

CHANGE OF ANTLERS MORPHO-METRIC PARAMETERS AND TOTAL TROPHY SCORE IN ROE DEER (*CAPREOLUS CAPREOLUS* L.) IN RELATION TO AGE

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Abstract: The aim of this study was to determine the change in the value of morpho-metric parameters of antlers and the total trophy score in relation to the age of roe deer (*Capreolus capreolus* L.). The study was conducted on 228 roe deer trophies from the "Barajevska reka" hunting ground in Serbia, aged one to seven years. From the second to the fourth year, the growth of antlers was the most intense, and the differences compared to one year old animals were significant ($P < 0.001$). The highest average length of the branches was monitored in six years old animals (22.4 ± 2.05 cm), with significant differences ($P < 0.001$) compared to younger animals, except for the three years old animals ($P > 0.05$). From the second to the fifth year, a gradual increase in antler weight (from 192.2 ± 30.41 g to 221.9 ± 61.86 g) and antler volume (from 74 cm³ to 90 cm³) was observed, with the highest values of antler weight (291.8 ± 58.43 g and 319.1 ± 98.89 g, respectively) and antler volume (123.8 cm³ and 121.2 cm³) in six and seven year old animals. Overall trophy scores increased from year one to year seven (42.6 ± 7.86 vs 97.4 ± 27.40), with differences in trophy scores for animals aged six and seven years significantly greater than for animals aged one to five years ($P < 0.001$). The highest quality antlers have six and seven year olds, at which time their hunting should be conducted.

Key words: *Capreolus capreolus* L., antlers, age, trophy

Introduction

According to the Law on Wild Game and Hunting ("Official Gazette of the Republic of Serbia" No. 18/2010), roe deer (*Capreolus capreolus* L.) belongs to big game species hunted only in restricted time periods during year (Beuković and Popović, 2014). Roe deer inhabits parts of the Asian continent and almost all of Europe, with the exception of some islands in the Mediterranean Sea and Ireland. In our country, roe deer inhabits the whole territory, from the Pannonian Plain to the mountain areas, but its abundance varies in different areas (Gajić and Popović, 2010).

The quality of hunting trophies is the indicator of health of population, environmental conditions in the hunting ground and breeding manipulations. Growth of the first antlers in roe deer ends with 7 – 9 months of age. After the end of the mating season and the decrease in testosterone concentration, which also coincides with the period of deposition of minerals into the bone extensions of horns, antlers gradually begin to separate from the bone extensions (Nečas, 1972). Healthy animals discard antlers during late autumn, after which the growth of new antlers begins immediately during winter (Sempéré et al., 1998). Growth and rejection of antlers is a very complex process, which comes as a result of achieving the balance between hormonal factors (Price and Allen, 2004), genetic factors (Scribner et al., 1989), environmental factors – nutrition, length of light period, conditions in the habitat and population density (Bán and Fodor, 1982; Pélabon and Breukelen, 1998; Czyżowski et al., 2018). Hormonal growth control is a result of the balance of testosterone, growth hormone (GH), insulin-like growth factor I (IGF-I) and thyroid hormones, as well as parathyroid and adrenal hormones that play a role in controlling the metabolism of minerals (Bartos et al., 2012). Genetic factors are of primary importance in the expression of antlers shape, while nutrition helps them to develop to their full genetic potential (Harmel et al., 1988). If sufficient quantity of good quality food is not available, smaller and narrower antlers will develop, and protein-deficient diets lead to the development of antlers with fewer branches (Ullrey, 1983). Roe deer in lowland habitats (agrobiotopes) consume easily digestible and energy-rich foods, which can have a direct impact on the quality of antlers (Kruuk et al., 2002). These individuals have faster body development and are of better body condition, so the morpho-metric elements and overall trophy score sooner culminate compared to roe deer from forest habitats (Pételis and Brazaitis, 2003; Janiszewski et al., 2009). Research of Czyżowski et al. (2018) conducted on 518 European roe deer animals (*Capreolus capreolus* L.) aged 4 to 7 years, originating from the hunting complexes in Lublin (Poland) showed that individuals from areas with denser forest cover have lower mean values of ontogenetic quality parameters (carcass weight, renal fat index, breast circumference, antler weight) compared to roe deer from typical agricultural areas.

