1. General observations on Awassi sheep

Distribution and nomenclature

The Awassi is the most numerous and widespread type of sheep in southwest Asia. It is the dominant breed in Iraq, the most important sheep in the Syrian Arab Republic, and the only indigenous breed of sheep in Lebanon, Jordan and Israel. In the north of Saudi Arabia it is bred under desert conditions (Pritchard, Pennell & Williams, 1975). The Awassi is not mentioned by Spöttel (1938, 1939) among the breeds of Anatolian sheep, but Past (1965) writes that the Awassi makes up 1 percent of the ovine population of Turkey, and Mason (1967), following Yarkin (1959) and Düzgüneş (1963), gives a similar figure (0.9 percent). There is a small increase in their number from year to year, so that in 1976 the Awassi accounted for 1.8 percent of the total number of sheep in Turkey (Yalçin, 1979). The breeding area in southern Anatolia is situated in a border strip, Antakya (Hatay) and south of the Gaziantep and Urfa vilayets along the main range of the breed in Syria. In Iraq the true Awassi is found north of the Al-Amarah *liwa* (administrative district) and in the centre of the country from Al-Kūt and the lower Tigris marshes, up between the rivers through Al-Hayy, Ad-Daghgharah, As- Samāwah, Al-Hillah and Al-Jazirah, west of the Tigris to the region of Mosul. The breed is also widespread east of the Tigris, north of the lower Diyālá and Baghdad, in the pastoral region stretching intermittently into the Mosul and Arbīl *liwas* and that lying between the middle Diyālá and extending north to the Little Zab (Williamson, 1949).

The name of the Awassi is attributed to the El-Awas tribe between the Tigris and Euphrates rivers. In literary Arabic, *awas* is the term for red and white camel garb or for a white sheep (Hirsch, 1933). In the Islamic Republic of Iran it has been referred to as Ahvāz (or Ahwāz), a town in Khuzestan, Iran, near the border with Iraq (Hinrichsen & Lukanc, 1978). The name of the sheep is also sometimes spelled Aouasse, Awasi, El Awas, Iwessi, Oussi or Ussy. In Turkey the breed is called İvesi or Arab and in some parts of Syria Nu'amieh (also spelled Na'ami, Naimi, Nami, Neahami, N'eimi, or Nuamiyat) or Shami, the latter being the Arabic name for Damascus.

In addition to the typical Awassi, several nearly allied varieties exist (Mason, 1967). In Syria, the Deiri variety (from Deir ez Zor) in the east has been distinguished by Schuler (1936) from the Baladi of the west, which is the typical Awassi, the term *baladi* meaning 'local'. Among Awassi flocks in the semi-desert and maritime plain of Syria, Mukhamed (1973) recognized three different types of sheep, namely, Shagra (Chacra, Chagra, Chakra) with a reddish-brown face, Absa with a black face and Porsha with a grey face, associating these colour markings with different physiological and anatomical properties. But the name Shagra has also been applied to other breeds such as Red Karaman and Parasi (Mason, 1967).

In Iraq, the Gezirieh (Jazirieh) or Gezrawieh variety from the region between the Tigris and Euphrates has been reported as being superior to the ordinary Awassi in mutton production, but inferior in milk yield. Two other Awassi varieties in Iraq are called N'eimi and Shafali, respectively. The N'eimi, which is bred in particular by the Jabal Shammar to the north of the area of the Dulaim (or Delaim) tribe in northwest Iraq, is a more compact sheep than the ordinary Awassi, with shorter and more muscular limbs, a finer and denser fleece and a higher milk yield. The face is generally black but may also be reddish, and this colour sometimes extends to the fleece. The N'eimi variety is named after a tribe. The name does not refer, as has been suggested, to its being superior.

In the region of Al-Hayy and Al-Kūt in south-central Iraq, Awassi sheep are kept on irrigation farms, to which the name 'Shafali' (meaning a low-lying plain) refers. This is rendered in English as Shevali, Shaffal or Ashfal, and into French as Chevali, Chaffal or Choufalié. The Shafali is distinguished by the high carriage of the head, a reddish-brown fleece with nearly black head and legs, and early maturity. Since the Shafali is also bred by the Dulaim tribe in northern Iraq, it is also known as Delimi, Dilem, Dillène or Douleimi. In Syria, Shafali sheep are found along the Euphrates, between Meyadin and Abu-Kemal on the Iraqi frontier. Apparently the name is applied to several types of sheep (Mason, 1967, 1974).

A somewhat more remotely related variety of the Awassi is kept in Iraqi Kurdistan, southwest of Mosul, by the Herki or Hargi tribe of Kurds. It is called Herki (Harrick, Herrik, Hirrick, Hurluck), Mosuli (Mossul, Moussouli) or Dazdawi and is distinguished from the true Awassi sheep of the same region by its larger size, longer caudal appendix, rudimentary horns, the frequent presence of a topknot and of brown spots on the fleece. The Herrik or Hirik of Turkish Kurdistan is of a similar type but has shorter ears and no horns. Because of its resemblance to the Awassi of Israel, the Herrik was chosen to overcome a shortage of Awassi sheep in Israel during the years 1953-57 when 17 shipments totalling 14 632 Herrik ewes were imported from the vicinity of Cizre on the Tigris in Turkish Kurdistan near the borders of Syria and Iraq. While resembling the Awassi sheep of Israel in general conformation and the shape of the fat tail, the imported sheep were smaller than the improved type of Awassi, the live weight of adult ewes varying between 40 and 45 kg, and their fleece being somewhat heavier than that of the Awassi. The body and legs were white, while the head was usually grey, occasionally brown or white. The milk yield, including the milk sucked by the lamb, was only 100-120 kg per lactation and the twinning percentage 5-6. No male Herrik sheep were imported and the ewes were bred to improved Awassi rams so that their descendants were absorbed by the Awassi flocks (Epstein & Herz, 1964).

The Cyprus fat-tailed sheep (see appendix Figs A-l and A-2) present a special problem with regard to their relation to the Awassi group. They are undoubtedly allied to the Awassi of the mainland, which they resemble in many physical and physiological respects. Maule (1937) writes that the 'Palestinian breed… is probably the one nearly akin to the Cyprus sheep', while Mason (1967), grouping the Cyprus with the Awassi, notes that the Cyprus breed 'is similar to the breeds of the neighbouring mainland and resembles the Awassi of Syria more than the White Karaman of Turkey'. Yet there are also significant differences between the two breeds, which may be due to the long isolation of the Cyprus sheep on their island or the influence of Turkish sheep. Thus, unlike the head of the Awassi with its typical brown coloration, that of the Cyprus sheep is commonly white with black on the nose and around the eyes, more rarely white, black, brown or mottled. The greatest difference is the size, weight and shape of the fat tail. In the Cyprus the tail is much longer, broader and heavier than in the Awassi, its twisted end often reaching to the ground. It is widest in the middle third and then tapers gradually to the tip, making a half-turn to the right or left at the junction of the middle and lower thirds (Mason, 1967). Mason (personal communication, 1979) also notes that 'it would be confusing to include the Cyprus as a variety of the Awassi since the name Awassi has never been used for them'.

Origin

In physical and functional properties, the Awassi seems to be very close to the prototype from which the fat-tailed sheep of Asia, Africa and Europe are derived. Many of these still show a close likeness to the Awassi. This holds true not only for the sheep of Cyprus and North Africa and several Turkish and Iranian breeds, but animals similar to the Awassi are also encountered among the Ronderib Afrikander sheep of South Africa and the Mongolian sheep of east Asia (Epstein, 1969,1970,1971). Fat-tailed breeds deviating from the Awassi in some physical or functional properties may owe their peculiarities either to evolution in a different environment, specialized breeding aims or to crossbreeding.

