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## Lamb and milk production in Awassi, Assaf, Booroola-Awassi and Booroola-Assaf sheep in Israel

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### ABSTRACT

Crossbreeding with Booroola Merino rams was initiated in 1986 in Israel to transfer the *Fec<sup>B</sup>* allele to the Awassi (Aw) and the Assaf (As) dairy breeds to increase their prolificacy. The prolificacy of the F1 ewes was higher by about 0.6 lambs/ewe lambing ( $P < 0.05$ ) over the prolificacy of Aw and As ewes. Growth rate up to 150 days of age did not differ between As,  $1/2$ As,  $3/4$ As and  $7/8$ As ram lambs ( $P > 0.05$ ). Results were similar in ewe lambs except for F1 ewe lambs which were smaller ( $P < 0.05$ ) than the As ewe lambs. Milk production in the Booroola crosses was lower ( $P < 0.05$ ) than in the Aw and the As, and no difference ( $P > 0.05$ ) was found between the milk production of  $1/2$ Aw and  $3/4$ Aw ewes in the first and the second lactations. While all Aw,  $1/2$ Aw and  $3/4$ Aw lambs had birthcoat type different from that of the Merino, 12%, 48% and 35% of As,  $1/2$ As and  $3/4$ As lambs had Merino-type birthcoat. The effect of the Booroola gene on lamb production in the Aw and the As crosses found to be similar to its effect in other Booroola crosses. Our results suggest that some major genes may be involved in controlling the differences between the Aw and the As and the Booroola in growth, milk production and birthcoat type.

**Keywords** Awassi, Assaf, Booroola, milk production, prolificacy, birthcoat, major genes.

### INTRODUCTION

To increase the prolificacy of the Israeli-improved-Awassi and the Assaf (originated from Awassi x East-Friesian cross) dairy breeds, crossbreeding with Booroola Merino rams was initiated, at the Volcani Center in Israel, in 1986. The improved Awassi and the Booroola Merino are different and unrelated sheep breeds developed through sheep domestication: The improved Awassi is an Asiatic nonprolific fat tail dairy breed which has large body size (mature rams weigh approximately 130 kg) and carrying coloured carpet wool fleece. The Booroola Merino on the other hand is a highly prolific medium woolled non-Pepin strain of Australian Merinos with small body size (rams weigh about 60 kg). As the high prolificacy of the Booroola Merino is due to the *Fec<sup>B</sup>* allele which increases ovulation rate and litter size in sheep (Piper *et al.*, 1985), the aim of the crossbreeding work was to transfer the *Fec<sup>B</sup>* allele to the Awassi and the Assaf.

Interest in the Awassi and its crosses with non-dairy breeds has increased recently in New Zealand with the introduction of the Awassi breed into the country. It is expected that by using the Awassi as a pure breed or by crossing it with local non-dairy breeds, dairy sheep production for cheese manufacture can be established and the quality of live lambs and carcasses exported to the Middle-east will be improved.

Data comparing body and carcass composition as well as wool production of Awassi, Assaf and their respective Booroola crosses have been presented elsewhere (Goot and Gootwine 1991, Goot *et al.*, 1991). The purpose of the present communication is to compare lamb production, growth, milk production and birthcoat types of Booroola-Awassi and Booroola-Assaf crosses, and their respective pure breeds. Based on these results, the use of the Booroola and the Awassi as exotic breeds in Israel and New-Zealand is discussed.

### MATERIALS AND METHODS

#### Crossbreeding plan

The crossbreeding work was carried out at the Central Farm of the Volcani Center at Bet Dagan, with the Golan flock at Be'er-Tuvia and with the flocks of kibbutz Nachshon and kibbutz Ein Harod. The F1 crossbreds were produced by inseminating local Awassi and Assaf ewes with semen taken from five BB Booroola Merino rams obtained from the Invermay Agricultural Centre, New Zealand. Most of the first backcrosses to the Awassi and the Assaf ( $1/2$ Aw and  $3/4$ As, respectively) were produced by mating F1 rams with local ewes. Some backcrosses to the Assaf ( $3/4$ As') and all the backcrosses to the Booroola ( $1/2$ B) were obtained out of F1 ewes and the respective purebred rams, and in those crosses, sire-daughter matings were avoided. By mating  $3/4$ As ewes with Assaf rams,  $7/8$ As lambs were generated.

