ALLOMETRIC GROWTH PATTERNS OF BODY AND CARCASS COMPONENT IN DOCKED AND INTACT KARADI LAMBS

D. A. O. Al-Sherwany* J. E. Alkass
Assit. Prof Prof
Coll. Agric. Engine. Sciences\ Univ. Salahaddin Coll. Agric. Engine. Sciences\ Univ. Duhok
dler.othman@su.edu.krd nljealkas2001@yahoo.com

ABSTRACT

To study the allometric growth of body and carcass traits, twelve new born Karadi lambs were docked within 3 days of their birth using rubber-rings, and left with their mothers till weaning (2.5 months). Another 12 weaned Karadi lambs obtained from local market were left intact. Following an adaptation period of a week, the docked and intact lambs with an average initial weight of 16.83±1.522 and 19.92± 0.748kg, respectively were randomly divided into three equal groups to be slaughtered at 20, 30 and 40kg. Results revealed that the allometric growth coefficients of both docked and intact lambs of dissectible lean and bone were negative heterogenic (b<1), indicating an early maturing tissues, while the growth of dissectible fat is a late maturing tissues. In both groups, loin, shoulder, foreshank and rack are an early maturing cuts, neck is isogonic, while leg in intact lambs is an early maturing whereas in docked lambs grew at a similar rate to carcass. In docked and intact lambs, carcass fat relative to empty body weight is an early and late maturing tissues, whereas non-carcass fat is isogonic and grew at a similar rate to empty body weight in both groups. The growth of pelt, liver, lung and trachea and heart were isogonic and grew at a similar rate to empty body weight in both groups

Keywords: carcass tissue, fat depots, non-carcass component, growth, Karadi.

نمط النمو لمكونات الجسم و الذبيحة في الحملان الكرادية الاعتيادية و مقطوعة الالية

دلير علي عثمان الشيرواني جلال ايليا القس
استاذ مساعد استاذ
كلية علوم الهندسة الزراعية/ جامعة صلاح الدين كلية علوم الهندسة الزراعية/ جامعة دهوك

المستخلص

تهدف هذه الدراسة الى تقويم نمط نمو وتطور وتقدير معامل النمو لمكونات الجسم و الذبيحة في الحملان الكرادية الاعتيادية والمقطوعة الالية، تم قطع الالية لـ 12 حمل كرادي عند عمر ثلاثة ايام باستعمال الحلقات المطاطية وتركت مع امهاتها لحين الفطام (2.5 شهر) وثم شراء 12 حمل مفطوم من الاسواق المحلية. وبعد فترة تاقلم لمدة اسبوع تم توزيع كل من الحملان المقطوع الالية والاعتيادية وباوزان الابتدائية 16.83 19.92 كغم عشوائياً لتذبح عند اوزان 20، 30 و 40 كغم. وتشير النتائج الى ان معامل النمو لكلا المجموعتين من الحملان بان انسجة اللحم والعظم غير متماثلة النمو (b<1) وتعني بان هذه الانسجة معنويا نموها مبكرا وأبطأ من وزن الذبيحة، بينما الدهن كان موجب وغير متماثل ويعد من الانسجة المتأخرة النضج. كان كل من القطن، الكتف، الصدر والزند ولكلا المجموعتين نموها مبكرا في حين كان نمو الرقبة مماثلاَ لوزن الذبيحة. أما الفخذ فكان مبكر النضج في الحملان الاعتيادية بينما كان مماثلاَ لنمو وزن الذبيحة في الحملان المقطوعة الالية. كان نمو الدهن الذبيحة منسوباَ لوزن الجسم الفارغ مبكراَ في الحملان المقطوعة الالية ومتأخر النضج في الحملان الاعتيادية. بينما دهن الاحشاء كان مماثلاَ في نمو لوزن الجسم الفارغ، ولكلا المجموعتين. كان نمو الجلد والكبد والرئتين والقصبة الهوائية والقلب متماثل في النمو مع وزن الجسم الفارغ ولكلا المجموعتين.

الكلمات المفتاحية: أنسجة الذبيحة، مستودعات الدهون، مكونات غير الذبيحة، نمو، كرادي.

Received:25/9/2021, Accepted:17/12/2021

INTRODUCTION

Sheep have historically been essential meat-producing animals in many parts of the world, including Iraq (1, 3, 16). Moreover, producing lambs with a high rate of lean meat and enough fat cover is also one of the options for approaching the need for sheep meat production (47). Although, docking fat tail is not common practice in the area that raises fat tail sheep (4), however, it is assumed that docking early in live will be improve the efficiency of growth (45) as well as dressed lamb carcasses have neater appearance and thus receive higher marked prices (15). Thus, the understanding of sheep carcass composition, quantitative accretion of each carcass component, and variations in growth patterns at various phases of growth is essential in both nutrition research and production system evaluations that try to maximize profit (29). Furthermore, allometry studies provide for a better understanding of the rate of growth and development of carcass areas, as well as a more precise slaughter time for each breed (17). Sheep carcass assessment and body composition research has received a major interest, particularly in developing nations where sheep are consumed a lot for meat production (32). Therefore, there is a need to characterize tissue partitioning and carcass composition of local breeds in Iraq, and particularly to the effect of docking fat tail. Thus, the main objective of the present study was to determine the growth pattern and carcass traits of docked and undocked Karadi lambs.

