

A limit for horn length in White of Rasquera Goat

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Abstract

Well-preserved adult skulls (twenty-two male and 27 female) from White of Rasquera Goat breed were studied. The greatest length of the skull has been used to estimate head size. Horn length was measured with a tape along the whole length of the right sheath. The equations obtained were $[\log y = 3.231 - 1.417 \log x]$ and $[\log y = 3.248 - 1.538 \log x]$ for males and females respectively. It is possible that, although horn traits can be important for this breed, which is mainly naturally selected, other important traits must exist when choosing a mate.

Introduction

It is well known that animals are not isometric; that is, their organs generally do not scale in a linear fashion with their bodies. Allometry describes the relationships between dimensions of organisms and changes in the relative proportions of these dimensions with changes in absolute size. This scaling has been observed even when variation in trait and body size is not a consequence of developmental progression. Because of this the term allometry has been introduced appended to describe different types of biological variation. When x and y are traits measured in the same individual through developmental time, the relationship is called an ontogenic allometry. For ontogenic allometry, the slope of the allometry reflects the difference in growth rate between an organ and body size.

The relationship of one variable with respect to another can be summarized by the allometric coefficient of the equation of the relationship. The value of this coefficient must be considered when determining whether a particular relationship exhibits isometric or allometric change. If a relationship is not isometric, the allometric coefficient will indicate which linear dimension increases at a faster rate than the other. To obtain the allometric coefficient, the first variable could be expressed as a function of the second, using the general exponential equation $y = \beta x^a$. In this equation, a and β are constants. β is the intercept of the line on the y -axis and a is the slope of the line, also known as the allometric coefficient. Both the slope (a) and the intercept (β) have biological meaning, although this meaning depends on the scaling relationship in question.

Another method to obtain the allometric coefficients is based on Jolicoeur (1963) with extensions by Kowalewski et al. (1997). The most commonly used allometric equation employs not a linear but a logarithmic scaling of both body size and the size of the organ under study (Howland et al., 2004). The equation is written in one of two equivalent equations, $\log y = a \log x + \log \beta$ where y is the size of the part and x is the size of another part or overall body size. When x and y are body or organ sizes at different developmental stages, the allometric coefficient captures the differential growth ratio between the organ and the body as a whole. When the organ has a lower growth rate than the other part or overall body size, then $a < 1$, which is called negative allometry or hypoallometry. All of these concepts are reviewed and discussed well by Schmidt-Nielsen (1984).

The size of the elaborate sexual ornaments (defined as exaggerated or novel structures used to visually attract mates) carried by many animal species has been traditionally explained in terms of the trade-off between the benefit, in the form of increased mating success, and the costs that arise from carrying these traits. Many studies have demonstrated the advantage of these elaborate secondary sexual traits (for instance when they are employed in male–male competition), but few have shown compelling evidence for the limits to the elaboration of these traits that must exist. Few if any investigations have been devoted to the study of the pattern of ornament expression and other body parts in domestic goats.

In this study we describe such ornament evidence in the exaggerated horns of White of Rasquera Goat, an ancient local breed from Catalonia (SE Spain) managed under extensive conditions for meat purposes.

Materials and methods

Breed description

The White of Rasquera Goat breed is a racial grouping located in several southern regions of Catalonia. The breed is medium-lined, middle-sized (71.92 ± 3.70 cm in height at withers on females), and mainly straight profiled, with a dominance of black-spots on a white background (79.7% on males and 64% on females) or solid white (11.6% on males and 18.6% on females) coat types. This goat breed also shows a strong sexual dimorphism as well as remarkable morphostructural variability within genders (Carné et al., 2007). It has a great rusticity and is perfectly

adapted to local hard orographic and weather conditions.

Population Samples

Twenty-two male and 27 female well-preserved adult skulls (all teeth erupted) were studied at a private collection. The greatest length of the skull was used to estimate head size. Both horn lengths were measured with a tape along the whole length of sheath, but only measurements on the right were taken into account.

