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Short Communication

An Easy-to-Measure Condition Factor Proposed for Domestic Goats

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Abstract

A proposal of an adapted Fulton's K of condition factor is proposed for goat breeds. The study included twenty five (25) adult animals of Catalan and forty-one (41) of Gwembe goat breeds, from which thoracic perimeters and body weights were obtained. The suggested formula (W/T^4), where W is the whole body weight expressed in kilograms and T is the thoracic perimeter expressed in metres, seems to be an easy-to-measure condition factor that is quite useful for within-breed individual evaluation.

Keywords: Body measurements, catalan goat, gwembe goat, length-weight relationship, zoometrics indexes.

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Introduction

The need to refer to a domestic mammal as being in poor, good or excellent condition is frequently mentioned. This qualitative measure is usually based on a visual assessment of appearance (which usually equates just "how fat" the animal is). In 1902, Fulton proposed the use of a mathematical formula that would quantify the condition of fish, assuming that the standard weight of a fish is proportional to the cube of its length. The value of this index is influenced by the age of the fish, sex, season, stage of maturation, fullness of gut, type of food consumed, amount of fat reserve and degree of muscular development. This simple condition index has been demonstrated to be a good measure of body condition, and is widely used in many fish researches; however, the question is: could we find a similar index to assess body condition in domestic mammals. Fulton's *K* condition factor (CF) can be expressed as CF= $(W*100)/L^3$, where *W* is the whole body weight and *L* is the total body length (Enin 1994). As length can vary according to body proportions (fixed for each breed: brevilinial – "shorter than high"-, eumetrical or longinial – "longer than high"-), the first step must be to substitute body length by another corporal variable. Alternative values could be taken into account, including body length, thoracic depth, etc. Thoracic perimeter can be measured in an easier way than body length, and is not a breed-dependent variable. Although many classical studies have shown a correlation between thoracic perimeter and body weight, their relationship in animals was estimated using linear regression:

$W=a+bT$, where *W* is the whole body weight in kilograms and *T* is the thoracic perimeter in metres, *a*=intercept and *b*=slope. However, in order to obtain linear regressions, a logarithmical transformation is performed: $\log W=\log a + b\log T$.

As the thoracic perimeter/body weight relationship appeared to be significant for both breeds, thoracic perimeter was finally chosen. According to the well-known law of cylinder volumes (we are considering domestic mammals for which body can be idealised by a cylinder), the volume of similarly-shaped bodies of the same specific gravity varies directly as the fourth potency of corresponding dimensions, so an animal which has doubled its length should have increased its weight by eight times. Thus, the final proposed formula was $CF=W/T^4$, with weight expressed in kg and thoracic perimeter expressed in m. The better the condition of the animal (as expressed by a lower *T*), the lower the value of CF was expected to be. Obviously, the average ratio will vary with breeds, health and management, so it will represent the "well-being" of a goat, taking into account those parameters.

Materials and Methods

Two independent goat breeds were used to assess the proposed method. The purpose was to compare a European and an African breed as one can expect no phylogenetic relationships to exist between them. Both are managed under semi-extensive conditions, being clearly lentic. The preliminary consideration is that standard CF can be used as a basis for comparison to assess the condition of goats; for example, as the Gwembe goat is a typical dwarf breed, its body weight will be always below that of eumetric breeds, such as the Catalan goat. Twenty five (25) adult animals of the Catalan goat breed and forty-one (41) of the Gwembe goat breed were studied. Catalan goat belongs to an ancient population that occupied Catalunya (NE Spain) until the middle of the 20th century. The breed is medium-sized, with an average weight of 68 kg for males and 56.6 kg for females, with characteristic long hair on the upper thigh, and a haired udder. Both sexes have horns, typically bending sharply backwards, although some have corkscrew-shaped horns that curve back and outwards. The breed is clearly different from other neighbouring Catalan breeds, e.g., Pyrenean and White Rasquera. In the past, the local breeds were viewed by some people to be inferior, unproductive, and without any foreseeable room for improvement; however, following a more critical analysis, today scientists view these breeds as a treasured genetic resource. Some years ago, a group of volunteers from 'Cultures Trobades' ('Slow Food Terres de Lleida') made an effort to gather the last individuals of Catalan goats, and relocated them to a 'conservation farm', a safer place under better