MATERIALS AND METHODS

Animal and experimental design: In the current work, twelve new born lambs were docked within 3 days of their birth using rubber-rings and left with their mothers till weaning (2.5 months). Another 12 weaned male lambs obtained from local market were left intact. After an adaptation period of a week, the docked and intact lambs with an average initial weight of 16.83± and 19.92± kg respectively, were randomly divided into three equal groups to be slaughtered at 20, 30 and 40kg, and each group was housed in a separate pen and fed a pelleted diet containing 16% crude protein and 2769 Kcal energy and straw ad libitum. Full details of the experiment are described in our previous paper (8)

Slaughtering of the animals

When each lamb reached its desired slaughter weight (20, 30 and 40 kg), they were slaughtered after fasting for 12 hours, with unlimited access to water. The lambs were slaughtered at abattoir according to Islamic method, by severing the necks and major blood vessels. Immediately after skinning was completed, evisceration was carried out and the carcass and non-carcass components were weighted. Hot carcass includes kidney and kidney fat, edible offal’s constitute of heart, testes, liver, lung and trachea, spleen and inedible offal’s comprised skin, head and feet were weighed. Omental, mesenteric, scrotal and cardiac fat were separated and weighed. The gastro-intestinal tract was weighed, then emptied of its contents, cleaned, and re-weighed in order to calculate the empty body weight by subtracting the weight of the digestive tracts content from the slaughter weight.

Carcass traits

The cold carcass was weighed after chilling it for 24 hours at 40 degrees Celsius, then the pelvic and kidney fat were removed and weighed separately. An electric saw was used to split the carcass in half along the spinal column. The left side of the carcass was cut into nine whole sale cuts and weighed.

Physical dissection

Each cut of the left half carcasses were weighed and dissected completely into lean, fat and bone. The three components were weighed separately to determine their percentages. Carcass fat including subcutaneous and intermuscular fat was separated from each cut. Non-carcass fat was the sum of the omental, mesenteric, pelvic, kidney, scrotal and cardiac fat.

Statistical analysis: The allometric growth equation of Huxley (18) was performed to analyze the differential growth of dissectible body components relative to carcass side and empty body weight using the slaughter and carcass data. The data was first transformed to logarithms (base 10) and log transformed weights of dissectible body components were regressed on carcass side and empty body weight using the allometric growth equation of the form Y= aX^b. The experimental relationship was converted to a logarithmic form as follows:

$Log_{10}Y = log_{10}a + b\ log_{10}X$

Where Y= weight of dissectible body component; X= empty body weight or weight of carcass side; a= the value of Y when X=1; and b= the growth coefficient of dissectible body component relative to weight of carcass or empty body weight.

To verify if b=1, the t-test was used, when b=1, growth was denominated isogonic, indicating that growth of both X and Y were similar during the growth period considered. On the other hand, when b≠1, growth was denominated heterogonic, being negative with precocious development if b<1 and positive with the late maturation if b>1. The regression procedure of the SAS software (43) was used to obtain the allometric coefficient.

RESULTS AND DISCUSSION

Carcass composition: The weights in kg of lean, fat and bone in the left side of the carcass increased linearly as the slaughter weight increased in the docked and intact lambs (Tables 1 , 2). This result were close to other workers (5, 7, 11, 30), who reported that as the carcass weight increased, the weights of lean, fat and bone increased. The allometric growth coefficients of dissectible lean and bone weights in docked and intact Karadi lambs were negative heterogenic (b<1), indicating low impetus and early maturing tissue, and the growth of these two tissues are significantly (P<0.01) slower than carcass weight. While, dissectible fat weight was greater than one and their values are 1.694 and 2.203 in docked and undocked lambs respectively, it means high impetus and late maturing tissue, and they grew higher than the carcass weight. This was predicted since tissue development follows the order of bone, lean and fat (36). These results are in agreement with (6, 9, 11, 13) who reported that fat is a late maturing tissue, whereas carcass lean and bone weights are early maturing when compared to empty body weight. However, Rosa et al. (34), working with Texel lambs, Yanez et al. (49) with Saanen goats and Santos et al. (38), with Santa Inês and Bergamasca lambs, also found early bone development and late fat tissue growth. However, they found that muscle tissue growth was identical to carcass growth. These variations might be due to differences in tissue composition and growth in various parts of the carcass. Also, Sousa et al., (46) and Al-Owaimer et al., (5) who found isogonic growth of dissectible lean. Furthermore, Silva et al. (44) discovered that the muscle growth of lambs born from Texel rams with Texel × Ideal ewes is isometric in relation to the carcass and its cuts, revealing that weights above 33 kg may not be the most appropriate at 105 days of age, because high proportions of muscle and good fat deposition in the carcass are obtained up to this weight. Thus, the variations between these experiments are most likely due to environmental factors, such as nutrition quality and the degree of maturity obtained at slaughter body weight.

Table 1. Allometric coefficient of lean, fat and bone weights (kg) in docked lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Left side of the carcass. Kg	4.19 ±0.06 c	6.18 ±0.05 b	9.32 ±0.06 a	0.63	L: **	--	--
Lean	2.55 ±0.06 c	3.51 ±0.02 b	5.21 ±0.33 a	0.34	L: **	0.889 **	0.952
Fat	0.437 ±0.02 c	1.068 ±0.02 b	1.754 ±0.24 a	0.17	L: **	1.694 **	0.892
Bone	1.048 ±0.02 c	1.396 ±0.04 b	2.078 ±0.01 a	0.13	L: **	0.861 **	0.984

**** (P≤0.01),. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q**

Table 2. Allometric coefficient of lean, fat and bone weights (kg) in intact lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Left side of the carcass. Kg	4.63 ±0.02 c	6.47 ±0.22 b	9.38 ±0.20 a	0.596	L: **	--	--
Lean	2.67 ±0.06 c	3.54 ±0.12 b	4.46 ±0.09 a	0.225	L: **	0.729 **	0.97
Fat	0.345 ±0.03 c	0.724 ±0.10 b	1.598 ±0.11 a	0.165	L: **	2.203 **	0.95
Bone	1.016 ±0.02 c	1.20 ±0.02 b	1.73 ±0.04 a	0.092	L: **	0.747 **	0.92

