Small Ruminant Research 144 (2016) 269–275

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Lifetime Reproductive and Lamb Crop Yields of Fat-tailed Naeemi and Imported Border Leicester Merino Ewes in Intensive System of Production

Samira Ahmed Mohammed*, Mohammed Abdur Razzaque

Desert Agriculture and Ecosystems Program, Kuwait Institute for Scientific Research, P.O. Box 24885, Safat 13109, Kuwait

ARTICLE INFO

Article history:
Received 25 April 2016
Received in revised form 3 October 2016
Accepted 4 October 2016
Available online 5 October 2016

Keywords:
Naeemi
BLM
Crossbreed
Seasons

ABSTRACT

Local fat-tailed and imported thin-tailed sheep breeds are used for lamb production in hot arid zones. These animals are exposed to an extended summer (seven months) and shorter autumn, winter and spring seasons. The present study examined relative reproductive and lamb crop yields of low and high prolific Naeemi (N) and Border Leicester Merino (BLM) ewes under the intensive management system respectively. Mating systems used were N × N pure breeding and BLM × N rams in three-way crossing. The BLM ewes gave birth to 1.48 lambs per ewe per year as compared to 0.78 lambs per ewe per year for N. The weight of lambs born per ewe was 35% higher and weight weaned 45% higher for BLM ewes compared to N ewes.

The lamb mortality was 10% with no significant differences between breeds. The parity significantly ($P \leq 0.05$) affected all reproductive traits in both the BLM and the N ewes, except the litter size in N, which was unaffected by parity. The N showed maximum reproduction at second parity (1.08 lambs/ewes) and BLM at third parity (1.63 lambs per ewe). While the lambs from BLM ewes' first parity showed the highest mortality (21%), lambs from fifth parity showed the lowest mortality (4.5%). The weight of lambs born and weaned was significantly higher ($P \leq 0.05$) in autumn-mated than summer-mated BLM ewes. For BLM ewes, mortality was significantly higher ($P \leq 0.05$) in summer-born lambs than the lambs born in autumn, winter or spring. This study has demonstrated a moderate lifetime productivity of local N ewes and marked superiority of BLM to N for ewe reproduction and lamb crop yields under the intensive management system.

1. Introduction

Fat-tailed sheep breeds form one-third of the sheep population in the Middle East and West Asia including the hot arid Arabian Gulf region yet they produce a very small proportion of lamb and mutton despite their high demand. Fat-tailed sheep, mainly Awassi (called Naeemi in Kuwait), is an important genetic resource playing a significant role in 30 West Asians countries including the Gulf region. They evolved to fit the harsh climate (Razzaque and Mohammed, 2010; Razzaque et al., 1995) and produce lean meats with excellent flavor and taste. Therefore, the market price of meats of fat-tailed sheep is two to three times higher than that of thin-tailed sheep. Yet, the self-sufficiency of highly preferred locally produced lambs and mutton in Kuwait of fat-tailed sheep ranged from 10 to 12% during the past five years (FAO, 2015).

Considering the demand and value of fat-tailed sheep in the hot arid Gulf region, studies were initiated to compare prolific grazing of thin-tailed sheep breeds of Australia and Europe with fat-tailed Naeemi (N). Nagdi and Arabi fat-tailed local breeds were also evaluated and they were phased out from continued studies for grazing and intensive lamb production (Razzaque et al., 2000; Razzaque and Mohammed, 2010) practice in Kuwait. Intensive (zero grazing) management of sheep in those studies resulted in increased lambing rate from 70% in grazed to 100% in intensive system (Razzaque et al., 1995). Comparative studies involved ewes of purebred N and imported Chios, Texel, Suffolk, Dorset and crossbred Suffolk × Merino and Border Leicester x Merino (BLM). Only N and BLM ewes were found to be suitable for Kuwait's intensive system (Razzaque et al., 2000). These studies involving N × N and BLM (ewes) × N (rams) crossbreeding in intensive housing were carried out for a shorter duration ranging from two to three breed-

* Corresponding author.
E-mail address: smohamad@kisr.edu.kw (S.A. Mohammed).

http://dx.doi.org/10.1016/j.smallrumres.2016.10.006

ing cycles (Razzaque et al., 2000). Therefore, the full reproductive and crop yield potential of N and BLM ewes during their lifetime have not been previously assessed.

The objective of this study was to investigate the lifetime reproductive performance and lamb crop yields of N and BLM ewes mated with N rams and managed in intensive system on high concentrate diets.

2. Materials and methods

2.1. Study location and environment

The experiments were conducted at the livestock research center (LRC) of Kuwait Institute for Scientific Research at Kabd located 25 km south west of Kuwait City. Maximum and minimum temperatures were 51 °C and 1 °C, in August and January, respectively. The relative humidity was 70–80% in winter (December–February) and 12–20% in mid-summer (June–August), and year to year variations of these two environmental factors was not significant. Both N and BLM sheep adjusted very well to environmental conditions in Kuwait (Razzaque and Ibnoaf, 1990).

2.2. Experimental animals

A total of 180 local N ewes, 323 imported Australian BLM ewes and 60 N rams were used for a 6-y duration study. N ewes and rams were purchased from local breeders and selected for the study (Razzaque et al., 1995). Naeemi ewe-lambs were 9 months–12 months old, and their mean live weight was 35 ± 1.5 kg. The N rams were 18–24 months old with a mean live weight was 50 ± 1.7 kg. The imported BLM lamb ewes were 7–8 months old and weighed 35 ± 1.8 kg at the time of importation from Australia.

