Pre-weaning growth performance and carcass traits of Awassi and Chios-Awassi lambs

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Abstract

One hundred and three lambs (26 Chios-Awassi (CA) and 77 Awassi (AA)) were used to evaluate the effect of crossbreeding on growth performance, body dimensions and carcass characteristics. At weaning, 8 CA and 8 AA male lambs were randomly selected to examine carcass traits. Crossbred CA lambs were heavier at birth than their AA counterparts, while average daily gain (ADG) and weaning weights were not affected by genotype. CA lamb genotype had greater diagonal body length, hip height and heart girth than AA lambs. Hot and cold carcass weight, dressing percentage, body length, leg length, maximum shoulder width, and width behind shoulder were greater in CA lambs compared with AA lambs. AA lambs had significantly heavier fat tail and leg cut weights, while shoulder cut weights were heavier in the CA lambs. CA lambs had greater rib fat depth and tissue depth thickness than AA lambs. *Longissimus* muscle area was significantly greater in CA than in AA lambs. In conclusion, CA lambs had greater birth weights, body dimensions and dressing percentage than AA lambs. Additionally, aside from the tail and leg cuts, carcass components were heavier in CA crossbred lambs.

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Introduction

The aim of genetic programmes is to improve traits of economic importance, while minimizing the production costs (Kosgey & Okeyo, 2007). In the sheep industry, pre- and post-weaning lamb growth traits are considered important. Several methods and technologies are used to improve lamb traits and growth rate, one of which is crossbreeding. Crossbreeding is usually used to improve carcass and low heritability (such as fertility traits). It can improve traits without the need for advanced and costly technologies (Nitter, 2000). However, crossbred animals are sold at cheaper prices than purebred ones owing to consumer preferences.

The sheep population in Jordan is around 2.5 million head, supplying about 47% of total meat production in the country. In developing countries such as Jordan, sheep and goats play a major role in household economics through meat and milk production (Steinfeld *et al.*, 2006). The growing demand for red meat owing to the increasing population makes it a necessity for Jordan to start up a genetic improvement programme to help in meeting the country's market requirements. However, one must keep in mind that consumers in Jordan prefer carcasses with certain phenotypic traits, such as the presence of a fat tail. Therefore, any crossbreeding programme should take this into consideration. Maintaining the fat tail can be accomplished by producing the first generation or backcrossing the first generation with Awassi (Rosov & Gootwine, 2013). However, backcrossed animals usually lose some levels of heterosis (Abdullah *et al.*, 2010) and, as a result, have reduced performance compared with first-generation animals. To avoid the need to create backcrossed animals, the choice of breed to be crossed with Awassi is of great importance. Because of these issues, the authors' hypothesis was that using the Chios as a semi-fat-tail sheep breed to

be crossbred with Awassi would produce fat-tailed lambs. The objectives of this study were to evaluate the effects of crossbreeding on birth weight, weaning weight and pre-weaning growth traits as well as carcass traits at weaning.

Materials and Methods

All procedures were approved by the Institutional Animal Care and Use Committee of Jordan University of Science and Technology (JUST). The study was conducted at the Agricultural Research and Training Unit at JUST from June 2014 to February 2015. One hundred and sixty homogenized Awassi ewes were divided into two groups: 100 ewes to produce pure Awassi lambs and 60 ewes to be bred to Chios rams. The occurrence of oestrus of the ewes were synchronized using intravaginal progesterone sponges (FGA) (Ceva, Santa Animals, Libourne, France) to ensure lambing uniformity. For Chios rams, mating was done with assisted hand mating. Ultrasonography performed 45 days post mating revealed that only 80% of the Awassi-mated and 50% of the Chios-mated ewes were pregnant. Single-born lambs were ear tagged and weighed, and data were recorded. Ewes with their lambs were fed a lactation diet until weaning. Of all lambs, 103 (77 AA and 26 CA) were weaned at 65 days old, at which time fasting bodyweights and body measurements were recorded. Body dimension measurements were recorded using a plastic tape and large callipers, namely diagonal body length (DBL), wither height (WH), hip height (HH), body circumference (BC), width behind the shoulders (WBS) and rump height (RH).

