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Weight estimation of Spanish ibex, *Capra pyrenaica*, and Chamois, *Rupicapra rupicapra* (Mammalia, Bovidae)

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Abstract

The relationships of body weight to horn length, chest girth and body length were analysed for Spanish ibex, *Capra pyrenaica* (Schinz, 1838), and Chamois, *Rupicapra rupicapra* (L., 1758). Different linear regressions were necessary for each population and for each sex. All relationships were statistically significant ($p < 0.01$). The best predictors of body weight were horn length for male Spanish ibex, body length for female Spanish ibex, and chest girth for both sexes in the chamois.

Introduction

In recent studies of ungulates (Geist 1966; Nievergelt 1966; Bunnell 1978; Clutton-Brock et al. 1980) great importance has been placed on the relationship between horn length and body size and its ecological, ethological, and evolutionary implications. However, for control or populations management purposes, the relationships between horn length and body weight is also valuable. Nevertheless, since reliable data on body weight is frequently absent in museum specimens or mounted trophies, other linear measurements related to body size, like horn length, have been studied in several ungulates by a large number of authors, among them Ross (1958), Blood and Lovaas (1966), McEwan and Wood (1966), Nievergelt (1966), Rideout and Worthen (1975), Hall Martin (1977), Gray and Simpson (1979), Bunnell (1980), Clutton-Brock et al. (1980), and Popp (1985).

Although difficulties occur when estimating weight from linear measurements (Rideout and Worthen 1975), and sometimes low correlations (Bunnell 1978), this paper shows that the relationships between body weight and various linear measurements can be used to predict body weight in two populations of Spanish ibex, *Capra pyrenaica* (Schinz, 1838) and one of Chamois *Rupicapra rupicapra* (L., 1757).

Material and methods

Ibex specimens (n = 169) came from the Sierra de Cazorla, Southeast of the Iberian peninsula, and also from the Sierra de Gredos, Central Mountain Range, two of the main places within the area of distribution of the species. The chamois specimens (n = 47) came from the Cantabrican Mountains, Northwest of the Iberian peninsula. In both species specimens were obtained for a broad study of their biology and ecology from shootings during 1980–1984. Attention was paid to obtain a representative sample of each population in terms of sex, age and seasonality.

The specimens were weighed on a platform scale with a precision of ± 0.1 kg. Horn length (Horn) was measured by using a cord which was applied closely to the convoluted surface of the horn from tip to base. This measurement provided a better estimator of horn length than the simple measurement of the shortest distance between the base of the horn and its tip. Body length (LCC) was measured from the extreme of the snout to the base of the tail using a metric tape. During this procedure the stretched-out neck was bent so that it lay on the same plane as the trunk. The chest girth (PTOR) was taken by placing the tape around the body behind the front legs. All measurements were made in millimeters with a precision of ± 1 mm.

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Using the body weight as a dependent variable and the linear measurements as independents, straight line regressions were treated separately owing to previously encountered significant differences (Fandos and Vigal in press).

Results

Horn length provided the most precise estimate of body weight in male ibex specimens from Gredos and from Cazorla ($R^2 = 0.86$ and 0.81 respectively, Table 1), while in females, this occurred with body length (LCC) ($R^2 = 0.82$ and 0.86). Error of estimation (Sxy) in these regressions were among the lowest ones. The chest girth measurement satisfactorily predicted body weight in both cases (see Table).

Regression equations used for the chamois gave different results. The highest value of R^2 was found between body weight and chest girth measurement (PTOR) ($R^2 = 0.86$ for males and 0.68 for females), while the lowest one was found between body weight and horn length. Although sexual dimorphism in the latter is not so pronounced as in the ibex, females showed a greater variability than males. All the regressions conform significantly to a probability lower than 0.01 (Table).

Discussion

In this paper males and females have been treated separately because of the significant sexual dimorphism occurring in both species (more pronounced in the ibex), the female/male rate in ibex is 0.35 for body weight and 0.15 for horn length (Fandos 1986; Fernandez-Lopez and Garcia Gonzalez 1986). This is probably related to the type of

The regression between body weight and linear body measurements of two ibex populations and one chamois population