Fat-tailed sheep have been bred in the breeding area of the Awassi for at least 5 000 years. A fat-tailed ram below a thoracic-humped zebu is represented in a floor mosaic of the synagogue of Beyt Alfa, Israel (Fig. 1-1). A similar motif is depicted in a wall panel in the synagogue of Dura Europus (El-Salihiyeh) on the Euphrates, 48 km upstream of ancient Mari, which was built in the middle of the third century AD. In Assyria, fat-tailed sheep were bred at the time of Tiglath Pileser III (Fig. 1-2). They seem to have differed from the recent Awassi sheep of Iraq mainly in their concave facial profile and the lesser development of the fat tail. In Sumer a woolless ram with a clearly marked fat tail is depicted on the mosaic standard of Ur, dated *c*.2400 BC (Fig. 1-3). The earliest representation of a fat-tailed sheep with an upturned tail tip is found on a fragment of a stone bowl from the Uruk III period of Ur (Fig. 1-4), indicating that the fat-tailed type is a very ancient product of domestication in this area.

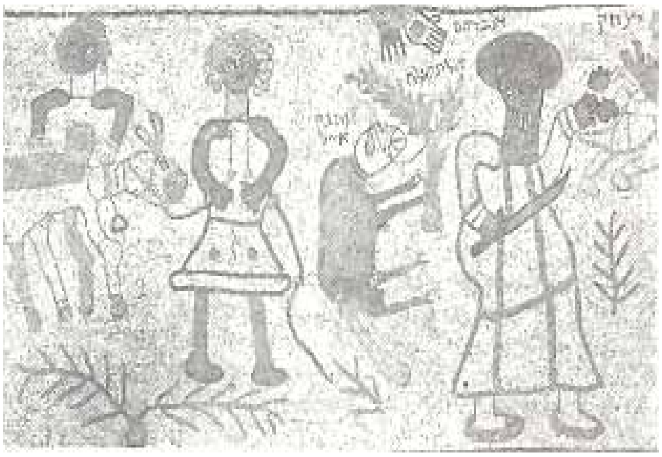


Figure 1-1. Fat-tailed ram from mosaic floor in the synagogue of Beyt Alfa (sixth century AD)

Figure 1-2. Assyrian fat-tailed sheep from the time of Tiglath Pileser **III** (745-727 BC)

Figure 1-3. Fat-tailed ram on mosaic standard from Ur (c. 2400 BC). (**Source:** The British Museum)

Figure 1-4. Fat-tailed sheep on a stone bowl from the Uruk **III** period of Ur (c. 3000 BC). (**Source:** The Metropolitan Museum of Art)

In the quest for the cradleland of the fat-tailed sheep, the peculiar character of the tail permits certain conclusions as the fat deposits on the tail represent an accumulation of reserve material similar to the humps of camels. Such deposits evolved under steppe and desert conditions which are noted for long periods of drought and feed scarcity. The fat tail points, therefore, to a steppe country as the place of evolution of these sheep.

The development of store reserves on which the animal draws during periods of nutritional scarcity can be explained by the mechanism of directed selection. This implies that fat deposits on the tails of sheep may sporadically occur among any breed, but that it is only in steppe and desert countries and among peoples lacking other fat-producing animals that this feature is of such economic importance that sheep with adipose deposits on the tail have been specially selected for breeding purposes.

The belief in the advantage of the fat tail to sheep in a semi-arid environment is, perhaps, fictitious and not founded on a factual usefulness, for the fat tail appears to constitute a concentration of reserve material which is not additional to the normal accumulation of fat in the body, but is merely away from the body. This assumption is based on an experiment in which the development and body composition of docked Awassi lambs were compared with those of an undocked control group (see also Table 5-13) (Epstein, 1961). In the docked lambs nearly all the fat that would normally have been stored in the tail was distributed over the body in the form of fat and muscle tissue. In other words, the body of the fat-tailed lambs was leaner by nearly the whole amount of their tail fat than the body of the docked lambs. Nel, Mostert and Steyn (I960), working with Karakul sheep, arrived at a similar conclusion: 'Once the tail has been removed the animal is capable of storing in other parts of the body the fat which is usually deposited in the tail.'

It is uncertain if the relatively lean body of fat-tailed sheep is advantageous to their heat economy in a subtropical environment. Sir John Hammond (quoted by Mason, 1963) argued that a store of fat was useful as a reserve of food and metabolic water and a means of avoiding the insulating layer of subcutaneous fat, and gave fat-tailed sheep as an example. Wright (1954) conceded that the localization of a large fat reserve may incidentally give some small advantage to animals in hot climates since in consequence they do not need a generalized subcutaneous layer to prevent the dissipation of body heat. Mason (1963), however, denied this on the grounds that cases of local fat deposits are an exception and not the rule in wild desert animals. The absence of a thick layer of subcutaneous fat could only be effective in the comparatively narrow range when the air temperature is below body temperature but high enough for the animal to feel uncomfortable, that is, about 27-38°C. Since the blood supply passes through the subcutaneous fat, this channel of heat loss would not be affected, nor would sweating or pulmonary evaporation, nor, it may be added, the conduction of body heat to drinking water and its elimination with the urine, which are the most important mechanisms of heat loss in sheep. Indeed, in a trial with five 15-month-old docked rams and five undocked control sheep of the fat-tailed Ausimi and Rahmani breeds of Egypt, Hafez, Badreldin and Sharafeldin (1956) found that docked sheep exhibited greater efficiency in heat regulation than fat-tailed sheep. The docked rams had a significantly lower respiration rate and lower skin temperature, a phenomenon particularly pronounced during the hottest months of the year as well as at the hottest time of the day. From May to October the mean respiration rate of the docked rams was in every month lower than that of the undocked animals, with a mean of 44.7 in the docked rams versus 46.4 in the undocked rams for the whole period. At the same time, the average skin temperature in all body regions studied was 35.9°C in the docked rams and 36.3°C in the fat-tailed control group. The authors suggest that the more efficient heat regulation of the rams without fat tails may be due to the better air circulation around their hindquarters since the middle and upper regions of the fat tail, which are in contact with the hindquarters, have a high skin temperature.

The concept of the fat tail as a store of metabolic water has been virtually abandoned. The oxidation of fat would lose more water in the pulmonary evaporation necessary to supply oxygen than would be gained by combustion.

The fact that localized fat reserves are not commonly found in domestic animals other than those that normally inhabit desert and semi-desert areas suggests that the fat reserves are primarily associated with the provision of stored energy. Even though the animal may not actually gain from the accumulation of fat in its tail and the breeder's belief in his own gain be fallacious, the concentration of fat in a lump instead of its intermuscular and subcutaneous distribution throughout the body may be an attraction to breeders under certain environmental and economic conditions. Whatever the value of the fat tail, real or assumed, the very fact that it has been regarded as desirable explains its evolution under domestication.

Among ordinary sheep the sporadic occurrence of both fat-tailed and fat-rumped sheep has been recorded. In the White-faced Woodland sheep of the United Kingdom 'the tail is inclined to be fatty' (CBABG *News-Letter,* 1969), and Ryder (personal communication, 1969) has 'seen reports that the Scottish Blackface has a tendency towards a fat tail'. The Cotswold and Romney Marsh breeds, as Lydekker (1912) points out, 'exhibit a marked tendency to accumulate fat on the rump almost to the degree of producing a deformity'; and further: 'In confirmation of the view that the accumulation of fat in the caudal region is merely a result of domestication, it may be recalled that two of the ordinary British breeds display a tendency to this feature.' Ewart (1913-14) was even more explicit on this point when he wrote that in 'some Border-Leicester and Cotswold rams there is a considerable amount of fat at the root of the tail or in the buttocks' and further, that 'in many lambs fat tends to accumulate in the root of the tail, while in not a few breeds, when food is abundant, fat accumulates to the extent of several inches over the rump. In this tendency to store fat, improved breeds ... approach the fat-tailed and fat-rumped breeds of Central Asia'. Again, 'in lambs of improved modern breeds, the tip of the long tail is sometimes turned upwards'.

Adametz (1927) has drawn attention to the tendency to fat tail formation observable in Merino, Rambouillet, Tsigai and Zackel sheep. New-born lambs of these breeds have moderate, but clearly discernible, lateral skin folds at the tail root, which correspond qualitatively to the marked development of folds (which subsequently fill up with fat) on both sides of the upper section of the tail displayed by the lambs of fat-tailed breeds. Since there exists no economic necessity in any of the countries where these breeds occur to produce a fat-tailed type of sheep, such animals are not selected for breeding purposes. On the contrary, in mutton breeds of the United Kingdom they are culled, as the fat deposits on the rump and tail are considered to be undesirable. But there can be little doubt that fat-tailed breeds could still be evolved from among ordinary sheep, were this desirable.

