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# Awassi sheep as a genetic resource and efforts for its genetic improvement

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## Abstract

Awassi is the most widespread sheep breed of non-European origin. The breed adapts to a wide range of environmental conditions from the steppe to the highly intensive system. Performance of the breed varies according to production environment and strain, the Israeli Improved Awassi being the heaviest and producing the highest amount of milk. Efforts to genetically improve milk production yielded positive results. In Israel the phenotypic average of lactation milk production increased from 297 kg in the 1940's to over 500 kg in the 1990's, while in Syria a selection program succeeded to increase it by 13% in eight years. In Turkey, the mean milked yield of ewes increased from 67 to 152 kg in a selection/outcrossing program that lasted for seven years. Although Awassi is best known for its high milk production, it is often used as a triple purpose sheep in most of the countries of its origin in the Middle East. Heritability estimates in different traits are within those for other populations of sheep but recent estimates for milk yield in the Improved Awassi indicated lower heritability and higher contribution of non-additive genetic effects.

*Keywords: Awassi sheep, animal genetic resources*

## 1. Introduction

Awassi is the most common breed of sheep in the east of Mediterranean. It is the main sheep breed in Iraq and Syria, the only native breed in Jordan (Hailat, 2005) and Israel (Epstein, 1985) and Palestine (Shanti, personal communication) and represents an important contribution to sheep breeds in Turkey (3.5% of total sheep population, Gürsoy, 2005). This breed is known to be the highest milking breed after East Friesian breed. Awassi also possesses very desirable characteristics as far as endurance to nutritional fluctuations, resistance to diseases and parasites, tolerance to extreme temperatures beyond its high milk producing and growth abilities (Gürsoy et al., 1992b; Gürsoy et al., 1993). It is no coincidence that the highest milk producing breeds of sheep, goat and cattle species, Awassi sheep, Damascus goats and Damascus cattle, were all inherited from the old Mesopotamian civilizations which undoubtedly must have placed high importance on milk producing abilities of these livestock breeds.

The breed has spread from its place of origin in South West Asia to all continents including South America. It is the only sheep breed of non-European origin that acclaimed such wide distribution.

The objective of this paper was to review recent literature on the breed performance, efforts to improve the breed and its impact as a genetic resource known for its ability to produce under varied production systems and adaptability to different specific environments.

## 2. Characterization

### *2.1. Appearance*

Awassi breed has been described earlier by Mason (1967); Epstein (1985) and more recently by Hailat (2005); Alkass and Juma (2005); Khazzal (2005); Kassem (2005) and Gürsoy (2005) in different countries. Body is covered with long coarse wool of creamy white color. The head is long and narrow with a convex forehead profile. It is bare and brown or black in color. Rams usually have horns that are twisted backwards and downwards with tips pointing outwards, while ewes are polled. Ears are of medium size and often pendulous. Neck is relatively long, strong in rams and fine in ewes. Body is relatively long and legs are medium in length and wide apart. Tail is characteristically fat, broad and medium in length ending above the hocks. The tail emerges from the rump in one stem that hangs down into two lobes that broaden out toward their lower portion which ends more or less abruptly in a short thick appendix. The lower part of the lobes is divided by a deep rift.

Udder and teats vary greatly from one Awassi population to another. In dairy populations, the udder is well developed and teats are regularly placed, while in other non-dairy non-selected populations the udder is of moderate size and teats are extremely variable in size, shape and orientation.

There are many variants or subpopulations of Awassi sheep. Some of these variants are Naiemi in Kuwait, Iraq and Syria, Shefali in Iraq and Herrik in Iraq (Alkass and Juma, 2005).

### *2.2. Performance*

Expectedly, performance varies greatly between populations within and among countries where Awassi sheep are raised. The intention in this paper is just to shed some light on the mean performance of these populations and the variability that exists among them.

#### *2.2.1 Growth*

The weights of Awassi lambs of different ages are summarized in Table 1 for different countries.

**Table 1**

#### *2.2.2 Reproduction*

Fertility of the Awassi ewes ranged from 76 to 95% in different countries, while twining rate was low in Syria (1.05) but relatively higher in Israel for the improved Awassi (1.4). Table 2 shows reported reproductive performance in different countries.