	Regression equation	R^2	n	Syx	95 %	F	DF	P
	Ibex cazorla							
Male	weight = 13.20 + 0.07 HORN	0.81	45	6.00	1.79	175.13	1–43	<0.01
	weight = –43.4 + 0.07 LCC	0.79	43	6.87	2.20	158.10	1–41	<0.01
	weight = –57.1 + 0.12 PTOR	0.77	25	4.14	1.70	81.34	1–23	<0.01
Female	weight = 4.78 + 0.16 HORN	0.70	36	4.73	1.60	79.22	1–34	<0.01
	weight = –33.4 + 0.06 LCC	0.86	34	2.91	0.76	214.31	1–32	<0.01
	weight = –24.1 + 0.07 PTOR	0.81	17	4.47	2.29	65.57	1–15	<0.01
	Ibex gredos							
Male	weight = 11.39 + 0.08 HORN	0.86	45	6.03	1.78	272.72	1–43	<0.01
	weight = –65.8 + 0.10 LCC	0.82	49	7.03	2.03	224.59	1–47	<0.01
	weight = –45.5 + 0.10 PTOR	0.81	49	8.10	2.31	207.49	1–47	<0.01
Female	weight = 8.75 + 0.12 HORN	0.79	39	4.75	1.53	136.36	1–37	<0.01
	weight = –34.1 + 0.09 LCC	0.82	39	3.25	1.23	169.39	1–37	<0.01
	weight = –26.1 + 0.07 PTOR	0.77	39	5.06	1.64	123.12	1–37	<0.01
	Chamois							
Male	weight = 4.22 + 0.11 HORN	0.75	23	2.66	1.15	67.67	1–21	<0.01
	weight = –22.2 + 0.04 LCC	0.84	26	1.35	0.54	142.04	1–24	<0.01
	weight = –19.1 + 0.06 PTOR	0.86	26	2.35	0.94	162.16	1–24	<0.01
Female	weight = 8.02 + 0.09 HORN	0.60	21	1.57	0.71	28.79	1–19	<0.01
	weight = –14.4 + 0.03 LCC	0.65	21	2.34	1.06	36.91	1–19	<0.01
	weight = –19.3 + 0.06 PTOR	0.68	18	1.41	0.70	36.80	1–16	<0.01

R^2 = Coefficient of estimate; n = specimens number; Syx = Standard error of estimate; 95 % = Confidents limits; F = Variance ratio; DF = Degrees of freedon; P = Probability of zero-slope. (HORN = Horn length, LCC = body length, PTOR = Chest girth) sexual selection which favors the development of secondary sexual characteristics, mainly related to fighting (SCHAFFER and REED 1972; CLUTTON-BROCK et al. 1980).

The relationship between horn-length and body weight gives a higher correlation index in males than in females of the two species considered. NIEVERGELT (1966) found similar results for the Alpine ibex where the length of the horn showed the greatest correlation with body weight of males.

Regressions between horn length and body weight have been reported in other bovids (GRAY and SIMPSON 1979; BUNNELL 1980; POPP 1985). In this study, differences in the degree of fitness of horn length/body weight regression were found. These differences can be seen at three levels; specific (Ibex specimens showing higher fitness than the Chamois), sexual (males having higher fitness than females), or population in Ibex females specimens, from Gredos being better fited than those from Cazorla. On the other hand, other studies (FANDOS 1986; FANDOS and VIGAL in press) suggested that the annual growth rate also shows differences connected with species, sex or population. Thus, we conclude from these two facts, that annual growth rate could be related to the degree of fitness of this regression.

A second reason why ibex shows a high correlation between body weight and horn length, can be explained by the methods used in the present study. The sample of specimens studied was considered to be sufficiently representative of the population concerning sex and age aspects, trying to avoid the error described by BUNNELL (1980) which occurs when all the age groups are not included in the sample. It must also be pointed out that these specimens were collected throughout the whole year, thus avoiding seasonal variations (GRAY and SIMPSON 1979).

Chest girth measurement (PTOR) provides the best estimate of body weight in the chamois in both sexes. Similar results for this species have been obtained by SCHROEDER and REDLICH (1976). However, R^2 values between these two measurements (0.86 and 0.68; table) is lower than the one obtained by BUNNELL (1980) for the mountain goat *(Oreamnus americanus).*

In chamois, when estimating body weight from the three variables, R^2 value for females was lower than for males (Table). This fact may be related to the higher energetic expenses of reproduction (gestation and suckling) in females, as suggested by GRAY and SIMPSON (1979) to explain the rates of development of horns in the Barbary sheep *(Ammotragus lervia).*

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Zusammenfassung

Gewichtsabschätzungen für den spanischen Steinbock, Capra pyrenaica und die Gemse, Rupicapra rupicapra (Mammalia, Bovidae)

Es wurde das Verhältnis zwischen Körpergewicht und den Maßen für Hornlänge, Brustumfang und Körperlänge für den spanischen Steinbock, *Capra pyrenaica* (Schinz, 1838) und die Gemse, *Rupicapra rupicapra* (L., 1758), analysiert. Für jede Population und für beide Geschlechter waren getrennte Berechnungen linearer Regressionen notwendig. Alle Beziehungen sind statistisch signifikant ($p < 0.01$). Die besten Voraussagen über das Körpergewicht erlauben für den männlichen Steinbock die Hornlänge, für den weiblichen Steinbock die Körperlänge sowie der Brustumfang für beide Geschlechter der Gemse.

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