Relationships between body fat depots, carcass composition, live weight and body condition scores in Blanca Celtibérica goats

Delfa R., González C., Teixeira A., Gosalvez L.F., Tor M.

in

Purroy A. (ed.).
Body condition of sheep and goats: Methodological aspects and applications

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 27

1995
pages 109-119

Relationships between body fat depots, carcass composition, live weight and body condition scores in Blanca Celtibérica goats

R. DELFA
C. GONZALEZ
UNIDAD DE TECNOLOGIA EN PRODUCCION ANIMAL
SIA-DGA
ZARAGOZA
SPAIN

A. TEIXEIRA
ESCOLA SUPERIOR AGRARIA DE BRAGANÇA
BRAGANÇA
PORTUGAL

L.F. GOSALVEZ
M. TOR
ETSIA
LLEIDA
SPAIN

SUMMARY - The relationships between body fat depots, carcass composition and body condition scores (BCS), assessed on lumbar, sternal and tail regions were determined in 19 adult Blanca Celtibérica goats. After slaughter the omental, mesenteric, kidney and pelvic fat were separated and weighed. The left side of the carcass was separated into muscle, bone plus remainder, subcutaneous and intermuscular fat. All body fat depots and carcass composition tissues have a logarithmic or semilogarithmic relationship with body condition scores. All body condition scores assessed on lumbar and sternal regions were better predictors than live weight (LW) of the body fat depots and carcass composition. The body condition score assessed on the sternal region was a better predictor than the other body condition methods for all fat depots and carcass composition except for the heart and pelvic fat. The variations in omental, mesenteric, subcutaneous, intermuscular, pelvic and kidney weight of fat depots per unit change in sternal body condition score (SBCS) were determined. These changes suggest that the increases in SBCS from 2.5 to 3.5 or from 3.5 to 4.5 result in the greatest rate of deposition occurring in the subcutaneous and omental fat depots.

Key words: Body fat depots, carcass composition, goat, sternal body condition score, lumbar body condition score, tail body condition score, live weight.

RESUME - *"Relations entre les dépôts adipeux corporels, la composition de la carcasse, le poids vif et la note d'état corporel chez des chèvres Blanca Celtibérica". Les relations entre les dépôts de gras du corps, la composition des carcasses et les notes d'état corporel, évaluées au niveau des régions lombaire, sternale et de la queue, ont été déterminées sur 19 chèvres adultes Blancas Celtibéricas. Après abattage, les graisses omentale, mésentérique, rénale et pelvienne ont été séparées et pesées. La demi-carcasse gauche a été soumise à dissection en ses différentes composantes, muscle, os plus déchets, gras sous-cutané et intermusculaire. Tous les dépôts adipeux du corps et des tissus qui forment la carcasse ont présenté une relation logarithmique ou semi-logarithmique par rapport aux notes d'état corporel. Toutes les notes d'état corporel évaluées au niveau des régions lombaire et sternale ont montré une meilleure prédiction que le poids vif des dépôts adipeux du corps et que la composition de la carcasse. La note concernant l'état corporel évaluée sur la région sternale a donné une meilleure prédiction que les autres méthodes d'état corporel pour tous les dépôts adipeux et pour la composition de la carcasse sauf pour le gras pelvien et du coeur. Les relations entre la note d'état corporel au niveau sternal et les dépôts de gras du corps fournis par le calcul de l'augmentation du gras omental, mésentérique, sous-cutané, intermusculaire, pelvien et rénal par unité de variation dans la note d'état corporel sternal ont aussi été déterminées. Ces variations indiquent que l'augmentation de la note d'état corporel au niveau sternal de 2,5 à 3,5 ou de 3,5 à 4,5 se traduit par un ratio de dépôt plus important au niveau des dépôts adipeux sous-cutané et omental.*

Mots-clés : *Dépôts adipeux du corps, composition des carcasses, chèvres, note d'état corporel sternale, note d'état corporel lombaire, note d'état corporel de la queue, poids vif.*

Introduction

Murray (1919) defined body condition as "the ratio of the amount of fat to the amount of non-fatty matter in the body of the living animal". Jefferies (1961) described a system of scoring the body condition of sheep, based on five points scale assessed by palpation of the lumbar region. Russel *et al.* (1969) working with Scottish Blackface ewes, showed that body condition score (BCS) was related to the proportion of chemical fat in the body, while the relationships between BCS and both total body fat and the individual fat depots in ewes from Rasa Aragonesa breed were determined by Teixeira *et al.* (1989). Delfa *et al.* (1989) described the lumbar square and its tissue composition in ewes from Rasa Aragonesa breed.

