Body fat reserves and their relationship to ultrasound back fat measurements in Pelibuey ewes

Reservas corporales de grasa y su relación con la grasa subcutánea medida por ultrasonido en ovejas Pelibuey

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ABSTRACT. This study was conducted to evaluate body fat reserves (BFD) and their relationship to ultrasound back fat thickness (BFT) measurements in twenty Pelibuey ewes. The BFT was determined 24 h before slaughter using real-time ultrasound equipment with a 6/8 MHz probe. At slaughter, internal fat (TIF) was dissected and weighed. The carcasses were split into two halves, weighed and chilled (6°C for 24 h). The left half-carcasses were completely dissected into muscle, bone and subcutaneous and intermuscular fat (carcass fat, TCF), and weighed separately. The r values for BFT and BFD ranged from 0.39 to 0.72. Regression equations between BFT and BFD had an R^2 ranging from 0.15 to 0.52. Using BFT to predict BFD in Pelibuey ewes was poorly correlated.
Key words: Pelibuey ewes, body condition, back fat thickness, energy reserves, ultrasound

RESUMEN. El estudio se realizó para evaluar las reservas corporales de grasa (DCG) y su relación con el espesor de la grasa subcutánea (EGS) medido con ultrasonido en 20 ovejas Pelibuey. EL EGS se determinó utilizando un equipo de ultrasonido en tiempo real con sonda de 6/8 MHz. Al sacrificio, la grasa interna (TIF) fue disecada y pesada; la canal se dividió en dos mitades, se pesaron y refrigeraron (6 ° C durante 24 h). La media canal izquierda se diseccionó en: músculo, hueso y grasa subcutánea e intermuscular (grasa de la canal, TCF), y fueron pesados por separado. Los valores de r para EGS y DCG variaron de 0.39 a 0.72. Las ecuaciones de regresión entre EGS y DCG tuvieron un R^2 que varió de 0.15 a 0.52. El uso del EGS para predecir DCG en ovejas Pelibuey fue pobremente correlacionada.
Palabras clave: Ovejas Pelibuey, condición corporal, espesor de la grasa subcutánea, reservas energéticas, ultrasonido

INTRODUCTION

Body condition score (BCS) has been used as an index of available body energy reserves in ewes (Mendizabal *et al.* 2003, Kenyon *et al.* 2014), goats (Mendizabal *et al.* 2011), dairy cows (Schröder and Staufenbiel 2006), Zebu cattle (Ayres *et al.* 2009) and donkeys (Quaresma *et al.* 2013). There are several methods available for the evaluation and prediction of body energy reserves namely: body weight (BW) and BCS. The BW is easy to measure, but it does not always represent the true body mass of the animal (Mendizabal *et al.* 2011). The BCS is a method which is easy to perform and does not require any particular equipment for the measurement (Mendizabal *et al.* 2011, Kenyon *et al.* 2014); however, this measurement is considered to be subjective to some extent. Nonetheless, some reports indicate that for Pelibuey ewes, one of the more common hair breeds in Mexico (Sánchez-Dávila *et* *al*. 2015), due to the particular pattern of deposition of internal fat, BW seems to be a better index of body energy reserves than BCS (Chay-Canul *et al*. 2011).

Several methods have been developed for the prediction of body reserves in sheep, cattle and other species (Quaresma *et al*. 2013), but in general they have been based on hand (palpation) and visual evaluations and because these are rather subjective, problems involving interpretation of results may occur with such techniques (Schröder and Staufenbiel 2006, Azzaro *et al*. 2011). Among those techniques are: heart girth, subcutaneous fat depth, adipocyte diameter, and digital and thermal images (Mendizabal *et al*. 2003, Schröder and Staufenbiel 2006, Teixiera *et al*. 2008, Azzaro *et al*. 2011, Halachmi *et al*. 2013).

Although ultrasound is not commonly employed to predict body fat reserves, reasonable results have been obtained (Silva *et al*. 2006, Quaresma *et al*. 2013) and it has been established that it can give good results when it is related to other methods (Broring *et al*. 2003; Mendizabal *et al*. 2003, Schröder and Staufenbiel 2006) such as BW. Ribeiro and Tedeschi (2012) reported that ultrasound can be used to predict body composition in animals in vivo. Teixeira *et al*. (2008) mentioned that ultrasound is a noninvasive method for predicting weights of muscle, subcutaneous and intramuscular fat and body fat in sheep. Ribeiro and Tedeschi (2012) and Gomes *et al*. (2012) reported that predictions of body fat and the various fat depots, may contribute towards the development of growth models of domestic animals and those measurements may contribute to animal management decision-making. Also, Hussein *et al*. (2013) and Schröder and Staufenbiel (2006) reported that due to the advent of ultrasonography, back fat thickness can be directly measured and used to assess the energy status of the cow in conjunction with BCS.

