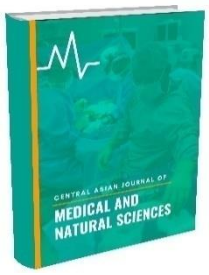
CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES



Volume: 04 Issue: 03 | May-Jun 2023 ISSN: 2660-4159

http://cajmns.centralasianstudies.org

Study of Some Genetic Markers and its Association with Performance Parameters of Iraqi Awassi Sheep: Review Article

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Received 5th Apr 2023,
Accepted 6th May 2023,
Online 8th June 2023

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Abstract: Genes express the genetic potential inherent in agricultural animals and therefore this article aims to explain the importance of genetic markers to be adopted in improving the characteristics of Awassi sheep through the selection of individuals with distinct genotypes associated with the best production. A number of genetic markers and their relationship to some traits in Iraqi Awassi sheep were studied in this article.

Key words: Genetic markers, Awassi sheep, Performance parameters.

Introduction

Sheep are considered one of the important natural resources in Iraq and contribute to the agricultural economy, especially as they constitute the focus of economic and social life in arid and semi-arid regions due to their contribution to the production of meat, milk and wool. Their numbers were estimated at about 6.600 million heads for the year 2018. Awassi sheep are among the most numerous and widespread local sheep, as they represent 60% of the Iraqi sheep, in view of the characteristics of the Awassi sheep, which have the characteristics of tolerance to environmental conditions and their good ability to produce meat and milk of good quality and desired by the consumer in conditions that may be difficult for many other sheep breeds. Awassi sheep are considered among the sheep with a distinct genetic ability to live, reproduce and produce under difficult environmental conditions (Al-Kudsi and Al-Rawi 2021).

The genotypes or polymorphisms of any gene or piece of a gene that can be obtained through the application of a molecular genetics technique through which the relationship between these structures or genetic manifestations and any other trait measured on the animal can be extracted in order to adopt it in strategies for genetic improvement and early selection of animals through these indicators to maximize the economic return of sheep breeding projects (Galal and Karam 2003; AL-Ithawi 2014).

The article aims to study some genetic markers and their relationship to performance parameters of Iraqi Awassi sheep by reviewing available research in this regard.

Review literatures

The results of Al-Murshidy et al., (2014) indicated that the genotypes of Awassi lambs with AA, AM and AH manifestations of leptin gene were significantly superior ($P \leq 0.05$) to the genotypes of AR in

body weight. The two genotyped groups AB and AH were significantly superior (P≤0.05) to the genotyped groups AA and AR in terms of total weight gain during three months (Table 1).

Table (1) The average body weight /kg and the total weight gain /kg for the genotypes of the leptin gene in Awassi lambs

Genotype	Body weight	Total weight gain
AA	44.650 ab	10.400 b
AB	40.500 bc	14.250 a
AH	41.593 ab	14.210 a
AM	43.683 ab	13.433 ab
AR	34.250 c	10.500 b
AS	40.750 bc	11.700 ab
Significant	*	*

*: (P≤0.05)

- Similar letters indicate that there is no significant difference between the means

The results of AL-Ithawi (2014) revealed that there were significant variances (P≤0.05) in the birth weight of Awassi lambs according to the difference in the genotype of the IGF-1 insulin-like gene in the ewes (dams), as the average weight reached its maximum in the genotype BB. It also turned out that there was a significant variation in the weaning weight of the lambs according to the genotype of the IGF-1 insulin-like gene in the ewes (dams), as the average weight reached a maximum in the BB genotype. Regarding body weight at the age of six months, it was maximum in lambs with genotype BB. The results indicated that there was a significant variation (P≤0.05) in the rate of weight gain between birth and six months, as the births with genotypes AB and BB achieved the highest gain (Table 2).

Inferred from this result is the possibility of improving the birth weight of Awassi sheep through selection for dams carrying allele B.

The distribution percentages of the genotypes of the insulin-like gene IGF-1 were 49.09, 41.82 and 9.09% for each of the genotypes AA, AB and BB respectively, and the difference between these percentages was highly significant. The allelic frequency was 0.70 for the A allele and 0.30 for the B allele.

