SEXUAL AND AGE DIFFERENCES IN CRANIOMETRIC CHARACTERISTICS OF ROE DEER (*CAPREOLUS CAPREOLUS* L.) FROM THE AREA OF MOUNTAIN PROKLETIJE

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Key words:
Capreolus capreolus, craniometric characters, sexual differences, age.

SYNOPSIS

Sexual and age differences in craniometric characteristics of roe deer (*Capreolus capreolus*), from Prokletije mountain were examined on the basis of variation pattern of twenty craniometric traits. Significant differences between the sexes was apparent for four characters: distance *interorbitale* (Ior), distance *ectorbitale* (Ect), frontal length (LF) and length of maxillar teeth row (PM3). Except length of maxillar teeth row, for all other traits males were significantly larger then females. The obtained results of the statistical analyses showed that there are statistically significant differences for most craniometric characters between the individuals of different age classes in both genders.

INTRODUCTION

Sexual dimorphism (SD) is a widespread phenomenon. In numerous species, pronounced differences between the sexes are found in various characteristics of morphology (body size), coloration, etc. A special case of sexual dimorphism, sexual size dimorphism (SSD), is defined as “any statistically significant difference in the mean length or weight of sexually mature organisms from the same population during a given time interval” (Lovich & Gibbons, 1992).

Sexual dimorphism is common and widely recognised in many ungulates. Its origin appears to be closely linked to sexual selection but also has important ecological consequences (Mystkowska, 1966; Fandos & Vigal, 1993; Garcia-Gonzalez & Barandalla, 2002; Perez-Barberia et al., 2002). Differences between male and female and age classes in body size and size of the skull is recognised in roe deer.

Various authors analyzed differences of craniometric characteristics between two sexes or different age classes with European roe deer (Markov et al., 1985, 1989, 1991; Fandos & Orueta, 1991; Fandos & Reig, 1993; Petelis & Brazaitis, 2003; Wustinger et al., 2005; Labus & Vasić, 2008). *Capreolus capreolus* has proved to be one of the species with the smallest sexual dimorphism in skull characters. Sex dimorphism is best illustrated by zygomatic breadth, maximum and condylobasal length of skull and characters of mandibula.

The aim of our research is to present the level of morphological differences between two sexes and different age classes through analyzes of the skull characters applying statistic methods.

MATERIAL AND METHODS

A total of 88 skulls (54 males and 34 females) were studied. 60 skulls were completed, while 28 skulls were missing jaws. This sample came from Prokletije mountain, including individuals found dead in the field, private donations and selective hunts. The morphometric variability of skulls dependece on sexes and age was analysed after grouping roebucks into classes: I male to 2th year, II male over 2th year, III female to 2th year and IV female over 2th year. In order to examine craniometrical variation, we measured the following 20 craniometrical characters to the nearest 0,1 mm (Figure 1). To avoid observer bias, the 1st author took all measurements.

Statistical analyses of craniometric characters included univariate and multivariate analyses. The descriptive statistics we calculated the mean value and standard error craniometric characters. Two age classes male and female were statistically compared by Student's t – test. ANOVA and MANOVA tests with sex as sources of variability were used to test for differences between the mean values of the craniometric traits of samples. Sexual size dimorphism was estimated with the LOVICH & GIBBONS (1992) sexual dimorphism index (SDI). Statistica 7.0. software was used for the statistical analyses.

RESULTS AND DISCUSSION

In tables 1, 2 and 3 the results of statistical analysis obtained from 20 measurements of skull analyzed characters are presented. The results of descriptive statistics reflect that the obtained mean values for total skull length (L), condylobasal length (Lcb), zygomatic width (Zyg) and length of nasals (Nas-L) within the limits of values for these characters for the species *Capreolus capreolus* (Bolkay, 1926; Markov et al., 1985, 1991; Lehmann & Sägesser, 1986; Danilkin et al., 1992; Zagorodniuk, 2002; Petelis & Brazaitis, 2003; Wustinger et al., 2005; Soffiantini et al., 2007).

