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ALLOMETRY GROWTH COEFFICIENTS OF CARCASS AND NON-CARCASS COMPONENTS IN SMALL RUMINANTS: A REVIEW

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ABSTRACT

In this review article attempt is made to present a comprehensive on growth and development of small ruminants (sheep and goat) using allometric growth coefficient of carcass composition (lean, fat and bone) and non-carcass components (edible and non-edible organs organs). It seems that allometry coefficient (b) for bone is precocious (b<1) and demonstrating a declining proportion of the component with increasing carcass and empty body weight. Similarly, it appears that lean part has growth coefficient (b<1) indicating lower impetus than the whole animal and they decline as a proportion of live body weight as the animal proceeds to maturity. With regard to different depots of fat, in the body, it seems that subcutaneous fat grow at a higher rate that intramuscular fat, and non-carcass fat depots is an early mature. Also, most of vital organs (heart, kidney, liver and spleen) had growth coefficient less than are indicating they are early maturing.

INTRODUCTION

Small ruminants have been an important meat-producing animals worldwide, and it is known that growth and development are the basis for meat production whereas distribution of carcass tissue is significant in determining carcass quality. Lean muscle and to a lesser degree fat are the major edible tissue of the carcass (Mahgoub and lodge, 1994).

Growth could be defined as an increase in size and is usually expressed relative to a given period of time (Butterfield, 1988). However, the growth processes are complex because animals grow at different relative rates, different adult sizes are common, and body parts are grow at different relative rates. Rate of body growth often has an impact on the composition of the body. Composition of the weight gain is important in domestic livestock that are used as a source of high-quality protein food and factors such as nutrition, genetics, environment and health status may affect the rate of total body growth as well as composition of weight gain (Gerrard and Grant, 2006).

The knowledge of small ruminant carcass composition, the quantitative accretion of each carcass component and changes of growth pattern at various stages of growth is important both in nutrition studies and production system analysis that attempt to optimize profit. Therefore, proper understanding of the quality and distribution of dissectible body components such as bone, fat and lean throughout the carcass is also required not only to assess the animal as a meat producer, but also to market the meat efficiently (Negussie et al., 2004). Furthermore, allometry studies allow to better understand the growth rate and development of carcass regions, serving as a reference for more accurate slaughter time for each breed (Hashimoto et al., 2012). Therefore, this article is an attempt to review the available information on the growth coefficient of carcass and non-carcass components in sheep and goats .

Carcass composition

Meat animal carcasses vary in composition through genetic, age and sex of animal, nutritional and environmental effects (Irshad et al., 2013). Thus, a higher proportion of muscle with a low proportion of bone and an optimum level of fat represent a superior carcass (Oprzadek et al., 2001) .

Growth coefficients of lean of different breeds of sheep and goat are illustrated in Table (1) It seems from the table that lean has growth coefficient ($b<1$) and maturity coefficient (q) of 1.3 (Butterfield, 1988) indicating lower imputes than the whole animal and they decline as proportions of liveweight as the animal proceeds to maturity. Overall results of the growth coefficients show that bone is an early maturing tissue followed by lean and fat. Furthermore, the growth of each individual muscle of sheep and goat may be expected to be related to its activity. The activities of most skeletal muscles are mainly concerned with locomotion, mastication, urination, defecation and specially reproduction make differential demands within the anatomical spectrum of the musculation (Butterfield, 1988). Furthermore, at birth it is necessary that the animal can stand, walk and suckle. As the animals grows, the activities become much more athletic so that is capable of quite vigorous frisking and of travel over long distance. From about weaning, functions change little for the rest of life. The muscle of the abdominal wall of ewes assumes greater load during pregnancy. In rams, the achievement of adulthood embraces the biological need to contest with other rams that right to mate with the available females. This contest takes the forms of fighting which demands, in addition the total mass, especially robust muscles of the neck. (Butterfield, 1988) .

It seems from the Table (1) that allometry (b) coefficient for bone indicates that the growth of the bone was precocious ($b<1$) as the tissue growth (impetus) was greater than the total weight of the cold carcass, and demonstrating a declining proportion of the component with the increasing carcass and empty bodyweight. Moreover, Butterfield (1988) demonstrated that the total "q" for the bones for each limb and for the axial skeleton indicates that the hind limb grows relatively more slowly followed by the forelimb and the axial skeleton.