#### Management

All flocks were kept indoors all year round. At about nine months of age, ewes joined an accelerated breeding program in which lambing was scheduled about every 8-10 months. Ewes were presented to the rams following natural heat or after synchronization treatment with progestagen pessaries and 400-600 IU PMSG (Intervet, France). Most of the lambs were separated from their mothers at one day of age and raised until weaning in artificial rearing units where commercial milk replacer was offered ad libitum. Following weaning, at about four to five weeks of age, all lambs had free access to concentrates, hay and water.

Dairy ewes were milked twice daily from lambing till the point were milk yield dropped to about 0.5 litres/day. Estimates of ewe milk production were based on monthly records.

## Birthcoat typing

Birthcoats were graded into six categories/types according to the shape of their fibers as follows: fine curls, curls, curls and waves, waves, waves and straight, straight.

## Data analysis

Data for lambing rates and birthcoat types were examined by Chi-square analysis. Data on milk production were analysed by Student's *t* test. Data on 150 day-weight were analysed by least squares analysis of variance with genotype, sex, genotype by sex interaction, sire within genotype, crop and type of birth included in the model. Data are reported as means  $\pm$  s.e.m. Differences of  $P < 0.05$  were considered significant.

## RESULTS

### Lamb production

Prolificacy of F1 ewes was significantly higher than in their contemporary purebred Awassi and Assaf ewes with an average increase of about 0.6 lamb born/ewe lambing (Table 1). Prolificacy of  $3/4$ Aw and  $3/4$ As ewes was intermediate to the respective purebreds and their F1 crosses.

**TABLE 1** Mean litter size (lambs born/ewe lambing) of Awassi, Assaf and their Booroola crosses at successive lambings

	1st lambing		2nd lambing		3rd lambing	
	n	mean litter size	n	mean litter size	n	mean litter size
Awassi	139	1.2 <sup>a</sup>	105	1.2 <sup>a</sup>	54	1.4 <sup>a</sup>
F1	20	1.6 <sup>b</sup>	19	1.8 <sup>b</sup>	17	2.0 <sup>b</sup>
$3/4$ Aw	108	1.4 <sup>c</sup>	82	1.5 <sup>c</sup>	26	1.6 <sup>c</sup>
Assaf	73	1.5 <sup>a</sup>	71	1.5 <sup>a</sup>	58	1.7 <sup>a</sup>
F1	43	1.9 <sup>b</sup>	42	2.1 <sup>b</sup>	38	2.5 <sup>b</sup>
$3/4$ As	174	1.7 <sup>b</sup>	154	1.9 <sup>b</sup>	95	2.0 <sup>b</sup>

Within column, means followed by different superscripts differ significantly ( $P < 0.05$ )

### Milk production

In the Ein Harod flock, Awassi ewes produced on the average 417 litres and 559 litres of milk in their first and second lactations, respectively (Table 2). Length of lactation and milk

production of Booroola-Awassi F1 and  $3/4$ Aw ewes were similar and significantly lower than that of Awassi ewes with milk production being about 62% and 51% of the Awassi for the first and the second lactations, respectively.

In the Nachshon flock,  $3/4$ As ewes produced only 56% and 60% of milk as compared to contemporary Assaf ewes in the first and the second lactations, respectively.

### Lamb growth

Generally, ram lambs were significantly heavier at 150 days of age than ewe lambs (Table 3). The difference in liveweight between the sexes of the different genotypes was 6.4-8.3 kg except for F1 lambs where that difference was significantly higher, being 12.5 kg. In ram lambs, no significant differences were noted at 150 days weight between the different genotypes except for  $3/4$ B ram lambs which were significantly lighter than the other lambs. In ewe lambs, both F1 and  $3/4$ B ewe lambs were significantly lighter than ewe lambs of other genotypes.