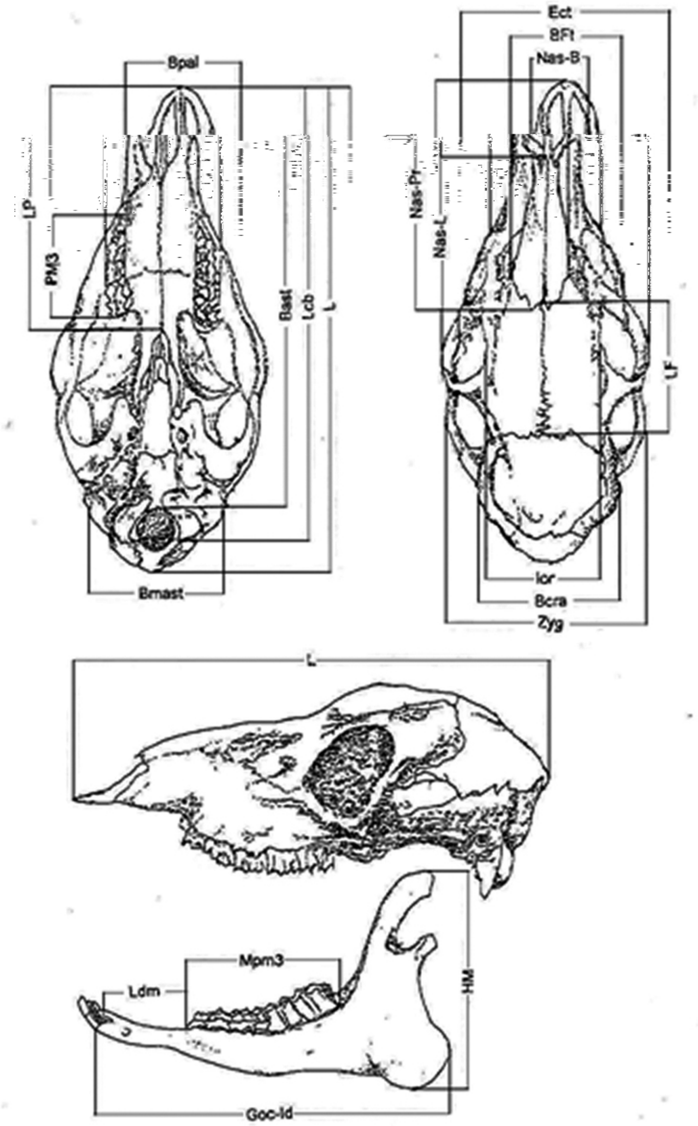

Figure 1: Measurements of roe deer cranium: L – total skull length, Lcb – condylobasal length, Basl – basal length, Zyg – zygomatic width, Ior – distance *interorbitale*, Bmast – mastoideum width, Ect – distance *ectorbitale*, Bcra – neurocranium width, Nas-L – length of nasals, Nas-B – greatest width across the nasals, LF – frontal length, Nas-Prosth – distance *nasion-prosthion*, LP – palatal length, BFt – facial tubers width, Bpal – maximum palatal width, PM3 – length of maxillar teeth row, Goc-Id – distance *gonion caudale-infradentale*, Mpm3 – length of mandibular teeth row, Ldm – length of diastem and HM – height of mandible.

Table 1: Descriptive statistics of 20 craniometric characters and results of ANOVA for *Capreolus capreolus* from the Prokletije mountain. Simple size (N) (neurocranium, mandible), mean value (in mm) ± SE, range, F – value and statistical significance of differences between sexes (p) tested by ANOVA (* p < 0,05, ** p < 0,01, *** p < 0,001, ns, non-significant). Abbreviations of characters are given in the Material and Methods.