In goats the fat proportion on lumbar region is lower than sheep and Santucci (1984) using and adaptation of Russel's method proposed a BCS system for goats by palpation on sternal region. On the other hand, Teixeira *et al.* (1989) proposed and additional body condition assessment in sheep, by palpation of tissues around the tail.

The main objective of the present study was to determine the relationships between the three methods of BCS, sternal body condition score (SBCS), lumbar body condition score (LBCS) and tail body condition score (TBCS), the live weight and both total body fat and the individual fat depots (omental, mesenteric, heart, udder, subcutaneous, intermuscular, pelvic and kidney).

Material and methods

Nineteen adult goats of Blanca Celtibérica breed, in unproductive stage, from the experimental flock of "Servicio de Investigación Agraria de la Diputación General de Aragón" were scored using the lumbar, sternal and tail palpation proposed by Hervieu *et al.* (1990).

Goats were fasted and then slaughtered after 24 h. Carcasses were cooled at 6ºC for 24 h. After slaughter, contents were removed from the digestive tract, weighed and subtracted from body weight to obtain empty body weight. Omental, mesenteric, kidney, pelvic, heard and udder fat were removed and weighed separately. Carcasses were halved carefully and muscle and fat in the left side of the carcass was separated into subcutaneous and intermuscular fat components. The total body fat was calculated as the sum of all these fat depots. This methodology is according to standard methods and procedures for goat carcass evaluation by Colomer-Rocher *et al.* (1987 and 1988).

The relationships between the various fat depots and the different methods of BCS and LW were analysed using regression analyses, in the sequence: untransformed variables; dependent variables on logarithmic scale and independent variables on logarithmic scale (Steel and Torrie, 1981).

Results and discussion

The means, standard errors and coefficients of variation of all characteristics measured, are shown in Table 1. All characteristics have a substantial variation seeming that we have worked with a great range of body condition.

The repeatability of different methods of BCS was 90% within individuals and 80% between individuals.

Table 2 shows the best correlation coefficients between the different methods of BCS, live weight, body fat depots and carcass composition. All coefficients are significant ($P<0.01$) except for those calculated for bone plus remainder. On the other hand, all body fat depots and carcass composition tissues have a logarithmic or semilogarithmic relationship with BCS.

The three methods of BCS were closely correlated, 0.98 between SBCS and LBCS, 0.97 between LBCS and TBCS and 0.95 between SBCS and TBCS. All of them are higher than the coefficients found by Morand-Fehr *et al.* (1987) and Hervieu *et al.* (1992).

Table 1. Means, standard errors (SE) and coefficients of variation (CV) of all characteristics measured

Variable	Mean	SE	CV
Sternal body condition score	2.9	0.2	38.5
Lumbar body condition score	2.7	0.2	38.8
Tail body condition score	2.8	0.3	45.9
Live weight (kg)	57.5	3.0	22.5
Empty body weight (kg)	51.1	3.3	28.3
Cold carcass weight (kg)	27.6	2.4	37.4
Half carcass weight (g)	13296	190	39.1
Half carcass composition			
Muscle (g)	7987	496	27.1
Bone plus remainder (g)	1992	50	11.0
Subcutaneous (g)	1146	313	119.1
Intermuscular (g)	1342	244	79.2
Subc. + interm. (g)	2488	554	97.0
Pelvic (g)	133	27	89.4
Kidney (g)	696	159	99.5
KKCF (g)	828	184	96.8
Total fat (g)	3317	733	96.3
Body fat			
Omental (g)	2646	561	92.4
Mesenteric (g)	1583	214	59.0
Heart (g)	160	18	49.1
Udder (g)	115	24	90.2
Tail (g)	51	58	114.0
Total (g)	11088	2236	87.9

The best equations for predicting body fat depots and carcass composition using the live weight and three methods of BCS are shown in Tables 3, 4 and 5. The determination coefficients, the residual standard deviations and regression analysis were used to describe those relationships.