management, and started a programme to preserve them. Measurements were taken by the second author. The Gwembe Dwarf goat, locally known as "Mpongo", is a small breed with an average weight of 35 kg for both males and females, and is found in the Gwembe valley in the Southern Province of Zambia. Well-adapted to hot and dry climatic conditions with low rainfall patterns, this breed has horns of medium size that are usually curved backwards (http://dad.fao.org/). Other goat breeds from Zambia include the Plateau goat located on the plateau regions of Southern Province, the Sinazongwe district of the Southern and North part of the Gwembe Valley, and the imported Boer and Saanen (http://dad.fao.org/). Measurements were taken by the first author.

The thoracic perimeter was obtained using a flexible ruler. Body weight was measured using a hanging digital scale and measured to the nearest 0.1 kg. Measurements for Catalan goat were obtained in 2013, and those from Gwembe goat in 2010. Females were not pregnant. The evaluations were made using adult animals older than one year.

The Reduced Major Axis (RMA) was the algorithm used for the study of the W and T relationship for each breed. RMA attempts to minimise both the x and the y errors. Values were previously log-transformed (base 10), in order to obtain a straight line. Analysis of covariance (ANCOVA) was used to evaluate whether population means of the body weight, as a dependent variable, was equal across the levels of body weight, as an independent variable. The ANCOVA tested was used for equality of means for both univariate groups, and adjusted for covariance with another variate. Mann-Whitney test was used to compare CF (CF=W/T4) for both breeds.

All statistical analyses were carried out in PAST- "Paleontological Statistics Software Package for Education and Data Analysis" (Hammer *et al.*, 2001).

Ethics Statement

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

Conflict of Interest Statement

There is no conflict of interest with any financial organization regarding the material discussed in this research.

Results and discussion

Plots of the thoracic perimeter/body weight relationship of both breeds are shown in Figures 1 and 2. The values of a, b, and r2 are given in Table 1. The b value was greater in the Gwembe goat. The low value of coefficient of determination for Catalan goat (23.5%), indicate that the predictive equation is completely ineffective, unlike obtained in Gwembe population (77.1%).

Table 1: Thoracic perimeter/body weight relationship for Catalan and Gwembe goats. Values of *a*, *b*, and r^2.

	Catalan goat (n=25)	**Gwembe goat (n=41)**
a (95% confidence)	1.451 (-0.631 to 2.113)	1.876 (1.505 to 2.232)
b (95% confidence)	-1.066 (-2.375 to 3.000)	-1.998 (-2.614 to -1.352)
r^2	0.235	0.771
p	0.001	<<0.000001