All studies refer to that fat had growth coefficient ($b>1$) in both sheep and goat Table (1) as well as fat with maturity coefficient (q) of 0.07 in Merino rams (Butterfield, 1988) indicating a high growth impetus and late maturing tissue and grow relatively faster than the growth of the carcass, and therefore constitutes an increasing proportion of live weight as the animal mature. The analysis verified that the intramuscular fat was late developing tissue than the subcutaneous fat, which have earlier developed than intramuscular fat (Al-Owaimer et al., 2013; Teixeira et al., 1995).

Table (1) Allometric growth coefficients (b) of lean, fat and bone in different breeds of sheep and goats.

Breed		No.	Coefficient (b) value			reference
			Lean kg	Fat kg	Bone kg	
Omani sheep		45	0.920 ns	1.448*	0.731*	Mahgoub and Lodge (1994)
Serrana kids		16	0.980 ns	Sub. 1.39* Int. 1.53**	0.690**	Teixeira *et al.,* (1995)
Arabi lamb		116	0.964*	1.634*	0.757*	Al-Saigh and Al-Jassim (1998)
Crriollo Cordobes kid goats		60	1.08	1.30	0.96	Bonvillani *et al.,* (2010)
Alpine		78	0.933ns	2.121*	0.745*	Lourencon *et al.,* (2016)
1/2Boer×1/2Alpine			0.911ns	1.891*	0.700*	
1/2Anglo×1/2Alpine			0.955ns	2.154*	0.736*	
3/4Boer×1/4Alpine			1.014ns	1.617*	0.521*	
1/2Anglo×1/4Boer×1/4Aloine			0.965ns	1.446*	0.751*	
Texel lambs		30	0.899	1.648	0.556	Carvalho *et al.,* (2005)
Santa Ines and crossbreed with Dorper		64	1.001	1.414	0.590	Sousa et al. (2019)
			0.941	2.055	0.195	
			0.942	2.022	0.446	
			0.991	2.152	0.167	
Menz lambs	(Relative to hot carcass)	147	0.87*	1.26*	0.78*	Negussie *et al.,* (2004)
	(Relative to empty body weight)		1.10*	1.45*	0.97*	
Horro lambs	(Relative to hot carcass)		0.92*	1.72*	0.78*	
	(Relative to empty body weight)		1.08*	1.79*	0.96*	
Churra Tensina lambs	(Relative to empty body weight)	49	0.96*	Sub.1.40* Int. 1.24**	0.81*	Alvarez-Rodriguez *et al.,* (2009)
	(Relative to half carcass) weight		0.94**	Sub. 1.42** Int. 1.22**	0.79	
Saanen goats		40	1.002	1.76	0.74	Yanez *et al.,* (2009)
Ardhi kids	As a weight (gm)	30	1.11 ns	Sub. 1.26** Int. 1.47**	0.69**	Al-Owaimer *et al.,* (2013)
	As a percentage (%)		0.139**	Sub. -0.01ns Int. 0.40**	-0.37**	
Karadi lambs	Relative to hot carcass	12	0.729**	2.203**	0.747**	Al-Sherwany and Alkass, (2024)
Awassi lambs	As relative to carcass side	25	0.853**	1.859**	0.793**	Yateem *et al.,* (2022)

NS (b=1), * (p≤0.05), ** (p≤0.01).

Fat Partitioning

The growth of fat in domestic animals is an extremely important part of the total growth process from several points of view (Berg and Butterfield 1976). The major biological role of fat is to serve as an energy store providing a survival during food scarcity such as in draught and winter season .

Fat is the most variable tissue in the carcass and it varies not only in total amount but its partitioning among the various depots alters markedly throughout growth. The pattern of this growth and distribution within the animal body has a vital physiological significance and it is an area demanding extensive investigation. This is mainly because a great deal of the relative carcass value of different types of animals depends on the manner in which they partition fat among body depots and particularly the survival of an animal during the dry season and or at times of energy deficiency depends on the extent to which they deposit their body fat reserves in readily utilizable depots. The sequence of growth and partition of fat among body depots, therefore, reflects the relative importance of each in serving the animal needs and also the market value of the carcass (Negussie et al., 2000).