	Males N = 54(54,33)			Females (N = 34)(34,27)			ANOVA	
Character	Mean		SE	Mean		SE	F	p
L	199,97	±	0,96	198,11	±	1,08	1,56	ns
	187,6	-	212,1	185,4	-	206,6		
Lcb	187,95	±	0,88	186,69	±	1,09	0,80	ns
	176,6	-	199,4	174,1	-	196,6		
Basl	177,33	±	0,87	176,1	±	1,15	0,69	ns
	165,9	-	190,2	163,1	-	185,5		
Zyg	83,53	±	0,26	83,64	±	0,58	0,03	ns
	79,4	-	87,6	75,8	-	91,1		
Ior	53,81	±	0,30	52,18	±	0,38	10,83	**
	48,6	-	57,6	46,6	-	55,8		
Bmast	54,59	±	0,32	54,73	±	0,43	0,07	ns
	49,8	-	58,4	49,1	-	59,6		
Ect	88,78	±	0,41	86,97	±	0,55	6,91	*
	81,2	-	93,8	78,1	-	91,6		
Bcra	60,48	±	0,21	61,02	±	0,19	2,88	ns
	56,1	-	63,7	59,2	-	63,7		
Nas-L	59,46	±	0,52	60,28	±	1,35	0,42	ns
	50,8	-	72,3	49,9	-	66,2		
Nas-B	26,59	±	0,27	26,51	±	0,49	0,01	ns
	22,1	-	30,6	18,5	-	32,6		
LF	69,21	±	0,53	66,65	±	0,66	8,85	**
	59,7	-	77,1	52,1	-	72,1		
Nas-Pr	101,03	±	0,91	99,75	±	0,42	1,13	ns
	84,5	-	112,3	92,7	-	103,1		
LP	107,07	±	0,56	107,54	±	0,78	0,24	ns
	95,6	-	116,1	98,8	-	116,1		
BFt	63,24	±	0,40	62,20	±	0,49	2,62	ns
	55,4	-	69,5	56,3	-	67,5		
Bpal	58,50	±	0,29	58,42	±	0,43	0,02	ns
	53,4	-	62,1	51,6	-	63,5		
PM3	56,79	±	0,39	57,96	±	0,24	5,38	*
	50,2	-	63,5	54,6	-	60,8		
Goc-Id	158,08	±	0,51	156,55	±	0,83	2,72	ns
	149,4	-	164,2	145,2	-	164,6		
Mpm3	64,66	±	0,37	65,15	±	0,34	0,77	ns
	57,1	-	70,3	58,6	-	68,9		
Ldm	41,91	±	0,42	42,61	±	0,51	1,09	ns
	32,7	-	47,8	31,2	-	48,3		
HM	85,93	±	0,26	86,75	±	0,63	1,84	ns
	81,6	-	90,8	77,4	-	92,5		

Table 2: Descriptive statistics of 20 craniometric characters and results of t-Student test for male *Capreolus capreolus* from the Prokletije mountain. Simple size (N) (neurocranium, mandible), mean value (in mm), standard deviation (SD), t – value and statistical significance of differences (p) between males *Capreolus capreolus* < 2 year and males *Capreolus capreolus* > 2 year tested by t-Student test (* p < 0,05, ** p < 0,01, *** p < 0,001, ns, non-significant). Abbreviations of characters are given in the Material and Methods.

	Males < 2 year (N = 20)(20,14)		Males > 2 year (N = 34)(34,19)			
Character	**Mean**	**SD**	**Mean**	**SD**	**t**	**p**
L	191,55	2,12	204,92	3,16	-16,79	**
Lcb	180,72	2,28	192,20	3,73	-12,41	**
Basl	170,12	2,24	181,57	3,72	-12,46	**
Zyg	82,28	1,42	84,27	1,80	-4,22	**
Ior	52,33	1,74	54,68	2,07	-4,24	**
Bmast	53,32	2,70	55,33	1,79	-3,29	**
Ect	85,90	2,07	90,47	2,17	-7,57	**
Bcra	59,70	1,98	60,93	1,15	-2,87	**
Nas-L	56,38	2,85	61,27	3,11	-5,73	**
Nas-B	26,37	2,29	26,71	1,87	-0,59	ns
LF	66,34	3,64	70,90	3,06	-4,91	**
Nas-Pr	95,26	5,77	104,43	4,62	-6,41	**
LP	104,77	4,89	108,42	2,93	-3,43	**
BFt	61,28	2,80	64,39	2,40	-4,31	**
Bpal	57,25	1,93	59,23	2,00	-3,55	**
PM3	54,75	3,05	57,99	1,53	-5,17	**
Goc-Id	156,66	3,62	158,92	3,63	-2,21	*
Mpm3	61,96	2,39	66,25	1,47	-8,16	**
Ldm	39,84	2,38	43,12	2,86	-4,31	**
HM	84,52	1,92	86,75	1,47	-4,78	**