Table (2) Effect of polymorphism of IGF-1 gene on body weight/kg of Awassi lambs

Traits	Genotype			Significant
	AA	AB	BB	
Birth weight	3.75 b	3.83 b	4.20 a	*
Weaning weight	20.17 a	19.72 b	20.20 a	*
weight at six months of age	31.42 b	32.17 a	32.63 a	*
Average weight gain between birth and six months	27.64 b	28.67 a	28.63 a	*

*: (P≤0.05)

- Similar letters indicate that there is no significant difference between the means

The birth weight of the Awassi lambs differed significantly (P≤0.05) according to the genotype of the MC4R gene in the dams, as the TT genotype achieved the maximum weight. The weight at weaning

was also affected significantly (P≤0.05), as the offspring with the genotype of TC dams achieved the maximum weight. With regard to body weight at the age of six months, it was maximum in lambs with genotype TT. The results revealed that there was a highly significant variation (P≤0.01) in the rate of weight gain between birth and six months, as the births with genotypes TT and TC achieved the highest gain (Table 3).

This result shows the need to focus on the two genotypes TT and TC in selection programs to improve the economic return of sheep breeding projects.

The distribution percentages of MC4R genotypes were 12.50, 75.00 and 12.50% for TT, TC and CC genotypes, respectively, and the difference between these percentages was highly significant. The allelic frequency was 0.50 for both the T and C alleles (AL-Ithawi, 2014).

Table (3) Effect of polymorphism of MC4R gene on body weight/kg of Awassi lambs

Traits	Genotype			Significant
	TT	TC	CC	
Birth weight	4.05 a	3.77 b	3.83 b	*
Weaning weight	18.14 b	20.42 a	19.00 ab	*
Weight at six months of age	35.67 a	32.91 b	24.25 c	**
Weight gain between birth and six months	31.50 a	29.00 a	20.25 b	**

*: (P≤0.05) **: (P≤0.01)

- Similar letters indicate that there is no significant difference between the means

The results of Addin et al., (2016) showed that Awassi ewes with genotype GA of the AA-NAT gene achieved the maximum fertility rate and the highest percentage of twins, followed by ewes with genotype AA, and that the differences between the rates were highly significant (P≤0.01). The results moreover explained that there were significant variances (P≤0.05) in the daily and total milk production according to the genotype of the AA-NAT gene, as it reached a maximum in the ewes with the genotype AA (Table 4). It is clear from this result that it is possible to improve the characteristic of daily milk production in Awassi sheep by selecting for individuals carrying the genotype AA.

The distribution percentages of the genotypes of the AA-NAT gene were 56.67, 33.33 and 10.09% for each of the genotypes AA, GA and GG respectively, and the difference between these percentages was highly significant.

Table (4) Relationship of polymorphisms of AA-NAT gene with the reproductive and productive performance of Awassi ewes

Traits	Genotype			Significant
	AA	AG	GG	
Prolificacy lamb/lambing	1.294 a	1.30 a	1.00 b	**
Twining %	29.40 a	30.00 a	0.00 b	**
Daily milk production /kg	1.152 a	1.041 a	0.992 b	*
Total milk production /kg	135.93 a	130.12 ab	123.42 b	*

*: (P≤0.05) **: (P≤0.01)

- Similar letters indicate that there is no significant difference between the means

The results of AL-Jubouri (2016) showed that there are two genotypes of the GDF9 exon1 gene in Awassi ewes, namely AB and BB. The allelic frequency was 0.36 for the A allele and 0.64 for the B allele. The percentage of Awassi ewes giving birth to twins was 78.79% for genotype AB. This indicates that the GDF9 exon1 gene can be used as a genetic marker for the production of twins Awassi sheep.

It was also found that there are two genotypes of the BMB15 exon2 gene in Awassi ewes, namely AB and AC. The allelic frequencies were 0.50 for the A allele, 0.078 for the B allele and 0.422 for the C allele. The percentage of Awassi ewes giving birth to twins was 100% for the genotype AC. This indicates the possibility of using the BMB15 exon2 gene as a genetic marker for the production of twins in Awassi sheep.