Eight ram lambs from each genetic group were slaughtered at weaning following 12 hours of fasting. Live bodyweight was recorded before slaughtering. Lambs were slaughtered and carcasses were dressed as described by Abdullah *et al.* (2010). Hot carcass weight was recorded the carcass was washed with fresh water. Carcasses were chilled for 24 hours at 4 °C, and then weighed to obtain the cold weights. Fat tails were separated (from the area around the hind legs of the carcass) and weighed. Carcass length (CL), leg length (LL), carcass maximum shoulder width (CMSW), and carcass width behind the shoulder (CWBS) were recorded on hanging carcasses using a metal metre and large callipers. Each carcass was then cut into four parts (leg, shoulder, lion and rack) following the procedure described by Abdullah *et al.* (2010). Each cut was weighed and then the depth of tissue over the surface of rib at point 110 mm from the midline and area of *M. longissimus* (GR), depth of subcutaneous fat over the *M. obliquus externus* abdomini (J), fat thickness over the ventral edge of *M. gluteus medius* (L3), the depth of subcutaneous fat over the *M. latissius dorsi* at a point at the right angles to the midline (S2), area of *M. Longissimus* (LMA), *M. longissimus* width (A), *M. longissimus* depth (B), and fat depth (C) was recorded. The right leg cut was then sealed into plastic bags and frozen at -20 °C until dissected.

Before dissection, legs were thawed in coolers at 4 °C in plastic bags. The leg was dissected, and subcutaneous fat, intermuscular fat, muscle, bone and scrap were separated and weighed. Four muscles from the right leg were examined. Those included *M. semitendinosus*, *M. quadriceps*, *M. semimembranosus* and *M. biceps femoris.*

Data were analysed using PROC mixed procedures of SAS (SAS Inst. Inc. Cary, NC). Lamb birth and weaning weights, pre-weaning average daily gain, and linear body measurements were analysed using mixed linear models. Fixed effects that were investigated, included lamb genotype, lamb sex and their interactions. Dam identification was modelled as a random effect as shown in the mathematical equation below.

$$Y_{ijk} = \mu + G_i + S_j + (GS)_{ij} + \varepsilon_{ijk}$$

where: Y_{ijk} the dependent variable
μ is the overall mean
G_i is the genotype effect, where i = AA or CA
S_j is the sex effect, where j = male or female
$(GS)_{ij}$ is the interaction between the two effects
ε_{ijk} is the random error

Carcass traits and meat quality were analysed using the generalized linear model of SAS, in which genotype was treated as the main effect. Carcass weight was included as covariate for weight analysis of cuts.

$$Y_{ij} = \mu + G_i + \varepsilon_{ij}$$

where: Y_{ij} is the dependent variable

μ is the overall mean
G_i is the genotype effect, where i = AA or CA
ε_{ij} is the random error

Mean separation for all traits was performed using Tukey-Kramer test and significance level was determined at (P <0.05).

Results and Discussion

Lamb sex had a highly significant effect on birth weight, weaning weight and pre-weaning ADG (Table 1). Male lambs were heavier at birth and weaning and gained more compared with female lambs, which is consistent with a previous study (Gardner *et al.*, 2007). CA lambs were heavier (P <0.01) at birth than AA lambs. These results agree with Emsen (2005), who reported that crossbred Awassi lambs tend to be heavier at birth than their purebred counterparts. Similarly, Gavojdian *et al.* (2013) reported that crossbred Morkaraman/Romanov lambs were heavier at birth than their purebred counterparts. On the other hand, Korkmaz & Emsen (2016) reported that crossbreeding did not affect lamb birth weight. In the current study, lamb genotype did not affect weaning weight and pre-weaning average daily gain (ADG). These results agree with Abdullah & Tabbaa (2011), who found that weaning weight for F_1 Chios-Awassi lambs did not differ from purebred Awassi lambs. However, Mellado *et al.* (2016) reported that crossbred Dorper-Turcana lambs were heavier at weaning than the purebred Turcana lambs.