2.3. Housing management of intensive system

Two corrugated steel sheds were used. The dimensions were 60 m length × 20 m width × 4 m height. The sheds were divided into 2 sections of 8 pens per section. Each section was open to a backyard. Animals were allowed to move freely in their respective backyards throughout the year but were restricted to their shed in hotter daylight hours during the summer.

2.4. Feeds and feeding management

Complete rations were formulated with a concentrate (C) to roughage (R) ratio of 70C:30R. Tables 1 and 2 show the dietary ingredients and their composition. Crude protein (CP) and digestible energy (DE) content were 13.42% and 12 MJ/kg in dry matter, respectively. The rams were offered maintenance (M) diets for two weeks before joining and the amount was increased by M × 1.25 two months post mating. All ewes were offered the same ration prior to mating season. Dietary adjustments were made based on desired body condition scores of 3.0–3.5 (BCS 1–5 scale) ewes during mating and post mating (NRC, 2007). All animals had ad libitum access to freshwater and mineralized salt licks. Lambs were weaned at two months of age. Suckling lambs were not creep-fed but had access to feed offered to their mothers prior to their weaning.

2.5. Seasonal breeding and lambing plan

The study plan was to breed the N and BLM ewes year round. However, in year one ewes that conceived in winter (January–February) had lambed in hot summer (June–July), resulting in high lamb mortality due to heat stress (Table 8). Therefore, the practice of winter breeding was discontinued. The subsequent mating plan followed was this: 1. summer (May–July), for lambing in October–December and 2. autumn (September–November) for lambing in February–April.

Table 1
Ration ingredients of concentrate and roughages.

Ingredients	Ration (%)
Concentrates	
Barley (*Hordeum vulgare*)	40.5
Wheat bran (*Triticum boeoticum* L)	10.0
Corn (*Zea mays*)	10.0
Soya bean Meal (*Glyine max*)	6.5
Vitamins and minerals premix*	1.0
Limestone	1.0
Salt	1.0
Roughages	
Alfalfa hay (*Medicago sativa*)	15.0
Wheat Straw (*Triticum boeoticum* L)	15.0

*Vitamins and minerals premix.
Phosphorus : 5.00%.
Calcium : 18.00%.
Sodium : 5.00%.
Magnesium : 5.00%.
Manganese : 500 mg/kg (as manganese oxide).
Cobalt : 100 mg/kg (as cobaltous sulphate).
Zinc : 2000 mg/kg (as zinc oxide).
Iodine : 125 mg/kg (as calcium iodate).
Selenium : 10 mg/kg (as sodium selenite).
Vitamin A : 400000 IU/kg.
Vitamin D3 : 100000 IU/kg.
Vitamin E (Alpha-Tocopherol) : 400 IU/kg.

Table 2
Chemical composition of mixed ration ±SD (%) on dry basis.

Moisture	8.01 ± 0.12
DE (MJ/kg DM)	12.00 ± 0.51
DM	91.99 ± 0.08
Ash	5.46 ± 0.17
CP	13.42 ± 0.27
EE	1.54 ± 0.85
NDF	20.09 ± 0.54
ADF	4.93 ± 0.26
Ca	0.38 ± 0.049
P	1.24 ± 0.02

DE: Digestible Energy; DM: dry matter; CP: crude protein; EE: ether extract; NDF: neutral detergent fiber; ADF: acid detergent fiber; Ca: calcium; P: phosphorous.

2.6. Estrus synchronization protocol

All ewe lambs were mated by the rams naturally at first parity with some assistance by the shepherd when needed. Synchronized estrus of ewes and natural mating by the N rams were introduced to the breeding plan from the second parity for both breeds. Estrus synchronization was carried out by intravaginal sponges charged with 30 mg progesterone (Chronogest CR, Intervet International B.V., Netherlands). The sponges were left in situ for 12 days. Folligon (400 IU) of pregnant mare serum gonadotrophin (PMSG) (Chronogest CR, Intervet International B.V., Netherlands) was injected two days prior to withdrawal of sponges, which coincided with the first day of three-months mating period. Proven fertile rams with good libido were introduced to ewe flocks following withdrawal of sponges at a ratio of eight to ten ewes/ram (Razzaque et al., 1995), and the rams remained with ewes throughout the mating period with diagnosed empty ewes only.

Table 3
Means ± S.E. for overall annual reproduction and lamb production of N and BLM ewes.

Biological trait	N	BLM	Contrast/Significant
Fertility (%) (EL/EJ)	60 ± 5.0 (880)	88 ± 20 (1590)	**
Litter size (LB/EL)	1.26 ± 0.06(439)	1.39 ± 0.02 (1351)	*
Lamb born (LB/EJ)	0.78 ± 0.13 (831)	1.28 ± 0.04 (1580)	**
Weight born (kg) (WTB/EJ)	3.4 ± 0.7 (831)	5.20 ± 0.2 (1580)	**
Lamb weaned (LW/EJ)	0.72 ± 0.12 (760)	1.30 ± 0.04 (1450)	**
Weight weaned (kg) (WTW/EJ)	12.9 ± 2.2 (760)	20.4 ± 0.8 (1450)	**

N: Naeemi; BLM: Border Leicester Merino; EL: ewes lambed; EJ: ewes joined; LB: lambs born; WTB: weight born; LW: lambs weaned; WTW: weight weaned. The number of records shown within parentheses. Data on yearling ewe lambs excluded. $^{*}P \leq 0.05$; $^{**}P \leq 0.01$.