**Table 2**

*2.2.3 Lactation traits*

Milk yield shows a wide variation among countries, ranging from 65.9 kg in 172-day lactation in Iraq to 506 kg in 214 days in Israel. Means of milk yield and milk composition traits as reported by different authors in different countries are presented in Table 3.

**Table 3**

*2.2.4 Carcass traits*

Gürsoy (2005) reported that Awassi meat has a strong flavor, most probably because of the fatty acid composition of the fat. Recognizing this fact, Australians cross Merino sheep with Awassi to give this desired distinctive aroma to lambs exported to Arab countries. Table 4 shows different estimates of dressing percentage in different countries.

**Table 4**

*2.2.5 Wool traits*

Awassi fleece is characterized as carpet wool. It is of coarse, somewhat glossy long fibers with relatively high kemp content. Awassi wool is used for making carpets and blankets. Studies in 1998 and 2001 in Jordan of Awassi fleece found it to have long fibers and a high percentage of medullated fiber. Tabbaa et al. (1998) reported that fiber diameter in Awassi fleece in Jordan was similar to that of the same breed in other countries in the Middle East. Means of wool traits of Awassi sheep are shown in Table 5.

**Table 5**

*Genetic characterization*

Using microsatellite analysis, Arranz et al. (2001) reported that the Israel originated Awassi was quite divergent from other Spanish sheep breeds used in their study, Churra, Latxa, Castellana and Rasa-Aragonesa, and that the Awassi was markedly less polymorphic in these microsatellite loci than those Spanish breeds. While Calvo et al. (2004) concluded that the level of polymorphism in Awassi was similar to two other Spanish breeds, Manchega and Rasa Aragonesa. Soysal et al. (2005) concluded that the Awassi sheep from Israel and Turkey had a larger average number of alleles per microsatellite than Icelandic, French, German and Hungarian sheep breeds studied. They also concluded that the Turkish Awassi is more diverse than the Israeli. There is a paucity of published information on molecular genetics of Awassi.

Table 6 shows some reported estimates of heritabilities for different traits in Awassi sheep in different countries. For Iraqi Awassi, heritability estimates for body weights ranged from 0.07 to 0.46 but in general, the heritability tends to increase with advancing age from birth to yearling (Juma and Alkass, 2006). They reported that the heritability for litter size was higher (0.16, 0.19) than the other reproductive traits. Al-Samarae (1999) reported that the heritability estimates for milk production and lactation length were 0.36 and 0.38, respectively.

Pollot and Gootwine (2001) measured monthly test-day records of milk production comprising 3740 lactations from 1360 fully pedigreed Israeli Improved Awassi ewes. They found a low heritability estimate (0.11) for total milk yield (TMY) throughout the lactation and a repeatability of 0.467. In that study the maternal genetic effect for TMY was estimated as 4% and the heritability of TMY of first lactation records alone was 0.14. For other lactation parameters, heritability and repeatability estimates were: 0.03 and 0.08 (day of peak yield), 0.12 and 0.36 (peak yield), 0.09 and 0.16 (increase in milk production per day) and 0.11 and 0.15 (persistency of lactation), respectively. They concluded that the level of the additive genetic variance for TMY and the other lactation parameters was low in this Improved Awassi population while the permanent environmental effects, which may include dominance and epitasis, have had a profound contribution (36%) to the total variance of milk yield traits in this population.

In Macedonia, Palasevski et al. (2006) found that the heritability estimates for milk yield varied from 0.14 to 0.40 with the highest values being for the morning milking. Also the heritability for fat percentage was 0.21 and its correlations with yield traits were all high and negative, they emphasized that the morning milking is the most important to use in carrying out a selection program.

In Syrian Awassi, ACSAD (1999) reported low heritability estimates for pre-weaning and post-weaning growth rates ($h^2$ <0.1). But high estimates were found for 30 day milk yield (0.5). Also positive genetic correlation (>0.90) was found between 30 day milk yield and total milk yield.

Pollott et al. (1998) reported moderate heritability estimates for different body weights of Turkish Awassi sheep (0.22 – 0.52). They also estimated heritability in the same population for first test day as 0.22 and that for 90-day milk yield as 0.25. Moreover, the genetic correlations for milk production traits were found to be higher than the phenotypic correlations ranging from 0.86 to 0.96.