In roe deer hunting populations, from an economic and biological point of view, it is highly important to reliably determine when males culminate in the growth of trophies and trophy values. *Hell and Holý (1988)* state that the age of roe deer at trophy shooting should not be taken uniquely for the whole country, but should be specifically determined for different areas depending on the biotopic potential of each region. The optimal management age, as an important factor in the management of roe deer populations, should be shorter for animals from agroecosystems compared to animals from typical forest habitats (*Gačić, 2006*).

Determination of roe deer trophy quality is performed according to formula suggested by *The International Council for Game and Wildlife Conservation (CIC)*. The highest importance for the final trophy score, according to this formula, is given to the morpho-metric elements of assessment: length, weight and volume of antlers, while the participation of characteristics such as antlers range and external appearance makes only 12.60% of the trophy score (*Popović, 2000*).

Urosević et al. (2017) compared different systems for evaluating trophy value of roe deer and found out that there was a stronger and more pronounced correlation between antlers volume and other antler value indicators, than between antlers weight and those indicators.

The aim of this study was to investigate the influence of roe deer age on morpho-metric elements of trophy score: the length of left and right antler, average length of antler, weight and volume of antlers, as well as on total trophy score (number of achieved CIC points).

Materials and Methods

Investigation on influence of roe deer age on morpho-metric parameters of trophy included trophies from 228 animals from "Barajevska reka" hunting ground, age one (N=13/228; 5.7%), two (N=10/228; 4.4%), three (N=23/228; 10.1%), four (N=32/228; 14.0%), five (N=51/228; 22.4%), six (N=86/228; 37.7%) and seven years (N=13/228; 5.7%). Determination of age was done based on incisor and molar teeth wear (*Lehmann and Sägeser, 1986; Lochman, 1987*).

The evaluation of roe deer trophy value was performed according to formula given by *The International Council for Game and Wildlife Conservation (Varičák, 1998)*. The length of the antlers was measured using a patch, across the middle of the outside edge of the antler, from the bottom of the rose to the top of the tine ends. To calculate the total trophy score, the length of both antlers were summed, divided by 2, and the mean obtained was then multiplied by 0.5. The weight of the antlers was expressed in grams, and the calculation of the number of points for this parameter was obtained by subtracting 65 - 90 grams from the weight of the dry trophy without lower jar (more than 3 months old) and multiplying by a factor 0.1. The volume of the antler is determined by the

hydrostatic balance, measuring the amount of water that antlers extrude from the vessel when immersed in it. The difference between the weight of the antler outside the water and the weight of the antlers immersed in water represents the volume of the antler expressed in cm^3 . The resulting value is multiplied by 0.3 to get the number of points that will be used in the formula for calculating the total trophy score.

Determination of statistically significant differences between the individual parameters of the trophy score within the examined age groups for normally distributed variables (the left and right antler length, average antler length, antler weight and total number of CIC points achieved) was performed by analysis of variance (ANOVA) and Tukey tests. A non parametric Kruskal-Wallis H Test and Mann-Whitney U test with a corresponding correction for the number of comparisons were used for the variable that did not follow the normal distribution (change in antler volume depending on the age of roe deer). Significant differences were considered for $P < 0.05$. The Sperman correlation analysis examined whether there was a significant correlation between age and the morpho-metric elements of the trophy score and the total trophy score, also the corresponding regression models and equations describing the influence of age on the parameters tested were defined.

Calculations were performed with software STATISTICA 8.0. (StatSoft, Inc. 2007) and Microsoft Office EXCEL 2007.

Results and Discussion

Table 1 shows the changes in the value of the morpho-metric elements of the antlers score - length of left antler, length of right antler and average length in relation to the age of roe deer.