On the other hand, when adult females are kept on pasture without or with low supplementation, which generally results in seasonal fluctuation in the energy intake and the use of their body energy reserves, their reproductive and productive performance is highly dependent on body fat and in general is low, as was pointed out by Yilmaz *et al*. (2011) and Abdel-Mageed *et al*. (2012). Therefore, body fat reserves should be accurately quantified in order to apply sound nutritional management to the ewes to enhance their productivity. The aim of the present work was to evaluate the relationship between back fat thickness (BFT), measured with ultrasound, and body fat reserves in adult Pelibuey ewes.

MATERIALS AND METHODS

The experiment was carried out at the Faculty of Veterinary Medicine and Animal Science, University of Yucatan, Mexico, located at 20° 45' N, 89° 30' W; 8 masl. Climate in the area is AW_0 (tropical warm sub-humid with summer rainfall). The average annual temperature ranges from 26 to 27.8 °C, and annual rainfall ranges from 940 to 1100 mm (Garcia 1988).

The study was carried out using twenty adult, 3-year-old, non-pregnant, non-lactating Pelibuey ewes with BW of 36.2 ± 4.9 kg and BCS of 2.6 ± 0.5 (Table 1). Twenty four hours before slaughter, BCS and back fat thickness (BFT) were recorded. The BCS for each ewe was evaluated by two experienced technicians, using a 1-5 scale, with 0.5 increments (e.g. 1.5, etc.), where BCS 1 represents a thin animal and 5 an obese animal as described by Russell *et al*. (1969). The BFT was determined using real-time ultrasound equipment mode B (Pie Medical® 100) with a 6/8 MHz probe; for this, the animals were shaved previously between the 12ª and 13ª thoracic vertebrae (TFT) and the 3ª and 4ª lumbar vertebrae (LFT).

Table 1. Mean, minimum and maximum values of variables in adult Pelibuey ewes.

Variable	n	Mean	Maximum	Minimum	SD
TFT (mm)	20	1.99	3.40	1.00	0.662
LFT (mm)	20	1.91	3.40	1.00	0.560
BW (kg)	20	36.15	48.80	29.00	4.990
BCS	20	2.56	3.50	1.50	0.510
TCF (kg)	20	1.74	3.25	0.66	0.770
TIF(kg)	20	2.25	4.11	0.52	0.890
TBF (kg)	20	4.07	7.03	1.69	1.470

SD: standard deviation; BCS: body condition score; BW: body weight; TBF total body fat; TCF: total carcass fat; TIF: total internal fat; TFT: thoracic fat thickness; LFT: lumbar fat thickness.

The ewes were slaughtered humanely following the Mexican Official Norms (NOM-08-ZOO, NOM-09-ZOO and NOM-033-ZOO) established for slaughter and processing of meat animals. Before slaughter, shrunk BW (SBW) was measured after feed and water were withdrawn for 24 h. Data recorded at slaughter were the weight of internal organs and carcass. Internal fat (TIF, internal adipose tissue) was dissected, weighed and grouped as pelvic (around kidneys and pelvic region) and surrounding the alimentary tract (omental and mesenteric fat). Subsequently, carcasses were then split at the dorsal midline into two equal halves, weighed, and chilled at 6°C for 24 h. After refrigeration, the left half-carcasses were completely dissected into subcutaneous and intermuscular fat (carcass fat, TCF), muscle, bone and each component was weighed separately. Dissected tissues of the left carcass were adjusted as whole carcass (Chay-Canul *et al.* 2011).

Relationships between BFT (TFT and LFT) and body fat reserves were estimated by linear regression models using PROC REG of SAS and correlation coefficients among variables by the procedure PROC CORR of SAS (SAS 2002).

RESULTS AND DISCUSSION

The paper presents an evaluation of the feasibility of using ultrasound measurements to predict body fat content of Pelibuey ewes. A number of articles have been published on this topic, because the BCS method is subjective; nonetheless, to the author's knowledge, this is the first study involving the Pelibuey breed. Studies with different breeds are important because the pattern of fat deposition can vary among genotypes.