**** (P≤0.01),. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q**

Carcass cuts : In the present experiment, the chilled carcass weight and weights of all wholesale cuts relative to chilled carcass side at different slaughter weights in docked and intact male lambs were increased linearly (p≤0.01) with increasing slaughter weight (Tables 3 , 4). Similarly, Al-Owaimer, et al., (5) reported that the weight of all wholesale cuts was increased linearly with increasing slaughter weight. The allometric growth coefficient of leg weight is differ between treatments in relation to half carcass weight, while it was found that the b value in docked lambs is near to one (1.036), which means isogonic growth and grew at a similar rate to carcass weight, on the other hand, the b value in intact lambs was (0.845), indicating low impetus and early maturing cut and the growth rate was lower than that of carcass weight. Such difference could be attributed to more deposition of fat in the leg of docked lambs compared to intact lambs (20.18 vs. 12.99%) (8). This result for intact lambs are in accordance with Alvarez-Rodriguez, et al., (9) who indicated that the allometric growth of leg cuts in relation to half carcass weight was an early developed. Also, the low relative growth of leg is in line with results noticed by other workers (21, 33, 41, 42). The results obtained for docked lambs is similar to those of Yáňez et al. (49) who found the coefficient of leg equal to one in saanen goats. The growth coefficient of neck in docked and intact lambs are isogonic with b=1 and their values are 1.159 and 1.075, respectively. (Tables 3 , 4) Similarly, Mora, et al., (26) showed isogonic growth of neck cuts with development growth of cold carcass weight. Furthermore, breast cuts (1.031) in docked had similar rate of growth to carcass side, and higher rate (1.350) of growth was observed in undocked lambs. This results were close to other workers (6, 48, 49), who reported that the breast cut was positive impetus and late growth which had a coefficient value greater than one. In both docked and intact lambs, loin, shoulder, foreshank and rack were low impetus and early maturing tissue, and growth rate of these components grew at slower rate than carcass rate. These results are in agreement with Sabbioni, et al., (37) who reported that the growth coefficient of loin cuts was early growth. Also, Santos, et al., (39) found that the loin proved to be an early growth rate in lambs slaughtered at 33.5 and 42.8kg. While, the growth coefficient of flank cuts in docked lambs is significantly less than one (0.990) indicating that grew at slower rate than the carcass, on the other hand, the b value in undocked lambs was significantly greater than one (1.610) demonstrated high impetus and late maturing tissue. These results are in agreement with Al-Owaimer, et al., (5) and Alvarez-Rodriguez, et al., (9) who found a positive heterogonic growth coefficients of flank cuts, because flank is considered a region with late maturation due to higher fat deposition and lower lean compared to other cuts.

Table 3. Allometric coefficient of carcass cuts (kg) in docked lambs

Components (weight)	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Chilled carcass wt. kg	4.19 ±0.06 c	6.18 ±0.05 b	9.32 ±0.06 a	0.14	L: **	--	--
Legs wt.	1.507 ±0.04 c	2.38 ±0.06	3.44 ±0.04 a	0.23	L: **	1.036 **	0.99
Loin wt.	0.396 ±0.02 c	0.546 ±0.01 b	0.846 ±0.01 a	0.05	L: **	0.959 **	0.97
Neck wt.	0.322 ±0.003 c	0.479 ±0.02 b	0.817 ±0.03 a	0.06	L: **	1.159 **	0.96
Shoulder wt.	0.871 ±0.03 c	1.235 ±0.02 b	1.864 ±0.06 a	0.12	L: **	0.949 **	0.96
Fore shank wt.	0.226 ±0.01 c	0.306 ±0.002 b	0.423 ±0.008 a	0.02	L: **	0.787 **	0.99
Breast wt.	0.447 ±0.01 c	0.670 ±0.02 b	1.023 ±0.02 a	0.07	L: **	1.031 **	0.98
Rack wt.	0.309 ±0.008 c	0.417 ±0.001 b	0.647 ±0.03 a	0.04	L: **	0.925 **	0.97
Flank wt.	0.115 ±0.002 b	0.136 ±0009 b	0.257 ±0.02 a	0.02	L: **	0.990 **	0.82

**** (P≤0.01) , SEM: Standard error of mean , R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q**

Table 4. Allometric coefficient of carcass cuts (kg) in intact lambs

Components (weight)	Slaughter weight (kg) Mean ± SE 20	30	40	SEM	P-value	Coefficients #b	R2
Chilled carcass wt. kg	4.63 ±0.02 c	6.47 ±0.22 b	9.38 ±0.20 a	0.596	L: **	--	--
Legs wt.	1.44 ±0.01 c	2.14 ±0.06 b	2.63 ±0.06 a	0.149	L: **	0.845 **	0.95
Loin wt.	0.386 ±0.002 c	0.553 ±0.02 b	0.761 ±0.03 a	0.047	L: **	0.954 **	0.96
Neck wt.	0.332 ±0.02 c	0.451 ±0.002 b	0.710 ±0.02 a	0.048	L: **	1.075 **	0.93
Shoulder wt.	0.887 ±0.03 c	1.13 ±0.04 b	1.50 ±0.03 a	0.078	L: **	0.758 **	0.97
Fore shank wt.	0.218 ±0.005 c	0.272 ±0.002 b	0.343 ±0.02 a	0.016	L: **	0.634 **	0.93
Breast wt.	0.419 ±0.002 b	0.575 ±0.02 b	1.088 ±0.09 a	0.091	L: **	1.35 **	0.95
Rack wt.	0.319 ±0.004 b	0.388 ±0.02 b	0.582 ±0.03 a	0.035	L: **	0.873 **	0.92
Flank wt.	0.088 ±0.007 c	0.159 ±0.02 b	0.267 ±0.01 a	0.023	L: **	1.61 **	0.92