Table 1. Changes in the value of the length of left antler, length of right antler and average length in relation to the age of roe deer (mean $\pm$ SD)

Age, years	No	LLA, cm	LRA, cm	ALA, cm
1	13	15.6 $\pm$ 1.86 ^a	15.7 $\pm$ 1.94 ^a	15.6 $\pm$ 1.88 ^a
2	10	19.4 $\pm$ 2.23 ^b	19.2 $\pm$ 2.07 ^b	19.3 $\pm$ 2.11 ^b
3	23	21.6 $\pm$ 2.07 ^{b,v}	21.9 $\pm$ 2.48 ^{b,v}	21.8 $\pm$ 2.22 ^{b,v}
4	32	21.0 $\pm$ 2.61 ^{b,v}	20.7 $\pm$ 2.60 ^{b,v}	20.6 $\pm$ 3.31 ^b
5	51	20.8 $\pm$ 2.70 ^{b,v}	20.7 $\pm$ 3.01 ^{b,g}	20.5 $\pm$ 3.02 ^b
6	86	22.5 $\pm$ 2.19 ^v	22.3 $\pm$ 2.21 ^v	22.4 $\pm$ 2.05 ^v
7	13	21.6 $\pm$ 4.60 ^{b,v}	22.8 $\pm$ 2.76 ^{v,g}	22.2 $\pm$ 3.53 ^{b,v}

LLA – length of left antler; LRA – length of right antler; ALA – average length of antler

The data is shown as Mean values $\pm$ Standard Deviation

Values by letters (^{a,b,v,g}) in one column describe significant differences ($P < 0.001$)

The lowest values of left and right antler lengths (15.6 ± 1.86 cm and 15.7 ± 1.94 cm), as well as average antler length (15.6 ± 1.88 cm) were observed in one year old males. The first statistically significant change in the length of the right and left, and therefore in the average length of the antlers ($P < 0.001$), were observed in two years old animals. This was followed by a slight increase in length, a plateau of growth was achieved and the length of antlers did not change significantly until six years of age. The second sudden jump in antler length was observed in six years old roe deer, which corresponds to the maximum achieved average length of the antlers (22.4 ± 2.05 cm). A slight decrease in the length of the left branch (21.6 ± 4.60 cm vs 22.5 ± 2.19 cm) and average branch length (22.2 ± 3.53 cm vs 22.4 ± 2.05 cm) was observed in seven years old animals compared to six years old, but the decrease was not statistically significant ($P > 0.05$). Obtained length of the branches (left and right), as well as the average length of antlers of seven years old roe deer were significantly higher only from one year old animals, and the length of the right branch compared to the value recorded in two years old animals ($P < 0.001$).

Between age and investigated parameters there was a statistically significant positive correlation, showing that with age also the values of morpho-metric parameters of trophy increase. Based on calculated correlation coefficients, a medium strength correlation was found between age of animals and length of left antler ($\rho = 0.389$), length of right antler ($\rho = 0.373$), as well as average length of antler ($\rho = 0.383$). Regression equations describe that the influence of age on length of left antler makes 30.42% of its variability, 28.22% of variability in length of right antler, and 29.04% variability for the average length of antlers.

Observed trend of growth and decline in antler length is also in line with the results of the *Gačić (2006)* survey, which included 546 roe deer animals from 12 hunting grounds in Bačka and Banat area, caught from 1998 till 2005. This author has determined that the highest quality antlers were found in six years old animals, with some individuals reaching these values as early as the fifth year, while the length of antlers shows a gradual decline from the age of seven. *Popović and Bogdanović (2004)* also reported intense antler growth between the first and fourth year of age, and maximum antler length at six years, as well as equalization the length of antlers at eight years with the length achieved in the fourth year. The observed trend of increasing and then decreasing the length of the antlers to the age of seven obtained in this research is in correspondance with the results of *Pélabon and Breukelen (1998)*, with slightly lower average values by years. *Bán and Fodor (1982)* found that maximal lengths of antlers were evenly maintained up to the age of 10 to 13 years.

Table 2 shows the changes in the value of the morpho-metric elements of the antlers score - weight and volume of antler, as well as the total score of the trophies (number of CIC points achieved) in relation to the age of roe deer.