Significant variations between the sexes (MANOVA, Wilks' lambda = 0.34, df1 = 20, df2 = 67, p < 0.001) were observed. With respect to skull measurements, the results of ANOVA showed significant differences in four craniometric characters (Table 1). Significant variations egzists for distance *interorbitale* (Ior), distance *ectorbitale* (Ect), frontal length (LF) and length of maxillar teeth row (PM3). Except PM3 for all other craniometric traits, males were significantly larger then females. The value of the sexual size difference (SSD) index based on total skull length was I = 1,009.

In regard to the roe deer, it is generally recognized that males have more robust skull than females (Markov et al., 1985, 1989, 1991; Danilkin et al., 1992).

line with literature data (Markov et al., 1985). However, as the results of ANOVA analysis showed, the differences in the dimensions of most craniometric characters are not statistically significant. Males have a significantly wider skull in its widest part, wider space between the orbits and longer frontal bone. This is probably because this is part of the skull wearing horns.

Poorly pronounced sexual dimorphism in craniometric features of the deer that we found in our study, is in accordance with literature (Markov et al., 1989; Fandos & Reig, 1993). A small number of characters of the skull for which there is significant differences between males and females feature is not only deer but also other types of ungulata (Mystkowska, 1966; Garcia-Gonzalez & Barandalla, 2002). The differences that occur between the sexes are conditioned by genetic and environmental factors. It is known that habitat also affects the level of the difference between the sexes, depending on whether the open or closed (Perez-Barberia et al., 2002). How doe deers from Prokletija inhabit closed habitats, as belonging to the forest ecotype, they are less pronounced sexual dimorphism.

The results of Student's - test comparing the mean values obtained craniometric male characters under the age of two years and males older than two years are shown in Table 2.

The table shows that significant differences is not only for greatest width across the nasals (Nas-B) and distance *gonion caudale*-*infradentale* (Goc-Id). For all other characters of the skull, males older than two years have significantly higher mean value than males under the age of two years. In percentage, males older than two years, compared to males under the age of two years have 6.54% higher total skull length (L), 5,99% higher condylobasal length (Lcb), for 2,38% higher zygomatic width (Zyg) and for 4, 98% higher distance *ectorbitale* (Ect). These differences are similar to the percentage difference in male from Lithuania in age class up to two years and more than two years (Petelis & Brazaitis, 2003).

The results of Student's - test for females under the age of two years and females older than two years are shown in Table 3.

And among them there are significant differences for most craniometric characters. Significant difference does not occure for neurocranium width (Bcra), length of nasals (Nas-L), greatest width across the nasals (Nas-B), maximum palatal width (Bpal), length of maxillar teeth row (PM3), length of mandibular teeth row (Mpm3) and length of diastem (Ldm). With the exception of greatest width across the nasals for all the rest of characters females older than two years have higher mean values. Percentage differences for the main longitudinally characters of the skull total skull length and condylobasal length and characters that define the maximum width of the skull zygomatic width and distance *ectorbitale* are similar to those among age classes of males, ranging from 5,36% for zygomatic width to 6,13% for condylobasal length.

Table 3: Descriptive statistics of 20 craniometric characters and results of t-Student test for female *Capreolus capreolus* from the Prokletije mountain. Simple size (N) (neurocranium, mandible), mean value (in mm), standard deviation (SD), t – value and statistical significance of differences (p) between females *Capreolus capreolus* < 2 year and females *Capreolus capreolus* > 2 year tested by t-Student test (* p < 0,05, ** p < 0,01, *** p < 0,001, ns, non-significant). Abbreviations of characters are given in the Material and Methods.