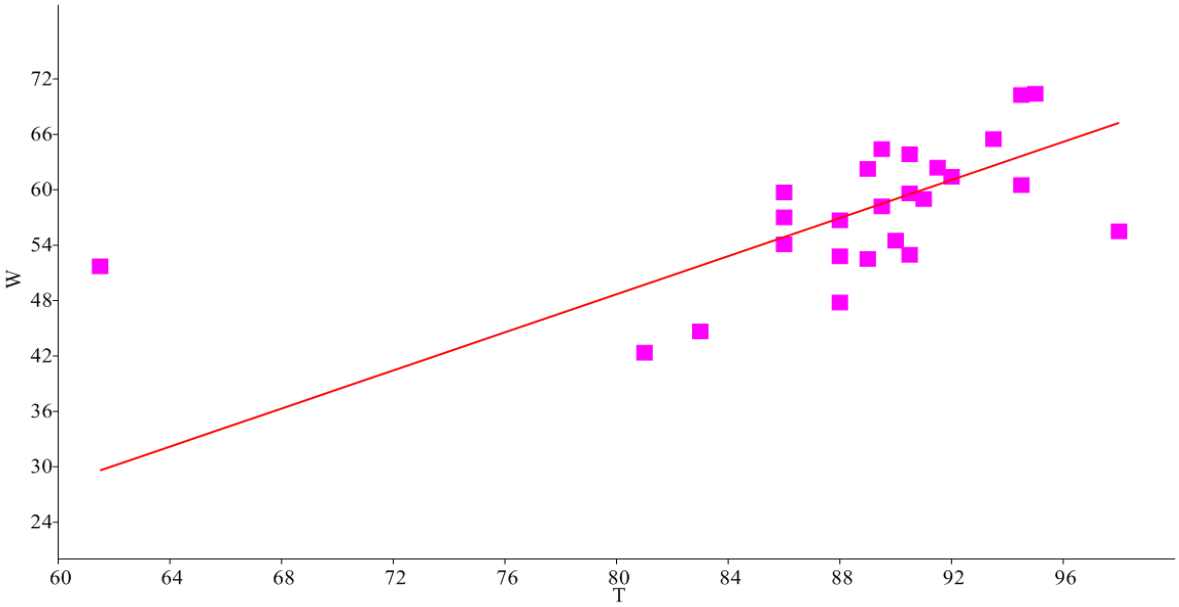

Fig. 1: Plot of the thoracic perimeter (*T*)/body weight (*W*) relationship (values log-transformed) of Catalan goat breed (n=25), where log *W*=log 1.451-1.0668*log*T*. r^2=0.235.

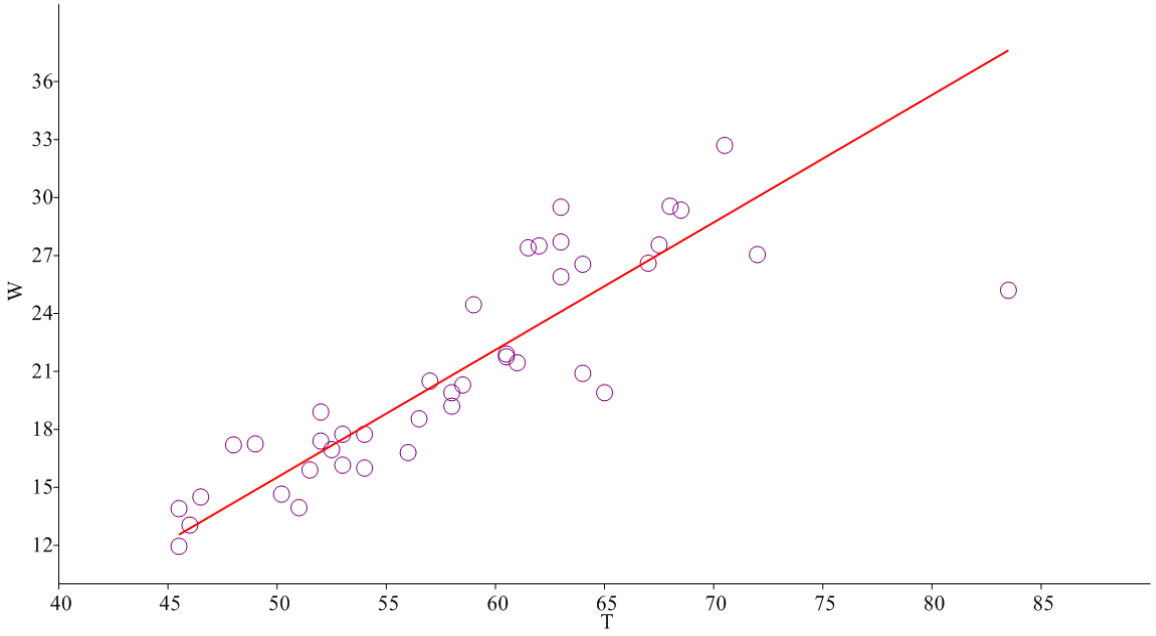

Fig. 2: Plot of the thoracic perimeter (*T*)/body weight (*W*) relationship (values log-transformed) of Gwembe goat breed (n=41), where log *W*=log1.876-1.998**T*. r^2=0.771.

The problem for this low reliability is probably due to the heterogeneity of animals in the Catalan breed. ANCOVA of the thoracic perimeter/body weight relationship showed different adjusted means (F=23.7, p<<0.001) as well as different slopes (F=13.3, p<<0.001) for both breeds (Figure

3). It can be seen that he relationship between weight and thoracic perimeter was stable.