Table 1 Least squares means and standard error for preweaning growth performance of Awassi and Chios-Awassi lambs

Trait	Male		Female	
	Awassi	**Chios-Awassi**	**Awassi**	**Chios-Awassi**
BWT (kg)	$4.52^{b,x} \pm 0.081$	$5.55^{a,x} \pm 0.16$	$3.89^{b,y} \pm 0.11$	$4.73^{a,y} \pm 0.15$
WWT (kg)	$18.33^{x} \pm 0.24$	$18.86^{x} \pm 0.45$	$16.55^{y} \pm 0.29$	$17.86^{y} \pm 0.42$
ADG (kg)	$0.23^{x} \pm 0.03$	$0.24^{x} \pm 0.01$	$0.21^{y} \pm 0.05$	$0.21^{y} \pm 0.06$

[a,b] Means with different superscripts with the same row and the same sex group differ (P <0.05)
[x,y] Means with different superscripts with the same row and the same genetic group differ (P <0.05)
BWT: birth weigh
WWT: weaning weigh
ADG: pre-weaning average daily gain

Birth weight is related directly to the genetics and nutrition of the pregnant ewe. Most genetic factors that affect birth weight are related to maternal and paternal genes. The additive effect of the Chios breed may have affected the birth weight results. On the other hand, weaning weight is greatly influenced by the dam's milk yield. Since the dams in this study were all from the Awassi breed, it was expected that weaning weight and pre-weaning ADG would not differ between cross and purebred lambs.

Awassi male lambs had greater body length, wither height, width behind the shoulders, heart girth, rump height and hip height compared with female lambs, while no sex effect appeared for the Chios-Awassi lambs for the same traits (Table 2). Genotype of lambs had a significant effect on diagonal body length, hip height and heart girth, while it did not affect (P >0.05) rump height, wither weight and width behind the shoulders. In general, F_1 CA male lambs had numerically greater body dimensions than the purebred male Awassi lambs. Chios-Awassi female lambs had greater (P <0.01) diagonal body length, heart girth, rump height, hip height, wither height and width behind the shoulders than AA female lambs. These results agree with Zamfir *et al.* (2012), who reported that crossbred female lambs had higher values for the same traits in question when compared with the purebred lambs. Contrary to this, Koritiaki *et al.* (2013) found no significant effect between purebred and first-generation crossbred lambs for heart girth and body length at weaning. The superiority of male lambs in body dimension in this study is expected to be due to the influence of the Y-chromosome, which has specific effects on body weight and linear body dimension (Kashan *et al.*, 2005). The effect of sire breed on body dimensions was previously reported by Al-Tarayrah & Tabbaa (1999).

Table 2 Least squares means and standard error for body dimensions in Awassi and Chios-Awassi lambs

	Male		Female	
	Awassi	**Chios-Awassi**	**Awassi**	**Chios-Awassi**
DBL (cm)	56.59[x] ± 1.10	58.44 ± 1.71	49.53[b,y] ± 1.26	56.96[a] ± 1.66
WH (cm)	59.23[x] ± 1.32	58.79 ± 1.87	53.84[b,y] ± 1.49	58.86[a] ± 1.78
WBS (cm)	20.33[x] ± 0.68	18.77 ± 0.98	16.61[b,y] ± 0.77	18.74[a] ± 0.92
HG (cm)	65.43[x] ± 0.97	66.55 ± 1.53	60.06[b,y] ± 1.14	65.09[a] ± 1.45
RH (cm)	61.94[x] ± 0.91	60.37 ± 1.41	55.70[b,y] ± 1.06	59.11[a] ± 1.32
HH (cm)	61.14[x] ± 1.14	61.12 ± 1.67	54.99[b,y] ± 1.30	60.26[a] ± 1.59

[a, b] Means with different superscripts in the same row and the same sex group differ ($P < 0.05$)
[x, y] Means with different superscripts in the same row and the same genetic group differ ($P < 0.05$)
DBL: diagonal body length
WH: wither height
WBS: width behind shoulder
HG: heart girth
RH: rump height
HH: hip height

Chios-Awassi lambs had higher ($P < 0.01$) hot and cold carcass weights, dressing percentage and carcass linear measurements compared with the straight-bred Awassi lambs (Table 3). These results agree with a previous study (Teklebrhan *et al.*, 2014). Since carcass traits are moderately to highly heritable (Waldron *et al.*, 1992), these results were expected.