	Females < 2 year (N = 17)(17,13)		Females > 2 year (N = 17)(17,14)			
Character	Mean	SD	Mean	SD	t	p
L	192,29	2,96	203,90	1,70	-14,00	**
Lcb	181,09	3,49	192,28	2,34	-10,95	**
Basl	170,13	3,42	182,13	2,17	-12,20	**
Zyg	81,34	2,71	85,93	2,33	-5,28	**
Ior	50,90	2,06	53,47	1,65	-4,01	**
Bmast	53,28	2,09	56,18	2,03	-4,09	**
Ect	84,51	2,71	89,44	1,11	-6,92	**
Bcra	60,56	0,78	61,47	1,30	-2,45	*
Nas-L	59,96	3,64	60,61	10,73	-0,23	ns
Nas-B	27,42	3,22	25,61	2,20	1,91	ns
LF	64,66	4,40	68,65	1,88	-3,43	**
Nas-Pr	98,16	2,42	101,34	1,14	-4,88	**
LP	105,12	4,23	109,95	3,60	-3,58	**
BFt	60,36	2,32	64,03	2,16	-4,75	**
Bpal	57,95	3,48	58,90	0,89	-1,08	ns
PM3	57,52	1,80	58,39	0,73	-1,82	ns
Goc-Id	153,76	3,59	159,34	4,41	-4,03	**
Mpm3	64,41	2,24	65,88	1,39	-2,29	*
Ldm	42,20	3,94	43,01	1,55	-0,78	ns
HM	84,98	4,08	88,52	2,13	-3,16	**

For the number of characters of the skull for which there is no significant difference between the two age classes of the females, is the result, above all, of greater homogeneity of the sample. How females are not " trophy nteresting" and because of the lack of older individuals because of their strong poaching, in a sample of females older than two years dominated by females aged 3-4 years. On the other hand, due to the presence of a number of skulls of older males in the age class over two years, the differences among age classes of males were more pronounced, with the presence of a number of characters for which the differences are significantly. In addition, the established differences among age classes of males and females are the result of non-simultaneously growth of their skulls. It is known for Cervidae (Mystkowska, 1966), that for females the most intensive growth of the skull is between the first and second year of life, while for males it later, between the second and third year. Also, the females have faster grow for viscerocranium than neurocranium and therefore the differences in the their analyzed mandible characters between age classes are fewer.

CONCLUSIONS

Based on the results of the statistic analysis of obtained values of analysed skull dimensions, we can conclude that gender dimorphism exists in a small extent, while the differences among age classes are much more prominent. Out of 20 analysed skull characters, a significant difference between genders exists only for 4 characters. Even so, we can say that males have longer and wider skulls compared to females. The skulls of both males and females over the age of two, compared to those of males and females below the age of two, are significantly different regarding almost all characters. Within different age classes of males, there are no significant differences only for nasal bones width; regarding females, there are no statistically significant variations for nasal bones and for some lower jaw dimensions.

By comparing our results to the results of other authors, we can conclude that there are no major deviations. Differences that occur for particular characters are primarily the result of heterogeneity of the specimen, although inconsistency of characters being analysed makes the comparison more difficult.

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SAŽETAK

RAZLIKE U KRANIOMETRIJSKIM KARAKTERISTIKAMA IZMEĐU POLOVA I UZRASNIH KLASA SRNE (Capreolus capreolus L.) SA PODRUČJA PLANINE PROKLETIJE

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Razlike između polova i uzrasnih klasa u kraniometrijskim karakteristikama srne (*Capreolus capreolus*) sa planine Prokletije, analizirali smo na osnovu variranja

20 kraniometrijskih karaktera. Statistički značajne razlike između polova ustanovljene su za četiri karaktera: rastojanje *interorbitale* (Ior), rastojanje *ectorbitale* (Ect), dužina frontale (LF) i dužinu zubnog niza gornje vilice (PM3). Osim dužine zubnog niza gornje vilice, za ostale karaktere mužjaci imaju statistički značajno veće vrednosti od ženki. Dobijeni rezultati statističkih analiza su pokazali da između jedinki različitih uzrasnih klasa kod oba pola, postoje statistički značajne razlike za većinu kraniometrijskih karaktera. Mužjaci i ženke stariji od dve godine u odnosu na mužjake i ženke mlađe od dve godine, imali su statistički značajno i dužu i širu lobanju.

Ključne reči: *Capreolus capreolus*, kraniometrijski karakteri, polni dimorfizam, uzrast.

Original research article

Received: 30 July 2010