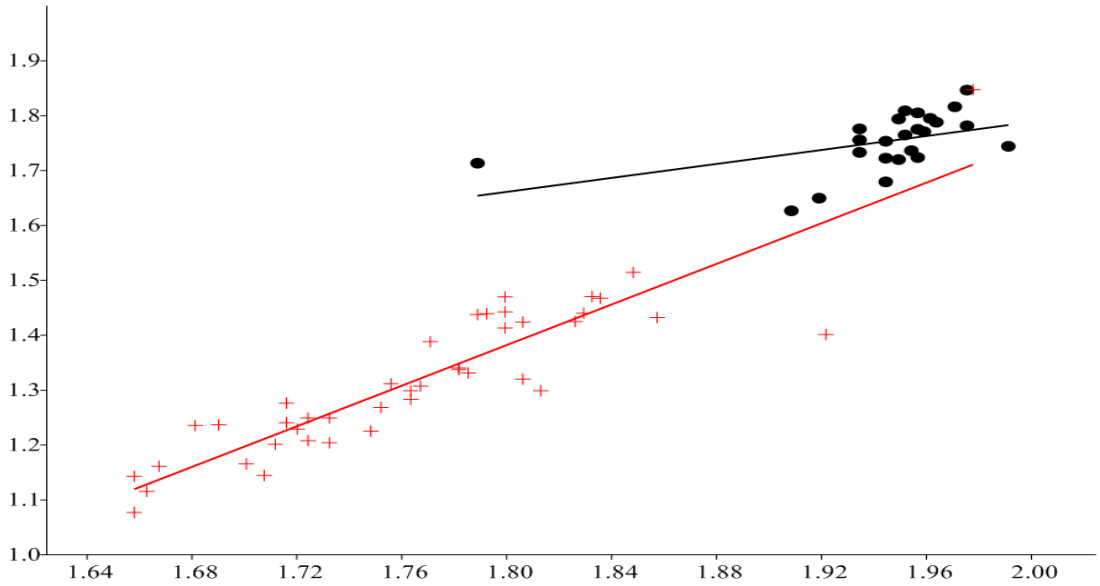

Fig. 3: ANCOVA plot of the thoracic perimeter/body weight relationship for Catalan (circle dots) and Gwembe (crosses) goat breeds. This showed different adjusted means (F=23.7, p<<0.001) as well as different slopes (F=13.3, p<<0.001) for both breeds.

In fact, thoracic perimeter is the measure that classically best predicts body weight (highest r2), and a great deal of scientific articles exist which deal with estimating weight formulas using thoracic perimeters. CF appeared to be significantly different for both breeds (p<<0.001) (Figure 4), being higher in Gwembe (X=192.8±61.79) than in Catalan goat (X=100.2±55.34) and with different deviations.