Table 3 Least squares means and standard error for carcass linear measurements for Awassi and Chios-Awassi lambs

Trait	Breed	
	Awassi	**Chios-Awassi**
HCW (kg)	8.48[b] ± 0.45	9.18[a] ± 0.46
CCW (kg)	8.4[b] ± 0.45	9.1[a] ± 0.45
DP%	44[b] ± 0.01	47[a] ± 0.01
CL (cm)	86.8[b] ± 1.69	95.6[a] ± 1.74
LL (cm)	17.89[b] ± 0.44	21.75[a] ± 0.44
CMSW (cm)	12.13[b] ± 0.46	14.98[a] ± 0.46
CWBS (cm)	11.25[b] ± 0.36	13.37[a] ± 0.36

[a,b] means with different superscripts with the same row differ ($P < 0.05$)
HCW: hot carcass weight;
CCW: cold carcass weight;
DP: dressing percentage;
CL: carcass length;
LL: leg length;
CMSW: carcass maximum shoulder width;
CWBS: carcass width behind the shoulder

The genotype of the lamb had a significant effect on shoulder, fat tail and leg weights, while it did not affect ($P > 0.05$) rack and loin weights (Table 4). Shoulder and leg weights were heavier ($P < 0.05$) for CA lambs than for AA lambs, while fat tail weights were lower ($P < 0.05$). These results agree with Moreno *et al.* (2001), who found that fat tail weights for F_1 Zel-Chaal were lower ($P < 0.05$) than in purebred Chaal lamb.

Chios-Awassi lambs did not differ ($P > 0.05$) from AA lambs in rack and loin weights. These results agree with Ružić-Muslić *et al.* (2012), who found no difference ($P > 0.05$) in rack and loin weights among two crossing F_1 Pramenka–Württemberg and three crossing F_1 Pramenka-Württemberg-Ile de France.

Table 4 Least squares means and standard error for carcass cuts in Awassi and Chios-Awassi lambs

Trait	Genetic group	
	Awassi	**Chios-Awassi**
Shoulder (kg)	3.34[b] ± 0.14	3.72[a] ± 0.15
Rack (kg)	0.58 ± 0.07	0.66 ± 0.07
Loin (kg)	0.66 ± 0.05	0.8 ± 0.05
Legs (kg)	2.98[b] ± 0.19	2.72[a] ± 0.19
Fat tail (kg)	0.41[a] ± 0.05	0.25[b] ± 0.05

[a, b] Means with different superscripts with the same row differ ($P < 0.05$)

The genotype of the lambs had a significant effect on the depth of subcutaneous fat over the *M. obliquus externus* abdomini (J), the depth of tissue over the surface of rib at point 110 mm from the midline and area of *M. longissimus (*GR). However, lamb genotype did not affect ($P > 0.05$) the depth of subcutaneous fat over the *M. latissius dorsi* at a point at the right angles to the midline (S2), fat thickness over the ventral edge of *M. gluteus medius* (L3), muscle weight (EMW), *M. longissimus* width (A), and *M. longissimus* depth (B). Table 5 shows least squares means and SE for fat thickness and *M. longissimus* measurements of AA and CA lambs. J and GR were greater ($P < 0.05$) in F_1 CA than in AA lambs. These results agree with Cloete *et al.* (2007). Neither S2 nor L3 differed ($P > 0.05$) between genotypes, which agrees with Kashan *et al.* (2005), who reported that S2 and L3 for F_1 Suffolk-Merino did not differ from purebred Merino lambs.

Table 5 Least squares means and standard error for fat thickness and *M. longissimus* measurements of Awassi and Chios-Awassi lambs

Trait	Genetic group	
	Awassi	**Chios-Awassi**
L3 (mm)	1.78 ± 0.28	1.63 ± 0.28
S (mm)	1.11 ± 0.18	1.16 ± 0.19
J (mm)	1.35[b] ± 0.31	2.44[a] ± 0.32
GR (mm)	8.2[b] ± 0.43	10.9[a] ± 0.43
A (mm)	53.7 ± 0.94	53.13 ± 0.94
B (mm)	19.13 ± 1.13	18.4 ± 1.13
LMA (cm^2)	9.0[b] ± 0.09	9.3[a] ± 0.10
EMW (g)	73.8 ± 3.84	70.9 ± 3.84