** (P≤0.01), SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q

Partitioning of fat

The dissectible subcutaneous, intramuscular, and carcass fat in relation to empty body weight from the left side of the cold carcasses in docked and intact male lambs were linearly increased (P≤0.01), (P≤0.05), with increasing slaughter weight (Tables 5 , 6), such effect of slaughter weight on carcass composition has been widely reported (25, 28, 49). Al-Owaimer et al. (5) also observed that as the Ardhi goat kids grew, the percentage of dissectible intramuscular fat as a percentage of the cold carcass side weight increased linearly (P≤0.01) with increasing slaughter weight. The current findings contrasts markedly with those of Mtenga et al. (28) in Saanen goats, who reported that the proportion of subcutaneous fat increased with the increased in slaughter weight from 9.5 to 36.5 kg. At similar carcass weights in general, similar trends of intermuscular fat were reported by Dhanda et al. (12) and Marichal et al. (24) who revealed that the proportions of intermuscular fat were positively impacted by age and slaughter weight. In the current investigation, it appears from Tables 5 and 6 that all non-carcass fat increased linearly with the increasing slaughter weight, except kidney and pelvic fat in docked lambs, whereas in intact lambs heart fat decreased and scrotal fat increased linearly, while all other fat depots including omental, mesenteric, kidney and pelvic and non-carcass fat increased quadraticly (P≤0.05) with the increasing slaughter weight. The allometric coefficients of carcass fat in docked and intact lambs were 0.955 and 1.415 respectively, indicating that low impetus in docked and high impetus in intact lambs, and between carcass fat showed that subcutaneous fat had heterogonic growth, >1, grew at higher rate than intermuscular fat which is <1, in docked and intact lambs (Tables 5 , 6). Similar results were obtained by Yanez, et al., (49); Santos, (40); Mahgoub and Lodge, (22); Mtenga et al., (27) and Al-Owaimer, et al., (5) who observed late growth for subcutaneous fat in relation to empty body weight. In contrast, Yanez, et al., (49); Santos, (40); Mahgoub and Lodge, (22); and Al-Owaimer, et al., (5) who observed later growth for inter-muscular fat in relation to empty body weight. Non-carcass fat of docked and intact lambs showed isogonic growth, it means grew at similar rate to empty body weight. Similarly, mesenteric and kidney fat had isogonic growth of both groups. In contrast, of omental and heart fat in docked and scrotal fat in undocked there were low impetus and early maturing tissue. These results are in agreement by Garcia, et al., (14) who found that allometric coefficients of the mesentery fat in purebred Ile de France x Santa Inês males and the females from all of the genetic groups equal to one for this component (isogonic growth), showing that the mesentery fat grows at a rate equivalent to the empty body weight. However, disagree with McGregor, (25) who found the early growth for mesenteric fat in Angora goats, also disagrees with Teixeira et al. (48); Mahgoub and Lodge, (22) and Alvares-Rodriguez, et al., (9) who found the late growth for omental and mesenteric fat in relation to empty body weight.

Non-carcass components

In the current work, in docked lambs, a non-significant quadratic increase in carcass, heart and spleen and decrease in liver, lungs and trachea was noticed. Whereas, with the exception of pelt, a significant linear decrease was noticed in head, feet, kidney and empty digestive and testes significantly increased linearly with increasing empty body weight. In intact lambs, a non-significant quadratic difference was noticed in liver, lungs and trachea and heart weights, and a significant decrease was found in empty digestive tract weights. However, with the exception of pelt, a significant linear increase was found in each of hot carcass and testes weight (P≤0.01), and a significant decrease (P≤0.01) was noticed in head, feet, kidney and spleen. These results are similar with those reported by Al-Owaimer et al. (5) who found that empty and hot carcass weight in Aradhi goats increased linearly (P≤0.05) and did not change in the percentage of liver based on empty body weight with increasing slaughter weight.

Table 5. Allometric coefficient of fat partitioning as a percentage of empty body weight in docked Karadi lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Empty body weight	16.96 ±0.39 c	24.12 ±0.19 b	34.30 ±0.72 a	2.16	L: **	--	--
Subcutaneous	3.83 ±0.04 b	7.15 ±0.31 a	7.99 ±0.90 a	0.61	L: **	1.029 **	0.77
Intramuscular	1.313 ±0.16 b	1.701 ±0.10 ab	2.15 ±0.32 a	0.15	L: *	0.728 **	0.51
Carcass Fat	5.14 ±0.20 b	8.86 ±0.21 a	10.15 ±1.22 a	0.74	L: **	0.955 **	0.76
Omental	0.579 ±0.03 b	0.641 ±0.09 b	0.992 ±0.15 a	0.07	L: *	0.691 *	0.38
Mesenteric	0.553 ±0.03	0.544 ±0.04	0.572 ±0.05	0.02	L: NS	0.025 NS	0.003
Kidney and pelvic	0.481 ±0.04 b	0.584 ±0.01 a	0.475 ±0.03 b	0.02	Q: *	-0.0099 NS	0.004
Heart	0.153 ±0.02 b	0.210 ±0.01 ab	0.267 ±0.05 a	0.02	L: *	0.707 *	0.44
Scrotal	0.374 ±0.09	0.362 ±0.10	0.327 ±0.07	0.04	L: NS	-0.148 NS	0.008
Non Carcass Fat	2.14 ±0.14	2.35 ±0.25	2.635 ±0.24	0.13	L: NS	0.268 NS	0.19