Several studies have been conducted to determine the growth coefficients of various fat depots in different body parts Table (2). It seems from the table that growth coefficients of three major classes of fat depots carcass fat, non- carcass fat and fat tail are differed between breeds. In sheep, the relative growth coefficient of carcass fat was significantly ($b>1$), indicating high impetus and late developing depots. Subcutaneous fat grew at a rate higher than intermuscular fat in both lambs and kids (Mahgoub and Lodege, 1994, Negussie et al., 2000, Mtenga et al., 2005 and McGregor, 1992) .

Relative to empty body weight, non- carcass fat had growth coefficient ($b>1$), indicating that their fat depots is an early developing one though kidney fat that has positive heterogenic growth relative to empty body weight. Omental and mesenteric fat are differed in their growth coefficients, some researchers found that growth coefficient of omental and mesenteric were greater than one (McGregor, 1992, Mahgoub and Lodege, 1994, Teixeira et al., 1995, Bonvillani et al., 2010 and Al-Owaimer et al., 2013), whereas, Garcia et al., (2014) in four breeds of sheep found that omental fat has an isogenic growth showed allometric growth equal to one. In contrast, mesenteric fat had a coefficient value greater than one ($P<0.05$) except in the Santa×Ile de France which is grows at a rate similar to the empty body weight in these lambs. Regarding the growth of fat depots relative to empty body weight, results showed that fat tail appears to be late maturing with a growth coefficient greater than one (Mahgoub and Lodege, 1994 and Negussie et al., 2000). Such differences in partitioning of fat between carcass and non- carcass of sheep was suggested to be influenced more by breed itself rather than mature size. Some of them are early maturing. For this reason, it is recommended that they be slaughtered at lighter weight to avoid higher fat depots (Mahgoub and Lodege, 1994).

Overall, the largest growth coefficients of non- carcass fat were for kidney fat followed omental, mesenteric and cardiac fat depots. Kidney fat was the latest developing internal fat depots, while omental, mesenteric, and cardiac fat were the earlier developing internal fat depots.

Table (2) Allometric growth coefficients (b) of various fat depots in different body parts.

Breed		No.	Coefficient (b) value								Ref.
			Subcutaneous fat	Intermuscular Fat	Kidney fat	Mesenteric fat	Omental fat	Tail fat	CF	NCF	
Angora Goats		170	1.078*	-	1.068*	0.923*	1.074*		1.034*		McGregor (1992)
Omani Sheep		45	1.614**	1.254*	1.972**	1.861**	2.016**	1.598*	1.448*	1.841*	Mahgoub and Lodge (1994)
Serrana Kids		16	1.50*	1.66**	2.81**	2.05**	2.94**	-	-	-	Teixeira *et al*., (1995)
Menz lambs	Relation to empty body weight	146	1.02	-	-	-	-	1.7	1.10	1.07	Negussie *et al*., (2000)
	Relation to total body fat		0.99	-	-	-	-	1.27	0.99	0.85	
Horro lambs	Relation to empty body weight		1.60	-	-	-	-	2.10	1.57	1.35	
	Relation to total body fat		1.13	-	-	-	-	1.21	1.10	0.79	
Saanen Goats		34	1.887**	1.619**	1.455**	-	-	-	-	-	Mtenga *et al*., (2005)
Awassi		25			1.020**	-0.309**	0.240**	1.036**	1.920**	0.089*	Yateem et al., 2022
Churra Tensina lambs	Relative to empty body weight	49	1.40*	1.24**	1.43**	1.73**	2.15**	1.07ns	-	-	Alvarez-Rodriguez *et al*., (2009)
	Relative to half carcass weight		1.42**	1.22**	1.42**	-	-	-	-	-	
	Relative to total carcass fat		1.15**	0.86**	1.15**	-	-	-	-	-	
	Relative to total body fat		1.08	0.83**	1.08	1.07**	1.42	0.71**	-	-	
Saanen Goats		40	2.15	1.34	-	-	-	-	-	-	Yanez *et al*., (2009)
Crriollo Cordobes male Kids		30	-	-	-	1.01ns	2.40*	-	-	-	Bonvillani *et al*., (2010)
Ardhi kids	As a weight (gm)	30	1.26**	1.47**	1.83**	1.43**	1.84**	-	-	-	Al-Owaimer *et al*., (2013)
	As a percentage (%)		-0.01ns	0.40**	0.111ns	-0.20ns	0.42**	-	-	-	
Santa Ines		103	-	-	2.051*	2.051*	0.379ns	1.269ns	-	-	Garcia *et al*., (2014)
Santa Ines × Texel			-	-	2.311**	1.608**	0.389ns	1.237ns	-	-	
Santa Ines × IIe de France			-	-	2.269**	1.256ns	1.044ns	1.195ns	-	-	
Santa Ines × Bergamasca			-	-	2.746**	1.644**	0.612ns	1.164ns	-	-	
Karadi lamb		12	1.59**	0.924**	-0.019ns	0.087ns	0.395ns		1.415**	0.135ns	Al-Sherwany and Alkass (2024)