Breeding programs used were pure breeding N × N and BLM ewes × N rams, three-way crossing. The aforementioned protocols were used in mating of N and BLM ewes for second to sixth parity in both summer and autumn seasons by the same trained professional staff and once in a breeding season. As a result, the procedural steps did not differ in mating, lambing and the recording the study variables.

2.7. Mating and pregnancy diagnosis

Rams used for breeding were fixed with a unique marking harness to allow identification of ewe for successful mating. Rams and the color of their marking harness were swapped out every 15 days. Pregnancy diagnosis was carried out 45 days after the introduction of the rams to ewes by ultrasound scanner (Draminski Animal profi, Poland). The confirmed pregnant ewes were housed in separate pens, and the pregnancy diagnosis was carried out again 45 days after the first negative one. Only empty ewes were kept for second synchronization of estrus by the same method used the first time.

2.8. Post-lambing management

After lambing, the ewes were weighed, body condition scored and kept in smaller individual pen (1.5 m × 1.0 m) for lambing. The lambs were weighed at birth, ear tagged and bottle fed the colostrum 50 ml three times a day from their dams. The ewes were vaccinated for *Pasteurellosis* and clostridium infections during the pregnancy. The lambs were also vaccinated for pasteurella and clostridia infections after weaning.

2.9. Statistical analyses

Unbalanced sheep breeding design was used with one sire breed (N) and two genotype ewes (N and BLM), with reciprocal crossing between BLM x N. The effect of year on ewe performance was not studied. For analysis the reproductive traits of ewe genetic group were fitted as a fixed effect. Ewe live weight was included as a linear covariate, found to be not significant, and therefore, deleted from the final analysis. To compare the genetic group means (pooled over ages) for the reproductive traits, weighed means were computed for each genetic group and pooled to compute standard error deviations. Sires effect was not included in the analysis since sires were replaced every two weeks during mating.

The analytical models used for birth weight, weaning weight, perinatal lamb mortality and pre-weaning lamb mortality included the fixed effects of genetic group, season of birth and sex of lamb. Dams' parity and litter size were used as covariates for the analysis of birth weight. The analyses of weaning weight and lamb mortality included regression on birth weight, dam's parity and litter size. Since all the sources of variation included in the statistical models were fixed, residual mean squares were used to test the significance of the effects. Analysis of variance provided "F" test for the comparing means for the major effects included in the models. However, where necessary the least significant difference test was used to separate individual means.

3. Results

3.1. Reproductive performance of ewes

There were significant differences between genetic groups in fertility ($P \leq 0.01$), litter size ($P \leq 0.05$), birth and weaning weights of lambs ($P \leq 0.01$) (Table 3). It was observed that crossing N rams with BLM ewes substantially increased lamb production. The overall BLM ewes out-produced N ewes by 31% in fertility, 9% in litter size and 47% lambs born per ewe joined per year. Total weight of lamb born and weaned per ewe joined were 35% and 45% higher in BLM than N ewes.

3.1.1. Effect of parity of ewes on fertility

Parity of ewes had significant effects on most reproductive traits in both breeds of ewes with the exception of litter size, which

Table 4
Means ± S.E for overall annual reproduction and lamb production of N and BLM ewes according to their parity.

Genetic group	Parity No.	Fertility (%) (EL/EJ)	Litter size (LB/EL)	Lamb born (LB/EJ)	Weight born (kg) (WTB/EJ)	Lamb weaned (kg) (LW/EJ)	Weight weaned (kg) (WTW/EJ)
N	1	61 ± 6^{a} (180)	1.15 ± 0.08^{a} (108)	0.70 ± 0.08^{a} (173)	2.9 ± 0.3^{a}	0.7 ± 0.08^{a} (156)	12.1 ± 1.6^{a}
	2	77 ± 5^{b} (177)	1.43 ± 0.12^{a} (136)	1.08 ± 0.12^{b} (164)	5.6 ± 0.6^{b}	1.02 ± 0.01^{b} (150)	17.7 ± 2.3^{b}
	3	53 ± 5^{ac} (177)	1.25 ± 0.10^{a} (94)	0.70 ± 0.12^{a} (170)	2.5 ± 0.5^{a}	0.63 ± 0.15^{a} (154)	11.3 ± 2.5^{a}
	4	42 ± 5^{c} (164)	1.24 ± 0.10^{a} (69)	0.55 ± 0.14^{a} (155)	1.9 ± 1.1^{a}	0.42 ± 0.14^{a} (146)	9.3 ± 2.4^{a}
	5	44 ± 3^{c} (153)	1.3 ± 0.04^{a} (67)	0.61 ± 0.22^{a} (143)	2.2 ± 0.9^{a}	0.77 ± 1.0^{a} (130)	16.5 ± 0.31^{b}
	6	46 ± 1^{c} (137)	1.32 ± 020^{a} (63)	0.69 ± 2.1^{a} (127)	3.45 ± 1.2^{a}	0.8 ± 0.52^{ab} (121)	15.9 ± 2.0^{ab}
BLM	1	79 ± 2^{a} (323)	1.09 ± 0.03^{a} (255)	0.87 ± 0.03^{a} (311)	3.7 ± 0.1^{a}	0.73 ± 0.0^{a} (197)	13.5 ± 0.5^{a}
	2	89 ± 2^{b} (318)	1.52 ± 0.05^{b} (284)	1.31 ± 0.4^{b} (312)	5.1 ± 0.2^{b}	1.11 ± 0.04^{b} (284)	21.5 ± 0.8^{bd}
	3	88 ± 9^{b} (312)	1.53 ± 0.07^{b} (274)	1.43 ± 0.06^{c} (309)	5.8 ± 0.2^{c}	1.44 ± 0.05^{c} (255)	25.0 ± 0.9^{c}
	4	93 ± 2^{b} (309)	1.45 ± 0.03^{b} (286)	1.36 ± 0.05^{c} (298)	6.5 ± 0.4^{c}	1.40 ± 0.05^{c} (263)	23.4 ± 0.8^{bc}
	5	100 ± 0^{b} (297)	1.37 ± 0.04^{b} (296)	1.39 ± 0.05^{c} (281)	5.0 ± 0.1^{b}	1.25 ± 0.09^{bc}(259)	19.4 ± 0.9^{d}
	6	95 ± 1^{b} (286)	1.40 ± 0.3^{b} (271)	1.34 ± 1.2^{c} (274)	5.0 ± 0.1^{b}	1.31 ± 1.1b^{c} (255)	18.3 ± 0.98^{d}