While the fat-tailed type could have been evolved in any climatic and floral environment where sheep can exist, it may be assumed that it was actually evolved in a steppe and desert region by a people who lacked the fat-producing pig for sacral or other reasons. The fat tail, then, may have been acquired long after the domestication of the thin-tailed parent stock, in a region far distant from the original home of the latter. Antonius (1922) suggested that the fat-tailed type was evolved in the steppes of Syria and Arabia where climatic conditions favoured the development of fat reserves. In support of this he pointed out that no records indicated the evolution of the fat-tailed variety in any other than those regions.

In view of the occurrence in central Arabia of several rock engravings of fat-tailed sheep with spears pointing to their bodies (Fig. 1-5), Anati (1968) claims that this environment 'may well have stimulated the development of the fat-tail without necessarily implying domestication'. He further claims that the fat-tailed type of sheep 'became domesticated in Arabia at a time when its physical characteristics, including the enormous fat-tail, were already formed', and that 'a general date in the second millennium BC may be suggested for the domestication of this animal in Arabia. Thereafter, a few depictions continue to show this animal wounded by the hunter's spears, and it is possible that wild specimens continued to exist side by side with those bred in captivity'.

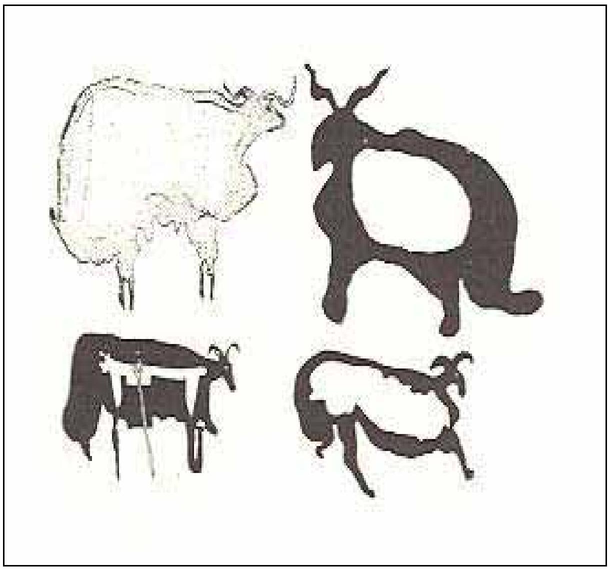


Figure 1-5. Fat-tailed sheep. Rock engravings from central Arabia, second or early first millennium BC. (**Source:** Anati, 1968)

This theory is unacceptable. Domesticated fat-tailed sheep were bred in Mesopotamia at least one millennium (and probably much more) before the date suggested by Anati for their domestication in Arabia. Further, none of the various races of wild sheep that have survived, including some living in deserts or semi-deserts, has developed a fat tail. Indeed, none of them has even a thin tail as long as that of the fat-tailed sheep depicted in the early rock art of Arabia. Again, it is unlikely that in a country like Arabia, teeming with wolves and jackals and other beasts of prey, wild sheep with the enormous fat tails attributed to them could have outrun their pursuers. Such heavy fat tails severely impede locomotion and can only be developed in sheep protected by man.

While Antonius' suggestion regarding the possible evolution of the fat-tailed type of sheep of the Syrian steppe may be correct, the evidence available is insufficient to prove it. From the viewpoint of environment, the fat tail could also have been evolved in another steppe region of western or central Asia, as were the fat rump in sheep and the hump in zebu cattle. Accordingly, Adametz (1927) suggested Mesopotamia, Armenia and Iran in addition to Syria as possible areas of evolution of the fat-tailed type. On the other hand, the fact that the Syrian steppe has since prehistoric times been the habitat of Semitic peoples, most of whom did not possess pigs, and that fat-tailed sheep could thence be readily diffused as far as China in the east and the Cape of Good Hope in the south, and further, that the fat-tailed sheep was known in ancient Mesopotamia but not in the Indus valley, favour Antonius' view.

The parent stock of the fat-tailed sheep has doubtless to be sought among the long-and-thin-tailed domesticated breeds of Asia. Although Duerst (1908) believed that the fat tail in sheep was developed at Anau after the climate of Turkestan changed and became more arid, sufficient grounds do not exist for this assumption. The fat-tailed type, like every other basic type of sheep, is the product of its total history. This includes descent from a particular wild race, and may include the outcrossing of domesticated stock to another or several other related wild races; the interbreeding of various domesticated types evolved from the originally domesticated stock in different environments; and artificial and natural selection under different circumstances. It is probable that the long-and-thin-tailed parent stock of the fat-tailed sheep was ultimately derived from one of the local races of wild sheep in western Asia.

Beginnings of improved Awassi breeding in Palestine

Sheep breeding is an ancient occupation in Palestine and its neighbouring countries where it has been practised for thousands of years. As early as 1500 BC, Nuzi documents mention Canaanite wool (Breasted, 1935) (see also Chap. 6) and the early books of the Bible continually refer to sheep breeding in Palestine and Mesopotamia. Sheep were bred by peasants and nomads alike. The system of shepherding, as established in early times (probably soon after the domestication of sheep) remained in vogue in southwest Asia virtually unchanged until the early 1920s. Indeed, in many parts of southwest Asia, which include the lands of the bedouin tribes of Israel, it has remained unchanged to this day. The flocks are usually composed of sheep and goats. In Israel those of the bedouin commonly include more sheep than goats, and the flocks of the Arab villagers contain more goats.

The indigenous breed of sheep in Palestine is the fat-tailed Awassi. Its recent history in this country began in 1884/85 when two young agricultural workers — immigrants from tsarist Russia — bought a flock of Awassi sheep and local goats from bedouin and, dressed in the manner of bedouin shepherds, pastured them in the fields of Rishon le Zion and the swamps of Nabi Rubin and learned to milk them. One night their flock was carried off by marauders and, while they succeeded in recovering it, they could not overcome the severe losses caused by disease and parasites. In despair they left the country, one for Australia and the other for lands beyond the Atlantic.

It took a quarter of a century for this sporadic attempt at sheep breeding in Palestine to be repeated by Jewish immigrants. In 1908 a villager at Yavneel, southwest of Lake Tiberias, acquired a flock of Awassi sheep from bedouin of the Daleiqa tribe and kept it in partnership with one of his bedouin neighbours. Following his example, other farmers at Yavneel also purchased sheep and goats, leaving them either in the care of hired bedouin shepherds or in partnership with them. In a few years the number of Awassi sheep and Syrian mountain goats at Yavneel rose to a thousand head. The animals were kept in the open day and night, summer and winter, and received no feed other than grazing. In these conditions mortality from disease and parasites was very high and many animals were stolen or killed by jackals. Sheep breeding at Yavneel was therefore given up after a few years.

In 1910 a flock of Awassi sheep was established at Ben Shemen. In 1912 the manager of the communal farming village of Merhavia bought a flock of Awassi sheep from bedouin. However, this was soon abandoned. A more lasting effort was made in 1914 when several members of the Jewish Guards' (Shomer) organization in Galilee in northern Palestine attached themselves to the Turkeman tribe of bedouin in the northern part of the Plain of Sharon in order to learn the art of shepherding. After a year of nomadic life with the tribal flocks, they returned to Galilee to work as shepherds in the villages of Kinneret and Beyt Gan. About the same time an organization called The Shepherd was founded for the purpose of establishing flocks of Awassi sheep in Jewish settlements (Mizpa, Sharona, Hamara and Sheikh Abriq).

In 1915 an Awassi flock was purchased for the Miqve Israel School of Agriculture (Fái, 1979). In 1920 a shepherds' settlement was set up at Sharona in eastern Galilee with a flock of Awassi sheep acquired from Arab breeders in Palestine. In 1922 the Sharona flock was transferred to Kefar Gil'adi in upper Galilee. Stud rams for this flock were purchased in Transjordan and the Jaulan (Jebel ed Druz). In 1923 an Awassi flock, obtained from bedouin, was established at 'Eyn Harod and in 1924 another flock of Awassi sheep at Tel Yosef under the care of shepherds who had learned to work with sheep from the Sakher tribe of bedouin near Beyt Shean. In Aiyelet Hashahar sheep farming was taken up in 1927 and in the same year in Beyt Alfa. Until 1931 these four flocks were the only ones kept at communal settlements (kibbutzim).