### Birthcoat pattern

None of the Awassi, F1 Booroola-Awassi or  $3/4$ Aw crossbred lambs had birthcoat with fine curls (Table 4). 12% of the Assaf lambs had birthcoat with fine curls. This birthcoat type was significantly more frequent in F1 Booroola Assaf and  $3/4$ As lambs being 48% and 35%, respectively.

**TABLE 3** Least squares means  $\pm$  s.e.m. of growth performance of Assaf and Booroola Assaf crossbred lambs

Breed	sex	n	150-dayweight (kg $\pm$ s.e.m)
Assaf	M	188	48.3 $\pm$ 1.1 <sup>a</sup>
F1	M	67	47.0 $\pm$ 1.5 <sup>a</sup>
$3/4$ As	M	170	48.2 $\pm$ 1.0 <sup>a</sup>
$3/4$ As'	M	61	45.6 $\pm$ 1.6 <sup>a</sup>
7/8As	M	60	46.6 $\pm$ 1.6 <sup>a</sup>
$3/4$ B	M	21	36.9 $\pm$ 2.0 <sup>b</sup>
Assaf	F	149	41.1 $\pm$ 1.1 <sup>a</sup>
F1	F	54	34.5 $\pm$ 1.5 <sup>b</sup>
$3/4$ As	F	167	41.8 $\pm$ 1.0 <sup>a</sup>
$3/4$ As'	F	56	38.7 $\pm$ 1.4 <sup>a</sup>
7/8As	F	54	38.3 $\pm$ 1.8 <sup>ab</sup>
$3/4$ B	F	11	30.5 $\pm$ 2.7 <sup>bc</sup>

Within trait and sex, means followed by a common letter do not differ significantly ( $P < 0.05$ ).

**TABLE 2** Milk production of Awassi, Assaf and their crosses with the Booroola Merino.

Genotype	group	First lactation			Second lactation		
		n	days $\pm$ SEM	milk $\pm$ SEM	n	days $\pm$ SEM	milk $\pm$ SEM
Ein Harod flock							
Awassi	1	26	184 $\pm$ 12	402 $\pm$ 43 <sup>a</sup>	26	215 $\pm$ 12 <sup>a</sup>	550 $\pm$ 35 <sup>a</sup>
F1	1	13	163 $\pm$ 14	249 $\pm$ 35 <sup>b</sup>	13	182 $\pm$ 11 <sup>b</sup>	272 $\pm$ 18 <sup>b</sup>
Awassi	2	57	207 $\pm$ 7 <sup>a</sup>	439 $\pm$ 22 <sup>a</sup>	51	210 $\pm$ 7 <sup>a</sup>	564 $\pm$ 24 <sup>a</sup>
<sup>3</sup> / <sub>4</sub> Aw	2	42	179 $\pm$ 7 <sup>b</sup>	269 $\pm$ 7 <sup>b</sup>	38	155 $\pm$ 8 <sup>b</sup>	307 $\pm$ 22 <sup>b</sup>
Awassi	3	53	192 $\pm$ 7 <sup>a</sup>	402 $\pm$ 18 <sup>a</sup>			
<sup>3</sup> / <sub>4</sub> Aw	3	52	161 $\pm$ 6 <sup>b</sup>	259 $\pm$ 14 <sup>b</sup>			
Nachshon flock							
Assaf	4	67	174 $\pm$ 9 <sup>a</sup>	258 $\pm$ 18 <sup>a</sup>	57	207 $\pm$ 10 <sup>a</sup>	357 $\pm$ 22 <sup>a</sup>
<sup>3</sup> / <sub>4</sub> As	4	57	125 $\pm$ 6 <sup>b</sup>	147 $\pm$ 11 <sup>b</sup>	50	158 $\pm$ 9 <sup>b</sup>	216 $\pm$ 17 <sup>b</sup>

Within group and lactation, means followed by different letter differ significantly ( $P < 0.05$ ).