*** (P≤0.05), ** (P≤0.01), NS: Non-Significant. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q**

Table .6. Allometric coefficient of fat partitioning as a percentage of empty body weight in intact Karadi lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Empty body wt. kg	18.49 ±0.13 c	24.71 ±0.37 b	35.05 ±0.31 a	2.06	L: **	--	--
Subcutaneous	2.58 ±0.18 c	4.66 ±0.71 b	7.08 ±0.46 a	0.614	L: **	1.59 **	0.84
Intramuscular	1.149 ±0.13 b	1.168 ±0.08 b	2.04 ±0.25 a	0.155	L: **	0.924 **	0.55
Carcass Fat	3.73 ±0.31 c	5.83 ±0.79 b	9.13 ±0.71 a	0.750	L: **	1.415 **	0.82
Omental	0.568 ±0.03 ab	0.385 ±0.03 b	0.735 ±0.10 a	0.055	Q: **	0.395 NS	0.11
Mesenteric	0.468 ±0.12	0.399 ±0.05	0.469 ±0.11	0.055	Q: NS	0.087 NS	0.002
Kidney and pelvic	0.391 ±0.02	1.11 ±0.78	0.429 ±0.02	0.257	Q: NS	-0.019 NS	0.002
Heart	0.141 ±0.02	0.143 ±0.002	0.113 ±0.01	0.009	L: NS	-0.316 NS	0.08
Scrotal	0.171 ±0.01	0.257 ±0.03	0.325 ±0.07	0.032	L: NS	0.831 *	0.38
Non Carcass Fat	1.74 ±0.08	2.296 ±0.91	2.073 ±0.30	0.297	Q: NS	0.135 NS	0.01

*** (P≤0.05), ** (P≤0.01), NS: Non-Significant. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q**

The allometric growth coefficients of hot carcass weight and spleen are isogonic in docked lambs and grew at similar rate of empty body weight, while, in undocked lambs are negative heterogonic (b<1), which grew at slower rate than empty body weight (Tables 7 , 8). Similar results were obtained by Alvarez-Rodriguez, et al., (9) who found that spleen had early developing growth in relation to empty body weight. The growth of organs head, feet, kidney and empty digestive tract grew at lower rate than empty body weight, it means low impetus and early maturing tissue and there values were -0.295, -0.375, -0.235 and -0.344 respectively, in docked lambs and -0.276, -0.593, -0.771 and -0.219 respectively, in undocked lambs. Such results were in agreement by (9) and (2) who revealed that the head, feet and kidney were low impetus and early growth compared to the growth of empty body weight. Also, Mahgoub and Lodge, (22) demonstrated that between weights of 18 to 38kg the head and feet grew at rate significantly lower and indicating early growth. However, Kirton, et al., (20) found that the kidneys growth has a high impetus and late developing relative to empty body weight. At birth, tissues important in life functions (such as metabolism and respiration) should be well developed, while those involved in locomotion and energy storage should be less developed (19). In fact, most visceral and thoracic organs, together with the feet and head, were proportionately greater at birth, with further slow postnatal growth (b<1) (Tables 7 , 8), similar to previously reports on Segurena (31) and Texel lambs (35). In this approach, Atti et al. (10) and Mahouachi and Atti (23) found that the weight of offal components rich in bone and/or with low metabolic activity (head, feet) is indicative of early maturation. The growth of pelt, liver, lungs and trachea and heart were isogonic, it means grew at similar rate to that of empty body weight of both docked and intact male lambs. This results are in the line with those found earlier by Alvarez-Rodriguez, et al., (9) who concluded that skin and liver in relation to empty body weight were isogonic, and indicating similar growth rate with increasing slaughter weight. Also, Mahgoub and Lodge, (22) demonstrated that the skin grew at a rate similar to empty body weight. However, different results was obtained in testes that’s found heterogonic growth in docked had early mature organ and grew at lower rate than empty body weight, while, late mature was noticed in undocked lambs and grew at higher rate than empty body weight. Such results are in agreement with (2) and (14) who reported that the allometric growth of testes weight greater than one. From the results presented in the text, it can be conclude that lean and bone are an early maturing tissues, whereas fat is late in both docked and intact lambs. In docked lambs carcass fat grew at a similar rate to empty body weight whereas in intact lambs this fat is a late maturing tissue. Non carcass fat grew at a similar rate to empty body weight in both groups.

Acknowledgment: The authors wish to express their deep thanks and appreciation to Prof. Dr. Nasir Al-Anbari, Dept. of Animal Resources, College of Agricultural Engineering Science, University of Baghdad for his valuable help in the statistical analyses of the data.

