iz trofejnih listova rogovlja jelena običnog ocijenjeni prema pravilima CIC-a: duljina grana, duljina nadočnjaka, duljina srednjaka, opseg vijenca, opseg grane između nadočnjaka i srednjaka (donji opseg) opseg grane između srednjaka i krune (gornji opseg) masa rogovlja, broj parožaka i trofejna vrijednost. Dob jelena određivana je brojanjem naslaga zubnog cementa na prvom donjem kutnjaku (M_1). Na temelju godine odstrela (ili uginuća) jelena i procijenjene dobi, određivana je godina u kojoj je grlo oteljeno (kohorta). Nakon toga je načinjena usporedba kohorti za svaku vrijednost spomenutih elemenata ocjene trofeja, kao i za ukupnu trofejnu vrijednost.

Rezultati analize kovarijance pokazali su kako s obzirom na parametar (indikator), broj otkrivenih razlika među kohortama varira (Tablica 1 do 9). Najviše signifikantnih razlika u kohortama moguće je otkriti trofejnom vrijednošću (35 od 55, 64 %), gornjim opsegom (35 razlika, 64 %), opsegom vijenaca (34 razlika, 62 %), masom rogovlja (31 od 55, 56 %) i donjim opsegom (30 od 55, 55 %). Parametrima duljina moguće je otkriti nešto manje razlike. Najmanje razlika otkriveno je duljinom srednjaka (15 od 55, 27 %), a nešto više duljinom grane i duljinom nadočnjaka (29 od 55, 53 %), dok je s pomoću broja parožaka broj otkrivenih razlika bio najmanji – svega 16 (29 %).

Broj kvalitativnih skupina koje je svaki pojedini parametar uspio prepoznati varira od 4 do 8.

Kako se broj skupina bazira na broju ustanovljenih signifikantnih razlika, što je više pronađenih razlika uporabljivost nekog parametra trebala bi biti viša. Međutim, pomoću mase rogovlja dobiveno je 8 skupina koje se uglavnom međusobno signifikantno ne razlikuju. Mali broj skupina dobiven primjenom duljine srednjaka i broja parožaka nije uspio jasno izdvojiti najbolje kohorte, tako da je u kategoriju "najboljih" stavio i neke osrednje (1992 i 1993). Stoga bi se kao indikator procjene kvalitete populacije u budućnosti mogla koristiti ukupna trofejna vrijednost, ali i opsezi (opseg vijenaca, donji i gornji opseg) budući da su kao kvalitetnije kohorte uspjeli izdvojiti iste kohorte – 1994, 1995, 1996 i 1997.

Rezimirajući rezultate naših istraživanja, može se reći kako su uglavnom potvrđene razlike u razini gospodarenja jelenom običnim u istraživanom lovištu. Kohorte s početka intenzivnog gospodarenja (druga polovica 1980-ih i početak 1990-ih godina) imaju niže vrijednosti parametara od kohorti koje su došle na svijet tijekom intenzivnog gospodarenja (sredina 1990-ih godina 20. stoljeća.).

KLJUČNE RIJEČI: ocjenjivanje trofeja, rogovlje, masa rogovlja, duljine, opsezi, trofejna vrijednost