Means within column and breed with different upper case letters differ at $P \leq 0.05$. N: Naeemi; BLM: Border Leicester Merino; EL: ewes lambed; EJ: ewes joined; LB: lambs born; WTB: weight born; LW: lambs weaned; WTW: weight weaned. The number of records shown within parentheses.

Table 5
Means ± S.E. for the effect of season of mating on overall reproduction and lamb production of N and BLM ewes.

	Naeemi		BLM	
	Autumn-mated	Summer-mated	Autumn-mated	Summer-mated
Fertility (%) (EL/EJ)	63.0 ± 7[a] (500)	56.0 ± 8[a] (488)	80.0 ± 2.0[a] (950)	92.0 ± 3.0[a] (895)
Litter size (LB/EL)	1.23 ± 0.09[a](276)	1.23 ± 0.09[a](271)	1.28 ± 0.2[a] (787)	1.53 ± 0.02[b](819)
Lamb born (LB/EJ)	0.72 ± 0.13[a](472)	0.61 ± 0.16[a](460)	1.17 ± 0.05[a](950)	1.19 ± 0.06[a](835)
Weight born (kg) (WTB/EJ)	3.6 ± 0.9[a] (472)	3.2 ± 0.7[a] (460)	5.6 ± 0.4[a] (950)	4.7 ± 0.2[b] (835)
Lambs weaned (LW/EJ)	0.68 ± 0.13[a](446)	0.59 ± 0.15[a](458)	0.91 ± 0.05[a](947)	0.96 ± 0.05[a](809)
Weight weaned (kg) (WTW/EJ)	12.9 ± 2.4[a] (446)	11.9 ± 2.2[a] (458)	21.5 ± 0.9[a] (947)	19.6 ± 0.8[b] (809)

Means within row and breed with different upper case letters differ at $P \leq 0.05$. N: Naeemi; BLM: Border Leicester Merino; EL: ewes lambed; EJ: ewes joined; LB: lambs born; WTB: weight born; LW: lambs weaned; WTW: weight weaned. The number of records shown within parentheses.

Table 6
Means ± S.E. of birth weight, weaning weight, perinatal and pre-weaning lamb mortality and regression coefficients for dams' parity, litter size, birth weight and birth weight for pure N lambs and N × BLM cross lambs.

	Birth weight (kg)		Weaning weight(kg)	Lamb mortality (%)	
	Perinatal	Pre-weaning			
Genetic group	**		*	N.S.	N.S.
N	3.2 ± 0.08 (1056)		17.0 ± 0.35 (1050)	5.7 ± 2.4	8.7 ± 2.4
N × BLM	3.5 ± 0.03 (1879)		17.8 ± 0.10 (1616)	6.3 ± 0.7	10.1 ± 0.9
Regression coefficients					
Dams' parity (linear)	0.054 ± 0.019**	−0.564 ± 0.083**		N.S.	N.S.
Litter size (Linear)	−0.923 ± 0.03**	−1.689 ± 0.165**		−3.497 ± 1.104**	3.560 ± 0.849**
Birth weight (Linear)	–	1.672 ± 0.105**		−3.681 ± 0.683**	−4.698 ± 0.849**
Birth weight (Quad)	–	N.S.		2.222 ± 0.365**	2.657 ± 0.453**

N: Naeemi; BLM: Border Leicester Merino; *$P \leq 0.05$; **$P \leq 0.01$; N.S.: Not Significant. The number of records shown within parentheses.

remained unchanged (Table 4). Fertility in N ewes significantly ($P \leq 0.05$) increased from first to second parity but decreased non-significantly from the third parity onwards ($P \geq 0.05$). Whereas, the fertility in BLM ewes increased significantly from 79% at first parity to 89% at second parity and this increase was maintained through to the sixth parity ($P \leq 0.05$). For N there was a significant increase ($P \leq 0.05$) in LB/EJ, WTB/EJ, LW/EJ and WTW/EJ from first to second parity. Litter size of BLM ewes increased from first to second parity and remained constant thereafter. BLM lambs born (LB/EJ), weight born (WTB/EJ), lamb weaned (LW/EJ) and weight weaned (WTW/EJ) increased from first to fourth parity and showed a decline at fifth parity, although this decline was not significant for LW/EJ. BLM ewes showed maximum performance at second to fifth parity and N at second parity in their lifetime.