Table 2. Changes in the value of the weight of antler, volume of antler and total score of the trophies in relation to the age of roe deer (mean±SD)

Age, years	No	Weight, g	Volume, cm ^{3*}	CIC points
1	13	156.6±29.79 ^a	52.0 (34.0-56.0) ^a	42.6±7.86 ^a
2	10	192.2±30.41 ^{a,b}	74.0 (62.5-83.5) ^b	60.9±7.57 ^{a,b}
3	23	225.3±51.58 ^b	92.0 (72.0-102.0) ^b	72.0±15.00 ^b
4	32	227.0±80.95 ^b	97.6 (68.5-109.0) ^{b,g}	74.1±19.10 ^b
5	51	221.9±61.86 ^b	90.0 (79.4-110.2) ^b	74.3±16.04 ^b
6	86	291.8±58.43 ^v	123.8 (101.5-141.9) ^{v,g}	92.4±16.26 ^v
7	13	319.1±98.89 ^v	121.2 (105.1-160.3) ^g	97.4±27.40 ^v

The data is shown as Mean values ± Standard Deviation; *median (interquartile range)

Values by letters (^{a,b,v,g}) in one column describe significant differences ($P < 0.001$)

The lowest measured weight of antler was observed in one year old roe deer (156.6 ± 29.79 g). Afterwards, there was a gradual increase in the weight of antler, and a significant increase was observed in three years old animals (225.3 ± 51.58 g; $P < 0.001$). Another intense growth of antler weight was observed in roe deer at six years of age (291.8 ± 58.43 g), when the values recorded were significantly higher than in all younger individuals ($P < 0.001$). Unlike to the length of antlers, the weight of antlers continued to increase at the age of seven, but the difference found was not statistically significant with respect to the values measured in the six year olds ($P > 0.05$).

The correlation between the age of animals and antler weight was very strong, with coefficient of correlation 0.608. The simple third degree regression equation and coefficient of determination calculated by regression analysis explain that proportion of total variability in roe deer antlers weight caused by age was 29.1%.

The first significant increase in the volume of antlers was observed in two years old roe deer (74.0 cm³). A slight increase in volume continued in the three year olds (92.0 cm³), but with no statistical significance compared to the two year old animals. After that period, a plateau followed, i.e. slowing down in increasing trophy volume. Other intense growth was observed in males aged six years, which represented the highest measured value of antler volume (123.8 cm³), and the value was significantly higher than in all the younger tested categories ($P < 0.001$). The volume of antlers in seven years old roe deer declined (121.2 cm³) compared to six

years old animals, and the measured values were significantly higher only than one-, two-, three- and five year old roe deer ($P < 0.001$).

The strongest correlation was obtained between age and trophy volume ($\rho = 0.696$). Based on fourth degree regression equation and coefficient of determination, 28,94% of changes in trophy volume could be explained by changes in age of animals.

The obtained results are in accordance with research by *Popović and Bogdanović (2004)*, who found that the increase in weight (about 50 g per year) and antler volume was the most intense between the first and fourth year, and that maximum values of these parameters were reached in seven years old roe deer. Thereafter, there is a slight trend of decrease in these values. The weight of antlers in the ninth year is equal to the weight of the antlers in the fifth year, its weight in the tenth year is below the average value achieved in the fifth year, while the volume of the antlers in the eighth year is slightly above the level determined in the fifth year. *Danilkin (1999)* found that the heaviest antlers were determined in animals between the ages of four and eight, and then the volume decreases, followed by a decrease in the size and weight. *Gačić (2006)* and *Urošević et al. (2016)* also states that growth of roe deer antlers culminates in the sixth year of age. However, several authors have found that maximum values of antlers weight and volume are reached only at the age of eleven (*Bakkay et al., 1978; Bán and Fodor, 1982*). *Krapinec et al. (2014; 2019)* found that roe deer antlers in Croatia have a significantly lower weight, and therefore lower proportion of trophies compared to large number of countries (Hungary, Romania, Serbia, Switzerland and the United Kingdom), but also significantly higher than in Bosnia and Herzegovina. At the same time, animals from the studies of *Krapinec et al. (2014; 2019)* had significantly higher share of antlers in the total value of trophies than those in Slovenia and Switzerland, and lower than roe deer in Bosnia and Herzegovina, Poland, Romania, Slovakia and United Kingdom. *Balčiauskas et al. (2017)* compared the different hunting strategies of the three Baltic States and examined the impact of age-restricted roe deer hunting, conducted in Lithuania for over 40 years, on improving the value of trophy morpho-metric parameters. These authors found that the largest roe deer trophies are from Lithuania, compared to trophies from Latvia and Estonia, in which roe deer hunting is not age-restricted, they also had significantly higher weight (538.54 g vs 391.63 g and 380.97 g), volume (231.71 cm³ vs 167.40 cm³ and 167.06 cm³), left antler length (26.14 cm vs 24.67 cm and 25.07 cm) and right antler length (26.59 cm vs 24.82 cm and 24.88 cm). The application of the restriction model in Lithuania has allowed the trophy value of 3 - 4 year old animals to be at the level of the most valuable mature individuals in Estonia and Latvia, despite lower availability of good quality food.