During the last years preceding the First World War and the first years following it, Awassi sheep were also introduced in several Jewish villages. In addition to Yavneel, they were brought to Kefar Tavor, Ssejera (Ilaniya), Beyt Gan, Menahemiya, Kinneret, Matspeh, Rosh Pinna, Metulla, Yesud Hama'ala, Mishmar Hayarden, Zikron Ya'aqov, Hadera and 'Atlit. In 1927 these village flocks numbered 1 500 animals and in 1931 over 2 100. The sheep were kept mainly for their manure which was needed for orange groves and vineyards. The majority of them were cared for by Arab shepherds. The sheep were kept in the open during summer and winter, day and night, without any feed other than pasture. Losses from exposure, disease, parasites, beasts of prey, and theft were heavy. This level of feeding and maintenance and the absence of an economic breeding aim rendered sheep farming in the Jewish villages unremunerative, with the result that most flocks were disbanded.

The flocks of the communal settlements, being maintained at a level of feeding, breeding and management similar to the customary system among Arab villagers and bedouin, were at the beginning not in a condition much better than the flocks of the Jewish villagers. Indeed, in some instances Arab shepherds were training their Jewish colleagues in the ancient ways of shepherding. However, the poor economic results did not cause the settlements to give up their flocks, but induced them to improve their methods of sheep farming. Thus, at the first annual meeting of sheep breeders at 'Eyn Harod in 1924, the discussion centred on the importance of sheep breeding to the economy of the communal settlements and the necessity of improving Awassi flocks. In 1927 an article published in the agricultural journal *Hassadeh* advised sheep breeders to study the modern methods of other countries. At the second meeting of sheep breeders, convened in Beyt Alfa, the importance of increasing milk yields by means of selective breeding was stressed. These events foreshadowed the beginning of development of the Awassi breed of sheep in compliance with modern economic requirements.

The establishment of the Sheep Breeders' Association at the annual meeting of breeders at Tel Yosef in 1929 marked an important step forward in the improvement of Awassi sheep. At the association's annual assembly at Kefar Gil'adi in 1932, the breeding aim of developing the Awassi into a milk-and-mutton breed was formulated and a plan for uniform milk recording and bookkeeping adopted. In 1937 the annual assembly at Kefar Hahoresh rejected a proposal to introduce the crossbreeding of Awassi with imported milch sheep in order to raise production more speedily than by selection alone. At the same time the breeding aim was modified by concentration on'… the increase of milk production, along with taking pains to preserve the robust and healthy constitution of the Awassi breed of sheep'. A detailed working plan was adopted, including fortnightly milk control by weight instead of measure, standardization of lactation records by including an estimated quantity of milk consumed by the lamb, and introduction of a common card system for the keeping of records. In 1940 the Sheep Breeders' Association began to publish the journal *Hanoked* ('the sheep breeder'). Progeny testing of rams was introduced in the stud flock of 'Eyn Harod in 1941, and in 1943 the Flock Book of the Improved Awassi was opened for the registration of flocks and individual ewes with minimum lactation records (see also Chap. 7). The first exhibition of Awassi sheep took place at Kefar Yeladim in 1944. In 1950 the flock book administration introduced ram certificates for every stud and flock ram, with particulars on pedigree, breeding and score, and in 1951 the publication of annual flock files began, providing information on the performance and breeding standards of all registered flocks (Finci, 1957).

These steps and events led to the speedy extension of sheep breeding to communal settlements. In 1931 two additional flocks (in Merhavia and Mishmar Ha'emeq), and in 1932 another three (in Mizra, Sarid and Ginegar), were established. This brought the number of Awassi sheep in Jewish settlements to 4 000 in 1931 and 4 500 in 1932. But these numbers represented only a small fraction of the total Awassi population of Palestine, which at that time counted approximately 250 000 head. In addition, import figures recorded at quarantine stations showed that in 1931,152 000 slaughter sheep reached Palestine from neighbouring countries. Actually the number of imported animals was considerably higher, since many flocks were driven into Palestine passing the borders without any veterinary observation (Hirsch, 1933). The sheep imported from Syria and Transjordan were all of the Awassi breed; only a relatively small number of Najd sheep were trekked to Palestine each year from Arabia.

During the period 1933-38, an average of six new Awassi flocks were established in Jewish settlements annually. In 1939 a further 18 flocks were added to the previous ones in communal settlements.

The establishment of the State of Israel in 1948 gave a great impetus to the breeding of Awassi sheep, so that by 1955, a quarter of a century after the formation of the Sheep Breeders' Association, the number of Awassi flocks in communal settlements, cooperative villages and on private farms had increased to 400 (Becker, 1958).

In cooperative villages and on private farms the size of flocks has not undergone major changes during the last four decades. But in the flocks of the communal settlements the average number of breeding ewes and rams has increased continuously. In 1937/38 it amounted to 89, in 1949/50 to 194, in 1959/60 to 440, and in 1969/70 to 723 (Fái, 1972).

Physical characteristics

Conformation. The unimproved Awassi is a robust and vigorous, medium-sized sheep of milk and mutton type. The improved Awassi of Israel is larger and more refined than the unimproved type and the characteristics of the respiratory type of milch sheep are more pronounced than are the mutton features (Fig. 1-6). The bodily proportions are affected by the size and weight of the fat tail which gives the impression of a want of balance between hind- and forequarters. In ewes this impression is enhanced by the large udder (see Fig. 1-7).

Figure 1-6. Awassi stud ram

Figure 1-7. Awassi ewe and lamb

Size. The height at withers of İvesi ewes in Turkey ranges from 65 to 70 cm (Yalçin, 1979). Sönmez (1955) and Yarkin, Sönmez and Özcan (1963) recorded the measurements of İvesi rams and ewes of different ages given in Table 1-1.

The body measurements of Awassi ewes in Iraq are higher. Eliya and Juma (1970a) recorded a heart girth of 81.8 cm in 157 yearling ewes and 92.5 cm in adult females, while Kazzal (1973) gives 86.3 cm for yearlings at the Hammām Al'Alil Agricultural Experiment Station. Further measurements of Iraqi Awassi rams and ewes of different ages have been taken by Eliya (1969) and Juma and Eliya (1973) (see Table 1-2).

For unimproved Awassi sheep in Palestine, Hirsch (1933) has set down the average measurements given in Table 1-3.

TABLE 1-1. **Body measurements of İvesi sheep in Turkey** (cm)

Age (years):	1		2		3 or more	
Sex:	♂	♀	♂	♀	♂	♀
Height at withers	59.5	57.7	—	62.9	68.3	65.0
Length of body	60.0	58.0	—	59.7	62.1	61.8
Heart girth	86.0	78.3	—	82.5	93.0	86.5

TABLE 1 -2. **Average body measurements of Awassi sheep in Iraq at different ages** (cm)

Age (years)	Number		Height at withers		Length of body		Depth of chest		Heart girth	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1	105	109	69.3	66.8	59.5	52.9	32.3	30.3	93.3	83.6
2	11	62	74.8	69.2	63.9	55.8	36.9	32.8	110.3	90.4
3	3	87	80.4	70.1	70.3	57.1	39.3	33.5	115.8	93.0
4	—	113	—	69.3	—	58.3	—	33.7	—	93.5
5	—	67	—	69.6	—	58.2	—	34.4	—	95.2
6 and above	—	65	—	70.5	—	58.0	—	34.5	—	94.3

TABLE 1 -3. **Average body measurements of unimproved Awassi sheep in Palestine** (cm)

Sex	Height at shoulder	Height at back	Height at rump	Length of body	Depth of chest	Width of chest	Heart girth
Rams	75	74	73	72	33	22	91
Ewes	68	67	67.5	67	27	18	80

Table 1-4 gives respective measurements for 421 improved Awassi rams and 2 039 ewes as recorded by Finci (1957) in Israel. In addition, Finci recorded width of pelvis and shank girth. For rams these are 23.8 (18-30) and 9.4 (8-11) cm, and for ewes 21.4 (15-28) and 8.0 (6.5-9.5) cm, respectively. In 1977/78, the author recorded the measurements given in Table 1-5 for nine adult rams and 17 ewes of highly improved Awassi dairy flocks in Israel (see also Tables 3-119 and 3-120). Of particular interest are the great changes in chest dimensions of ewes between 1931 and the present, namely, an addition of 8.2 cm to the width of the chest and 20.2 cm to its circumference, illustrating the increase in the size of heart and lungs necessitated by the large increase in milk production and metabolic rate.