Table 7. Allometric coefficient of non-carcass components as a percentage of empty body weight in docked lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Empty body wt. kg	16.96 ±0.39 c	24.10 ±0.19 b	34.31 ±0.72 a	2.16	L: **	--	--
Hot carcass wt.	55.94 ±1.58	54.41 ±0.22	55.94 ±1.57	0.711	Q: NS	-0.012 NS	0.007
Head wt.	8.04 ±0.27 a	6.73 ±0.16 b	6.54 ±0.12 b	0.227	L: **	-0.295 **	0.70
Pelt wt.	12.45 ±0.11	12.43 ±0.61	12.10 ±0.80	0.311	L: NS	-0.036 NS	0.02
Feet wt.	3.62 ±0.14 a	3.25 ±0.19 ab	2.77 ±0.22 b	0.144	L: *	-0.375 **	-0.375
Liver wt.	2.43 ±0.07	2.45 ±0.15	2.39 ±0.02	0.053	Q: NS	-0.025 NS	0.01
Kidney wt.	0.490 ±0.02 a	0.446 ±0.01 ab	0.409 ±0.02 b	0.013	L: *	-0.235 **	0.45
Testes wt.	0.107 ±0.01 b	0.158 ±0.01 ab	0.221 ±0.05 a	0.021	L: *	0.944 **	0.54
Lungs Trachea wt.	2.02 ±0.14	2.034 ±0.06	1.964 ±0.07	0.053	Q: NS	-0.019 NS	0.01
Heart wt.	0.556 ±0.01	0.508 ±0.03	0.565 ±0.02	0.013	Q: NS	0.0042 NS	0.002
Spleen wt.	0.263 ±0.01	0.214 ±0.02	0.265 ±0.04	0.015	Q: NS	0.0017 NS	0.001
Empty digestive tract wt. kg	9.34 ±0.98 a	8.62 ±0.32 ab	7.29 ±014 b	0.407	L: *	-0.344 **	0.45

* (P≤0.05), ** (P≤0.01), NS: Non-Significant. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q

Table 8. Allometric coefficient of non-carcass components as a percentage of empty body weight in intact lambs

Components	Slaughter weight (kg) Mean ± SE			SEM	P-value	Coefficients	
	20	30	40			#b	R2
Empty body wt. kg	18.49 ±0.13 c	24.70 ±0.37 b	35.05 ±0.31 a	2.06	L: **	--	--
Hot carcass wt.	48.38 ±0.82 b	54.31 ±0.90 a	54.59 ±1.18 a	1.004	L: **	0.178 **	0.53
Head wt.	6.49 ±0.20 a	5.95 ±0.15 b	5.44 ±0.06 c	0.152	L: **	-0.276 **	0.76
Pelt wt.	12.10 ±0.15	12.33 ±0.37	13.32 ±0.70	0.293	L: NS	0.153 NS	0.29
Feet wt.	3.24 ±0.02 a	3.14 ±0.12 a	2.24 ±0.05 b	0.140	L: **	-0.593 **	0.82
Liver wt.	2.22 ±0.03	2.35 ±0.04	2.12 ±0.21	0.073	Q: NS	-0.116 NS	0.07
Kidney wt.	0.525 ±0.03 a	0.406 ±0.02 b	0.321 ±0.008 c	0.028	L: **	-0.771 **	0.84
Testes wt.	0.102 ±0.01 c	0.195 ±0.003 b	0.381 ±0.02 a	0.035	L: **	2.03 **	0.97
Lungs Trachea wt.	2.05 ±0.01	1.53 ±0.04	1.73 ±0.34	0.124	Q: NS	-0.386 NS	0.16
Heart wt.	0.526 ±0.01	0.470 ±0.006	0.475 ±0.02	0.011	Q: NS	-0.163 NS	0.30
Spleen wt.	0.311 ±0.02 a	0.215 ±0.007 b	0.212 ±04 b	0.019	L: *	-0.648 *	0.40
Empty digestive tract wt. kg	7.57 ±0.21 ab	7.94 ±0.36 a	6.66 ±0.33 b	0.228	Q: *	-0.219 *	0.33

* (P≤0.05), ** (P≤0.01), NS: Non-Significant. SEM: Standard error of mean, R2: Determination Coefficient. #b: Regression Coefficient. Probability of either linear-L, or Quadratic-Q

REFERENCES

1. Abd, Z. F.; M. M. Sultan and S. S. Abd. 2020. Impact of herd size on the productive efficiency of sheep breeding projects at the kokjali region in Nineveh governorate for the production season 2018. Iraqi Journal of Agricultural Sciences :51(6):1613-1622. https://doi.org/10.36103/ijas.v51i6.1188

2. Al-Jassim, A.F. and M.N.R. Al-Saigh. 1999. Some aspects of postnatal growth of Arabi sheep. 2. Live weight and body organs. Indian Journal of Animal Sciences. 69: 604-608

3. Aljubouri, T. R. S.; A. F. Hassan. M. B. S. Al-Shuhaib. 2021. Remarkable correlation of non-genetic factors with growth traits in two breeds of sheep. Iraqi Journal of Agricultural Sciences –2021:52(2):309-314. https://doi.org/10.36103/ijas.v52i2.1292

4. Alkass, J.E., Kh.A Darwesh and K.Y. Merkhan. 2014. Performance of docked vs. undocked fat tailed sheep: A review. Advanced Journal of Agricultural Research, 2(003): 029-037

5. Al-Owaimer, A., G. Suliman, A. El-Waziry, H. Metwally and M. Abouheif. 2013. Allometric Growth Patterns of Body and Carcass Components in Ardhi Goat. International Journal of Animal and Veterinary Advances 5: (5), 183-189. ISSN: 2041-2894; e-ISSN: 2041-2908

6. Al-Saigh, M.N.R. and A.F. Al-Jassim. 1998. Some aspects of postnatal growth of Arabi sheep. 1. Carcass muscle, bone, fat and wholesale joints. Indian Journal of Animal Sciences. 68: 965-968

7 Al-Sherwany, D.A.O. and J.E. Alkass. 2021. A comparative study on growth, carcass traits and body composition of Awassi and Karadi lambs raised under two levels of feeding and slaughtered at different weights: 1- Growth performance and carcass traits. Iraqi Journal of Agricultural Sciences. 52 (5): 1101-1108. https://doi.org/10.36103/ijas.v52i5.1448

