Crossbreeding Components for Some Semen Parameters of Bucks Obtained From Crossing Saudi Aradi Goats with Damascus

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Received: 10/6/2009

Abstract: A crossbreeding program between Aradi Saudi breed (A) with Syrian Damascus breed (D) was practiced for three years to produce three genetic groups of AA, DD, and ½D½A. A total number of 191 ejaculates collected from 42 bucks fathered by 12 sires and mothered by 42 dams were used to evaluate semen characteristics of bucks. An animal model was used to estimate heritabilities and permanent environmental effects and variance components obtained by this animal model were used to solve the corresponding mixed model equations, obtaining solutions for the genetic group means and their standard errors. A generalized least square procedure was used to estimate direct additive genetic effects and direct heterosis. Heritabilities obtained for semen characteristics were mostly moderate or low and ranged from 0.04 to 0.16. Direct additive effects were in favour of Aradi bucks by 11.4% for ejaculate volume, 4.2% for live sperms and 5.7% for total sperm output relative to Damascus bucks, while a reverse trend in favour of Damascus bucks was recorded for sperms concentration (-3.6%), total motility of sperms (-15.0%), and dead sperms (24.5%). Positive and significant estimates of direct heterosis for volume of ejaculate (16.3%), total sperms output (12.5%), sperms concentration (5.4 %) along with a negative estimate recorded for abnormal sperms percentage (-3.3%) were favorable for crossbred bucks; *i.e.* crossing Saudi Aradi does with Damascus bucks was associated with an increase in ejaculate volume (0.245 ml, $P<0.01$) and sperm concentration (0.15 x 10^9 per ml, $P<0.05$) along with a reduction in percentage of abnormal sperms (-0.45 %, $P<0.05$).

Keywords: Goats, crossbreeding, semen, direct additive, direct heterosis.

INTRODUCTION

In developing countries, two-breed cross bucks derived from exotic breed (that has demonstrated considerable potentiality in improved productivity in their country of origin) and indigenous goats (that are superior in adaptability) could be more productive under local conditions and requirements. In Saudi Arabia, there is a great deal of interest to improve reproductivity of goats by using crossbreeding and upgrading programs. These programs together with selection are required to characterize genetically these local goat breeds as well as of the so-called exotic breeds that could be used for genetic improvement (Barillet, 2007; Fahmy and Shrestha, 2000; Shrestha and Fahmy, 2007 *a,b*). Since 2006, a goat project was established in Saudi Arabia to develop new line of meat goats convenient for hot climate (Al-Saef, 2009). This program is based on crossing bucks of meat-type sire breed with does of fecund-type dam breed to produce kids with improved growth rate and consequently with improving of semen parameters. Unfortunately, reviewed studies concerning genetic and crossbreeding analyses for semen quality traits in goats raised in hot climate countries are scarce (Mavrogenis *et al.*, 1984 *a,b*; Dosari *et al.*, 1996; Al-Ghalban *et al.*, 2004). The main objectives of this study were: (1) to evaluate genetically Aradi local goats and their crosses with Damascus goats (½D½A) in terms of semen characteristics, (2) to apply the technology of estrus synchronization and artificial insemination in such crossbreeding program to accelerate the rate of genetic improvement, and (3) to compare the cross obtained (½D½A) with the founder breeds for semen traits.

MATERIALS AND METHODS

Crossbreeding plan:

A three-year crossbreeding program between Saudi Aradi goats (A) and Syrian Damascus goats (D) was started since 2006 in Animal Production Research Station in Qassim University, Saudi Arabia. A 120 does of Aradi goats were randomly divided into two groups and were subdivided into two subgroups; one division was inseminated artificially from semen of bucks of the same breed and the second division was inseminated artificially from semen of bucks of Damascus breed, producing a genetic group of ½D½A. Does of Damascus breed were inseminated from bucks of the same breed to produce purebred bucks. In such crossbreeding program, three genetic groups of AA, DD, and ½D½A were produced. Bucks were evaluated for semen characteristics and does were estrus synchronized using intravaginal progestagen sponges containing 30-40 fluorogestone acetate (FGA) or controlled internal drug release (CIDR) device containing 60 mg progesterone. Pregnancy was diagnosed 45-60 days post insemination with the aid of ultrasound scanner. A total number of 191 ejaculates collected from 42 bucks fathered by 12 sires and mothered by 42 dams were used to evaluate semen characteristics of bucks.