TABLE 1 -4. **Average body measurements of improved Awassi sheep in Israel** (cm)

Sex	Height at shoulder	Height at back	Height at rump	Length of body	Depth of chest	Width of chest	Heart girth
Rams	77.7	77.0	77.3	74.8	35.9	20.7	100.7
(range)	(66-87)	(68-86)	(67-86)	(62-87)	(28-42)	(16-28)	(80-124)
Ewes	69.3	69.3	69.4	68.5	32.7	19.5	94.0
(range)	(58-78)	(59-79)	(58-79)	(56-80)	(28-39)	(13-28)	(76-116)

TABLE 1 -5. **Average body measurements of improved Awassi rams and ewes in Israel** (cm)

Sex	Height at withers	Height at hook bones	Length of body	Width of chest	Heart girth
Rams	85.4	86.8	87.3	29.4	113.0
Ewes	73.7	76.7	75.8	26.2	100.2

Weight. In Palestine in 1930, Hirsch (1933) recorded a mean live weight of 74.6 kg for 13 Awassi rams kept in three communal settlements and 41.7 kg for 116 ewes. The exceptionally large mean weight for that time of 74.6 kg for unimproved rams must be attributed to the small number weighed, very strict selection and a high plane of feeding. Actually, the average live weight of unimproved rams bred by the bedouin and fellahin in Israel does not exceed 60 kg, while in Syria and Iraq, because of superior grazing, it is somewhat higher. Thus, in a flock of Awassi sheep established at the American University farm in Lebanon on the basis of 47 ewes of about five years old purchased from Syrian nomads summering in El Baq'a valley, Rottensten and Ampy (1971a) recorded an average live weight of 45 kg in two-year-olds and 57 kg in four-year-old ewes in three weighings, four months apart, and approximately 90 kg in three-year-old rams.

The recorded live weight of Awassi sheep slaughtered in Syrian town slaughterhouses was about 42-45 kg (Gadzhiev, 1968). The weight of adult Syrian Awassi rams, recorded by Erokhin (1973), ranged from 68 to 80 kg and of adult ewes from 40 to 45 kg. In 1942-45 Epstein (1977) established an average weight of 42 kg for several thousand Awassi ewes that had been purchased in Transjordan, Syria and Iraq for slaughter. In Turkey, Sönmez (1955) reported an average live weight of 38.1 kg in İvesi ewes. Yarkin and Eliçin (1966) recorded a weight of 52.9 kg in mature İvesi ewes, while Sidal (1973) found that 225 adult ewes from three village flocks weighed only 44.4 kg on average. Mason (1967) gives a weight of 60-90 kg for unimproved Awassi rams and 30-50 kg for unimproved ewes throughout the range of the breed in Syria, Lebanon, Israel, Jordan, Iraq and Turkey.

For 391 improved Awassi rams in Israel, Finci (1957) established a mean live weight of 74.4 kg, and for 1211 improved ewes a mean live weight of 50.3 kg. In 1978 the author recorded an average weight of 126 kg in 20 adult rams and 68 kg in 60 ewes of improved Awassi dairy flocks in Israel. The live weight of adult stud rams, bred and employed by the highly developed ram-breeding flock of the country, now varies between 130 and 160 kg. Three culled stud rams sold for slaughter in 1978 had an average weight of 138 kg and four others culled in 1979 averaged 141 kg. The mean live weight of 25 rams of improved dairy type culled from four flocks in 1978 was 116 kg and of 1 799 ewes culled from 15 flocks 65 kg. During the same period the weight of 460 culled ewes from the stud flock was 75 kg on average.

The average weight of 56 yearlings, recorded in Palestine in 1930, was 34.6 kg (Hirsch, 1933). Between 1963 and 1965 it had risen to 40 kg (Table 1-11). In well-managed flocks in Israel in 1977 it was not less than 50 kg, an increase of 50 percent over 35 years. In Iran, 48 Israeli Awassi yearlings, which did not lamb until the end of May, weighed 65.5 kg on average (Wallach & Eyal, 1974).
The live weights of Awassi sheep vary with age, year and month. In ewes these differences are particularly pronounced. (See Fig. 1-8.)

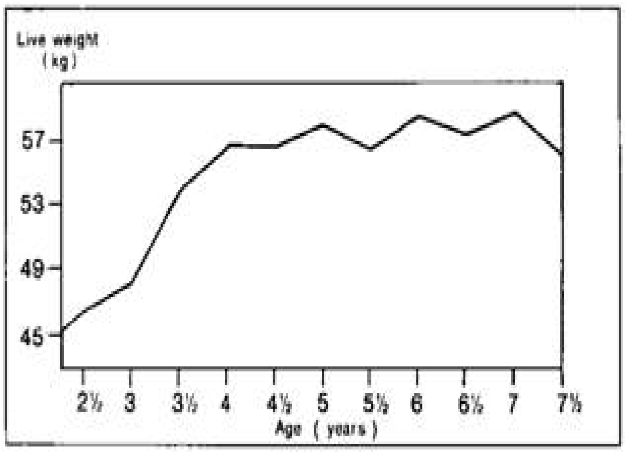


Figure 1-8. Average live weights of Awassi ewes in Lebanon at different ages. (**Source:** Rottensten & Ampy, 1971a)

In Iraq, Asker and Juma (1966) found that the average body weight of Awassi ewes increased from 40.1 kg at the first shearing to 47.9 kg at the fourth, and then declined to 45.9 kg at the fifth shearing. After the lambing season, 157 Awassi yearling ewes in Iraq had a mean weight of 43.3 kg and adult ewes 51.3 kg (Eliya & Juma, 1970a). In an experimental flock Eliya (1969) recorded the weights of Awassi rams and ewes at different ages (Table 1-6).

In improved Awassi dairy ewes in Israel, the weights of animals given in Table 1-7 were recorded at different ages three days after lambing during the years 1958/59-1962/63 (Goot, 1966).

In Iran the weights, according to age, of pure-bred Awassi ewes imported from Israel in 1965 and 1966, or the progeny of the latter born in Iran, were recorded in 1970 (Wallach & Eyal, 1974). (See Table 1-8.)

TABLE 1-6. **Mean weights of Awassi sheep at different ages in Iraq**

Age (years)	Male		Female	
	Number	Weight (kg)	Number	Weight (kg)
1	105	44.0	109	43.2
2	11	60.9	62	51.0
3	3	74.6	87	52.2
4	—	—	113	51.1
5	—	—	67	51.4
6 and above	—	—	65	53.0

TABLE 1-7. **Mean live weights of ewes of different ages three days after lambing**

Age	Number of ewes	Mean weight (kg)
Mean	201	61.1
2-tooth	51	52.6
4-tooth	33	60.7
6-tooth	25	61.2
Adult	31	65.5
$5^1/_2$-year-old	24	71.6
Aged	37	62.6

TABLE 1-8. **Weights of Israeli Awassi ewes of different ages in Iran**

Age (years)	Three days after lambing		End of lambing season (25/5/1970)		
	Number of ewes	Mean weight (kg)	Number of ewes	Mean number of days after lambing	Mean weight (kg)
1	54	66.8	71	67	62.2
2	19	78.2	33	82	68.3
3 and above	21	82.0	53	94	74.6

In Iraq a comparison between the mean body weights of four adult Awassi ewes that were barren and six others that had lambed in October or November showed a decrease from 60.1 kg in October to 40.9 kg in February for the ewes with lambs and from 60.2 to 55.9 kg for the barren ewes during the same period. The ewes with lambs therefore lost 19.2 kg or 31.9 percent of their initial weight owing to milk production and a poor level of nutrition during the winter, while the barren ewes lost only 4.3 kg or 7.1 percent (Eliya *et al.*, 1969).