8. Al-Sherwany, D.A.O. and J.E. Alkass. 2023. Impact of docking Karadi lambs on growth performance, carcass trait and body composition. Iraqi Journal of Agricultural Sciences. 54 (3): 625-635. https://doi.org/10.36103/ijas.v53i3.1572

9. Alvarez-Rodrıguez, J., A. Sanz, M. Joy, S. Carrasco, G. Ripoll and A. Teixeira. 2008. Development of organs and tissues in lambs raised on Spanish mountain grassland. Canadian Journal of Animal Science. Box 172. Zip code 5301-855. P: 37-45

10. Atti, N., H. Ben Salem and A. Priolo. 2003. Effects of polyethylene glycol in concentrate or feed blocks on carcass composition and offal weight of Barbarine lambs fed Acacia cyanophylla Lindl. foliage. Anim. Res. 52: 363-375

11. Carvalho, S., L.C. Zago, C.C. Pires, A.A. Martins, R.S. Venturini, J.F. Lopes, V.M. Pilleco, R.R. Simões, D.D. Bruti and A.B. Moro. 2016. Tissue composition and allometric growth of tissues from commercial cuts and carcass of Texel lambs slaughtered with different weights. Semina: Ciências Agrárias, Londrina. 37: (4), 2123-2132

12. Dhanda, J.S., D.G. Taylor, J.E. McCosker and P.J. Murray. 1999. The influence of goat genotype on the production of Capretto and

Chevon carcasses. 1. Growth and carcass characteristics. Meat science, 52: 355−361
13. Galvani, D.B., C.C. Pires, F. de. Oliveira; T.P. Wommer and F. Jochims. 2008. Allometric growth of the carcass components of feedlot Texel × Ile de France crossbred lambs from weaning to 35kg live weight. Ciência Rural, 38: 2574-2578.
14. Garcia, I.F.F., T.I.R.C. Alvarenga, J.R.O. Perez, A.K.. de Almeida, S.B. Gallo, I.G. Pereira, N.G. Alves and F.A.P. Alvarenga, 2014. Allometric growth of non-carcass components in crossed lambs. Ciência Rural, Santa Maria, 44: (7), 1229-1235
15. Gokdal, O., T. Aygun, M. Bingol and F. Karakus. 2003. The effect of docking on fattening performance and carcass characteristics of male Karakas lambs. South Afr. J. Anim. Sci., 33: 185-192
16. Hadi, Y. A.; A. A. Mnati; and S. Y. Abdulfattah. 2020. Study of genetic diversity using microsatellite markers in Iraqi sheep breeds. Iraqi Journal of Agricultural Sciences :51(5):1367-1374.
https://doi.org/10.36103/ijas.v51i5.1146
17. Hashimoto, J.H., J.C. da S. Osorio, M.T.M. Osorio, M.S. Bonacina, R.I. Lehmen, And C.E. da S. Pedroso. 2012. Carcass quality, parts and tissue development of lambs finished in three systems. Revista Brasileira de Zootecnia, 41: 438-448.
18. Huxley, J. 1932. Problems of Relative Growth. Methuem, London
19. Jenkins, T.G. and K.A. Leymaster. 1993. Estimates of maturing rates and masses at maturity for body components of sheep. J. Anim. Sci. 71: 2952-2957
20. Kirton, A.H., P.D. Fourie and K.E. Jury. 1972. Growth and development of sheep. New Zealand Journal of Agricultural Research. 15: 214-227.
21. Luaces, M.L., C. Calvo, A. Fernandez, J.L. Viana, B. Fernandez and L. Sanchez. 2007. Comericial cuts study and their development in Gallega breed lambs carcasses. Arch. Zootec. 56 (214): 157-168
22. Mahgoub, O. and G.A. Lodge. 1994. Growth and body composition of Omani local sheep. 2. Growth and distribution of musculature and skeleton. Animal Production 58: 373–379
23. Mahouachi, M. and N. Atti. 2005. Effects of restricted feeding and re-feeding of Barbarine lambs: intake, growth and non-carcass components. Anim. Sci. 81: 30 5-312
24. Marchial, A., J. Castro, M.L. Capote and A. Zamorano. 2003. Effects of live weight at slaughter (6, 10 and 25 kg) on kid carcass and meat quality. Livestock. Prod. Sci., 83: 247-256
25. McGregor, B.A., 1992. Body composition, body condition scores and carcass and organ components of grazing Angora goats. P. Aus. S. Ani., 19: 273-276
26. Mora, N.H.A.P., F. de A.F.de. Macedo, J.C.S. Osorio, E.N. Martins, A.A. Mexia and T.G. de. Macedo. 2014. Allometry in carcasses of lambs of the Pantaneiro genetic group slaughtered with different subcutaneous fat thickness. Acta Scientiarum: Animal Sciences, 36: 427-432
27. Mtenga, L.A., E. Owen, V.R.M. Muhikambele and G.C. Kifaro. 2005. Developmental Changes of Fat Depots-in Male Saanen Goats. Tanzania J. Agric. Sc. 6: (2), 99-103.
28. Mtenga, L.A., E. Owen, V.R.M. Muhikambele, G.C. Kifaro, D.S.C. Sendalo, N.F. Massawe, S.M. Kiango and D.R. Nkungu. 1994. Growth and partition of fat depots in male British Saanen goats. In “Small Ruminant Research and Development in Africa. Third Biennial Conference of the African Small Ruminant Research Network,” (L. S. H. B. a. K. E., ed.), pp. 255-258.
29. Negussie1, E., O.J. Rottmann, F. Pirchner, and J.E.O. Rege. 2004. Growth and carcass composition of tropical fat-tailed Menz and Horro sheep breeds. British Society of Animal Science. 78: 245-252
30. Osorio, J.C.S., M.T. Osorio, N. M. Oliveira and L. Siewerdt. 2002. Qualidade, morfologia e avaliacao de carcaças. Pelotas: Editora e Gráfica Universitária, 196 p
31. Pena, F., V. Domenech, F. Aparicio and D. Mendez 1989. Caracterısticas de la canal en corderos de raza Segurena. I. Componentes corporales no incluidos en la canal. Archiv. Zootec. 38 (141): 107-125
32. Phoya, R.K.A. and T.H.A. Kamoto. 2000. Tissue partitioning of the indigenous Malawi goat. Tropical Agriculture, Trinidad 77: 38–41