The means, standard deviation (±SD), minimum and maximum values of BW, BCS, LFT, TFT, TIF, TCF and TBF of adult Pelibuey ewes are listed in Table 1. It was possible to determine BFT in the thoracic and lumbar regions by means of ultrasound techniques in Pelibuey ewes with BCS between 1.5 and 3.5, though the BFT was very thin and ranged from 1.0 to 3.4 mm.

The correlation coefficients between BW, BCS, LFT, TFT, TIF, TCF and TBF are shown in Table 2. It can be observed that the relationship between TFT and LFT had a high correlation coefficient ($r=0.83$, $P<0.0001$). Also, there was a moderate correlation between BCS and TFT ($r = 0.66$) and BCS and LFT ($r = 0.61$). In the present study, this relationship indicated that one BCS point represents on average an increment of 0.5 mm of BFT. Other authors have reported different relationships; Sanson *et al.* (1993) reported that one BCS point was equal to a 1.10 mm increase of BFT. Also, Ptáček *et al.* (2014b) indicated that in Suffolk sheep the average increase was 1.66 mm. Mendizabal *et al.* (2003) in Rasa Aragonesa ewes indicated that BFT ranged between 1 to 14 mm in ewes with a BCS between 0.75 and 4.5. On the other hand, Abdel-Mageed and El-Maaty (2012) and Ptáček *et al.* (2014a) reported that the kg of lamb weaned/ewe joined increased gradually by increasing the back fat thickness of the ewes.

The correlation coefficient values for TFT and body fat depots (TIF, TCF and TBF) ranged between 0.39 for TCF and 0.58 for TBF. Similarly, LFT had correlation coefficients that ranged from 0.39 for TCF and 0.72 for TIF. It is worth noting that r values for TCF and both BFT (TFT and LFT) were not significant (Table 2). In this respect, most of the experiments where body composition has been determined in sheep of different BCS have been carried out with sheep of temperate climates and wool breeds or wool and hair crossbred sheep; it has thus been generalized that subcutaneous fat de-

Table 2. Correlation coefficients of variables in adult Pelibuey ewes.

Variable	TFT	LFT	BW	BCS	TCF	TIF	TBF
TFT	1.00						
LFT	0.827***	1.00					
BW	0.336ns	0.527*	1.00				
BCS	0.657**	0.613*	0.583*	1.00			
TCF	0.392ns	0.394ns	0.566*	0.546*	1.00		
TIF	0.584*	0.727**	0.749**	0.775***	0.714**	1.00	
TBF	0.585*	0.682**	0.784***	0.758***	0.854***	0.945***	1.00

***P<0.0001; **P<0.001; *P<0.05; ns: not significant, BCS: body condition score; BW: body weight; TBF: total body fat; TCF: total carcass fat; TIF: total internal fat; TFT: thoracic fat thickness; LFT: lumbar fat thickness.

Table 3. Regression equations to estimate fat body reserves (Y) in adult Pelibuey using the thoracic and lumbar fat thickness (X).

N	Eq.^{c}		a±SE	TFT±SE	LFT±SE	R^2	MSE	RSD	P-value
20	1	BCS	1.589***±0.279	0.491**±0.133		0.43	0.158	0.398	0.0017
20	2		1.581***±0.312		0.515**±0.156	0.38	0.173	0.416	0.0040
20	3	TCF	0.868ns±0.508	0.439ns±0.243		0.15	0.525	0.725	0.0870
20	4		0.796ns±0.543		0.494ns±0.271	0.16	0.524	0.724	0.0854
20	5	TIF		1.098**±0.081		0.27	0.581	0.762	<.0001
20	6				1.169**±0.069	0.52	0.378	0.615	<.0001
20	7	TBF		1.970**±0.139		0.22	1.683	1.297	<.0001
20	8				2.087***±0.124	0.43	1.232	1.109	<.0001

R^2: coefficient of determination, MSE: Mean Square Error, RSD: Residual Standard Deviation, SE: Standard Error, ^{c} Number of equation, ns: not significant; *P<0.05; **P<0.001; ***P<0.0001, BCS: body condition score; TBF: total body fat; TCF: total carcass fat; TIF: total internal fat; TFT: thoracic fat thickness; LFT: lumbar fat thickness.

posited in the lumbar region, dorsal and/or caudal, is what really determines BCS of the animals (Russell *et al*. 1969, Junkuszew and Ringdorfer, 2005).