**Table 6**

## 3. Production systems

Awassi sheep are raised and produce under widely varied production systems. The greatest majority of Awassi in different countries in the Near East are raised extensively and/or semi-extensively, i.e. Bedouin, steppe or transhumant (Rummel et al., 2005; Alkass and Juma, 2005; Hailat, 2005; Khazzal, 2005 and Kassem, 2005). In such extensive systems, lamb is the primary production but milk is also harvested and usually used domestically and surplus is processed into highly valued ghee and cheese. Wool is a tertiary product in all Awassi sheep production systems. Small number of Awassi populations is raised and produces under intensive systems. These intensive systems range from intensive only in some segment of the production cycle as in fattening operations in nearly all countries to the very intensive dairy production as in Israel and other countries, where lambs are usually artificially reared and animals are housed most of the time.

## 4. Genetic improvement efforts and achievements

This section reviews efforts made for the genetic improvement of Awassi sheep in each of major countries having the breed, viz. Jordan, Iraq, Israel, Syria and Turkey. These efforts include the selection within Awassi and outcrossing with a different strain of Awassi or crossing with other breeds.

*Jordan*

There have been little efforts for the genetic improvement of Awassi sheep in Jordan. Outcrossing to Israeli Improved Awassi is currently taking place but no results have been published yet (Hailat, 2005). Also crossing with exotics, Charolais, Romanov, Chios, was tried but it was generally concluded that the Awassi outperformed the crosses (Kridli et al., 2000; Kridli et al., 2002; Tabbaa, 1999).

*Iraq*

Genetic improvement programs of Awassi sheep started in Iraq in 1950 (Alkass and Juma, 2005) when two lines were established, one for meat and another for milk (Al-Rawi et al., 1996). The selection program continued until 1992 where it was reduced in scale. No results of this selection program have been published but it has been reported that "improved rams" were put out from experiment stations to flock owners in a project jointly carried out with International Center for Research in Dry the Areas (ICARDA). Also, efforts have been made to screen owners' flocks for superior genetics for body weight (Al-Rawi et al., 2003).

Many experiments were carried out in Iraq on crossing Awassi with many local and exotic breeds or outcrossing with other Awassi strains , e.g. the local Arabi and Karadi, Moroccan D'man, Israeli Assaf which is an Awassi derivative, Turkish Awassi , Chios from Cyprus, Hungarian Merino, Suffolk and Finnish Landrace (Alkass and Juma, 2005; Shujaa et al., undated; Al-Rawi et al., 2002). The aim of these crossing experiments was not clear whether to establish a synthetic strain or to design crossing systems utilizing different assets of different breeds and possible heterosis between them.

*Israel*

Historically Turkish Awassi contributed significantly to the so called Improved Awassi of Israel. Finci, (1957) reported that a great number of Awassi sheep were imported by Palestine between 1925 and 1935 mainly from Urfa and Mardin provinces of Turkey forming the basis of Improved Awassi. Epstein (1985) clearly expressed that between 1953 and 1957 a total of 14,632 ewes were imported from Cizre county of Mardin.

Systematic genetic improvement of Awassi was started in Palestine in 1932 with the aim to develop milk and meat production of Awassi sheep (Epstein, 1985; Rummel et al., 2005). These continuous efforts resulted into what is called now Improved Awassi with a high level of milk production and heavy body weight as compared to "other" Awassi populations. With the highly intensive system of sheep production and higher demand on sheep meat in Israel however, a need arose for a sheep with larger litter size and reduced fat-tail size without compromising the high milk yield of the Improved Awassi (Goot, 1986).

Thus Improved Awassi was crossed with East Friesian and eventually a new synthetic breed, Assaf, was developed which contains 3/8 of the former and 5/8 of the latter. (Gootwine and Goot, 1996). Breeding research work in Israel also included the introduction of the Booroola fecundity gene into Improved Awassi. These efforts culminated into the production of homozygous BB rams for distribution to commercial flocks to produce heterozygous B+ offspring which can be selected by marker-assisted genotyping (Rummel, 2005).

