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The dynamics of the horn growth in Bulgarian chamois *Rupicapra rupicapra balcanica*

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Measures of horn growth of Bulgarian chamois *Rupicapra rupicapra balcanica* Bolkay, 1925 were compared between males and females. The hypothesis that rapid early growth of horn is followed by slower subsequent growth was tested through the regression of the horn increment in the first two years against the third, fourth and fifth year respectively in the same individual. Sexual dimorphism in annual growth increment was significant up to the third year, males having higher values than females. Negative correlation coefficients were found when regressing the third, fourth and fifth individual annual increment on the second one in males, thus showing that individuals which had horns which grew fastest in the first two years tended to have slower horn growth in subsequent years.

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Introduction

The horns of chamois *Rupicapra rupicapra* Linnaeus, 1758 are epidermal derivates that grow throughout the life of both males and females (Couturier 1938). The growth process slows down in winter (Schroder 1971) and annual rings are formed, so that it is possible to estimate the age of an individual by counting the rings on its horns. The length of the annual increment is the greatest in the first years of life and decreases rapidly with advancing age until an almost constant amount of growth per year is reached. Annual rates of horn growth are associated with many factors such as physiological conditions, food availability, diseases, density, etc. (Niethammer 1971).

In game management the length of the horns is often considered an important criterion in estimating the trophy value of individuals as well as of a whole population (Hrabě and Koubek 1983, Koubek and Hrabě 1983). In systematics, the size and shape of the horns have been included among those morphological characters of subspecific importance (Couturier 1938). The description of the horns

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of *R. r. balcanica* Bolkay, 1925 by Couturier (1938) was based on a very small sample, with only one pair of horns coming from Bulgaria. The growth rate of horns in different chamois populations has been discussed by several authors (e.g. Briedermann and Still 1976, Salzmann 1977, Koubek and Hrabě 1983, 1984, Hrabě *et al.* 1986, Tosi *et al.* 1987).

This paper concentrates on individual patterns of horn growth of the Bulgarian chamois. The aims of the study were the following: (1) to document sexual dimorphism and dynamics of the horn growth in *R. r. balcanica*, (2) to examine whether individuals which show relatively rapid early growth of horns, show relatively slower subsequent growth.

Material and methods

The study was based on 56 pairs of horns (39 males and 17 females) of chamois. Material was obtained from the National Museum of Natural History of Sofia and from private collections. All the samples had been either shot or found dead during the period 1909–1986 in the four main Bulgarian massifs: Rila, Rhodope, Pirin Mountains and the Balkan Range. Measures of annual increment represent the distance between each pair of complete annuli and were recorded on the anterior side of the horn to the accuracy 0.1 mm. Since the boundary between first and second annual increment of the first two years is not well marked, increments of the first two years were pooled. Subsequent annual increments were measured singly up to the sixth year. After the sixth year the horns are virtually fully developed in the chamois (Schroder 1971). Sexual dimorphism was studied by comparing males' and females' annual increments by Student's *t*-tests. To test the hypothesis that rapid early growth of horn was followed by slower subsequent growth, the horn increment in the first two years was regressed against the third, fourth and fifth year respectively in the same individual. Due to the small sample size of females, only males were used for the regression.

Results

Sexual dimorphism in annual horn increments was significant up to the third year, males having higher values than females (Table 1). Males also grew more

Table 1. Growth increments (mm) in male and female *R. r. balcanica*.

Annual increment	Sex	*n*	Mean	SD	*t*-test *p*
1+2	M	39	177.84	12.35	< 0.01
	F	17	155.10	14.67	
3	M	26	43.32	5.99	< 0.01
	F	11	36.72	7.40	
4	M	15	22.03	8.68	ns
	F	7	19.36	8.33	
5	M	14	8.21	4.65	ns
	F	6	8.85	2.31	
6	M	9	4.43	1.92	ns
	F	6	5.47	1.05	