94% and 83% of the variation in omental and mesenteric fat weight were accounted for by variation in the SBCS. Regarding carcass fat depots, 93% of the variation in subcutaneous fat weight was accounted for by variation in SBCS, and 87% of the variation in intermuscular fat weight was accounted for by variation in SBCS, LBCS or LW. The best predictor of pelvic fat weight was the LBCS, which accounted for 87% of the variation, but 94% of the variation in kidney fat weight was accounted for by variation in SBCS. The 93% of the variation of the sum of kidney and pelvic fat weight (KKCF) was accounted for by variation in SBCS. For the muscle weight, proportionately 87% of the variation was accounted for by variation in LBCS and 94% of the variation in total body fat weight was accounted for by variation in SBCS.

Concerning the tissue composition of both anatomical regions where palpations are made, the average in percentage of muscle in the lumbar square joint of our goats reached 73% *versus* just 32% in the sternal triangle joint. However, the fat percentage of the lumbar square joint was only 15% compared to 41% in the sternal triangle joint.

Therefore, it is evident that when we carry out the palpation of the lumbar region we are mainly evaluating the depth of *M. longissimus dorsi* such as Jefferies (1961), Russel *et al.* (1969) and Delfa *et al.* (1989) proved in sheep. However, in goats, the subcutaneous fat of this anatomical region is less important since in our case it only represented as average 8%.

The results from regression analysis show that SBCS was a better predictor of the weight of half carcass fat and total body fat than LW and the other BCS methods. This agrees with the results of Santucci and Maestrini (1985), Morand-Fehr *et al.* (1987) and Morand-Fehr *et al.* (1989) in goats and with Russel *et al.* (1969), Milligan and Broadbent (1974), Paramio and Folch (1985), Teixeira *et al.* (1989) and Sanson *et al.* (1993) in ewes.

Table 2. The best correlation coefficients (r) between the body fat depots, carcass composition, live weight and the three methods of body condition scores[†]

Variable		SBCS[††]		LBCS[†††]		TBCS[††††]	LW[†††††]
Sternal body condition		1.00		0.98		0.95	
Lumbar body condition				1.00		0.97	
Tail body condition						1.00	
Live weight		0.84		0.85		0.83	
Omental fat				0.93			0.93
Ln omental fat	(Ln)	0.97				0.91	
Mesenteric fat				0.89		0.87	0.85
Ln mesenteric fat		0.91					
Heart fat		0.84		0.87		0.87	0.81
Udder fat				0.87		0.90	0.88
Ln udder fat		0.90					
Subcutaneous fat							0.94
Ln subcutaneous fat		0.96		0.96	(Ln)	0.93	
Intermuscular fat							0.93
Ln intermuscular fat		0.93		0.93		0.91	
Sub.+interm. fat							0.94
Ln sub. + interm. fat		0.95		0.95		0.92	
Pelvic fat							0.88
Ln pelvic fat	(Ln)	0.92	(Ln)	0.93	(Ln)	0.90	
Kindey fat							0.93
Ln kidney fat		0.97		0.94		0.90	
KKCF							0.92
Ln KKCF		0.96		0.94		0.90	
Tail fat							0.92
Ln tail fat		0.93		0.91		0.92	
Total half carcass fat							0.94
Ln total half carcass fat		0.96		0.92		0.91	
Total body fat							0.95
Ln total body fat		0.97		0.96		0.92	
Muscle		0.91				0.91	0.89
Ln muscle			(Ln)	0.93			
Bone plus remainder		0.10		0.14		0.17	0.44

[†]All coefficients are significant for P≤0.01, except for those calculated for bone plus remainder
[††]SBCS: Sternal body condition score
[†††]LBCS: Lumbar body condition score
[††††]TBCS: Tail body condition score
[†††††]LW: Live weight

The best predictor of heart fat weight was the TBCS or LBCS, which accounted for 75% of the variation, but 81% of the variation in udder fat weight was accounted for by variation in TBCS or SBCS. Of the variation in the weight of the main individual fat depots, proportionately 76% to 86% was accounted for by variation in TBCS while the variation in SBCS accounted for 83% to 94% of those variations.