33. Rodrigues, S., V. Cadavez, E. Pereira, R. Delfa and A. Teixeira. 2003. Alometria das pecas de talho em cordeiros das racas Churra Galega Bragancana e Suffolk. Page 90 in Produzir qualidade em seguranca. Livro de resumos, XIII Congresso de Zootecnia, Associacao Portuguesa dos Engenheiros Zootecnicos

34. Rosa, G.T., C.C. Pires, J.H.S. Silva, and O.S. Motta. 2005. Muscle, fat and bone allometric growth in Texel lambs carcasses cuts in relation to the feeding methods and slaughter weight. Ciência Rural, Santa Maria, 35 (4): 870-876

35. Rosa, G.T., C.C. Pires, J.H.S. Silva, and O.S. Motta. 2002. Proportions and Coefficients of Growth Components, Non-Carcass of the Live Weight of Male and Female Lambs under Different Feeding Methods. R. Bras. Zootec. 31: 2290-2298

36. Rouse, G.H., D.G. Topel, R.L. Vetter, R.E. Rust and T.W. Wickersham. 1970. Carcass composition of lambs at different stages of development. J. Anim. Sci. 31: 846855

37. Sabbioni, A., V. Beretti, M. Ablondi, F. Righi and P. Superchi. 2018. Allometric coefficients for carcass and non-carcass components in a local meat-type sheep breed. Small Ruminant Research, 159: 69-74. DOI: https://doi.org/10.1016/j. smallrumres.2017.11.005

38. Santos, C.L., J.R.O. Perez, L.C. Gerassev, O.V. Prado and J.A. Muniz. 2001. Estudo do crescimento alométrico dos cortes de carcaça de cordeiros das raças Santa Inês e Bergamácia. Ciência e Agrotecnologia, 25(1): 149-158.

39. Santos, C.A., F.A.F. Macedo, G.R.A. Santos, A.D.F. Santos, M.J.A.F. Melo, L.C.G. Rassetti, A.J.C. Teixeira and N.H.A.P. Mora. 2020. Allometric growth of ½ Dorper + ½ Santa Inês lambs slaughtered with different subcutaneous fat thicknesses. Animal Science. 55:1678-3921

40. Santos, C.L. 1999. Performance, carcass characteristics and growth allometric of Santa Ines and Bergamacia lambs. Lavras: Universidade Federal de Lavras, (Dissertação-Mestrado en Zootecnia). 143p

41. Santos, V., J. Azevedo and S. Silva. 2000. Crescimento relativo dos varios componentes corporais de borregos da raca Ile-de-France. Rev. Portug. Zootec. VII: 29-41

42. Santos, V.A.C., S.R. Silva, E.G. Mena and J.M.T. Azevedo 2007. Live weight and sex effects on carcass and meat quality of ‘‘Borrego terrincho–PDO’’ suckling lambs. Meat Science 77: 654–61

43. SAS. 2012. Statistical Analysis System, User's Guide. Statistical. Version 9.1th ed. SAS. Inst. Inc. Cary. N.C. USA.

44. Silva, L.F., C.C. Pires, J.H.S. Silva, D.O. Meier, G.C. Rodrigues and R.M. Carneiro, 2000. Growth of lambs slaughtered at different weights. Bone, muscle and fat of the carcass and its cuts. Ciência Rural, Santa Maria, 30(4): 671-675

45. Snyman, M.A., M. Van Heerden, B.R. King, J.A.N. Cloete and M.I. Jonker. 2002. The effect of docking on growth, carcass quality, fat distribution and reproductive performance of Namaqua Afrikaner sheep. Grootfontein Agric. 5: 7-11

46. Sousa, M.A.P., A.C.S. Lima, J.C. Araujo, C.M.C. Guimaraes, M.R.S.P. Joele, I. Borges, L.C.C. Daher, and A.G.M. Silva. 2019. Tissue composition and allometric growth of carcass of lambs Santa Inês and crossbreed with breed Dorper. Tropical Animal Health and Production. https://doi.org/ 10.1007/ s11250-019-01886-2

47. Souza, D.A., A.B. Selaive-Villarroel, E.S. Pereira, J.C.S. Osório and A. Teixeira. 2013. Growth performance, feed efficiency and carcass characteristics of lambs produced from Dorper sheep crossed with Santa Inês or Brazilian Somali sheep. Small Rumin. Res. 114, 51–55

48. Teixeira, A., J. Azevedo, R. Delfa, P. Morand-Fehr and C. Costa. 1995. Growth and development of serrana kids from Montesano natural park NE of Portugal. Small Ruminant Res., 16: 263-269

49. Yanez, E.A., K.T. Resende, A.C. Ferreira, J.M. Filho, A.N. Medeiros and A. Teixeira. 2009. Relative development of tissues, commercial meat cuts and live weight components in Saanen goats. R. Bras. Zootec. 38: 366-373.