Biometry

We first tested for variation in skull length and horn length among the sexes using untransformed data. Then, the allometric line was quantified by performing a first-order polynomial with a Reduced Major Axis (RMA) linear method. RMA tries to minimize both the x and y errors. Both x and y values are log-transformed, fitting the data to the "allometric" function $\log y = a \log x + \log b$. Data were analysed using Statistica 7 (StatSoft, Tulsa, OK) and PAST (Hammer et al., 2001).

Ethics statement

No specific permits were required for this study as it involved neither slaughtering of any animal nor manipulation of endangered or protected specimens.

Results

Skull length ranged from 9.7 to 13.8 cm and horn length ranged from 30 to 65 cm. Sexual differences were found in mean horn length ($p < 0.001$) but not in mean skull length ($p > 0.05$), with horns being longer in males. The estimated equations were $[\log y = 3.231 - 1.417 \log x]$ and $[\log y = 3.248 - 1.538 \log x]$ for males and females, respectively. The negative allometric coefficients a for both sexes indicated hypoallometry. The allometric slope in females was slightly steeper than the slope in males, with the difference being statistically significant (Figure 1).

Discussion

In this case, it seems that the hypoallometric trait does not affect fitness among animals as they were adult and sexually active animals that died from natural causes.

For males, longer horns were consistent with the hypothesis that according to the natural management of the breed, they need strong horns for their head-to-head combat. The large horn size of males in relation to females is related to battles occurring during the rut in the sense that the horn mass tends to absorb the energy of impacts, thus minimizing the risk of skull fracture and preventing its rotation (Granados et al., 1997). In fact, horns would act as shock absorbers, as the keratin sheath of the horns is considerably more elastic than bone, allowing a relatively greater amount of deformation (Kitchener, 1987, 1988). Their competition for reproductive opportunities with female animals could generate strong selection favouring long horns, although having horns with a size limit would not affect the male reproductive fitness. The exaggeration of horn lengths in males is probably reinforced by the slight selection of heifers, who direct selection towards "big horned bucks". It is possible that, although horn traits can be important for males, other important traits might exist when choosing a mate. With regard to females, our hypothesis is that horn size would contribute to the maintenance of a hierarchy within groups, as Locati and Lovari (1991) reported for Apennine chamois (*Rupicapra pyrenaica*) females. Thus the detected changes clearly showed logical differences in both sexes.

It has been suggested that birds with bigger sexual ornaments must maintain a high degree of symmetry to reduce the costs of having the ornament (Evans et al., 1994). In the White of Rasquera Goat breed, shorter or longer horns present similar differences in right and left lengths [$p(\text{uncorr}) > 0.05$, $n = 49$, data not presented here]. Our study has been focused only on horn length, which can be partially understood as its "size". Biases may have arisen because we used one-dimensional distances, and horns grow by coiling in three dimensions. The use of 3-D geometric morphometric methods would be useful to assess the horn form symmetries, which would help to assess this hypothesis in the domestic goat. For future researches in this direction, each horn "form" would be taken into account (because although the Prisca and "wheel-shaped" types are the most common, more than 10 recognized types exist in this breed) (Sabat  et al., 2011).

Declarations

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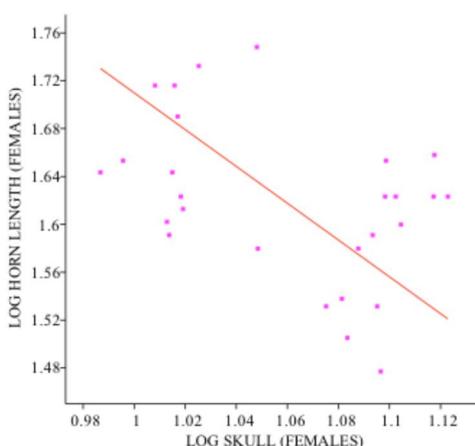


Figure 1. Allometric relationship between skull length and horn length in male and female White of Rasquera Goats.

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