ns (b=1), * (p≤0.05), ** (p≤0.01)

Non- Carcass Components

The rearing of sheep and goat for meat production is growing in many countries but slaughtering these animals produces, in addition to the carcass, considerable quantities of other body components. These components are also usable and are known as the non-carcass components or "the fifth quarter" (Rosa et al., 2002). Non-carcass body components are important parts that should be studied more carefully especially because they influence the yield of the edible parts of the animals that are economically valuable and because some components are directly related to basal metabolism. According to Carvalho et al., (2005), the relative weight of non-carcass components ranges from 40 to 60% of live weight. This proportion is influenced by genetics, age, slaughter weight, sex, type of birth and diet (Souza-Junior et al., 2009).

With exception of Angora goat, studies revealed that the growth coefficient of head, feet, lung and liver in sheep and goat ($b<1$), indicating low impetus and early maturing relative to body weight as a whole and were greater at birth and then decreased at maturity (Garcia et al., 2014, Kirton et al., 1972, Al-Jassim and Al-Saigh, 1999, Mahgoub and Lodge, 1994, and Al- Owaimer et al., 2013) Table (3).
The growth coefficients of skin showed is equal to ($b=1$), therefore the skin grew isogonically, indicating growth at the same rate as the body weight (Garcia et al., 2014, Mahgoub and Lodge, 1994 and McGregor, 1992) .
Working with Arabi sheep, Al-Saigh and Al- Jassim, (1998) reported that coefficients of testes, spleen and empty alimentary canal, were 1.410, 1.131 and 1.038, respectively. They are high impetus and observed that these components of lambs grow higher than body weight and considered late maturing organs. However, heart is a component that has different results some breeds of sheep have an isometric growth with growth coefficient equal to one and grew at same rate than body weight (Garcia et al., 2014). Others found that growth coefficient was significantly less than one, indicating low impetus and early maturing organ (Kirton et al., 1972 and Al-Saigh and Al- Jassim, 1998) .

It was indicated in many studies that kidney is an organ that has different growth coefficient between species and breeds. Garcia et al., (2014) indicated in two breeds of sheep, low impetus and early maturing with relative growth coefficient less than one, while in two other breeds it was found isometric growth, it means that the growth rate of this organ was similar to the rate of empty body. However, Kirton et al., (1972), found that relative growth coefficient greater than one, indicating high impetus and late maturing organ. In contrast Arabi lambs by Al- Jassim and Al- Saigh, (1999), who found ($b<1$), indicating low impetus.

CONCLUSIONS

According to the results presented in the text, it can be concluded that bone and muscle shows an early growth whereas fat has a late growth within fat depots, it appears that subcutaneous fat grow at a higher rate than intramuscular fat.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

Table (3) Allometric growth coefficients (b) of non-carcass components.

