Estimating live weight of sheep of Guatemala by a simple formula

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A sample of 64 native ovines (50 females and 14 males) of different ages (from sucklings to very old individuals) belonging to different flocks, from different local communities of the Quetzaltenango Department in W Guatemala, were weighed and measured for thoracic girth (TG), ear length, cannon perimeter, face length and head length. Measurements were obtained by the same persons. Live weight (LW) was estimated using a linear model. Coefficient of determination (R2) values computed for LW versus TG were 0.871. It was concluded that thoracic girth is a useful tool in predicting weight of sheep from Guatemala for all ages. From this, the derived predictive equation for the live weight determination from thoracic girth, LW (kg) = TG0.735 is a quite simple, easy to remember formula, presenting a high coefficient of determination, and with no statistical differences between real and estimated weight values.

Barometry, body measurements, body weight, “criollo” sheep, size allometry

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Introduction

Knowledge of precise animal body weight is useful in determining how much daily feed is needed, reducing the number of medication errors, evaluating growth… Moreover, weight can be an important health indicator, as knowing how much an animal weighs and whether it is currently gaining or losing weight can help identify health issues. Often, however, veterinarians and zootechnicians simply rely on their "best guess" to assign a conventional weight. It requires good training and, being a subjective method, is subject to important errors.

Body measurements can be used to predict live weight fairly well in a situation where weighbridges are not available (Goonerwardene and Sahaayuraban, 1983). The use of zoometric measurements can accurately predict an animal's weight. This is why functions used to predict live weight from live animal measurements are of considerable interest to livestock enterprises, especially those managed extensively or focused on small flocks, where no tools are available. Zoometric formulae to estimate live animal weight have widely been reported in the zootechnics literature, for all species and for many breeds (authors will not conduct a bibliographical review). Despite this quantity of research, none is known for the indigenous sheep of Guatemala, this being the objective of the present study.

As local technicians do not have access to a set of scales, this research constitutes more than a simple statistical or descriptive work, trying to provide them with the best formula. Morphological detailed characterization and breed inventories are important in the conservation of ovine genetic resources and, thus, although this research seems simple.

It provides first-time information about body weight estimation, and some other traits, in addition to weight, are also presented here.

The native sheep from Guatemala is a breed that appears as "Criollo" or "Chusco" (we have never heard the latter) in the FAO database (http://dad.fao.org/). According to the same source, it descended from Spanish Churro and probably also Spanish Merino. FAO registers the breed as a meat producer, although nowadays it only has a "fertilizer" purpose in "milpa" crops (mixed system of maize, beans and squash), its traditional wool production (composed of long fibers) barely being undertaken at present. The breed is phenotypically identical to the Chiapas sheep (which does not appear with this name in the above-mentioned FAO database, but as"Criollo" or "Chusco", too), with which it seems to form a large ovine indigenous population (probably with different ecotypes) that occupies most of the ancient occidental Mayan territory, in the W parts of Mexico and Guatemala. FAO database does not include more detailed information about this Guatemalan breed and thus no census is available, although the breed is clearly becoming scarce throughout Guatemalan territory (in part due to the presence of fine wool breeds, in part due to the abandoning of traditional livestock farms).

Material and methods

The data for this study were obtained from 64 animals (50 females and 14 males) of different ages and corporal scores, belonging to different flocks in different local highland communities (located in Quetzaltenango, Cabrican, Santa Catarina Ixtahuacan, Santa Maria Chiquimula and Aguacatán) in Quetzaltenango Department, W Guatemala.

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Animals were managed extensively, without supplementary feeding or a health management system. Ages ranged from suckling lambs (fresh deciduous incisor series) to very old ones (incisor series fully lost), according to individual dentition obtained during the field work. Only those animals considered pure breed (the so-called “Criollo” type) were considered for this study, as many exotic breeds (especially from fine wool breeds, such as Merino and Corriedale) were erroneously imported to the area some years ago (of a total of 105 sample animals, 41 were discarded as being clearly “non pure”). Coat of sampled animals was mainly black (the chromotype most frequently seen), but white and coffee animals were also detected and sampled, although no distinction has been made between colors. Field data collection was performed during October 2014.

Live animal measurement

Animals were weighed by suspending them on a hanging dynamometer (precision: 0.1 kg). The dimensional body measurements included the following 5 linear traits: thoracic girth (measured as the body circumference immediately posterior to the front leg), ear length, cannon perimeter (at the forelimb just below the knee), face length (from tip of the muzzle to a virtual line just below the eyes) and head length (from tip of the muzzle to occipital protuberance). They were obtained with a standard flexible measuring tape. Same measurements were obtained by the same persons (Marta for linear measurements and Laura for body weight).

Statistical analysis

As the Kolmogorov-Smirnov test reflected non-significant differences in distribution of sex samples ($D=0.348$, $p=0.108$), the non-parametric ANOVA Kruskall-Wallis test was performed to detect differences between male and female body weight medians. As some measurements (cannon perimeter, ear length and face length) presented a non-normal distribution ($p<0.05$), correlation between them was studied using the non-parametric Spearman’s coefficients. Linear regression was undertaken with log-transformed values for all traits, with a zero intercept option (using a log scale, animals separated by the same factor lined up in a straight line).