The SBCS is a better predictor than TBCS of the weight of individual fat depots. Nevertheless, the TBCS could be used as an additional method of assessing body condition in Blanca Celtibérica breed when the range in body condition is wide.

Inclusion of LW with the different methods of BCS in multiple regression equations can not improve the efficiency of prediction of body fat depots. This agrees with the results of Russel *et al.* (1969), Teixeira *et al.* (1989) and Sanson *et al.* (1993) in ewes.

Table 3. Best equations for predicting omental, mesenteric, heart and udder fat depots using the three methods of body condition score and live weight

Dependent var. (y)	Independent var. (x)	R^2	RSD	s^2yx	S_b	Slope	Intercept
Ln omental fat	Ln sternal body condition score	0.94	0.28	0.16	0.97	2.7	4.7
Omental fat	Lumbar body condition score	0.86	954.17	216.19	0.93	2176.4	-3195.5
Ln omental fat	Tail body condition score	0.82	0.50	0.09	0.91	0.8	5.1
Omental fat	Live weight	0.86	928.94	16.88	0.93	175.3	-7440.1
Ln mesenteric fat	Sternal body condition score	0.83	0.26	0.06	0.91	0.5	5.7
Mesenteric fat	Lumbar body condition score	0.80	434.69	98.49	0.89	800.9	-567.0
Mesenteric fat	Tail body condition score	0.76	475.73	87.98	0.87	636.9	-185.5
Mesenteric fat	Live weight	0.72	511.88	9.30	0.85	61.0	-1624.4
Heart fat	Sternal body condition score	0.71	43.07	9.20	0.85	60.0	-12.6
Heart fat	Lumbar body condition score	0.75	40.11	9.10	0.87	65.3	-15.8
Heart fat	Tail body condition score	0.75	40.30	7.45	0.87	53.2	-11.8
Heart fat	Live weight	0.65	47.44	0.86	0.81	4.9	-121.4
Ln udder fat	Sternal body condition score	0.81	0.50	0.11	0.90	0.9	1.7
Udder fat	Lumbar body condition score	0.76	52.17	11.85	0.87	85.0	-111.5
Udder fat	Tail body condition score	0.81	46.75	8.65	0.90	71.4	-82.0
Udder fat	Live weight	0.77	51.23	0.94	0.88	6.9	-285.3

Table 4. Best equations for predicting subcutaneous, intermuscular, subcutaneous plus intermuscular, pelvic, kidney and KKCF fat depots using the three methods of body condition score and live weight

Dependent var. (y)	Independent var. (x)	R^2	RSD	s^2yx	S_b	Slope	Intercept
Ln subcutaneous fat	Sternal body condition score	0.93	0.36	0.08	0.96	1.2	3.7
Ln subcutaneous fat	Lumbar body condition score	0.92	0.38	0.09	0.96	1.2	3.8
Ln subcutaneous fat	Tail body condition score	0.86	0.51	0.22	0.93	2.3	5.0
Subcutaneous fat	Live weight	0.88	967.23	17.57	0.94	197.7	-9081.2
Ln intermuscular fat	Sternal body condition score	0.87	0.28	0.06	0.93	0.6	5.8
Ln intermuscular fat	Lumbar body condition score	0.87	0.28	0.06	0.93	0.7	5.85
Ln intermuscular fat	Tail body condition score	0.83	0.32	0.06	0.91	0.5	6.1
Intermuscular fat	Live weight	0.87	774.02	14.06	0.93	153.3	-6138.4
Ln sub.+interm. fat	Sternal body condition score	0.91	0.28	0.06	0.96	0.8	5.1
Ln sub.+interm. fat	Lumbar body condition score	0.91	0.29	0.07	0.95	0.8	5.1
Ln sub.+interm. fat	Tail body condition score	0.85	0.37	0.07	0.92	0.7	5.6
Sub.+interm. fat	Live weight	0.89	827.14	15.03	0.94	175.5	-7609.8
Ln pelvic fat	Ln sternal body condition score	0.85	0.38	0.22	0.92	2.1	3.2
Ln pelvic fat	Ln lumbar body condition score	0.87	0.35	0.19	0.93	2.1	3.3
Ln pelvic fat	Ln tail body condition score	0.80	0.43	0.19	0.90	1.6	3.8
Pelvic fat	Live weight	0.77	107.77	1.96	0.88	14.6	-584.7
Ln kidney fat	Sternal body condition score	0.94	0.30	0.06	0.97	1.0	3.6
Ln kidney fat	Lumbar body condition score	0.89	0.40	0.09	0.94	1.1	3.7
Ln kidney fat	Tail body condition score	0.81	0.53	0.10	0.90	0.8	4.3
Kidney fat	Live weight	0.86	499.12	9.07	0.93	94.8	-4150.3
Ln KKCF fat	Sternal body condition score	0.93	0.31	0.07	0.96	1.0	3.4
Ln KKCF fat	Lumbar body condition score	0.88	0.39	0.09	0.94	1.0	3.5
Ln KKCF fat	Tail body condition score	0.81	0.50	0.09	0.90	0.8	4.0
KKCF fat	Live weight	0.85	315.47	5.73	0.92	57.1	-2458.4