3.1.2. Effects of mating season on performance of ewes

There was no significant effect of season on the reproductive traits of N ewes (Table 5). The effect of season was only significant ($P \leq 0.05$) for LB/EL, WTB/EJ and WTW/EJ of BLM ewes. It thus appeared both BLM and N ewes were successfully mated in the summer and maintained their pregnancy.

3.2. Performance of lambs

3.2.1. Birth weight

Crossbred (N x BLM) lambs were significantly heavier ($P \leq 0.01$) at birth (adjusted for dams' parity and litter size) and at weaning ($P \leq 0.05$) (adjusted for dams' parity, litter size and birth weight) than purebred N lambs (Table 6). Effect of genetic group on lamb

Table 7
Means ± S.E. of the effect of N and BLM ewe parity number on lamb birth weight, weaning weight and perinatal and pre-weaning lamb mortality.

Geneticgroup	Ewe parity	Birth weight (kg)	Weaning weight (kg)	Lamb mortality (%)	
				Perinatal	Pre-weaning
N	1	3.3 ± 0.23[a] (173)	16.2 ± 1.1[a] (156)	4.2 ± 1.9[a]	5.1 ± 5.0[a]
	2	2.6 ± 0.44[a] (164)	19.7 ± 2.1[a] (150)	2.9 ± 3.0[b]	6.5 ± 73.7[a]
	3	3.2 ± 0.20[a] (170)	17.4 ± 1.0[a] (154)	2.0 ± 0.9[b]	5.4± 6.2[a]
	4	3.5 ± 0.25[a] (155)	19.1 ± 1.2[a] (146)	1.4 ± 2.3[b]	4.4 ± 6.0[a]
	5	3. 5 ± 0.05[a] (143)	16.5 ± 0.05[a] (130)	4.6 ± 1.7[a]	5.0 ± 0.33[a]
	6	3.5 ± 0.50[a] (127)	18.9 ± 1.00[a] (121)	0.8 ± 0.4[b]	3.9 ± 0.23[a]
BLM	1	3.8 ± 0.06[a] (311)	17.3 ± 0.26[a] (197)	15.6 ± 1.4[a]	21.0 ± 1.7[a]
	2	3.1 ± 0.07[b] (312)	20.4 ± 0.28[b] (284)	3.9 ± 1.8[b]	5.0 ± 1.8[b]
	3	3.3 ± 0.04[b] (309)	17.9 ± 0.17[a] (255)	6.1 ± 1.0[b]	11.3 ± 1.3[c]
	4	3.6 ± 0.05[a] (298)	16.4 ± 0.20[c] (263)	4.2 ± 1.1[b]	7.4 ± 1.4[b]
	5	3.6 ± 0.07[a] (281)	17.4 ± 0.30[a] (259)	3.3 ± 1.5[b]	4.5 ± 2.0[b]
	6	3.7 ± 0.04[a] (274)	18.3 ± 0.21[a] (255)	3.0 ± 1.6[b]	3.9 ± 1.1[d]

N: Naeemi; BLM: Border Leicester Merino. Means within column and breed with different upper case letters differ at $P \leq 0.05$. The number of records shown within parentheses.

Table 8
Means ± S.E. for the effect of season of N and BLM lambing on lamb birth weight, weaning weight and perinatal and pre-weaning lamb mortality.

Genetic group	Lambing season	Birth weight (kg)	Weaning weight (kg)	Lamb mortality (%)	
				Perinatal	Pre-weaning
N	Winter	4.0 ± 0.33^{a} (85)	15.2 ± 1.6^{a} (80)	3.00 ± 3.3^{a}	5.1 ± 6.7^{a}
	Spring	3.0 ± 0.29^{b} (380)	18.3 ± 1.4^{ab} (359)	3.2 ± 4.7^{a}	4.7 ± 5.7^{a}
	Summer	2.8 ± 0.28^{b} (88)	20.1 ± 1.4^{b} (83)	1.2 ± 5.2^{a}	6.0 ± 11.7^{a}
	Autumn	2.8 ± 0.26^{b} (379)	18.7 ± 1.3^{ab} (351)	2.5 ± 4.6^{a}	6.5 ± 5.6^{a}
BLM	Winter	3.7 ± 0.06^{a} (150)	17.4 ± 0.23^{a} (135)	5.3 ± 1.4^{a}	7.1 ± 1.8^{a}
	Spring	4.0 ± 0.05^{b} (734)	18.9 ± 0.22^{b} (660)	2.4 ± 1.2^{a}	9.8 ± 1.8^{a}
	Summer	3.2 ± 0.07^{c} (161)	17.7 ± 0.30^{a} (83)	22.3 ± 1.5^{b}	27.4 ± 1.8^{b}
	Autumn	3.2 ± 0.04^{c} (740)	17.5 ± 0.16^{a} (666)	4.4 ± 0.8^{a}	6.7 ± 1.0^{a}