AL-Saadi et al., (2017) noted that Awassi ewes with genotype AA of BMP15 gene achieved the maximum fertility rate against genotypes AC and CC with a significant difference (P≤0.01). The results showed that the lambs produced from ewes with the CC genotype were significantly (P≤0.05) superior in weaning weight and rate of weight gain from birth until weaning against the rest of the genotypes. Ewes with AC genotype achieved the maximum average daily and total milk production with a significant difference (P≤0.01). The genotype of the BMP15 gene had a significant (P≤0.05) effect on the percentage of fat in milk, as it reached a maximum in the milk of ewes with genotype AA (Table 5). From this it is clear that the distinct genotypes of this gene can be adopted in selection.

The distribution percentages of genotypes of BMP15 gene were 36, 24 and 40% for AA, AC and CC genotypes respectively, and the variance between these percentages was highly significant. The allelic frequency was 0.56 for the A allele and 0.44 for the C allele.

Table (5) Relationship of polymorphisms of the BMP15 gene to the productive and reproductive performance of Awassi sheep

Traits	Genotype			Significant
	AA	AC	CC	
Prolificacy lamb/lambing	1.389 a	1.150 b	1.167 b	**
Weaning weight /kg	19.85 b	19.58 b	21.41 a	*
Weight gain between birth and weaning /kg	15.87 b	15.58 b	17.35 a	*
Daily milk production /kg	0.782 b	1.112 a	0.833 b	**
Total milk production /kg	92.36 b	126.98 a	100.36 b	**
Milk fat %	7.84 a	6.84 b	6.90 b	*

*: (P≤0.05) **: (P≤0.01)

- Means with different letters are significantly different

Al-Brkat and Al-Samarrai (2017) found that there was a significant (P≤0.05) superiority of the genetic marker HSC in Awassi ewes carrying the genetic loci consisting of 5 alleles, in weaning weight and rate of daily gain of litters compared to litters of ewes bearing other genetic loci.

It was also found that there was a high significant (P≤0.01) superiority of the genetic marker BM1818 in Awassi ewes carrying the genetic loci consisting of 5 alleles, in the birth weight of the lambs, and a significant superiority (P≤0.05) in the weaning weight of the lambs, compared to the offspring of ewes that carry other genetic loci.

There was also a significant (P≤0.05) superiority of the genotype marker MAF035 in the weaning weight of Awassi ewes carrying the genetic loci consisting of 4 alleles compared to the offspring of ewes carrying the other genetic loci (Table 6).

Table (6) Relationship of the genotypes of markers HSC, BM1818 and MAF035 with the growth characteristics of Awassi lambs

Genotype	Weaning weight /kg	Weight gain /kg
HSC 2	15.23 b	10.21 b
3	15.40 b	10.17 b
4	15.49 b	10.32 b
5	17.67 a	12.62 a
Significant	*	*
Genotype	Birth weight /kg	Weaning weight /kg
BM1818 3	4.17 b	15.13 b
4	4.25 b	14.25 b
5	6.59 a	17.19 a
Significant	**	*
Genotype	Weaning weight /kg	
2 MAF035	14.93 b	
3	15.41 b	
4	17.31 a	
Significant	*	

*: (P≤0.05) **: (P≤0.01)

- Means with different letters are significantly different

The results of Al-Samarrai and Al-Brkat (2017) indicated that there was a significant (P≤0.05) superiority of the HSC genetic marker in Awassi ewes carrying the genetic loci consisting of 2, 3 and 4 alleles, in total milk production over ewes carrying the genetic loci consisting of 5 alleles. It was observed that there was a significant (P≤0.05) superiority of Awassi ewes carrying the genetic loci consisting of two alleles, in the percentage of milk fat compared to ewes carrying the other genetic loci. There was a significant (P≤0.01) superiority of the genetic marker MFA035 in Awassi ewes carrying the genetic loci consisting of 4 alleles, in total milk production compared to the ewes carrying the other genetic loci. It was found that there was a significant difference (P≤0.05) in the percentage of milk fat, as the Awassi ewes carrying the genetic loci consisting of 3 alleles outperformed, followed by the ewes carrying the genetic loci consisting of two and then 4 alleles.

It was found that there was a significant (P≤0.05) superiority of the genetic marker BM1818 in Awassi ewes carrying the genetic loci consisting of 3 and 5 alleles, in total milk production compared to other ewes. Ewes carrying genetic loci consisting of 4 alleles also excelled in milk fat percentage, followed by ewes carrying genetic loci consisting of 3 and 5 alleles (Table 7).