Also, other crossbreeding trials were carried out in Israel in an effort to further improve Awassi sheep. Improved Awassi was crossed to Finnish Landrace and Romanov but these crosses were not favored by the consumer because of the much reduced tail size (Gootwine et al., 2001). Other breeds experimented with were Australian Suffolk, American Suffolk, Dorper and Charolais (Rummel. et al., 2005). None of the resulting crosses succeeded in the market place.

*Syria*

The Arab Center for Studies of Arid Land Zones and Dry Land (ACSAD) in Syria in conjunction with the Syrian Ministry of Agriculture and Agrarian Reform (MAAR) at Al-Sallamia Research Station initiated a genetic improvement project for Awassi sheep in 1973. The original objectives were to improve the performance of these sheep in milk, meat and wool production (Fareed and Hossamo, 1981). The project started by screening local Awassi in state farms. The base flock was partitioned into four lines, a line each would be selected for single trait, milk, meat or wool while the fourth would be kept as control. It had been planned that at a certain stage of the selection program the three lines would be inter-crossed to produce one composite line. Also, during the initiation phase Awassi germplasm was brought in from Cyprus, Iraq and Turkey to widen the gene pool. At a later stage of the project however, the wool line was discontinued. Kassem (2005) reported that in 1996, mature body weight of ewes (at 5 yr of age) was 63.9 kg for the milk line and 70.6 kg for the meat line while milk yield of 5-yr old ewes was 327 kg in 168 days and 195 kg in 151 days, respectively for the two lines. Kassem (2005) mentioned that adult ewe weight in traditionally managed Awassi flocks as 47 kg. The average differences in milk yield per lactation per ewe between the milk line and control line increased from 19.6 kg (=13.5%) in 1977 to 100.6 kg (=78.6%) in 1995 (Kassem, 2005). Selection among Syrian Awassi sheep for milk and for meat led to increase in litter size. While the litter size in the experimental flock generally ranged between 1.11 and 1.19, that of the meat line and milk line averaged 1.45 and 1.25, respectively. Kassem (1998) reported the average litter size in traditional production systems as 1.02-1.07. Further more, in a recent work by Al-Azzawi et al. (2006), they reported highly significant differences between the milk and meat lines for the period 2000-2005 in total milk yield (188 kg vs.160 kg, respectively), litter size at birth (1.17 vs. 1.32, respectively) and average litter weight at 90 days of age (30.80 vs. 31.23 kg, respectively)

Although the Syrian effort focused on improvement of Awassi through selection, crossbreeding trials were also made in attempt to synthesize crossbreds with increased meat, milk or/and wool production. Breeds used for crossing were Merino, Karakul, East Friesian, Dorset, Suffolk, Finnish Landrace and Chios (Kassem, 2005). These trials were discontinued for reasons of risk of affecting the adaptability of Awassi, unfavorable consumer response to crosses produced, and crossbred showing no superiority to the Awassi or lack of funds to continue on with the trials (Kassem, 2005).

*Turkey*

Gürsoy (2005) reported that a progeny testing program was started in 1992 in a state farm with a very large sheep flock (65,000 animals of all sexes and ages) in the early nineties of the last century and proven rams were selected for planned matings with superior ewes of the nucleus flock to produce both test rams and rams for distribution. In this program milked yield (marketable milk) per ewe per lactation increased from 66.9 kg in 1990 to 152.3 kg in 1997, an increase which was due to both selection using progeny testing and outcrossing with Improved Israeli Awassi and Awassi from Cyprus, introduced into Ceylanpinar State Farm breeding stocks along with possible improvement made in the environment (Gürsoy et al., 1988). However, this genetic improvement program was discontinued in 1999 when the farm milked yield reached 190 kg per ewe per lactation as compared to 90-100 kg as a national average. Gürsoy (2005) reported that Turkish Awassi possessed great variation with respect to milk production and the highest individual lactation milk yield was 592 kg in 1998. Many pedigreed rams obtained from progeny tested rams and outcrossing were distributed to producers.