Regression equations between TFT and body fat depots had a coefficient of determination (R^2) that ranged from 0.15 for TCF and 0.27 for TIF (Residual Standard Deviation, RSD = 0.725 and 0.762 respectively). Similarly, equations between LFT and body fat depots had an R^2 that ranged from 0.15 for TCF and 0.52 for TIF (RSD = 0.724 and 0.615 respectively). Nonetheless, the equations of both TFT and LFT between TCF were not significant (Table 3). The relationship between BFT and BCS had an R^2 that ranged between 0.38 and 0.43. In general, it can be observed that the relationships between BFT and body reserves were positively but inconsistently related. Mendizabal *et al*. (2003) working with Rasa Aragonesa ewes reported that by measuring BFT at the first lumbar vertebrae to predict body fat depots, they obtained an R^2 which varied from 0.38 to 0.40 for the various internal depots and for carcass depots (subcutaneous) R^2 was 0.62; as for total body fat, they found an R^2 of 0.54. In dairy and beef cattle, Hussein *et al*. (2013) reported that the ultrasound measurements of BFT showed a representation of amount of subcutaneous and carcass fat. Similarly, Singh *et al*. (2015) stated that the ultrasonographic BFT gives an accurate measure of fat reserves in crossbred cows.

In beef cattle of different genotypes, Ribeiro and Tedeschi (2012) reported the relationship of BFT determined with ultrasound and the total internal fat (IFAT) had a correlation coefficient of 0.71. It was also indicated that the prediction equation involving BFT had an R^2 of 0.65. Working with sheep of different breeds and both sexes, using the BFT on the *Longissimus dorsi* muscle, at the 12^{th}-13^{th} rib region, Gomes *et al*. (2012) reported that the correlations between BFT and total visceral fat had an r of 0.43 (P < 0.01). Nonetheless the correlations between BFT and other internal depots (mesenteric depots) were non-significant. The prediction equation using BFT as independent variable to predict internal fat had an R^2 of 0.18.

Other studies have determined that the pattern of fat deposition of the Pelibuey breed is directed towards the internal depots. It was also observed that a large proportion of the metabolizable energy (ME) absorbed by adult Pelibuey ewes was deposited internally, from which the pelvic depot was the more dynamic due to its ability to accumulate and mobilize fat (Chay-Canul *et al.* 2011). On the other hand, it has been reported that the pattern of fat deposition of the different species of domestic animals may be a strategy for adapting to environmental conditions (Ermias *et al.* 2002). For example, there are some reports which indicate that deposition of internal fat may represent an advantage in terms of energy utilization and resistance to high ambient temperatures (Ørskov 2007). Ermias *et al.* (2002) reported that the preferential sites for the deposition of the main fat depots of heat resistant breeds of sheep are the tail and the hindquarters. Ørskov (2007) pointed out that in warm areas, fat is usually deposited in several parts of the body such as the hump in Zebu-type cattle and camels and in the tail and dewlap of sheep.

Deposition of fat in those anatomical regions and the internal depots, in contrast with the subcutaneous depots of animals adapted to warm and dry areas such as Pelibuey breed ewes, would be a strategy for energy storage (fat), without losing the adaptation to the loss of the high thermal load in hot environments due to the fact that those depots do not constrain the loss of heat from the body (Ermias *et al.* 2002, Ørskov 2007). Therefore, the relatively thin subcutaneous fat cover observed in Pelibuey ewes in the present work may represent an adaptation for heat dissipation, with the aim of obtaining an easier loss of stored core heat in tropical and subtropical regions.

The above may help to explain the fact that, particularly for the Pelibuey ewe, the use of ultrasound techniques has limited usefulness for the prediction of body fat depots. Thus, more work is required in this respect, along with the development or adaptation of a BCS scale for animals of warm and tropical regions, due to the pattern of internal fat deposition and poor subcutaneous fat cover of this type of sheep. Nonetheless, in the present study, the number of animals utilized and the range of BW and BCS values were small; these factors may explain the low r values obtained for correlations between BFD and BFT. Therefore, it is necessary to evaluate more animals with a wide range of BW and improve the database by including animals with BCS greater than 4.

In conclusion, using BFT in both regions to predict body fat reserves in Pelibuey ewes produced poor results. It can be observed that the relationships between BFT and body fat reserves were positively but inconsistently related. Therefore, in order to predict the total body fat in live animals other alternatives should be considered.

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