Because body size, *x*, is not fixed and is estimated with error, ordinary least squares regression (OLS, model I) tends to underestimate both a and the confidence interval around *a*. Some form of model II regression therefore seemed more appropriate for both parameter estimation and hypothesis testing. Given that all sizes were measured in the same manner and using the same scale, both measurement error and intrinsic error should be very similar, especially when transformed to a logarithmic scale. Under these conditions, major axis regression (RMA) provided an accurate estimate of a and allows statistical testing for the general null hypothesis. RMA is a least squares data modeling technique in which sample errors (sampling and measurement errors) are taken into account for both the dependent (Y-axis) and independent (X-axis) variables. The non-parametric Wilcoxon signed-rank test was used to test paired differences between real and estimated weights. Finally, a multiple regression was performed to analyze a possible formula using more than one trait.

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The PAST version 2.17c software (available at http://www.nhm.uio.no/norlex/past/download.html) was used for statistical analysis. Confidence level was established at 5% for all tests.

Results and discussion

As body weights between males and females were not significantly different (H-tie corrected=1.349, p=0.248), sexes were considered globally for subsequent analysis. The results showed that mean weight ranged between 7.8 and 40.0 kg (Table 1). The maximum weights obtained are clearly higher that those reported by FAO database (http://dad.fao.org/), which are 32.8 and 26.1 kg for males and females, respectively. As FAO database does not reflect all information (not even the most evident), these differences could be due to deficient field work by persons who collected data for FAO. Of all the measurements studied, body weight was the most variable (CV=31.6%), while thoracic girth, cannon perimeter and head length were the least (CV<13.5%) (Table 1). Obviously, the fact that our sample included a wide range of ages would explain the great variability of body weight. The marked variability of ear length (CV=21.5%) is attributed to the fact that for this breed many animals present microty, a non-pathological reduction of ear size frequently observed among these animals.

With Spearman's correlation modules of the dimensional characters, thoracic girth (TG) was a trait related to body weight, as were the other traits except ear length (Table 2). Thus, the data failed, overall, to reject the null hypothesis. Coefficient of determination (R^2) values computed for the TG were 0.871, while for cannon perimeter, head length and face length were 0.605, 0.690 and 0.793.

Body weight was allometrically dependent on most of the traits measured.

The predictive equation for live weight (LW) using TG as estimator is presented in Figure 3. From the log transformed data, y=0.735x, for which y=LW and x=TG. Its *posteriori* transformation to logged formula established that LW (kg) = $TG^{0.735}$ (TG expressed in cm). The non-parametric Wilcoxon signed-rank test reflected no differences (W=1,161, p=0.429) between real and estimated body weight using this formula, so it is reinforced that the formula can be considered as a good predictor of LW. Multiple regression was not possible as the overall ANOVA-type significance test was not significant (F=134.7 and p<<<0.051), so an estimation formula using two or more traits was not mathematically possible. This reduces the practical usefulness of using other body measurements in conjunction with chest girth.

This study demonstrated that a prediction equation for live weight using TG is possible and that this measurement can predict LW with good precision. This observation is in agreement with many previous studies for sheep and many other domestic mammals (Parés *et al*., 2013), although for each breed different equations have been established. In our study, the formula is easily performed using a pocket calculator and, moreover, the thoracic girth measurement ("tighten" perimeter around the body of the animal immediately behind the front legs) as predictor is easily taken with a flexible ruler. Moreover, under field conditions, live weight estimation using chest girth alone would be preferable because of difficulties of animal restraint during measurements. Moreover, the calculation is easier.

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	Body weight	Cannon perimeter	Thoracic girth	Ear length	Head length	Face length
Min	7.8	5.0	40.5	4.5	19.5	8.0
Max	40.0	9.0	79.5	13.0	36.0	19.0
Mean	21.5	6.2	62.1	8.8	27.7	13.8
Std. error	0.847	0.093	1.038	0.235	0.416	0.249
Variance	45.876	0.553	68.914	3.524	11.086	3.963
Stand. dev	6.773	0.744	8.301	1.877	3.330	1.991
Median	21.3	6.0	63.0	9.0	28.0	14.0
Coeff. Var.	31.535	11.993	13.378	21.454	12.015	14.405

Table 1 Summary of live-measurement traits for animals studied (N=64). Traits expressed in cm, except for weight (kg) and coefficient of variation (%).

	Body weight	Cannon perimeter	Thoracic girth	Ear length	Head length	Face length
Body weight		0.000	0.000	0.948	0.000	0.000
Cannon perimeter	**0.785**		0.000	0.813	0.000	0.000
Thoracic girth	**0.923**	**0.723**		0.851	0.000	0.000
Ear length	0.008	0.030	0.024		0.325	0.577
Head length	**0.779**	**0.572**	**0.772**	-0.125		0.000
Face length	**0.840**	**0.719**	**0.853**	-0.071	**0.770**	

Table 2 Spearman's coefficients for all traits studied (down diagonal). P-values appear above the diagonal and coefficients below. Correlated values appear in bold.

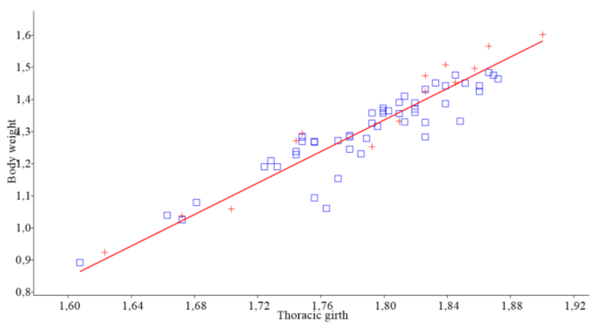

Figure 1 Linear regression for live weight using thoracic girth as predictor. Coefficient of determination (R2) is 0.871. Values log transformed. Crosses correspond to males and squares to females. In this plot using Reduced Major Axis, the "best-fit" or least square line is optimized such that it minimizes the error for both variables simultaneously.