Goot (1966) also compared the mean live weights of two-tooth and adult ewes in two consecutive years, in June, shortly before the onset of the breeding season, and three days after lambing (Table 1-9).

TABLE 1-9. **Mean weights of improved Awassi ewes in two successive years (kg)**

Year	Age	Mean weight in June	Mean weight 3 days after lambing
1961/62	2-tooth	47	55
1962/63		50	62
1961/62	Adult	58	68
1962/63		72	74

Large annual differences in the body weight of Awassi ewes have also been recorded in Turkey. At the Ereğli Animal Breeding Research Station, mature ewes averaged 51.6 kg in 1966/67, but only 45.0 kg in 1967/68 (Yalçin & Aktaş, 1969).

In 1962/63 Goot (1966) recorded the mean weights of improved Awassi ewes of different ages in different months of the year, beginning with June (Table 1-10).

In a test carried out between 1963 and 1965, 22 yearlings and 70 two- to ten-year-old ewes were separated at random from an improved Awassi flock of 60 yearlings and 400 ewes. The new units were divided into two groups, each according to similar average initial body weights. One group of yearlings and one group of ewes were pastured and the other two groups were stall-fed. The pastured ewes had a mean annual milk record of 300 kg and the stall-fed ones 281 kg. The weighing of the pastured yearlings and ewes was done in the morning before feeding and watering and of the stall-fed animals twice a day, before and after being driven out for exercise. The mean, maximum and

TABLE 1-10. **Mean weights of ewes in different months (kg)**												
Age	Month											
	6	7	8	9	10	11	12	1	2	3	4	5
2-tooth	50	50	51	52	53	55	59	63	63	64	65	62
4-tooth	57	58	61	61	59	62	66	66	66	68	70	65
6-tooth	61	63	65	67	68	70	73	74	73	72	72	69
Adult	72	72	72	73	74	78	78	75	76	78	79	76

TABLE 1-11. **Live weights of yearlings and adult ewes in five consecutive months (kg)**

Weight		January	February	March	April	May
	Pastured — 12 yearlings					
Mean		41.8	40.3	45.9	51.3	53.0
Maximum		48.0	47.0	51.0	61.0	62.0
Minimum		36.0	36.0	40.0	45.0	47.0
	Stall-fed —10 yearlings					
Mean		42.2	42.0	45.5	48.6	54.7
Maximum		44.0	45.0	49.0	53.0	59.0
Minimum		41.0	38.0	42.0	46.0	51.0
	Pastured — 50 ewes					
Mean		57.0	54.3	56.5	59.8	61.5
Maximum		69.0	68.0	76.0	78.0	78.0
Minimum		46.0	43.0	45.0	48.0	55.0
	Stall-fed —20 ewes					
Mean		57.6	54.0	60.3	61.2	63.5
Maximum		59.0	61.0	66.0	68.0	70.0
Minimum		57.0	50.0	50.0	53.0	56.0

minimum weights of the four groups were recorded in five successive months (Klein, 1974) and are given in Table 1-11.

The live weight of Awassi ewes is influenced not only by nutrition but also by the physiological state of the animal. This is illustrated by two trials conducted in Cyprus with improved Awassi ewes derived from Israeli stock. In Trial I, two groups of 28 ewes each were kept on an unlimited ration of straw for six weeks before lambing, one group with an addition of 0.5 kg and the other with 1.0 kg of concentrates per day (Cyprus ARI, 1973). In Trial II, two groups of 17 ewes each were fed 0.9 and 1.3 kg of concentrates, respectively, in addition to a basic ration of 0.3 kg of lucerne straw per day during the last six weeks of pregnancy (Cyprus ARI, 1975). The average live weights of the ewes varied under different physiological conditions, as shown in Table 1-12.

TABLE 1-12. **Effects of nutritional and physiological conditions on live weight of improved Awassi ewes in Cyprus (kg)**

Physiological state		Plane of nutrition	
Trial 1		*Low*	*High*
	6 weeks before lambing	56.0	55.9
	Shortly before lambing	62.8	69.2
	After lambing	54.3	59.3
Trial II		*Medium*	*High*
	At mating	62.1	61.6
	43 days before lambing	64.5	66.2
	1½ days before lambing	70.1	73.7
	Immediately after lambing	62.0	66.0

Head and horns. The head is long and narrow with a convex profile. In adult, strongly horned rams, the convex line of the profile may be broken by a slight indentation between the forehead and the markedly curved nasal part of the head. The ears are pendulous, about 15 cm long and 9 cm broad (see Fig. 1-9). Occasionally the auricula is rudimentary or entirely absent, and small, fleshy ears also sometimes occur. In improved Awassi flocks the male lambs from such ewes are not used for breeding, even though they themselves may have normal ears.

Figure 1-9. Head and horns of an improved Awassi ram

Rams are nearly always horned. The horns, which are 40-60 cm long and strongly wrinkled, curve backwards and downwards with the tips directed outwards; in adult animals 1½ turns are usually described (see Fig. 10). In Syria and Iraq Awassi rams with up to six horns are often encountered in bedouin flocks. Horns of polycerate rams show a high degree of variability and want of symmetry in shape and direction (Fig. 1-11). The ewes have been described by Hirsch (1933) as 'very rarely' horned and Finci (1957) similarly writes that 'the females are mostly hornless'. In Turkey 90 percent of İvesi (Awassi) ewes are polled, the remaining 10 percent having poorly developed rudimentary horns (Yarkin & Eliçin, 1966). According to Mason (1967), Awassi ewes have 'occasionally (up to 25%) short horns (up to 10 cm)'. But the present author has found that in Awassi dairy flocks in Israel the large majority (perhaps 80 percent) of the ewes have thin, weak and shapeless rudimentary horns or scurs, about 3-8 cm long, which are partly covered by curls of hair. Fully developed, 10- to 15-cm-long crescentic horns are rare indeed in Awassi ewes, although not as rare as are polled rams (see Figs 1-12 and 1-13).