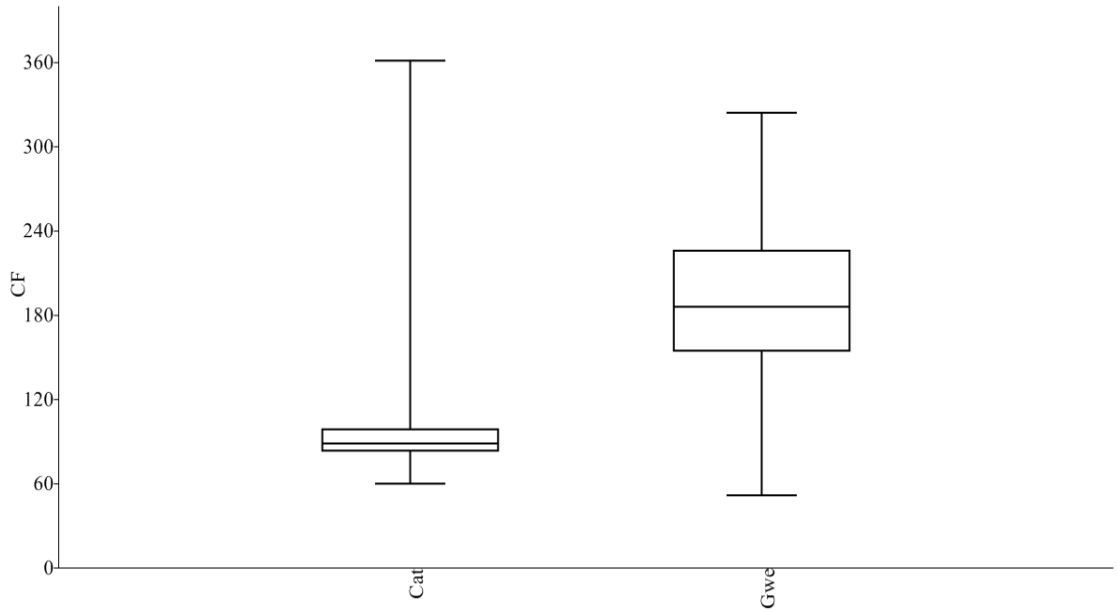

Fig. 4: Box plot of Condition Factor (CF=W/T^4, where W is the whole body weight in kilograms and T is the thoracic perimeter in meters) for Catalan (n=25) and Gwembe (n=41) goat breeds. This factor appeared to be significantly different for both breeds (p<<0.001), being higher in Gwembe goat ("Gwe", X=192.8±61.79) than in Catalan goat ("Cat", X=100.2±55.34).

The lower variation in the values of Gwembe goat was surprising, as the studied animals belonged to different herds. Therefore, the condition factor used seems to be a valuable tool that can be applied to compare the "slimness" of individuals within a breed (Figure 5); this may be used for management targets, but not for comparison purposes between breeds. The factor could be also used to assess the health of an individual, considering that animals which present a lower CF than the standard for that breed will be healthier, and will have greater energy reserves for normal activities, growth, production and reproduction. It could be used to measure the effectiveness of management practices. For instance, the Catalan outlier that appears in Figure 5 corresponded to a skinny female (that weighed only 61.5 kg).

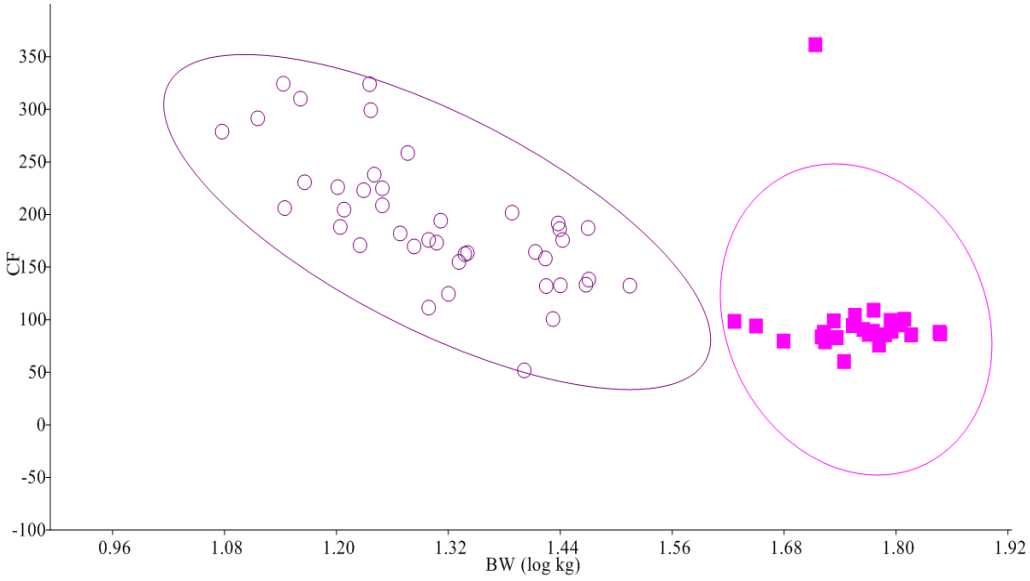

Fig. 5: XY graph for Catalan (n=25) and Gwembe (n=41) goat breeds. Body weight (BW, expressed as log kg) on X-axis. Condition Factor (CF) on Y-axis. Circles express 95% confidence. The outlier for the Catalan goat breed corresponded to a female with low body weight.

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