Numerous crossbreeding trials were conducted with exotic breeds like Ile de France, Rambouillet, Merino German Black Head and East Friesian but none of them proved to be successful mainly due to the adaptation problems of the crossbreds and lack of clear superiority in growth rates and reproductive performances. However Awassi is a good improver breed for increasing the milk production and growth performances in the crossbreds of Akkaraman, Morkaraman, Daglic and other fat tailed indigenous breeds of Turkey and other West Asian breeds (Gürsoy, 2005).

## 5. Proliferation of Awassi genetics into other countries

Beside its widespread presence in countries of origin, Iraq, Israel, Jordan, Palestine, Syria and Turkey, the Awassi has proliferated, for breeding purposes, into at least 30 countries in all continents not accounting for genetics exported through the Assaf breed which is a crossbred obtained via East Friesian x Awassi mating (Table 7). The great majority of these proliferations were from Israeli Improved Awassi and the Syrian Awassi either directly or indirectly through a third country. Some of the countries introducing Awassi used it as an improver breed. Published results showed negative results on livability and growth (Fahmy et al., 1969 in Egypt and Hassen et al., 2002 in Ethiopia) but positive results on milk production (Epstein, 1985, reporting on Iranian data). Crossing Cyprus Fat-Tailed sheep to Awassi was associated with considerable improvement in milk production and increased body weight (Cyprus ARI, 1972, 1973, 1975, Mavrogenis, 1987; Mavrogenis, 1995). Mavrogenis, (1995) reported that Improved Awassi and its crosses could not compete with Chios both in milk production and prolificacy, while Welham (1976) concluded that using Improved Awassi on Spanish breeds (Talavera, Mancha, Churro and Castilian) had an overall increase in milk yield and body weight but with compromised fertility aspects. The same author reported that a variety of Awassi cross called Malpica were spread all over Spain. Florescu (2004) quoted by Rummel et al. (2005) reported that crosses of Improved Awassi with local breeds in Romania did not perform well in the mountains due to disease problems but their performance in the plains was satisfactory. However, there is no information as in how many of these countries the breed has established itself as a viable population.

Many authors in Mediterranean countries have been working to improve lamb and milk production in Awassi by crossing with East Frisian sheep (Galal, 1994; Gabina and Serradilla, 2000).

**Table 7**

## 6. Conclusions

Awassi sheep breed is an important genetic resource that plays a significant role in sheep industry in more than 30 countries beside the countries of its origin. In many places, it became the breed of choice, especially for dairy, because of its high performance in milk and lamb production and ability to produce under varied production environments. Efforts to improve performance of the breed through selection in countries of its origin often yielded favorable or very favorable results. Selection for either milk yield or for body weight was accompanied by positive trend in the other trait and in litter size. Crossing Awassi with other native and exotic breeds in countries of origin gave results that favored the Awassi either because it outperformed the crossbreds or that the latter failed in the marketplace. Using Awassi as an improver breed outside the countries of origin, however, had generally favorable effect on milk production with varied effects on fertility and lamb production. Much work is needed to study the molecular genetics of Awassi sheep in different population in the countries of origin.

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**Table 1. Means of some growth traits of Awassi sheep, kg**

| Country | Body weight at | | | | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | Birth | | 6-mo | | 12-mo | | Adult | | |
| | M | F | M | F | M | F | M | F | |
| Egypt | --- | | --- | | 31.6[c] | | --- | | Fahmy et al.(1969) [c] |
| Iraq | 4.5 | 4.1[a] | --- | | 43.2 | 35.5[c] | 63.4 | 46.2[d] | Asker (1964) [a]; Fahim (1985)[a]; Aziz (1977) [c]; Badawi (1989)[c];Al-Jalili (1988) [d] |
| Israel | 4.5[a] | | 50[b] | | 81[c] | | --- | | Goot et al. (1982) [a] ; Atzmon , Doron (1951)[b]; Goot (1967) [c] |
| Jordan | 4.2 | 3.9[a] | 38.0 | 31.0[b] | 35.3[c] | | 75 | 47.5[d] | Ministry of Agriculture (1980,1981,1983) [a]; ACSAD (1983) [b]; Ministry of Agriculture (1998)[c]; Ministry of Agriculture(1983) [d] |
| Kuwait | 4.6[a] | | --- | | 50[a] | | --- | | Bahmen (1985) [a] |
| Syria | 4.4 | 4.2[a] | 37[b] | | 70 | 48[c] | 67.6[b] | 63.9[d] | Khori (1965) [a]; Kassem (1998)[b]; (2005) [d]; Unpublished data from pastoral area[c] |
| Turkey | 4.4 | 3.8[a] | 32.2 | 29.1[a] | 40.0 | 34.9[a] | 58.2[b] | 73.9[c] | Gürsoy (1980) [a]; Özcan et al. (1983b)[b]; Kirk (2001)[c] |