Table 5. Best equations for predicting tail, half carcass and total body fat depots and carcass composition using the three methods of body condition score and live weight

Dependent var. (y)	Independent var. (x)	R^2	RSD	s^2yx	S_b	Slope	Intercept
Ln tail fat	Sternal body condition score	0.85	0.47	0.10	0.92	1.0	0.5
Ln tail fat	Lumbar body condition score	0.83	0.50	0.11	0.91	1.0	0.6
Ln tail fat	Tail body condition score	0.84	0.49	0.09	0.92	0.8	1.0
Tail fat	Live weight	0.85	23.52	0.43	0.92	4.2	-187.4
Ln half carcass fat	Sternal body condition score	0.92	0.29	0.07	0.96	0.8	5.3
Ln half carcass fat	Lumbar body condition score	0.85	0.38	0.07	0.92	0.7	5.8
Ln half carcass fat	Tail body condition score	0.84	0.49	0.09	0.92	0.8	1.0
Half carcass fat	Live weight	0.89	1079.24	19.61	0.95	232.6	-10068.2
Ln total body fat	Sternal body condition score	0.94	0.23	0.05	0.97	0.8	6.6
Ln total body fat	Lumbar body condition score	0.91	0.29	0.07	0.95	0.8	6.7
Ln total body fat	Tail body condition score	0.84	0.39	0.07	0.92	0.7	7.1
Total body fat	Live weight	0.90	3173.38	57.66	0.95	712.8	-29925.1
Muscle	Sternal body condition score	0.83	909.92	194.35	0.91	1786.8	2861.4
Ln muscle	Ln lumbar body condition score	0.87	0.10	0.06	0.93	0.6	8.4
Muscle	Tail body condition score	0.83	929.36	171.88	0.91	1540.5	3710.0
Muscle	Live weight	0.79	1031.66	18.74	0.89	147.6	-504.8
Bone plus remainder	Sternal body condition score	0.01	224.00	47.84	0.11	22.8	1926.8
Bone plus remainder	Lumbar body condition score	0.02	222.76	50.47	0.15	32.7	1904.4
Bone plus remainder	Tail body condition score	0.03	221.68	41.00	0.18	31.5	1904.8
Bone plus remainder	Live weight	0.19	202.90	3.69	0.44	7.4	1568.1

The partitions of fat at different BCS are summarized in Fig. 1. This shows that the higher proportions of total fat in SBCS from 1.5 to 2.0 are the intermuscular and mesenteric fats, while in SBCS higher than 3.0, the subcutaneous, intermuscular, omental and kidney fats are the main fat depots represented in total body fat. The pelvic fat starts to be important at scores higher than 3.5.