Breed	No. of Animal	Coefficient (b) value										
		head	Skin	Feet	Lung	Liver	Testes	Spleen	Heart	Kidney	Empty DS	Reference
Santa Ines	103	0.761	1.140 ns	0.778**	0.490*	0.738*	-	-	0.989ns	0.706ns	-	Garcia *et al.*, (2014)
Santa Ines ×Taxel		0.662**	0.980 ns	0.628**	0.478*	0.898*	-	-	1.092 ns	0.618*	-	
Santa Ines ×Ile de France		0.606**	1.176 ns	0.671**	0.678*	0.753*	-	-	0.809 ns	0.565*	-	
Santa Ines ×Bergamasca		0.768**	1.172 ns	0.766**	0.813*	0.769*	-	-	1.057 ns	1.047 ns	-	
Ardhi goats	30	-	-	-	-	0.911*	-	-			-	Al-Owaimer *et al.*, (2013)
Arabi sheep	116	0.585*	0.916*	0.581*	0.666*	0.740*	1.410*	1.131*	0.798*	0.681*	1.038*	Al- Jassim and Al-Saigh, (1999)
Omani sheep	45	0.636*	0.983 ns	0.606*	-	0.612*	-	-	-	-	-	Mahgoub and Lodge, (1994)
Angora goats	170	0.999 ns	1.036 ns	0.983*	0.975*	0.979*	-	-	-	-	-	McGregor *et al.*, (1992)
Southdown	212	0.752*	-	-	0.741*	0.864*	-	-	0.769*	1.354*	-	Kirton *et al.*, (1972)
Romney		0.831*	-	-	0.863*	0.842*	-	-	0.872*	1.206*	-	
Southdown× Romney		0.776*	-	-	0.707*	0.787*	-	-	0.767*	1.276*	-	
Karadi	12	-o.276**	0.153ns	-0.593**	-0.386ns	-0.116ns	2.03**	-0.648*	0.163ns	-0.771**	-0.219*	Al-Sherwany and Alkass (2024)
Awassi	25	-0.240**	0.064ns	-0.598**	-0.368*	-.0.369**	-0.257ns	-0.240ns	-0.219**	-0.155ns	-0.547**	Yateem *et al.*, (2022)

معادلات النمو لمكونات الذبيحة وغير الذبيحة في المجترات الصغيرة: مراجعة

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الخلاصة

سيتم في هذه الدراسة محاولة لاستعراض شامل للمراجع العلمية المنشورة معتمدا على المعلومات والبيانات المتوفرة في المجلات العلمية حول النمو والتطور في المجترات الصغيرة (الأغنام والماعز) وذلك باستخدام معامل النمو لتركيب الذبيحة (اللحم والدهن والعظم) ولمكونات غير الذبيحة (الاجزاء القابلة للآكل والاجزاء غير القابلة للآكل) يتضح بان معامل النمو للعظام هو اقل من الواحد الصحيح ويشير ذلك بان العظام هي مبكرة النضج وان نسبتها تنخفض بزيادة وزن الذبيحة ووزن الجسم الفارغ. كما يتبين أيضا بان اللحم ذات معامل نمو اقل من الواحد الصحيح ونموه اوطآ لدى مقارنته بالجسم الكلي ويعد بذلك مبكر النضج وتتناقص نسبته من وزن الجسم كلما اقترب الحيوان من النضج. واما بخصوص الدهون فيتضح بان دهن تحت الجلد ينمو بمعدل أسرع من دهن بين العضلات كما وان دهون غير الذبيحة (الاحشاء الداخلية) مبكرة النضج وكذلك دهون حول الأعضاء الحيوية (الكبد، القلب والكليتين) تعد مبكرة النضج. يمكن الأستنتاج بان كل من العظام واللحوم هي مبكرة النضج في حين تعد الدهون متأخرة النضج.

الكلمات المفتاحية: معادلات النمو، الذبيحة، مكونات الذبيحة، المجترات الصغيرة.