Means within column and breed with different upper case letters differ at $P \leq 0.05$. Data of summer and winter lambing seasons of N and BLM were means of the first parity only. The number of records shown within parentheses.

perinatal and preweaning mortality (adjusted for dams' parity, litter size and birth weight) was not significant. Regression of birth and weaning weights on dams' parity was significant ($P \leq 0.01$) but that of lamb mortality was not. Litter size (linear) was significant ($P \leq 0.01$) for all traits. Only linear regression on birth weight was significant ($P \leq 0.01$) for weaning weight, whereas, for lamb mortality both linear and quadratic terms were significant ($P \leq 0.01$).

3.2.2. Ewe parity affecting lamb performance

Parity of N ewes had little effect on the birth and weaning weights of their lamb. The N parity effect was significant ($P \leq 0.05$) only in the perinatal mortality (Table 7). Significantly heavier ($P \leq 0.05$) lambs were produced by the BLM ewes (3.6 to 3.8 kg) during first, fourth, fifth, sixth parities compared to second and third parity. There were no consistent trends between weaning weight of lambs and parity of BLM ewes. Weaning live weight of BLM lambs was significantly heavier ($P \leq 0.05$) in second parity.

An overall regression of lamb mortality of ewe parity based on the combined data of the N and BLM ewes was not significant (Table 7). However, the lambs of BLM ewes of first parity showed significantly higher ($P \leq 0.05$) mortality both in perinatal and preweaning periods. More than 50% of the total preweaning loss was observed in the perinatal period. Over 50% of the lambs that died were either born dead or died within one week of birth.

3.3. Effects of season on birth and weaning weights of lambs

Purebred N lambs born in winter had heavier birth weights whereas summer-born lambs had heavier weaning weights than the lambs born in other seasons (Table 8). Lambs from BLM ewes born in summer and autumn had similar birth weights, but they were smaller and lighter than lambs born in spring and winter. In turn, spring born lambs from BLM ewes weighed heavier at birth than winter born lambs. The spring born lambs were also heavier at weaning than lambs born in other seasons. Perinatal and preweaning mortality was significantly higher ($P \leq 0.05$) for lambs from BLM ewes born in summer than in other seasons. There was no significant effect of season on N lamb mortality.

4. Discussion

4.1. Fertility of local N and imported BLM ewes

The most important aspects of the present study were focused on two ewes' genotypes and seasonal differences affecting ewe and lamb performance. An improved fertility of ewes is necessary for efficient lamb crop yield and meat production. Most of the feed required to produce a lamb is consumed by the ewe. Thus, the larger lambs the ewe produces, the lower her maintenance requirement would be.

The BLM ewes used in the present study had 50% Merino inheritance while the remaining 50% werederived from Border Leicester breed. The better performance of the BLM ewes compared with the N ewes may be due to the inheritance of the fecundity genes from Border Leicester parent.

An overall 60% ± 5.0 fertility in N ewes in the present study (Table 3) was lower than that in Australian BLM (88% ± 20). The fertility rate of improved Awassi ewes in Turkey has been reported to range from 85.0 to 97% (Galal et al., 2008; Gul and Keskin, 2010). Fertility of 66.7% was reported in naturally mated fat-tailed Ghezel ewes in Iran (Najafi et al., 2014). Studies on fat-tailed Najdi sheep in Saudi Arabia and Rahmani and Ossimi sheep in Egypt also recorded 65 to 67% fertility rate (Ismail, 2000; Shaat 1997). The N sheep used in this study were not from the improved strain of Awassi sheep as found in Turkey and Israel (Ustuner and Ogan, 2013).

4.2. Ewe parity, reproduction and lifetime performance

The economically productive lifetime of sheep is generally considered to be six years. Therefore, the six parity performance recorded in the present study indicated almost the complete lifetime performance for both local N and imported BLM. The fertility rate of yearling ewe lambs appeared to be variable and 79% lambing rate for BLM and 61% for N in present study (Table 4) is comparable to other studies (Abegaz et al., 2002; Ismail, 2000).

There was a significant decline in fertility rates when the parity advanced in N ewes (Table 4). But BLM ewes showed opposite trend of increased fertility rate with advancing of parity. Reason for such differences of the two genotypes could be due to adjustment of imported BLM ewes to Kuwait's environment and the intensive production system. While, the N ewes and their ancestors were already acclimatized to the hot zone for centuries. The performance of BLM in this study was somewhat consistent with the study of Fogarty and Hall (1995). They reported maximum performance of Merino crosses at four to five years old. In the present study an average litter size of the first parity BLM ewes was 1.09 as compared to around 1.5 for second to third parity (Table 4).

4.3. Effect of breeding season on lamb performance

In spite of the higher litter size of the summer-mated ewes, the total weight of lambs born (WTB/EJ) and the total weight weaned (WTW/EJ) for autumn-mated ewes was greater than the summer-mated ewes (Table 5).