Figure 1-10. Skull and horns of an Awassi ram

Figure 1-11. Four- five-and six-horned Awassi rams

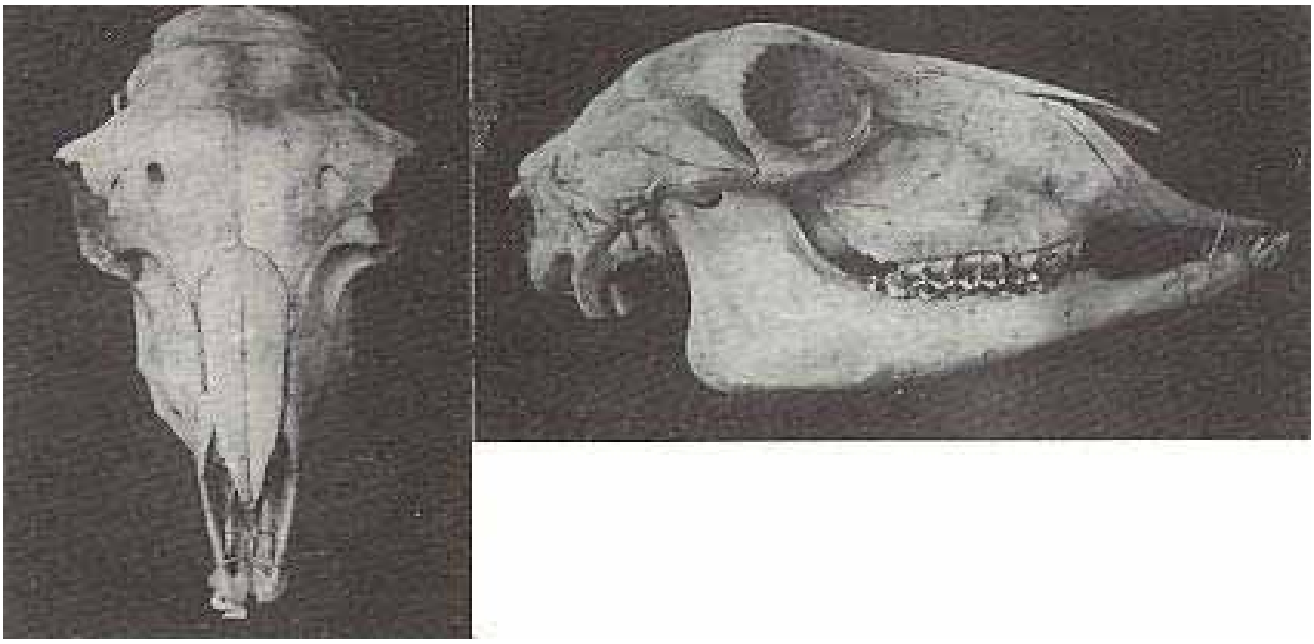


Figure 1-12. Skull of a polled Awassi ewe. Frontal and lateral views

Figure 1-13. Horned Awassi ewe

Body and legs. The neck is fairly long, fine in the ewe, stronger in the ram. Lappets *(Appendices colli)*, consisting of skin, connective tissue, nerves and blood vessels (differing from goat lappets in the absence of muscle tissue) and constituting a dominant single-factor characteristic, are frequent. The chest is long but of only moderate depth and width, with a small, thin dewlap and prominent brisket. In unimproved flocks narrowness at heart is a common weakness, but in improved sheep this is rare. The barrel is deep and wide, the back long and straight, not more than 1 cm lower than the shoulder and usually of equal height. The anterior part of the rump is relatively broad and nearly on a level with the back, but aborally the rump of the Awassi strongly slopes to the fat tail. The drooping rump is caused by the anatomical structure of the *ossa pelvis.* The angle between the *os ilium* and *os ischii* is nearly 180°. Taking the head of the femur as the rotary centre, the entire pelvic girdle slopes backwards and downwards. In addition, the *os sacrum* is strongly bent down (Hinrichsen & Lukanc, 1978).

The legs are of medium length and thickness, not as short and sturdy as those of some of the early maturing mutton breeds of the United Kingdom such as the Romney Marsh, Hampshire Down, Shropshire Down or Dorset Horn, nor as long and thin as the legs of the hairy thin-tailed sheep of the savannah region of West Africa. They are usually well placed, with strong pasterns and their hoofs are of a strong material that wears well.

Fat tail. The fat tail is broad and relatively short, usually ending above the hocks, more rarely extending below them. In improved flocks long fat tails are considered undesirable (see Figs 1-14 and 1-15), mainly because they are an obstacle in the process of milking. The fat tail of the ewe is largest before lambing and loses weight during the early months of lactation, more especially in deep milkers which have difficulty in consuming enough concentrates to make up for the loss. In rams the fat tail is larger than in ewes, not only absolutely but also in relation to body size and weight. In adult rams the weight of the fat tail may amount to as much as 12 kg and in ewes up to 6 kg; in heavy male lambs it may reach 8 kg (see Table 5-7). Without the fat cushions the tail weighs about 70 g. The length and width of the fat tail of Awassi rams and ewes of different ages have been recorded by Eliya (1969) in Iraq (Table 1-13).

Figure 1-14. Awassi ewe with an excessively long fat tail

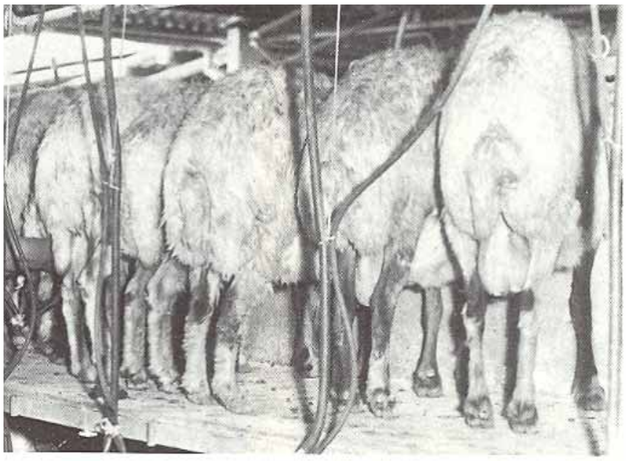


Figure 1-15. Awassi ewes with fat tails of moderate length

TABLE 1-13. **Average length and width of fat tail of Awassi sheep in Iraq** (**cm**)

Age (years)	Number		Length of tail		Width Of tail	
	♂	♀	♂	♀	♂	♀
1	105	109	21.7	14.3	18.5	12.2
2	11	62	24.2	17.0	22.0	14.8
3	3	87	27.8	17.3	25.5	15.1
4	—	113	—	17.8	—	15.5
5	—	67	—	18.7	—	16.0
6 and above	—	65	—	17.6	—	15.3

In the improved dairy type of Awassi in Israel the width of the fat tail is greater than the width recorded in Iraq. Goot (1966) has measured the breadth of the tail at its widest part in male lambs, yearlings and adult ewes (Table 1-14). At the same time he remarks on the difficulty of taking exact measurements of the width of the fat tail and on the possibility that the tail may actually be broader than the figures indicate.
The main portion of the tail emerges from the lower part of the rump with the same width as the thurls and hangs down in two lobes which are separated by the caudal skeleton and are bare of hair or wool on the under-surface. In animals in good condition the lobes broaden out toward their lower portion which ends somewhat abruptly. In the middle of the lower portion the lobes are not connected but are divided by a deep notch which gives the under-side of the tail a heart-shaped appearance (Fig. 1-16). Slightly above this notch the tail skeleton turns upwards (Figs 1-17 and 1-18) to emerge from the fat moieties, producing a hairy tassel of variable length, which is usually devoid of fat but in some instances may contain some fat in the upper portion. This tassel hangs down from the apex of the upturned tail skeleton and is called a 'thorn' by breeders.

TABLE 1-14. **Width of fat tail in improved Awassi dairy sheep in Israel** (**cm**)

Type of sheep	Number	Width of fat tail	
		Mean	Range
Male lambs	13	18.4	13-21
Yearling ewes	20	20.1	13-25
Adult ewes	91	23.5	15-34

Figure 1-16. Hairless under-side of an Awassi ram's fat tail

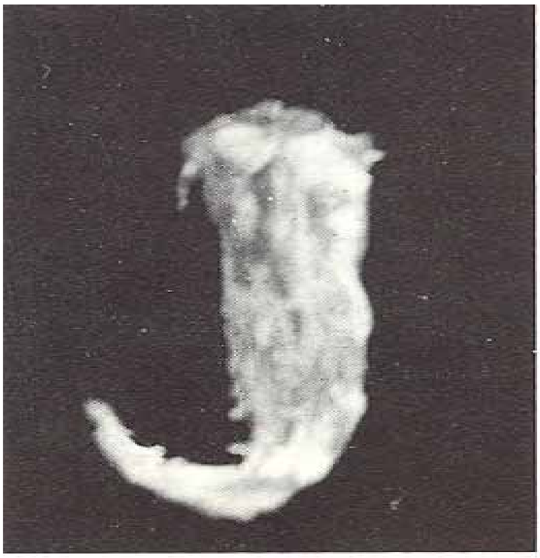


Figure 1-17. Tail of a 3-month-old Awassi lamb after removal of fat cushion

Figure 1-18. Fat tail of a 3-month-old male Awassi lamb with pelt removed

The scrotum. The scrotum is well developed, extending to the level of the hocks, with large testes of which the left one is usually a little larger than the one to the right. In aged rams the scrotum is often elongated to below the hocks. On each side of its attachment there is an opening of a large sebaceous gland and close to these openings are two or more rudimentary teats. Rams in which only one testicle has descended into the scrotum are not used for breeding. Other than in local goats, hermaphroditism is extremely rare in the Awassi.

The udder. In unimproved Awassi ewes the udder and teats are extremely variable in shape and with numerous faults. In some animals the udder is pendulous, occasionally extending down as low as the heels. It may have the shape of two bottles or sausages, with a deep indentation between the two halves. Frequently the teats are very small, with either a downward, lateral or upward direction, or they project, not from the bottom of the udder, but from its outer sides, rendering milking difficult. (See Figs 1-19 to 1-25.)