Table (7) Relationship of the genotypes of markers HSC, MFA035 and BM1818 in total milk production and fat percentage in Awassi sheep

Genotype	Total milk production /kg	Milk fat %
HSC 2	75.00 a	7.69 a
3	76.80 a	6.33 b
4	77.08 a	6.69 b

5	72.60 b	6.36 b
Significant	*	*
Genotype	Total milk production /kg	Milk fat %
BM1818 3	76.02 a	6.78 ab
4	72.59 b	7.44 a
5	76.18 a	6.05 b
Significant	*	*
Genotype	Total milk production /kg	Milk fat %
2 MAF035	72.28 b	6.14 b
3	78.50 b	7.16 a
4	82.87 a	5.85 c
Significant	**	*

*: (P≤0.05) **: (P≤0.01)

- Means with different letters are significantly different

The results of Ibrahim and Kali (2017) explained that there were significant variances (P≤0.05) in the flavor and juiciness of meat according to the different genotypes of the calpastatin gene in Awassi sheep. The flavor and juiciness of the meat of the NN genotype was characterized by the highest value compared to the other genotypes (Table 8). It is clear from this the possibility of relying on the genotype of calpastatin gene in selection processes for the purpose of meat quality.

The distribution ratios of calpastatin genotypes were 75, 22.5 and 2.5% for MM, MN and NN genotypes, respectively, and the variance between these ratios was highly significant (P≤0.01). The allelic frequency was 0.86 for the M allele and 0.14 for the N allele.

Table (8) Effect of polymorphisms of calpastatin gene on the sensory characteristics of Awassi sheep carcasses

Genotype	Flavor / degree	Juiciness / degree
MM	4.70 b	2.85 b
MN	4.74 b	2.80 b
NN	5.00 a	3.16 a
Significant	*	*

*: (P≤0.05)

- Means with different letters are significantly differen

Ayied and Zaqeer (2019) noted that the genotype of the ND5 gene had a significant effect (P≤0.05) on weaning weight in Awassi sheep, as the H12 genotype was superior to the rest of the genotypes. While the ND5 gene genotypes did not significantly affect the daily milk production, the ewes of the H12 genotype achieved the highest milk production. This enhances the possibility of adopting the ND5 gene as a genetic marker in selection for weaning weight.

The results of the genetic diversity of the ND5 gene showed that there were 13 haplotypes in the Iraqi Awassi sheep breed from H1 - H13.

Table (9) Effect of genotype of ND5 gene on daily milk production and weaning weight in Awassi sheep

Genotype	Daily milk production /g	Weaning weight /kg
H 9	524.00	17.80 b
H 11	486.00	16.47 b
H 12	567.60	19.03 a
Others	521.37	16.68 b
Significant	N.S	*

*: (P≤0.05) N.S: Non significant

- Means with different letters are significantly different

The results of Ayied and Zaqeer (2018) showed that there are 13 haplotypes (H1-H13) of the COI gene in the Iraqi Awassi sheep breed. The genotype of the COI gene had a significant effect (P≤0.05) on weanling weight, as the H3 genotype was superior to the rest of the genotypes. While the genotype of the COI gene did not significantly affect the daily milk production, the ewes of the H3 genotype achieved the highest milk production. This result reinforces the possibility of adopting this gene as a genetic marker in selection for weaning weight.

Table (10) Effect of genotype of COI gene on daily milk production and weaning weight in Awassi sheep

Genotype	Daily milk production /g	Weaning weight /kg
H 1	500.00	16.58 b
H 2	486.00	16.68 b
H 3	592.67	19.85 a
Others	524.74	17.81 b
Significant	N.S	*

*: (P≤0.05) N.S: Non significant

- Means with different letters are significantly different

Ibrahim et al., (2019) showed that the distribution percentage of genotypes for the β-Lactoglobulin gene in Awassi sheep was 30% and 70% for both AA and AB genotypes, respectively and the difference between these percentages was highly significant (P≤0.01). The allelic frequency was 0.65 for the A allele and 0.35 for the B allele.

The results also explained that there was a significant difference (P≤0.05) in total milk production and the percentage of fat in milk according to the genotype, as genotype AA was superior to genotype AB. This result reinforces the possibility of adopting this gene as a genetic marker in selection for milk production and fat percentage in Awassi sheep.