The seasonal differences in the WTB/EJ and WTW/EJ cannot be explained by maternal nutrition as food intake of ewes in the two seasons was identical, but may be a consequence of other seasonally related factors such as ambient temperature (Koycegiz et al., 2009). Jenkinson et al. (1995) reported that near full-term fetuses (140 days of gestation) from December-mated (summer) Romney ewes in New Zealand had a lower mean birth weight (4.15 ± 0.16 kg) than fetus from March-mated (autumn) ewes (5.07 ± 0.16 kg). These results are consistent with the present study. In first parity, high BLM lamb losses (21.0%) in summer (Table 7) were obviously related to high ambient temperature, therefore, the lambing plan should coincide with favorable weather of Kuwait for both lambing and growing period.

4.4. Effect of ewe parity on lamb performance

For birth weight, there was a positive regression on ewes' parity but negative regression on litter size (Table 6). This indicates that while older ewes gave birth to heavier lambs, larger litter size reduced birth weight of individual lambs even though total weight of lambs born was heavier when litter size was two or more than when it was one.

Single lambs from second to sixth parity ewes were heavier at birth than single lambs from ewes of first parity (Table 7). Negative regression of weaning weight on ewes' parity may be due to larger litter sizes of older (second to sixth parity) than younger (first parity) ewes, which was consistent with the negative regression of weaning on litter size (b = −1.689, Table 6). Negative regression of perinatal mortality on litter size was due to more single lambs dying in the first week due to diarrhea.

Higher overall preweaning lamb mortality (zero to two months) in lambs born in larger litters (b = 3.56) was probably because of the competition for milk and the mother's inability to meet the demand of two or more offspring. The increase in lamb mortality with increased litter size in this study is in good agreement with several other studies (Holmoy and Waage, 2015; Chniter et al., 2009; Macedo and Hummel, 2006).

At 3.75 kg birth weight, lamb mortality was about 10% and increased rapidly at birth weight of 4.5 kg and above. Fogarty et al. (2000) had also reported curvilinear responses in single lambs, where heavier birth weight lambs died due to dystocia. The linear and quadratic effects of birth weight observed in the present study agree with the data of Thomson et al. (2004), in which lambs of intermediate weight had lowest mortality.

The heavier average birth weight of lambs from first parity ewes (3.8 kg) as compared to the 3.1–3.3 kg average birth weight from second to third parity BLM ewes can be explained on the basis of the difference in litter size (Table 7). Average birth weight of single born lambs, irrespective of parity of the ewe was 4.3 kg. A reduction in birth weight of roughly 20% for each additional littermate was observed. Weaning weights of lambs (adjusted for birth weight and litter size) showed significant differences due to dames' parity in BLM but not in N, which lacked a specific parity-related trend.

Higher perinatal and preweaning mortality in lambs from primiparous first parity BLM ewes in the present study could be due to their relatively poorer mothering ability/milk yield (not measured) than older ewes. A different pattern was noticed for local N lambs, where perinatal mortality was 4.2%. Apart from this, the association of ewes' parity with preweaning lamb mortality appeared to be rather irregular, and regression on parity of ewe was not significant. There were conflicting reports in the literature regarding the effect of parity on lamb mortality. Dwyer et al. (2005) and Fogarty and Hall (1995) both reported a quadratic pattern for the effect of parity. However, while, the former reported minimum lamb mortality in ewes of fourth to fifth parity, the latter found a reverse pattern of mortality with less lamb losses in ewes lambing between first to third parity and more lamb losses in advanced parity.

4.5. Effect of season of birth on lamb performance

The significant effect of season of lambing on birth weight observed in this study (Table 8) was consistent with the finding of Petrovic et al. (2015). They reported significantly heavier birth weight in spring-born than in autumn- or winter-born lambs. The heavier weaning weight of spring-born lambs from BLM ewes that grew in hot conditions of May and June is difficult to explain as higher temperatures would normally be expected to reduce feed intake and weight gain of lambs.

The heavier weight of N lambs born in late summer (June–July) might be due to more favorable weather conditions when these lambs were weaned in autumn. Moreover, lambs from N (being a local breed) are expected to withstand hot weather conditions better than the lambs from BLM ewes imported from Australia. About 22% of the lambs from BLM ewes born in summer died in the first week.

5. Conclusions

This study has demonstrated a moderate lifetime productivity of local N ewes and marked superiority of BLM to N for ewe reproductivity and lamb production under the intensive system. A substantial increase in reproduction, especially in the number and weight of lambs born and weaned, could be achieved by crossing imported BLM ewes with N rams.