M: Male, F: Female, 6-mo, 6 months, 12-mo: 12 months, kg: kilogram
Superscripts following figures correspond to those in reference column

**Table 2. Means of reproduction traits for Awassi sheep**

| Country | Fertility (%) | Litter size at birth | Litter size at weaning | Reference |
|---|---|---|---|---|
| Iraq | 76[a] | 1.09[a]<br>1.02-1.12[b] | --- | Hamdon (1980) [a]; Alkass, Juma (2005)[b] |
| Israel | 95[a] | 1.4[b] | --- | Wallach , Eyal (1974) [a]; Gootwine et al. (1992) [b] |
| Jordan | 87[a] | 1.02 | --- | ACSAD (1983) [a] |
| Syria | 82.5[a] | 1.02-1.05[b]<br>1.11-1.45[c] | 0.74 [b] | Kassem (1989a) [a] ; Kassem (1998) [b]; Kassem (2005)[c] |
| Turkey | 85.0[a]<br>92.2[b] | 1.12[a]<br>1.12[b] | 88.4 - 98.0[c] | Ozsoy et al. (1987) [a]; Gürsoy (1992a) [b] ; Gürsoy (1992b)[c] |

Superscripts following figures correspond to those in reference column

**Table 3. Means of lactation traits for Awassi sheep**

| Country | Milk yield (kg) | Lactation period (day) | Fat % | Protein % | Total NFS,% | Reference |
|---|---|---|---|---|---|---|
| Iraq | 60 - 134[a] | 93 - 131[a] | --- | --- | 15.6[b] | Alkass , Juma (2005) [a]; Epstein (1985) [b] |
| Israel | 301.5[a] | 323.2[a] | 6.1[b] | 5.6[b] | 11.3[b] | Goot (1974) [a]; Epstein (1985) [b] |
| | 506[c] | 214[c] | | | | Rummel et al. (2005)[c] |
| Jordan | 85[a] | 120[a] | --- | --- | --- | ACSAD (1983) [a] |
| Kuwait | 100[a] | 150[a] | 8.3[a] | 4.5[a] | --- | Bahmen (1985) [a] |
| Syria | 236[a]<br>327 [c]<br>195 [c] | 171[a]<br>168 [c]<br>151 [c] | 6.8[b] | 5.26[b] | 17.8[b] | ACSAD (1996) [a]; Fadel et al. (1989b)[b]; Kassem (2005) [c] |
| Turkey | 222.5[a] | 187[a] | 6.6[b] | 5.7[b] | 11.6[b] | Gürsoy et al. (1992b)[a]; Uraz (1983)[b] |

Kg: kilogram, NFS: Non Fatty Solid
Superscripts following figures correspond to those in reference column

**Table 4. Means of carcass traits of Awassi sheep**

| Country | Dressing percentage | Reference |
|---|---|---|
| Iraq | 47.8 | Juma , Alkass (2000) |
| Israel | 48.7 | Epstein (1985) |
| Jordan | 52.1 | Abdullah et al. (2002b) |
| Syria | 48.1 | Hossamo (1983) |
| Turkey | 48.7[a]; 44.3-52.4[b] | Bicer et al. (1992)[a]; Gürsoy (2005)[b] |