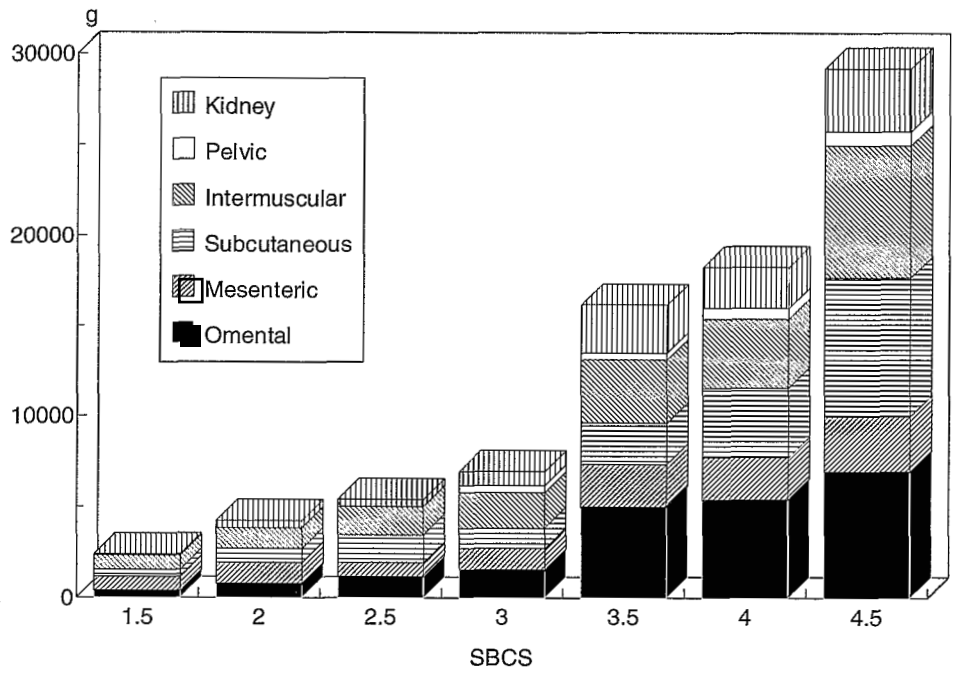

Fig. 1. Fat partition (g) at different Sternal Body Condition Scores (SBCS).

Table 6 shows the changes in weight of fat depots per unit change in SBCS, calculated according to Teixeira *et al.* (1989). These changes suggest that omental and intermuscular fat would be the first depots to be mobilized during reduction of SBCS from 2.5 to 1.5 while increases in SBCS from 2.5 to 3.5 or from 3.5 to 4.5 would result in the greatest rate of deposition occurring in the subcutaneous and omental fat depots which have been demonstrated by Teixeira *et al.* (1989) for Rasa Aragonesa adult ewes.

Table 6. Change in weight of fat depots per unit change in Sternal Body Condition Score, calculated according to Teixeira *et al.* (1989)

Fat depots	Changes in body condition		
	1.5 - 2.5 n†= 7	2.5 - 3.5 n= 6	3.5 - 4.5 n= 6
Omental fat (g)	995	1962	3183
Mesenteric fat (g)	440	733	1221
Subcutaneous fat (g)	510	1610	5086
Intermuscular fat (g)	784	1472	2764
Pelvic fat (g)	118	182	247
Kidney fat (g)	322	910	2576
Kidney and pelvic fat (KKCF) (g)	438	1154	3046
Half carcass fat (kg)	0.9	2.1	4.9
Total body fat (kg)	3.1	7.1	15.9

†n: number of animals

It is evident that in SBCS 1.5 to 2.0 the intermuscular and mesenteric fats have a higher proportion of total body fat (Fig. 1). This suggests that the intermuscular and mesenteric fat in the Blanca Celtibérica breed, when the SBCS ranges between 1.5 to 2.0, could be assessed individually by palpation.

Fat partition in percentage at different SBCS are presented in Fig. 2 and the relative growth coefficients for all body fat depots reported by Delfa *et al.* (1994) for Blanca Celtibérica adult goats (Table 7) indicate that as the total body fat increased the proportion of subcutaneous, kidney and omental fat increased and the proportion of intermuscular and mesenteric fat decreased. The pelvic fat is isometric. There were no significant differences between subcutaneous, kidney and omental fat deposition and mesenteric fat are earlier developing than intermuscular fat. These evidences are shown on Fig. 2.