Management and feeding:

All does in the present study were housed in semi-shaded/open front barn and ear-tagged. Goats were fed on a commercial concentrate and alfalfa hay. The amount of concentrate and hay were calculated according to the nutritional requirements for goats which dependent on animal ages and production status. Water, straw, salt and minerals supplemented in blocks

were freely available to all animals. Animals were fed *ad libitum* individually. The guidelines in the feeding goats are showed in Table 1.

Semen collection, evaluation and preparation for artificial insemination:

Bucks used in the breeding program were evaluated for semen characteristics. Two to three ejaculates per buck were collected (using artificial vagina) with two weeks intervals. Immediately after collection, the semen tubes were placed in a water bath at 37 °C and samples were evaluated for general appearance, pH, colour, volume, consistency and examined microscopically for individual motility, sperm concentration and percent of normal spermatozoa. All these steps were done within 10 minutes of collection, using standard techniques described by Boussit (1989) and Pirohit *et al.* (1992). Semen with good quality were extended with egg yolk citrate extender (Azawi *et al.*, 1993), using dilution rate of 1:1 to 1:4 (semen:diluent) according to sperm concentration. The diluted semen samples were gradually cooled and stored in a refrigerator at 5 °C to be used in artificial insemination (Leboeuf *et al.*, 2000).

Estrous synchronization and artificial insemination (AI):

Synchronization of estrus was applied to does used for breeding program. Intravaginal progestagen sponges containing 30-40 fluorogestone acetate (FGA) or controlled internal drug release (CIDR) device containing 60 mg progesterone were administered to does, according to Freitas *et al.* (1997) and Romano *et al.* (2000) and maintained in situ for 12-14 days. At the day of sponge withdrawal 200-400 IU/eCG were injected intramuscular, according to Muna *et al.* (1998). The inseminations were applied 36-60 hours after sponge removal, using fresh diluted semen (0.5 *ml* containing at least 120 x 10^6 motile spermatozoa). Cervical AI was applied according to Ghalsasi and Nimbkar (1998). The hind legs of the doe were lifted and placed at an angle of 45° to the horizontal on a 2.5' high railing. A vaginal speculum was introduced into the vaginal passage. The cervix was located with the help of a headlight and by gentle sideways or downward manipulation of the speculum. Semen was deposited up to a depth of 2-5 cm into the cervix. Pregnancy diagnosis was done 45-60 days post insemination with the aid of ultrasound scanner.

Data collected:

Semen parameters collected for bucks were volume of ejaculate in *ml*, pH of semen, sperm cells concentration, x10^9 per ml, percent of spermatozoa motility, percent of abnormal spermatozoa, percent of living spermatozoa, percent of dead spermatozoa, total motile sperm (x10^9 per ml), and total sperm output (x10^9 per ml).

Statistical analyses and estimation of crossbreeding effects:

Variances were calculated by SAS program applying REML procedure (SAS, 1999) to be used as starting values in the analyses of single-trait animal model. The single-trait animal model in matrix notation (Boldman *et al.*, 1995) used to analyse semen traits was:

$$\mathbf{y= Xb + Z_a u_a + Z_p u_p + e}$$

Where y = vector of observed semen parameter for bucks; b= vector of fixed effects of genetic group of buck, age of buck, and year-season of semen collection; u_a= vector of random additive effects of the bucks; u_p= vector of random effects of the permanent non-additive effects of the bucks; X, Z_a and Z_p are the incidence matrices relating records to the fixed effects, additive genetic effects, and permanent environment, respectively; and e = vector of random error.

The inverse of the numerator relationship matrix ($\mathbf{A^{-1}}$) was considered; Var(a)= $A\sigma^2_a$, Var(c)= $I\sigma^2_c$ and Var(e)= $I\sigma^2_e$ Where σ^2_A, σ^2_p and σ^2_e are variances due to the effects of direct additive, permanent environment, and random error, respectively. Heritabilities for different traits were computed from variance components estimated by DFREML of the animal model using the following equation:

$$h^2_A = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_p + \sigma^2_e}.$$

Heritability estimates and permanent environmental effects for different traits were used to solve the corresponding mixed model equations, obtaining solutions for the genetic group means and their error variance–covariance matrix, using the PEST program (Groeneveld, 2006). The procedure of generalized least squares (GLS) using CBE program of Wolf (1996) was used to estimate crossbreeding effects. The following model of Dickerson as summarized by Dickerson (1992) and Wolf *et al.* (1995) was used:

$$\mathbf{y = Xb + e,\ Var(y) = V}$$

Where **y** = vector of genetic groups means, **X** = incidence matrix of the coefficients for crossbreeding effects, **b** = vector of crossbreeding genetic parameters, **e** = vector of residual effects, and **V** = full covariance matrix of **y**. The coefficients relating genetic crossbreeding parameters to the means of the genetic groups are shown in Table 2 (Wolf *et al.*, 1995). Because the reciprocal cross of Aradi x Damascus was not praticed, the maternal additive effects showed a high co-linearity with the direct additive effects because the corresponding errors highly correlated. For this reason, the maternal additive effects have been excluded from the model. The crossbreeding parameters of direct additive effects and direct heterosis were estimated using the CBE program of Wolf (1996). The parameters representing differences between the breeds in terms of direct additive genetic effects ($G^I = G^I_A - G^I_D$) and direct heterosis (H^I) were estimated. Thus, we have two parameters to be estimated (a vector called b-vector):

$$b = \left[(G^I_A - G^I_D) \quad H^I \quad \right]$$

The estimates of **b** were calculated by the method of generalized least squares (GLS) using the following equation:

$$\hat{b} = (X'V^{-}X)^{-1}X'V^{-}y$$

Where **X** was the matrix of coefficients of estimable crossbreeding effects, coming from Table 2, with the variance-covariance matrix of the estimate of ***b*** being,

$$Var\ (\hat{\mathbf{b}}) = (\mathbf{X}'\mathbf{V}^{-}\mathbf{X})^{-1}$$

This matrix was used to test the significance of the crossbreeding effects.

RESULTS AND DISCUSSION

Actual means and variations:

Favourable estimates in semen parameters were recorded in terms of ejaculate volume (1.52 ml), sperms concentration (2.16 x10^9 per *ml*), percentages of motile sperms (78.8%), total motile sperms (2.72 x10^9 per *ml*), total sperm output (3.36 x10^9 per ejaculate), abnormal sperms (10.8%) and dead sperms (14.0%) as shown in Table 3. Most estimates of semen traits obtained here are comparable to those recorded for other breeds of goats and crosses in most parts of worldwide (*e.g.* Amir *et al.*, 1986; Roca *et al.*, 1992; Azawi *et al.*, 1993; Karagiannidis *et al.*, 2000; El-Fadili and and Leroy, 2001; Al-Ghalban *et al.*, 2004; Webb *et al.*, 2004).

Heritability estimates and permanent environmental effects:

Heritabilities estimated for most semen characteristics were moderate or low (Table 4). The estimates ranged from from 0.04 to 0.16. Accordingly, non sustainable improvement in some semen characteristics of bucks could be achieved through selection of bucks based on their semen performance. Recently, Khalil *et al.* (2007) in rabbits stated that genetic improvement for semen parameters is not easy to be achieved due to that heritabilities were low caused by low variability in semen parameters between and within bucks.

Permanent environmental effects for semen traits were slightly higher than the respective heritabilities since they ranged from 0.05 to 0.18 (Table 4). It is very important to say that permanent environmental effects appeared to have strong effects on semen parameters even up to late age.

Direct additive genetic effects:

As shown in Table 5, direct additive effects were in favour of Aradi bucks by 11.4% for ejaculate volume, 4.2% for live sperms and 5.7% for total sperm output relative to Damascus bucks, while a reverse trend in favour of Damascus bucks was recorded for sperms concentration (-3.6%), total motility of sperms (-15.0 %), and dead sperms (24.5%). Garcia-Tomás *et al.* (2006 *a,b*) stated that differences in direct genetic effects between two sire lines (C and R) were significant and relevant for some semen production traits (e.g. concentration and total number of spermatozoa per ejaculate) and some semen quality traits (e.g. percentages of sperms viability, percentage of spermatozoa with normal apical ridge, percentage of sperm morphological abnormalities of neck-midpiece and percentage of sperm with proximal cytoplasmatic droplet) and those differences were of high magnitude (about 50% of the actual mean) and in favour of line C for sperms concentration and total number of spermatozoa per ejaculate.

Direct heterosis:

Crossbred bucks were associated with existence of direct heterotic effects in some semen parameters (Table 6). The estimates of direct heterosis were positive and significant for volume of ejaculate (16.3%), total motile sperms (12.5%) and sperms concentration (5.4 %), while the negative estimate recorded for percentage of abnormal sperms (-3.3%) was favorable. These estimates indicate that crossing Saudi Aradi does with Damascus bucks was associated with heterotic effects on some semen characteristics of crossbred bucks. Such crossing was associated with an increase in ejaculate volume (0.245 ml, $P<0.01$) and sperm concentration (0.15 x 10^9 per ml, $P<0.05$) along with a reduction in percentage of abnormal sperms (-0.45 %, $P<0.05$). One of the explanations for positive heterotic effects in percent of sperm motility could be that sexual maturation in crossbred bucks was faster than in purebred bucks. However, at the adult stage, differences among purebred and crossbred bucks in semen parameters tending to disappear (Wilson, 1992; Noran *et al.*, 1998; Babiker, 2003). In rabbits, crossbreeding among breeds, raised in hot climates, was associated with heterotic effects in semen characteristics as stated by El-Ezz *et al.* (1985) in Egypt, Al-Sobayil and Khalil (2002) and Khalil *et al.* (2007) in Saudi Arabia. Brun *et al.* (2002 *a,b*, 2004) and Khalil *et al.* (2007) reported high variability in the estimates of heterosis for the function of seminal trait since they observed moderate estimate of heterosis in mass motility (6.8%) and in percentage of motile spermatozoa (4.1%) along with high values of heterosis in sperms concentration (37.5%), total number of spermatozoa per ejaculate (37.6%) and number of motile spermatozoa per ejaculate (42.3%). García-Tomás *et al.* (2006 *a,b*) found high variabilities in the estimates of direct heterosis for several semen characteristics, being practically negligible for sperm normalcy (about 2%) but very high for the percentage of spermatozoa with presence of cytoplasmatic droplet (57%).

Table (1): Nutrient requirements for goats (National Research Council, 1981)

Nutrient	Kids		Does		Bucks
	Weanling	Yearling	Dry pregnant	Lactating	
Daily feed, lb (forage + concentrate)	2.0	3.0	4.5	4.5 - 5.0	5.0
TDN %	68	65	60	60 – 65	60
Protein %	14	12	10	11 – 14	11
Calcium %	0.6	0.4	0.4	0.4 – 0.6	0.4
Phosphorus %	0.3	0.2	0.2	0.2 – 0.3	0.2

Table (2): Genetic groups of bucks with their sires and dams and coefficients of the matrix relating genetic group means of bucks with crossbreeding parameters

Genetic group			Mean	Coefficients of the matrix		
Buck	Sire	Dam		D_A	D_D	H^I
AA	A	A	1	1	0	0
DD	D	D	1	0	1	0
½D½A	D	A	1	0.5	0.5	1

D_A and D_D = Direct additive genetic effects for the Aradi breed and the Damascus breed, respectively; H^I = Direct heterosis.

Table (3): Actual means, standard deviations (SD) and ranges for semen characteristics of bucks used

Semen character	Mean	SD	Minimum	Maximum
Volume of ejaculate, ml	1.52	0.65	0.50	3.0
***pH* of semen**	7.0	0.26	6.8	7.5
Concentration or count of sperms, x10^9 per *ml*	2.16	0.63	0.6	2.9
Motility of sperms, %	78.8	13.3	60	90
Live sperms, %	86.0	7.2	68	90
Abnormal sperms, %	10.8	4.8	5.0	25.0
Dead sperms, %	14.0	7.9	5.0	50.0
Total motile sperms, x10^9 per *ml*	2.72	1.79	0.30	7.83
Total sperm output, x10^9 per ejaculate	3.36	1.86	0.6	8.7

Number of records = 191, number of bucks = 42.

Table (4): Estimates of proportion of the phenotypic variance due to genetic additive effects (h^2) and to permanent non-additive environmental effects (p^2) and random error (e^2) for semen parameters

Semen character	h^2	p^2	e^2
Volume of ejaculate, ml	0.10	0.13	0.77
***pH* of semen**	0.04	0.05	0.91
Concentration or count of sperms, x10^9 per *ml*	0.14	0.08	0.78
Motility of sperms, %	0.09	0.12	0.79
Live sperms, %	0.10	0.11	0.79
Abnormal sperms, %	0.16	0.12	0.72
Dead sperms, %	0.10	0.12	0.78
Total motile sperms, x10^9 per *ml*	0.14	0.18	0.58
Total sperm output, x10^9 per ejaculate	0.12	0.16	0.72

Number of records = 191, number of bucks = 42.
Standard errors of estimates ranged from 0.12 to 0.24.

Table (5): Estimates of differences between Damascus and Aradi breed in direct additive effects and their standard errors ($D^I \pm SE$) for semen characteristics

Trait	$D^I=(D^I_A-D^I_D)$		
	Estimate	SE	D^I %[+]
Volume of ejaculate, ml	0.17*	0.014	11.4
***pH* of semen**	-0.01 [NS]	0.303	-0.1
Concentration or count of sperms, x10^9 per *ml*	-0.1 [NS]	5.61	-3.6
Motility of sperms, %	0.4 [NS]	1.76	0.5
Live sperms, %	3.6 [NS]	1.42	4.2
Abnormal sperms, %	0.3 [NS]	0.54	2.7
Dead sperms, %	3.3**	0.28	24.5
Total motile sperms, x10^9 per *ml*	-0.5**	0.02	-15.0
Total sperm output, x10^9 per ejaculate	0.23 [NS]	0.6	5.7

[+]Percentage of the difference referred to the average of the values for Damascus and Aradi breed; NS = Non-significant; *= P<0.05; **= P<0.01.