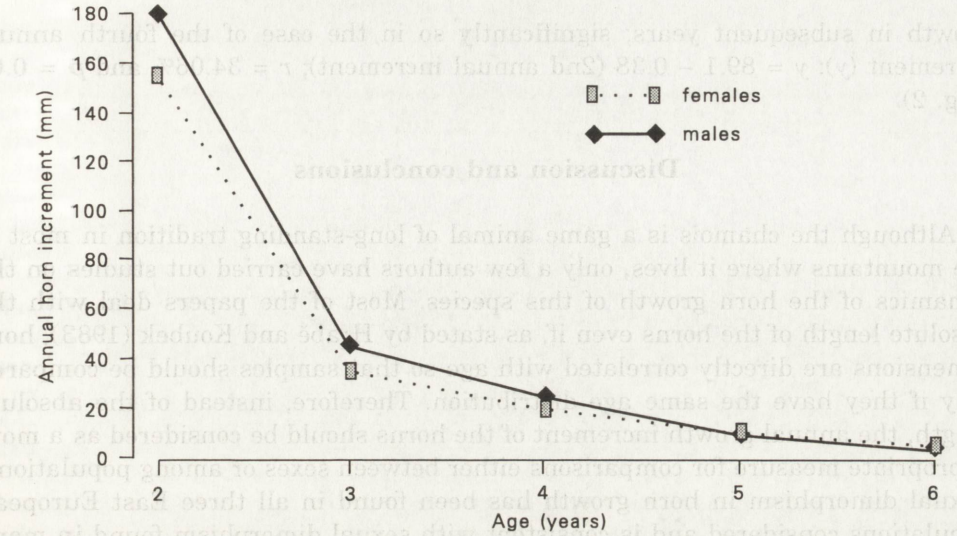

Fig. 1. Relationship between annual horn increment (in mm) and age (in years) for female and male chamois.

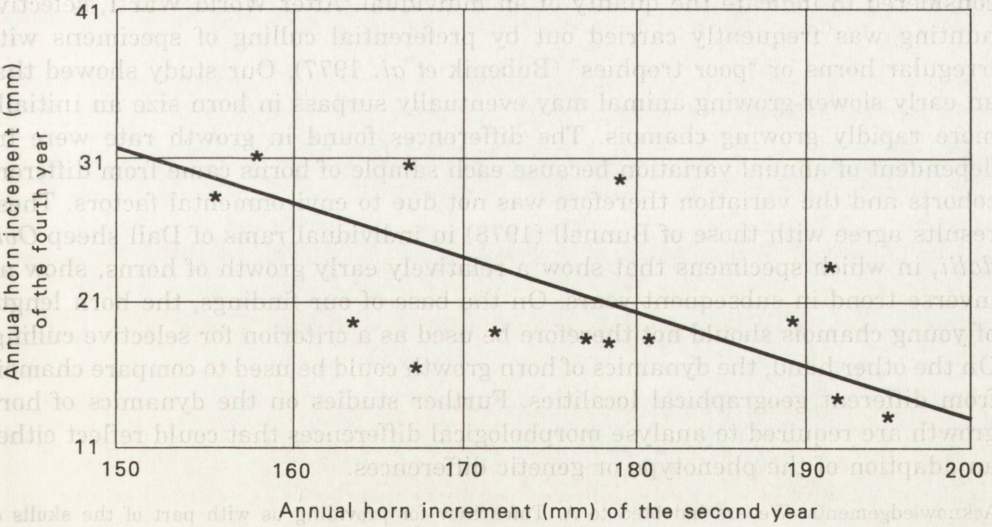

Fig. 2. Regression of annual increment horn lengths of the fourth year against the second year in males.

rapidly than females up to the fifth year of age (Fig. 1). Negative correlation coefficients were found when regressing the third, fourth and fifth individual annual increment on the second one in males, thus showing that individuals which had horns which grew fastest in the first two years tended to have slower horn

growth in subsequent years; significantly so in the case of the fourth annual increment (y): $y = 89.1 - 0.38$ (2nd annual increment); $r = 34.06\%$ and $p = 0.02$ (Fig. 2).

Discussion and conclusions

Although the chamois is a game animal of long-standing tradition in most of the mountains where it lives, only a few authors have carried out studies on the dynamics of the horn growth of this species. Most of the papers deal with the absolute length of the horns even if, as stated by Hrabě and Koubek (1983), horn dimensions are directly correlated with age so that samples should be compared only if they have the same age distribution. Therefore, instead of the absolute length, the annual growth increment of the horns should be considered as a more appropriate measure for comparisons either between sexes or among populations. Sexual dimorphism in horn growth has been found in all three East European populations considered and is consistent with sexual dimorphism found in many skull characters of chamois, where significantly higher values were found in males (Koubek and Hrabě 1984, Massei *et al.* 1994).

In game management and particularly in hunting, the length of the horns is considered to indicate the quality of an individual. After World War I, selective hunting was frequently carried out by preferential culling of specimens with irregular horns or "poor trophies" (Bubenik *et al.* 1977). Our study showed that an early slower-growing animal may eventually surpass in horn size an initially more rapidly growing chamois. The differences found in growth rate were independent of annual variation because each sample of horns came from different cohorts and the variation therefore was not due to environmental factors. These results agree with those of Bunnell (1978) in individual rams of Dall sheep *Ovis dalli*, in which specimens that show a relatively early growth of horns, show an inverse trend in subsequent years. On the base of our findings, the horn length of young chamois should not therefore be used as a criterion for selective culling. On the other hand, the dynamics of horn growth could be used to compare chamois from different geographical localities. Further studies on the dynamics of horn growth are required to analyse morphological differences that could reflect either an adaption of the phenotype or genetic differences.

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