**Table 5. Means of wool traits for Awassi sheep**

| Country | Annual greasy fleece wt, (kg) | Staple length, cm | Fiber diameter, µm | Kemp score% | Reference |
|---|---|---|---|---|---|
| Egypt | 2.37 | --- | | --- | Fahmy et al. (1969) |
| Iraq | 1.86[a] | 16.47[b] | 31.1[c] | 6.9[d] | Azzawi et al. (1994)[a]; Epstein (1985)[b]; (1977)[c]; Al-Azzawi (1977)[d] |
| Israel | 2.35[a] | -- | 45.8[b] | 4.5[b] | Goot (1972)[a]; Epstein (1985)[b] |
| Jordan | 2.2[a] | 14.8[a] | 34[b] | 7.2[a] | Tabbaa et al. (1998)[a]; ACSAD (1983)[b] |
| Kuwait | 2.4 | -- | | -- | Bahmen (1985) |
| Syria | 2.96 | 19 | | -- | Khori (1965) |
| Turkey | 2.80[a] 2.75-2.89[b] | 19.19[a] | 37.09[b] | 5.1[c] | Torun et al. (1993)[a]; Epstein (1985)[c]; Gürsoy (1980)[b] |

Superscripts following figures correspond to those in reference column

**Table 6. Heritability estimates for different traits in Awassi sheep reported by different authors**

| Trait | Estimate |
|---|---|
| Fertility | 0.10 Ir, [1] |
| Litter size at birth | 0.18 Ir, [2] |
| Birth weight | 0.19, 0.07 Ir, [3, 4] ; 0.16 Is, [5] ; 0.24 S, [6] ; 0.44 T, [7] |
| Yearling weight | 0.20, 0.11, 0.10 Ir, [3, 8, 9] |
| Milk yield | 0.21 Ir, [2] ; 0.10 Is, [10] ; 0.53 S, [6] ; 0.22 T, [7] |
| Lactation period | 0.38 Ir, [11] ; 13 Is, [10] ; 0.24 S, [12] |
| Dressing percentage | 0.29 Ir, [13] |
| Annual fleece weight | 0.47, 0.20, 0.64 Ir, [2, 14, 15] ; 0.26 S, [12] |
| Staple length | 0.08, 0.24 Ir, [14, 15] |
| Kemp score | 0.30 Ir, [14] |

Ir: Iraq Awassi, Is: Israel Improved Awassi, S: Syrian Awassi, T: Turkish Awassi.
[1]Abdul-Rahman (1996); [2] Al-Azzawi (1999); [3] Kazzal (1973); [4] Al-Tae (1981) ; [5] Gürsoy et al. (1995); [6] ACSAD (1999); [7] Pollott et al. (1998); [8] Aziz (1977); [9] Alkass et al. (1991); [10] Pollott , Gootwine (2001); [11]Al-Samarae (1999); [12] Hossamo (1983); [13] Al-Hillali et al. (1990); [14] Sabbagh et al. (1995); [15] Al-Azzawi et al. (2002).

**Table 7. Proliferation of Awassi genetics into other countries**

| Recipient Country | Source | | | |
|---|---|---|---|---|
| | Israel | Jordan | Syria | Turkey |
| Albania* | ● | | | |
| Algeria | | | ● | |
| Australia* | ● | | | |
| Bahrain | | ● | ● | |
| Bulgaria | ● | | | |
| Cyprus | ● | | | ● |
| Egypt | | | ● | |
| Emirate | | ● | ● | |
| Ethiopia | ● | | | |
| Hungary | ● | | | |
| India | ● | | | |
| Iran | ● | | | |
| Iraq | | ● | | ● |
| Israel | | | ● | ● |
| Italy* | ● | | | |
| Jordan | ● | | ● | ● |
| Kyrgyzstan * | ● | | | |
| Kazakhstan | ● | | | |
| Kuwait | | ● | | |
| Lebanon | | | ● | ● |
| Libya | | | ● | ● |
| Macedonia | ● | | | |
| Morocco | | | ● | |
| Myanmar | ● | | | |
| NZ | ● | | | |
| Pakistan | | | ● | |
| Palestine | ● | | | ● |
| Peru | ● | | | |
| Portugal | ● | | | |
| Qatar | | | ● | |
| Romania | ● | | | |
| S. Arabia | | | ● | ● |
| Spain | ● | | | |
| Tunisia | | | ● | |
| Turkey | ● | | | |
| UK* | ● | | | |
| Yemen | | | ● | |
| Yugoslavia | ● | | | |

* Albania, Australia, Italy, Kyrgyzstan , UK received Awassi through a third country.