REFERENCES

Al-Jassim, A. F., & Al-Saigh, M. N. R. (1999). Some aspects of post- natal growth of Arabi sheep: Live weight and body organs. *Indian Journal of Animal Science*. 69(8): 604- 608. https://2u.pw/digy0G

Al-Owaimer, A., Suliman, G., El-Waziry, A., Metwally, H. & Abouheif, M. (2013). Allometric growth patterns of body and carcass components in Ardhi goat. *International Journal of Animal and Veterinarian Advance*. 5(5):183-189. https://www.maxwellsci.com/msproof.php?doi=ijava.5.5595

Al-Saigh, M. N. R., & Al- Jassim, A. F. (1998). Some aspects of post- natal growth of Arabi sheep: Carcass muscle, bone, fat and Wholesale joints. *Indian Journal of Animal Science*. 68(9): 965- 968. https://www.researchgate.net/publication/321874380

Al-Sherwany, D. A. O., & Alkass, J. E. (2014). Allometric growth patterns of body and carcass component in docked and intact Karadi lambs. *Iraqi Journal of Agricultural Sciences*. 55(3). (In Press).

Alvarez-Rodrıguez, J., Sanz, A., Joy, M., Carrasco, S., Ripoll, G., & Teixeira, A. (2009). Development of organs and tissues in lambs raised on Spanish mountain grassland. *Canadian Journal of Animal Science*. Vol. 89(1): 37-45. https://doi.org/10.4141/CJAS08064

Berg, R. T., & Butterfield, R. M. (1976). "New concepts of cattle growth," Sydney University Press, Sydney. https://hdl.handle.net/1813/1008

Bonvillani, A., Pena, F., de Gea, G., Petryna, A. & Perea, J. (2010). Carcass characteristics of Criollo Cordobes kid goats under un extensive management system: Effect of gender and live weight at slaughter. *Journal of Meat science*. 86(3):651-659. https://doi.org/10.1016/j.meatsci.2010.05.018

Butterfield, R. M. (1988). New concepts of Sheep Growth. University of Sydney. Griffin Press Limited, South Australia. https://hdl.handle.net/1813/2095

Carvalho, S., Vergueiro, A., Kieling, R., Teixeira, R. C., Pivato, J., & Viero, A. N. (2005). Evaluation of concentrated supplementation in Tifton-85 pasture on the components other than carcass of lambs. *Ciencia Rural, Santa Maria* 35(2): 435- 439. https://doi.org/10.1590/S0103-84782005000200030

Garcia, I. F. F., Alvarenga, T. I. R. C., Perez, J. R. O., de Almida, A. K., Gallo, S. B., Pereira, I. G., Alves, N. G. & Alvarenga, F. A. p. (2014). Allometric coefficient of non- carcass components in crossed lambs. *Ciencia rural, Santa Maria* 44(7): 1229-1235. https://doi.org/10.1590/0103-8478cr20130489

Gerrard, D. E., & Grant, A. I. (2006). Principle of animal growth and development. Kendall/ Hunt publishing Co. USA. https://he.kendallhunt.com/product/principles-animal-growth-and-development

Hashimoto, J. H., Osorio, J. C. da S., Osorio, M. T. M., Bonacina, M. S., Lehmen, R. I., & Pedroso, C. E. da S. (2012). Carcass quality, parts and tissue development of lambs finished in three systems. *Revista Brasileira de Zootecnia*, 41(2):438-448. https://doi.org/10.1590/S1516-35982012000200029

Irshad, A., Kandeepan, G., Kumar, S., Ashish K. A., Vishuraj, M. R., & Shukla, V. (2013). Factors influencing carcass composition of livestock: a Reivew. *Journal of Animal Production Advance* 3(5):177-186. https://www.researchgate.net/publication/273716160

Kirton, A. H., Fourie, P. D., & jury, K. E. (1972). Growth and development of sheep III. Growth of the carcass and non- carcass components of the Southdown and Romney and their cross and some relationships with composition. *Journal of agricultural Research* 15(2): 214- 227. https://doi.org/10.1080/00288233.1972.10421249

Lourencon, R. V., Goncalves, H. C., de Lima Meirelles, P. R., Junior, R. B., Leite-Browning, M. L., Chavari, A. C. T., Marques, R. O., Canizares, G. I. L., Leal, N. S., & Gomes, H. F. B. (2016). Relative growth of carcass tissue of goat kids from five breed types finished on pasture or feedlot. *Semina: Ciências Agrárias, Londrina*. 37(2):989-996. https://doi.org/10.5433/1679-0359.2016v37n2p989