The higher price of both pure and crossbred lambs in Kuwait offers the opportunity to produce lambs from intensively managed indoor sheep. These can be a high cost specialist system to produce lambs in seasons when demand is high during festivals and when the prices are attractive. The comparison of two different genotypes provides information to help producers identify breeds that will meet specific production requirements in arid zones, especially Kuwait.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abegaz, S., Duguma, G., Negussie, E., Gelmaesa, U., Terefe, F., Rege, J.E.O., 2002. Factors affecting reproductive performance and estimates of genetic parameters of litter size in Horro sheep. J. Agric. Sci 139, 79–85.
Chniter, M., Maali, S., Hammadi, M., Khorchani, T., Harab, H., Krit, R., Ben Hamouda, M., Khaldi, G., Nowak, R., 2009. Effects of dam age, litter size and gender on birth weight of D'man lamb: consequence on lamb mortality. J. Arid Land Stud. 19, 169–172.
Dwyer, C.M., Calvert, S.K., Farish, M., Donbav, J., 2005. Breed, litter and parity effects on placental weight and placentome number, and consequences for the neonatal behaviour of the lamb. Theriogenology 63 (4), 1092–1110.
FAO, 2015. Statistical Pocketbook World Food and Agriculture. Food and Agriculture Organization of the United Nations.
Fogarty, N.M., Hall, D.G., 1995. Performance of crossbred progeny of trangie fertility Merino and Booroola Merino rams and Poll Dorest ewes. 3. Reproduction, live weigh and wool production of adult ewes. Aust. J. Exp. Agric. 35, 1083–1091.
Fogarty, N.M., Hopkins, D.L., van de, Ven R., 2000. Lamb production from diverse genotypes 1. Lamb growth and survival and ewe performance. Anim. Sci 70, 135–145.
Galal, S., Gursoy, O., Shaat, I., 2008. Awassi sheep as a genetic resource and efforts for their genetic improvement-a review. Small Rumin. Res. 79 (1–2), 99–108.
Gul, S., Keskin, M., 2010. Reproductive characteristics of Awassi ewes under Cornell alternate month accerlerated lambing systems. Ital. J. Anim. Sci. 9, 255–259.
Holmoy, I.H., Waage, S.W., 2015. Time trends and epidemiological patterns of perinatal lamb mortality in Norway. Acta Vet. Scand. 57, 65–76.
Ismail, M.D., 2000. Reproductive performance of local sheep breeds under an intensive breeding system and improvement strategies. In: Malik, R.C., Razzaque, M.A., Al-Nasser, A.Y. (Eds.), Sheep Production in Hot and Arid Zones. Kuwait Institute for Scientific Research, Kuwait, pp. 25–32.
Jenkinson, C.M.C., Mackenzie, D.D.S., McDonald, M.F., McCutcheon, S.N., 1995. Seasonal effects on birth weight in sheep are associated with changes in placenta development. N. Z. J. Agric. Res. 38, 337–345.
Koycegiz, F., Emsen, E., Diaz, C.A.G., Kutluca, M., 2009. Effects of Lambing season, lamb breed and ewe parity on production traits of fat tailed sheep and their lambs. J. Anim.Vet. Adv. 8 (1), 195–198.
Macedo, R., Hummel, J.D., 2006. Influence of parity on productive performance of Pelibuey ewes under intensive management in the Mexican dry tropics. Livest. Res. Rural Dev. 18, 1–7.

NRC National Research Council, 2007. Nutrient Requirements of Small Ruminants. Sheep, Goats, Cervids, and New World Camelids. The National Academic Press, Washington, D.C.

Najafi, G., Cedde, F., Kohram, H., Sharif, A.A., 2014. The effects of using artificial insemination techniques on reproductive performance in Ghezel sheep. Int. J. Adv. Biol. Biomed. Res. 2 (12), 2898–2904.

Petrovic, M.P., Caro Petrovic, V., Ruzic-Muslic, D., Maksimovic, N., Petrovic, M.M., Ilic, Z., Stojkovic, J., 2015. Effect of genetic and environmental factors on the phenotype characteristics of lambs. Biotechnol. Anim. Husbandry 31 (2), 223–233.

Razzaque, M.A., Ibnoaf, M.O.M., 1990. Responses of young and mature wethers exposed to micro-mist cooling in feedlot environment. J. Arid Environ. 19, 341–351.

Razzaque, M.A., Mohammed, S.A., 2010. Three breeds of fat tailed sheep: productive performance in Arabian Gulf Region. Indian J. Small Rumin. 16 (2), 183–189.

Razzaque, M.A., Malik, R.C., Al-Khozam, N., Al-Matrouk, F., Abbas, S., Al-Sabbagh, T., Abdullah, T., Al-Mutawa, T., Al-Taqi, M., Sahni, S., Al-Awadi, A., Hamada, S., 1995. Intensive Lamb Production Using Local and Imported Sheep. Kuwait Institute for Scientific Research, Kuwait (Report No. KISR4719).

Razzaque, M.A., Malik, R.C., Al-Khozam, N., Al-Awadi, A., Mohammed, S.A., Al-Mutawa, T., Taqi, M.A., Al-Sabbagh, T.A., Abdullah, T., 2000. Growth feed efficiency and carcass characteristics of straight bred and crossbred lambs raised under intensive management conditions. In: Malik, R.C., Razzaque, M.A., Al-Nasser, A.Y. (Eds.), Sheep Production in Hot and Arid Zones. Kuwait Institute for Scientific Research, Kuwait, pp. 53–62.

Shaat, E., 1997. Performance of Finn cross ewes. In: Shehata, E.I. (Ed.), Symposium on Use of Exotic Breeds in Improving Sheep Production, Finn Sheep as a Case Study. Finnish-Egyptian Sheep Breeding Project, Egypt, pp. 11–115.

Thomson, B.C., Muir, P.D., Smith, N.B., 2004. Litter size, lamb survival, birth and twelve week weight in lambs born to cross-bred ewes. Proceeding of the New Zealand Grassland Association 66, 233–237.

Ustuner, H., Ogan, M.M., 2013. Main productive performance of Awassi sheep in the Central Anatolian Region of Turkey. Turk. J. Vet. Anim. Sci. 37, 271–276.