One year old roe deer trophies had the lowest grade, ie. the lowest CIC score (42.6 ± 7.86). Significant changes in the total trophy score were observed in three years and older animals, compared with one year olds ($P < 0.001$). Intense

growth is accompanied by a plateau, i.e. by slowing the growth of the antlers, so that the total trophy ratings in animals 3 to 5 years old (from 72.0 ± 15.00 to 74.3 ± 16.04) did not differ significantly ($P > 0.05$). The highest value was recorded for the oldest individuals caught at the age of seven, although it was only slightly different from the values achieved at the age of six. Six and seven year old roe deer trophies were considered as ones with the highest quality, and received a significantly higher overall score (92.4 ± 16.26 and 97.4 ± 27.40 ; $P < 0.001$) compared to trophies of younger animals (one to five years old).

Also a strong correlation was found between age and parameters of trophy score ($p = 0.601$). A more complex fourth degree regression equation and coefficient of determination are indicating that age of animals contributes 40.99% to variability in trophy score.

Obtained results are in accordance with the results of *Popović and Bogdanović (2004)*, who noted that the increase in the total trophy score was most pronounced by the age of four, and that from the fourth to sixth year, the growth was more moderate. These authors also found that maximum average value of the trophy score is reached in the seventh year, primarily due to the influence of weight and volume, whose values culminate in the seventh year, while the other parameters reach the maximum mainly in the fifth or sixth year. *Rihter (1997)* points to a large jump in trophy score between the second and third year of age, since the largest increase in the length and volume of the antlers, as well as the antler weight, appear in this period. In the study conducted by *Urošević et al. (2013)* on 66 trophies from three hunting seasons (2006/07, 2007/08 and 2008/09) from the area of Žagubica Hunting Authority, low mean CIC points were determined, ranging from 46.33 to 52.23. Five years later, *Urošević et al. (2018)* found that in 2013 and 2014, 61 animals whose trophy value also had an unsatisfactory CIC score were shot in the same hunting area. The animals were too young, about 3 years old. Such inappropriate hunting scheme did not allow the animals to develop antlers to their maximum trophy value, and a very high coefficient of variation for all observed traits indicated the inhomogeneity of the population and the necessity of planned selection procedures. The results obtained in our study are in accordance with results of *Hell and Hollý (1988)*, who reported that in lowland habitats of southwestern Slovakia the total trophy score culminates at the age of 6 years. The values found were significantly higher compared to the trophy score for the entire state, which was highest for seven years old animals. *Gačić (2006)* stated that in Vojvodina field hunting grounds, the culmination of the antler trophy value is reached in the sixth year (105.7 ± 17.7 points for the total trophy score, 146.8 ± 32.2 cm³ for the volume of the antlers, 363.7 ± 63.6 g for the antlers weight and 24.4 ± 2.1 cm for the length of the antlers). This author has determined that individual animals can reach maximum values at four or five years, while from the age of seven, the first signs of over-aging and the decline of trophy value are observed. *Urošević et al. (2016)* founded highest trophy value for six

year old roe deer from the hunting ground in Slavonia (97.0 ± 18.1 points for the total trophy score). Also, all parameters observed during this assessment were maximally developed (23.7 ± 3.0 cm for length of left antler, 24.1 ± 3.1 cm for length of right antler, 364.7 ± 53.8 g for the antlers weight and 9.3 ± 3.2 cm for inside span). *Sadiković et al. (2019)* analyzed 154 trophies from three localities in Bosnia and Herzegovina and also found that roe deer reach maximum trophy quality between the sixth and seventh year, after which this value gradually declines. The average age of hunted roe deer in this investigation was 4.4 years and the average trophy value was only 69.6 CIC points, which indicates a very low quality of trophies. The authors considered management, a premature shooting that prevented the prospective animals from reaching their body and trophy maximum, the absence of breeding and selective shooting as the reasons for such a low trophy value.