Mahgoub, O., & Lodge, G. A. (1994). Growth and body composition of Omani local sheep 1. Live weight growth and carcass and non- carcass characteristics. *Journal of Animal Science*, 58(3): 365-372. https://doi.org/10.1017/S0003356100007303

McGregor, B. A. (1992). Body composition, body condition scores and carcass and organ components of grazing Angora goats. *Australian society of animal Production 19*: 273- 276. https://www.researchgate.net/publication/293109326

Mtenga, L. A., Owen, E., Muhikambele, V. R. M., & Kifaro, G. C. (2005). Development changes of fat depots in male Saanen Goats. *Tanzania Journal of Agricultural Science* 6(2): 99- 103. https://www.ajol.info/index.php/tjags/article/view/115213

Negussie, E., Rottmann, O. J., Pirchner, F. & Rege, E. O. (2000). c. American institute for goat research, conference, Langston University, P. 151-163. https://www.researchgate.net/publication/268055520_Allometric_growth_coefficients_and_partitioning_of_fat_depots_in_indigenous_Ethiopian_Menz_and_Horro_sheep_breeds

Negussie, E., Rottmann, O. J., Pirchner, F., & Rege, E. O. (2004). Growth and carcass composition of tropical fat- tailed Menz and Horro sheep breed. *Journal of Animal Science*, 78(2):245- 252. https://www.researchgate.net/publication/268055520

Oprządek, J., Dymnicki, E., Oprządek, A., Słoniewski, K., Sakowski, T. & Reklewski, Z., (2001). A note on the effect of breed on beef cattle carcass traits. *Animal Science Paper and Report*. 19, 79–89. https://www.infona.pl/resource/bwmeta1.element.agro-article-1c99afb5-fd67-400d-993a-58a472f1f840

Rosa, G. T., Pires, C. C., Silva, J. H. S., & Motta, O. S. (2002). Proportions and coefficients of growth components, non- carcass of the live weight of male and female lambs under different feeding methods. *Revista Brasileira de Zootecnia*. 31(6): 2290- 2298. https://doi.org/10.1590/S1516-35982002000900018

Sousa, M. A. P., Lima, A. C. S., Araujo, J. C., Guimaraes, C. M. C., Joele, M. R. S. P., Borges, I., Daher, L. C. C., & Silva, A. G. M. (2019). Tissue composition and allometric growth of carcass of lambs Santa Inês and crossbreed with breed Dorper. *Tropical Animal Health and Production*.51(7):1903-1908. https://www.proquest.com/docview/2211208999

Souza-Junior, Oliveria, A. A., Santos, dos, C. L., Carneiro, Souza, P. L., Malhado, Mendes, C. H., Suzart, Caruso, J. C., Riberio-Junior & Milton, R. J. (2009). Allometric study of lamb carcass cuts from crosses between Dorper and the local breeds Rabo Largo and Santa Inês Estudo alométrico dos cortes da carcaça de cordeiros cruzados. *Revista Brasileira de Saude e Producao Animal* 10 (2), 423-433. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=5paCU-kAAAAJ&cstart=200&pagesize=100&citation_for_view=5paCU-kAAAAJ:jE2MZjpN3IcC

Teixeira, A., Azevedo, J., Delfa, R., Morand-Fehi, P. & Costa, C. (1995). Growth and development of Serrana kids from Montesinho Natural Park (NE of Portugal). *Journal of Small Ruminant Research 16*(3):263-269. https://doi.org/10.1016/0921-4488(95)00625-U

Yanez, E.A., Resende, K. T., Ferreira, A.C., Filho, J. M., Medeiros, A. N., & Teixeira, A. (2009). Relative development of tissues, commercial meat cuts and live weight components in Saanen goats. *Animal Production Revista Brasileira de Zootecnia*. (2) 38: 366-373. https://doi.org/10.1590/S1516-35982009000200021

Yateem, Ch. A. M., Alkass, J. E., & Mustafa, K. N. S. (2022). Allometric Growth Coefficients of Carcass Components and Carcass Waste in Awassi Lambs. *Basrah Journal of Agricultural Sciences*. 35(2):271-280. https://www.bjas.bajas.edu.iq/index.php/bjas/article/view/759