**TABLE 4** Birthcoat types distribution in Awassi, Assaf Booroola-Awassi and Booroola-Assaf crossbred lambs

Genotype	n	Birthcoat description					
		fine curls	curls + curls	waves waves	wave wave	straight straight	waves+ straight
		% of lambs with birthcoat type					
Awassi	102	0	22	25	30	15	8
F1	53	0	7	15	55	19	4
3/4Aw	137	0	24	11	29	14	22
Assaf	131	12	6	24	36	8	14
F1	96	48	8	13	22	1	8
3/4As	92	35	13	27	16	6	3

## DISCUSSION

The results of these studies show that significant increases in prolificacy in Awassi and Assaf dairy breeds can be obtained by the introduction of the *Fec<sup>B</sup>* allele. However, as other traits of the Booroola-Merino are undesirable, they have to be eliminated during the crossbreeding programs. Our results also suggest that some major genes might control milk, growth and wool production in Booroola-Awassi and Booroola-Assaf crosses. The presence of such genes should be considered in designing the crossbreeding programme of Awassi and New-Zealand breeds.

The increase in prolificacy in the F1 ewes over the Awassi and the Assaf averaged 0.6 lamb born/ewe lambing, similar to the effect of the *Fec<sup>B</sup>* allele on litter size found in other Booroola crosses (Piper *et al.*, 1985). Based on this result, it can be expected that in homozygous BB Awassi and Assaf, the prolificacy will be increased by about one lamb/lambing making these genotypes more profitable for intensive commercial dairy farms.

The Awassi is the most numerous and widespread breed in Southwest Asia (Epstein, 1985). In this region most Awassi flocks are nomadic and rely mainly on indigenous pasture. Attempts to intensify Awassi sheep production does not pay in most cases due to the inherent low prolificacy of this breed. Following introduction of the *Fec<sup>B</sup>* allele to the improved Awassi, the newly formed high prolific Awassi can be used not only in intensively managed flocks, but also as a vehicle to increase lamb production in extensive Awassi flocks, without altering the traditional preferred Awassi phenotype.

As the Merino is a non-dairy breed, reduction in milk production in its crosses with the Awassi and the Assaf, to about 50%-60% of the milk production of the respective pure breeds is expected. However, the observation that the milk production of 3/4Aw and 3/4As sheep is not significantly higher from that of the F1 sheep indicate that the difference in milk production between the Awassi and the Assaf on one hand, and the Booroola Merino on the other hand, is not inherited in a simple quantitative manner and the presence of major genes controlling that trait in sheep is possible. Establishing of dairy sheep industry in New Zealand will be achieved most probably by crossing the Awassi with local Romney, Coopworth or Merino sheep which will be followed by backcrossing to the Awassi. The possibility that the milk production in the Awassi crosses will not show a linear increase with the increase in the proportion of Awassi blood should be taken into consideration when designing these crosses.

Except for 3/4B, all ram lambs exhibited similar 150 day weight indicating heterosis for high growth rate in Booroola-

Assaf crosses. Positive heterosis for growth has been found in sheep in many studies (reviewed by Nitter, 1978). However, as opposed to the situation in males, F1 ewe lambs were significantly smaller than Assaf ewe lambs, suggesting a sex-linked effect on growth rate in the Booroola-Assaf crosses. This means that genes coding for small body size may be located on the Booroola X chromosome. It can be postulated that substitution the Booroola X chromosome with X chromosome of other breeds by crossbreeding may have a dramatic effect on the Booroola body size.

According to our classification, the birthcoat of the Booroola Merino can be typed as having fine curls. This birthcoat type is not present in the Awassi and it has a low frequency in the Assaf. The observation that the fine-curls-birthcoats were not found in F1 Booroola-Awassi lambs and in 3/4Aw lambs, and on the other hand were present in 48% of the F1 Booroola-Assaf lambs, can be explained by the presence of a single gene with two alleles: a recessive allele coding for fine-curls and a dominant allele coding for non-fine-curl birthcoat. In this case, the variation in birthcoats within the Awassi has to be controlled by a different genetic system. If upgrading to the Awassi is part of the breeding plan of using the Awassi in New Zealand, intercrossing among the backcrosses followed by selection for lambs having fine-curls-birthcoats may result in Awassi with fine birthcoat.

## ACKNOWLEDGEMENT

This research is supported by the United States-Israel Binational Agricultural Research and Development Fund (BARD).

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