Table (11) Effect of genotype of β-Lactoglobulin gene on total milk production and fat percentage in Awassi sheep

Genotype	Total milk production /kg	Milk fat %
AA	81.43	4.26
AB	73.22	3.39
Significant	*	*

*: (P≤0.05)

Ajam et al., (2019) found that there are two genotypes of the TGF-B exon 1 gene in Awassi sheep, namely AF and FF. The allelic frequency was 0.36 for the A allele and 0.64 for the F allele. Awassi ewes with genotype AF showed a twinning rate of 78.79%. This result indicates the possibility of using this gene as a genetic marker for the production of twins in Awassi sheep.

The results of Fadhil (2019) revealed that there are three genotypes of the CSN3 gene in Awassi sheep, namely AA, AB, and BB. The distribution percentages of genotypes for this gene were 70%, 16% and 14% for AA, AB and BB, respectively and the variance between these percentages was highly significant (P≤0.01). The allelic frequency was 0.78 for allele A and 0.22 for allele B.

The results showed that there was no significant variance between the measures of milk components, with a positive influence of the mixed genotype of the AB gene on the increase in milk fat. This indicates the possibility of using this gene as a genetic marker in selection to increase the percentage of fat in the milk of Awassi sheep.

Table (12) Effect of the genotype of the CSN3 gene on the milk components of Awassi sheep

Genotype	Fat %	Protein %	Solid no fat %
AA	8.432	4.336	13.197
AB	9.158	4.342	11.708
BB	8.619	3.910	10.541
Significant	N.S	N.S	N.S

N.S: Non significant

The results of Al-Jubori et al., (2019) showed the presence of two genetic mutations of the GDF-9 exon2 gene in Awassi sheep, namely G721A and G750A. As it was found that there were two genotypes in the case of G721A, namely GA and GG, the distribution ratios of genotypes were 70% and 30% for both GG and GA, respectively and the variance between these ratios was highly significant (P≤0.01). The allelic frequency was 0.85% and 0.15% for the G and A alleles, respectively.

It was also found that there were two genotypes in the case of G750A, namely GG and GA. The distribution percentages of genotypes were 92% and 8% for both GG and GA, respectively and the variance between these percentages was highly significant (P≤0.01). The allelic frequencies were 0.96 and 0.04 for both the G and A alleles, respectively.

The results revealed that there was a significant influence of the interaction between mutations in the prolificacy of Awassi ewes, as the ewes with the genotype GGGG and then AGGG were significantly superior to the rest of the genotypes in prolificacy. Inferred from this is the possibility of improving the prolificacy of Awassi sheep through selection for ewes with genotypes GGGG and AGGG.

Table (13) Effect of the interaction between mutations on the prolificacy of Awassi sheep

Genotype	Prolificacy lamb/lambing
GGAG	1.45 b
GGGG	1.61 a
AGAG	1.22 c
AGGG	1.58 a
Significant	*

*: (P≤0.05)

- Means with different letters are significantly different

The results of Al-Murshidy et al., (2020) using the Single Standard Conformation Polymorphism (SSCP) technique revealed the presence of five genotypes of the gene (CAPNS1) Calpains1 in Iraqi

Awassi lambs, namely A, B, C, D and E, with a ratio of 12.90. , 19.36, 9.68, 45.16 and 12.90%, respectively. There was a significant variance (P≤0.05) between the genotypes of the Calpains1 gene, as group D excelled in weaning and 6 months old weight, group C excelled in weight at 9 months old, and group E excelled in weight at 12 month old (Table 14). This gene can be considered as a candidate genetic marker for growth traits and meat production in Awassi sheep.

Table (14) Effect of the genotype of Calpains1 gene on the growth characteristics of Awassi lambs

Genotype	Weaning weight /kg	Weight at 6 months /kg	Weight at 9 months /kg	Weight at 12 month /kg
A	20.49 b	29.63 b	35.90 b	40.08 b
B	21.84 b	31.37 ab	38.32 a	41.97 ab
C	20.21 b	30.96 ab	39.56 a	41.51 ab
D	22.38 a	31.83 a	37.13 ab	41.13 ab
E	20.82 ab	31.38 ab	37.64 ab	42.89 a
Significant	*	*	*	*

*: (P≤0.05)

- Means with different letters are significantly different

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