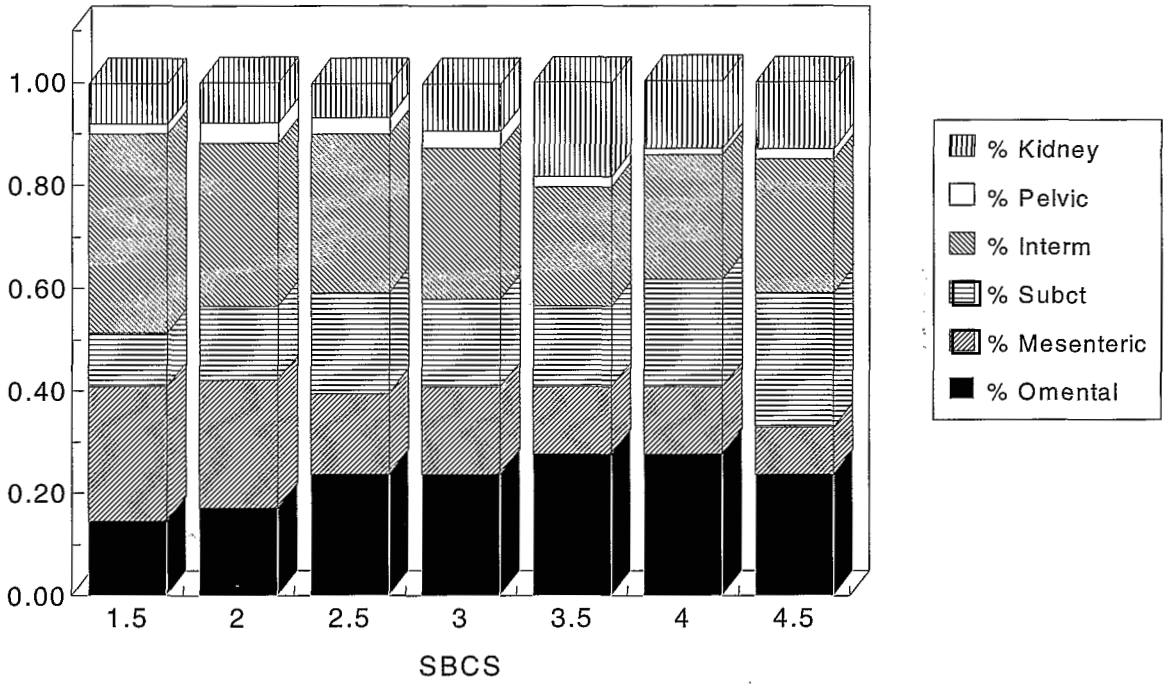

Fig. 2. Fat partition in percentage at different Sternal Bone Body Condition Scores (SBCS).

Table 7. Relative growth coefficients (b) for all body fat depots (Delfa *et al.*, 1994)

Dependent var. (y)	Independent var. (x)	R^2	RSD	s^2yx	S_b	b	Intercept
Ln omental fat	Ln total body fat	0.98	0.16	0.04	0.99	ac1.25**	-3.82
Ln *mesenteric fat*	Ln total body fat	0.91	0.19	0.05	0.95	b0.64**	1.43
Ln heart fat	Ln total body fat	0.78	0.30	0.08	0.88	b0.59**	-0.35
Ln udder fat	Ln total body fat	0.84	0.46	0.12	0.92	a1.09NS	-5.49
Ln subcutaneous fat	Ln total body fat	0.95	0.30	0.08	0.98	c1.40**	-5.46
Ln intermuscular fat	Ln total body fat	0.96	0.96	0.04	0.98	d0.79**	0.56
Ln pelvic fat	Ln total body fat	0.88	0.87	0.09	0.94	d0.97NS	-3.45
Ln kidney fat	Ln total body fat	0.97	0.21	0.05	0.99	ac1.27**	-4.75
Ln KKCF fat	Ln total body fat	0.97	0.19	0.05	0.99	a1.19**	-4.40
Ln tail fat	Ln total body fat	0.87	0.44	0.11	0.93	ac1.19NS	-7.32

NS: non significant; ** $b \neq 1$ for $P \leq 0.01$; $a \neq b \neq c \neq d$ for $P \leq 0.01$

Conclusions

From the results obtained and under the experimental conditions of the present work we could conclude:

BCS assessed on lumbar and sternal regions were better predictors than LW of the body fat depots and carcass composition. The BCS assessed on sternal region was a better predictor than the other body condition score methods for all fat depots and carcass composition except for the heart and pelvic fat.