Table (6): Estimates of direct heterosis and their standard errors ($H^I \pm SE$) for semen characteristics

Trait	Units	SE	H^I %+
Volume of ejaculate, ml	0.245**	0.03	16.3
***pH* of semen**	-0.065 NS	0.21	-0.9
Concentration or count of sperms, x10^9 per *ml*	0.15*	0.06	5.4
Motility of sperms, %	0.4 NS	0.6	0.4
Live sperms, %	1.2 NS	1.42	1.5
Abnormal sperms, %	-0.45 NS	0.52	-3.3
Dead sperms, %	1.35**	0.45	10.0
Total motile sperms, x10^9 per *ml*	0.505**	0.07	12.5
Total sperm output, x10^9 per ejaculate	0.11 NS	0.10	3.3

+Percentage of heterosis referred to the average of the values for Damascus and Aradi breed; NS = Non-significant; *= P<0.05; **= P<0.01.

CONCLUSIONS

1. Crossing Damascus breed with a local Aradi breed (well adapted to hot climates) was associated successfully with forming a cross that could be used in hot climate areas efficiently since the bucks performed better in semen traits than the founder breeds.
2. Differences in direct additive effects between Aradi and Damascus bucks were generally in favor of Damascus bucks for semen traits, i.e. Damascus bucks could be used in crossbreeding programmes in Saudi Arabia and other hot climatic countries.
3. Heterosis estimates obtained in this experiment are of considerable importance, particularly for volume of ejaculate, total motile sperms, sperms concentration, abnormal sperms, while the estimates related to pH and sperms livability traits were of little importance.

ACKNOWLEDGEMENT

This project (No: SR-D-007023) is granted by the Deanship of Scientific Research, Qassim University, Saudi Arabia.

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مكونات الخلط لبعض مقاييس السائل المنوي للتيوس الناتجة من خلط الماعز العرضي السعودي مع الماعز الدمشقي

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قسم إنتاج وتربية الحيوان- كلية الزراعة والطب البيطرى- جامعة القصيم- بريدة- القصيم- المملكة العربية السعودية

بدأ برنامج تهجين الماعز السعودية العرضية (A)بالماعز الدمشقية الشامية (D) اعتبارا من عام ٢٠٠٦ بمحطة بحوث الإنتاج الحيواني بجامعة القصيم لإنتاج ثلاثة مجموعات وراثية هي العارضي النقي AA، والدمشقي النقي DD والهجينA½D!. أستخدم لذلك ١٩١ قذفة منوية جمعت من ٤٢ تيسا منتجة من ١٢ أباً ،٤٢ أماً لتحليل البيانات حيث استخدم لذلك النموذج الوراثى للحيوان لتقدير المكافئات الوراثية والتأثيرات البيئية الدائمة التي تلازم الحيوان في حين استخدمت طريقة المربعات الدنيا المعممة Least Square Procedure Generalized لتقدير التأثيرات التراكمية المباشرة للجينات وقوة الهجين المباشرة لصفات السائل المنوي. كانت المكافئات الوراثية لمعظم صفات السائل المنوي متوسطة أو منخفضة وتراوحت القيم من ٠,٤ إلى ٠,١٦ كانت التأثيرات التراكمية المباشرة للجينات لمقاييس السائل المنوي للتيوس العارضي أفضل معنويا عن التيوس الدمشقية في تركيز الحيوانات المنوية بالقذفة، الناتج الكلي للحيوانات المنوية، الحركة الفردية والكلية للحيوانات المنوية، نسبة الحيوانات المنوية الشاذة والميتة. كانت الفروق في التأثيرات التراكمية المباشرة ملائمة ومعنوية وفي صالح التيوس العرضية بمقدار ١١,٤% لصفة حجم القذفة المنوية مقارنة بالتيوس الدمشقية. أظهرت التيوس الهجينة تفوقا معنويا مقداره ١٦,٣ % لحجم القذفة المنوية، ٥,٤ % في تركيز الحيوانات المنوية بالقذفة ، ١٢,٥ % في الناتج الكلي للحيوانات المنوية مع نقص معنوي مقداره ٣,٣ % في نسبة الحيوانات المنوية الشاذة مقارنة بمتوسط السلالتين النقيتين.