According to *Nečas (1972)*, the total trophy score culminates in the age of 5 to 7 years. *Popović and Bogdanović (2004)* believe that from the view point of management, the quality of trophies is the highest between the sixth and eighth year, and that trophy shooting should not take place before the age of five. These authors stated that the increase in the overall trophy score is most pronounced by the age of four and that this fact must be taken into account in the selection of roe deer. Proper utilization of compensatory hunting model in Lithuania, banning roe deer hunting under the age of five and if the weight of antlers is less than 300 - 320 g, has led to an increase in the quality of antlers and the attainment of trophy maturity in roe deer animals five to seven years old (*Balčiauskas et al., 2017*). *Hromas (1982)*, *Vach (1993)* and *Gačić (2006)* consider that animals with very good body condition, living in an adequate environment with the best hunting management should not be hunted before six years of age. However, reaching the culmination of the overall trophy score at seven years of age in our study is significantly earlier than results obtained by *Bakkay et al. (1978)*.

Conclusion

Performed analysis of roe deer trophies show that:

- The most intense growth of antlers appears between year 2 to year 4
- The weight of trophy increases all the way up to 7th year of age
- The highest volume of antlers is achieved in the 6th year
- The total trophy score is the highest in 7th year of age. Somewhat lower score is achieved with six years, however there is no significant difference in the total trophy score between 6th and 7th year
- There is a significant correlation between age of animal and parameters of trophy score, where changes in age contribute to almost one third of changes in trophy score parameters.

Promena vrednosti mernih elemenata ocene parogova i ukupne ocene trofeja u odnosu na uzrast srndaća (*Capreolus capreolus* L.)

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Rezime

Cilj rada je bio da se utvrdi promena vrednosti mernih elemenata ocene parogova i ukupne ocene trofeja u odnosu na uzrast srndaća (*Capreolus capreolus* L.). Istraživanje je obavljeno na 228 trofeja srndaća iz lovišta "Barajevska reka" u Srbiji, uzrasta od jedne do sedam godina. Od druge do četvrte godine rast rogovlja je bio najintenzivniji, a utvrđene razlike su bile signifikantne ($P < 0,001$) u odnosu na jednogodišnje jedinke. Najveća prosečna dužina grana parogova je zabeležena u periodu oko šeste godine ($22,4 \pm 2,05$ cm), pri čemu su utvrđene razlike bile signifikantne ($P < 0,001$) u odnosu na mlađe jedinke, osim u odnosu na jedinke u starosti od tri godine ($P > 0,05$). Od druge do pete godine uočen je postepeni porast mase rogovlja (od $192,2 \pm 30,41$ g do $221,9 \pm 61,86$ g) i zapremine rogovlja (od 74 cm³ do 90 cm³), dok su vrednosti mase rogovlja ($291,8 \pm 58,43$ g i $319,1 \pm 98,89$ g) i zapremine rogovlja ($123,8$ cm³ i $121,2$ cm³) kulminirale kod jedinki u starosti šest i sedam godina. Ukupne ocene trofeja su rasle od prve do sedme godine ($42,6 \pm 7,86$ prema $97,4 \pm 27,40$), pri čemu su razlike u ocenama trofeja kod jedinki uzrasta šest i sedam godina bile signifikantno više u odnosu na jedinke starosti od jedne do pet godina ($P < 0,001$). Najkvalitetnije rogovlje imaju jedinke uzrasta šest i sedam godina, kada bi trebalo i vršiti odstrel.

Ključne reči: *Capreolus capreolus* L., parogovi, starost, trofej

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