Acknowledgements

This work has been supported by "Instituto Nacional de Investigacion y Tecnología Agraria y Alimentaria (INIA)". Project of research No. 9127.

References

Colomer-Rocher, F., Morand-Fehr, P. and Kirton, A.H. (1987). Standard methods and procedures for goat carcass evaluation, jointing and tissue separation. *Livest. Prod. Sci.,* 17: 149-159

Colomer-Rocher, F., Morand-Fehr, P., Kirton, A.H., Delfa, R. and Sierra-Alfranca, I. (1988). Standardized methods for the study of the quantitative and qualitative characters of sheep and goat carcasses. Ministerio de Agricultura, Pesca y Alimentación. *Cuadernos INIA,* No. 17, p. 41 (in Spanish).

Delfa, R., Teixeira, A. and Colomer-Rocher, F. (1989). The use of a lumbar joint as a predictor of body fat depots in adult ewes of Aragonesa breed with different body condition scores. *Anim. Prod.,* 49: 327-329.

Delfa, R., Teixeira, A. and González, C. (1994). Growth and development of body fat depots of Blanca Celtibérica goats. *Portuguese Review of Animal Production,* 1: 131-155. (in Spanish).

Hervieu, J., Colomer-Rocher, F., Branca, A., Delfa, R. and Morand-Fehr, P. (1990). *Définition des notes d'état corporel des caprins.* Réseaux Agrimed et FAO des recherches coopératives sur les productions ovines et caprines, p. 5.

Hervieu, J., Delfa, R., Lloret, M. and Morand-Fehr, P. (1992). Relations between body condition scores and tissue composition of dairy goats. *43rd Annual Meeting of the EAAP,* Vol. 2: 386-387.

Jefferies, B.C. (1961). Body condition scoring and its use in management. *Tasm. J. Agr.,* 32: 19-21.

Milligan, K.E. and Broadbent, J.S. (1974). Condition scoring of sheep. *Proceedings of the New Zealand Society of Animal Production,* 34: 114 (Abstr.).

Morand-Fehr, P., Branca, A., Santucci, P. and Napoleone, M. (1987). Méthodes d'estimation de l'état corporel des chèvres reproductrices. *Symposium "Philoetios" sur L'evaluation des Ovins et des Caprins Méditerranéens,* Réunion CEE-AGRIMED, Santarém, Portugal, Rapport EUR 11893.

Morand-Fehr, P., Hervieu, J. and Santucci, P. (1989). Notation de l'état corporel: A vos stylos! *La Chèvre,* 175 : 39-42.

Murray, J.A. (1919). Meat production. *J. Agr. Sci.,* Cambridge, 9: 174-181.

Paramio, M.T. and Folch, J. (1985). Puntuación de la condición corporal en la oveja Rasa Aragonesa y su relación con las reservas energéticas y los parámetros reproductivos. *ITEA,* 58: 29-44.

Russel, A.J.F., Doney, J.M. and Gunn, R.G. (1969). Subjective assessment of body fat in live sheep. *J. Agr. Sci.,* Cambridge, 72: 451-454.

Sanson, D.W., West, T.R., Tatman, W.R., Riley, M.L., Judkins, M.B. and Moss, G.E. (1993). Relationship of body composition of mature ewes with condition score and body weight. *J. Anim. Sci.,* 71: 1112-1116.

Santucci, P. (1984). Essai de mise au point d'une méthode d'estimation de l'état d'engraissement des chévres corses. *Séminaire FAO sur la Nutrition et l'Alimentation des caprins.* Grangeneuve, Switzerland.

Santucci, P. and Maestrini, O. (1985). Body composition of dairy goats in extensive systems of production: method of estimation. *Ann. Zoothech.,* 34: 473-474 (Abst.).

Steel, R.G.D. and Torrie, J.H. (1981). *Principles and Procedures of Statistics. A Biometrical Approach.* McGraw-Hill Interntional Book Company, (3rd edition), p. 633.

Teixeira, A., Delfa, R. and Colomer-Rocher, F. (1989). Relationships between fat depots and body condition score or tail fatness in Rasa Aragonesa breed. *Anim. Prod.,* 49: 275-280.