[a, b] Means with different superscripts with the same row differ ($P < 0.05$)
L3: fat thickness over the ventral edge of *M. gluteus medius*
S2: depth of subcutaneous fat over the *M. latissimus dorsi* at a point at right angles to the midline
J: the depth of subcutaneous fat over the *M. obliquus externus abdominis*
GR: depth of tissue over the surface of rib at point 110 mm from the midline
A: *M. longissimus* width
B: *M. longissimus* depth
LMA: area of *M. longissimus*
EMW: eye muscle weight

The area of *M. longissimus* was higher ($P <0.05$) in CA than in AA lambs. These results agree with those of Ružic-Muslic *et al.* (2012), who found that the area of *M. longissimus* was greater in F_1 Poll Dorset-Border Leicester Merino than in purebred Merino lambs. CA lambs did not differ ($P >0.05$) from AA lambs at eye muscle weight, *M. longissimus* width, and *M. longissimus* depth. Similar results were reported by Teklebrhan *et al.* (2014), who found that eye muscle weight, *M. longissimus* thoracis depth and *M. longissimus thoracis* width did not differ for F_1 Ile de France-Merino Branco from purebred Merino Branco lambs.

Least squares means and standard error (SE) for dissected leg cut components in AA and CA lambs are presented in Table 6. Lamb genotype did not affect subcutaneous fat weight, intermuscular fat weight, total muscle weight, total bone weight, *M. semitendinosus*, *M. semimembranosus* and *M. quadriceps*, but had a significant effect on *biceps femoris* muscle weight. Chios-Awassi lambs had similar subcutaneous fat weight, intermuscular fat weight, total muscle weight and total bone weight to AA lambs. These results agree with those of Gardner *et al.* (2007), who found that crossbred Awassi lambs did not differ from Awassi lambs for the same traits. In the present study, the lack of difference in three of the leg muscles agrees with Scales *et al.* (2000), who found that *semimembranosus, semitendinosus* and *quadriceps* muscle weight was not affected by crossbreeding in Romney lambs. Chios-Awassi lambs had heavier ($P <0.01$) *biceps femoris* muscle weight than the AA lambs. Similar results were reported by Scales *et al.* (2000), who found the *biceps femoris* muscle weight was heavier in F_1 East Friesian (Finn-Texel) than in purebred Romney lambs.

Table 6 Least squares means and standard error for dissected leg cut weight in Awassi and Chios-Awassi lambs

Item	Genetic group	
	Awassi	**Chios-Awassi**
Semitendinosus muscle weight (g)	51.74 ± 2.91	43.62 ± 3.01
Semimembranosus muscle weight (g)	109.6 ± 6.11	94.34 ± 6.29
Biceps femoris muscle weight (g)	119.7[b] ± 5.47	101.1[a] ± 5.55
Quadriceps muscle weight (g)	196.5 ± 14.98	138.6 ± 15.43
Subcutaneous fat weight (g)	91.25 ± 15.90	85.12 ± 16.12
Intermuscular fat weight (g)	38.7 ± 1.35	37.0 ± 1.37
Total muscle weight (g)	912.06 ± 43.1	875.7 ± 44.16
Total bone weight (g)	405.9 ± 13.94	440.6 ± 14.33

[a,b] Means with different superscripts within the same row differ ($P <0.05$)

Conclusion

In conclusion, using Chios rams as sires had a positive effect on lamb birth weight without affecting weaning weight and pre-weaning ADG. Reciprocal crosses may be created to improve these traits because of the higher milk production in the Chios breed ewes. Finally, aside from leg and tail weights, crossbreeding Awassi with Chios improved some carcass traits at weaning.

Authors' Contributions
M.D.O: Designing, supervising and writing the manuscript, A.Y.A.: Helping in statistical analysis and manuscript writing, S.K.: Drafting the manuscript, B.S.O.: Helping in technical writing, K.J.: Drafting the manuscript, H.S.S.: Drafting the manuscript.

Conflict of Interest
The authors declare that there are no conflicts of interests.

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