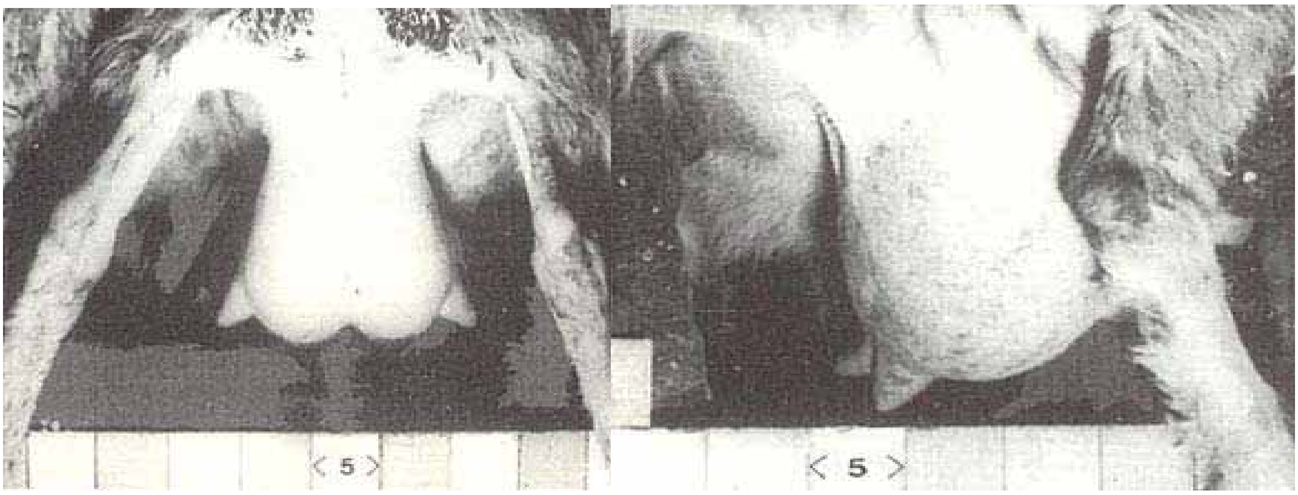


Figure 1-19. Pendulous udders of old Awassi ewes. Caudal and lateral views. (Measure in cm)

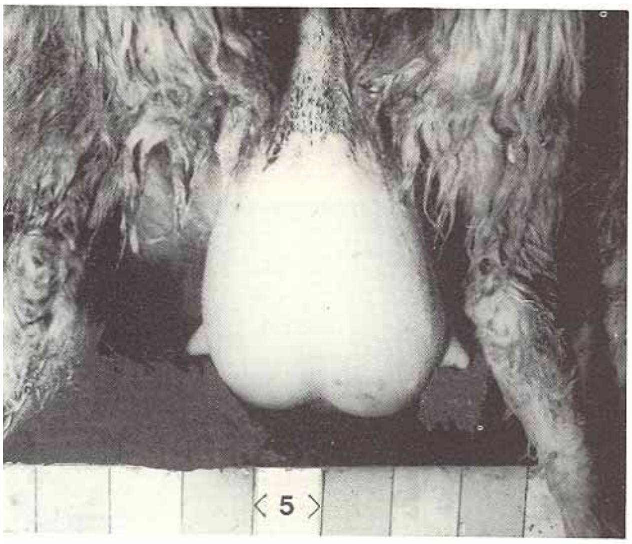


Figure 1-20. Well-shaped udder of an Awassi ewe, but teats too high-set and projecting laterally. Caudal view. (Measure in cm)

Figure 1-21. Large, well-shaped udder of an Awassi ewe, but teats too large for easy suckling. Lateral view. (Measure in cm)

Figure 1-23. Awassi ewe with a baggy udder and high-set, laterally projecting teats

Figure 1-22. Well-shaped udder of an Awassi ewe (with additional rudimentary teats), but functional teats too high-set and nearly horizontal. Frontal view

Figure 1-24. Large, faulty udder of an Awassi ewe: pendulous, baggy with teats very high and horizontal. Caudal view

Figure 1-25. Large udder of an Awassi ewe, baggy with teats very high and horizontal. Lateral view

In ewes of improved Awassi dairy flocks the udder is generally well attached, of moderate depth, not pendulous but of globular shape, wide between the legs, elongated anteriorly and extending well to the rear. The teats are of fair length and moderate thickness, with a downward direction. (See Figs 1-26 and 1-27.)

Figure 1-26. Improved Awassi ewe with a well-shaped udder

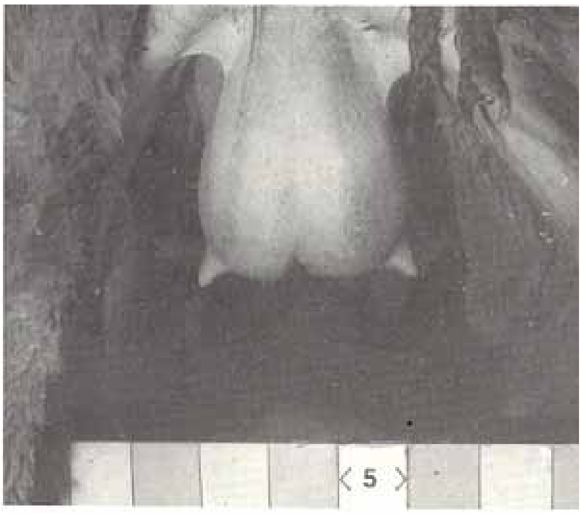


Figure 1-27. Typical udder of an improved Awassi ewe. (Measure in cm)

Prior to the introduction of mechanical milking in the majority of improved Awassi flocks in Israel, breeders paid little attention to the shape of the udder in the selection of breeding stock. Even at the present time there still exists considerable variability in this respect in many flocks, although a suitable conformation of udder and teats is a precondition for successful machine milking.

In 1957, Eyal, Volcani and Sharav (1958) and Sharav, Volcani and Eyal (1962) examined the udders of 200 ewes in an improved Awassi flock. The age of the ewes ranged from 2 to 11 years. At the time of the investigation their mean daily milk production was 1.28 kg, with a range of 0.25-2.50 kg.

The measurements shown in Figure 1-28 and Table 1-15 were taken before and after milking.

The authors noted that practically all udders differ in shape or in the size, placement and direction of the teats, with many udders also having dissimilar halves. However, with regard to general conformation, three main types can be recognized: 1) cylindrical udders, of similar circumference throughout their length; 2) pear-shaped udders, which are narrower near the attachment to the body than at the level of the teats; and 3) spherical udders, generally small and firmly attached to the body.

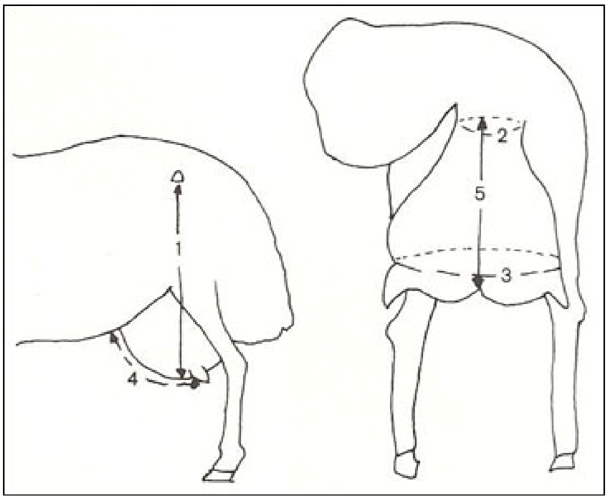


Figure 1-28. Sketch of measurements taken before and after milking

TABLE 1-15. **Measurements of Awassi udders before and after milking** (**cm**)

Measurement	Condition of udder	Mean	Minimum	Maximum
Depth of udder (from hip bone to lowest point of udder)	full	45.00	37.5	56.0
	empty	44.00	33.5	51.0
Superior udder girth	full	43.20	30.0	55.5
	empty	39.30	26.5	49.0
Udder girth at level of teats	full	49.70	39.0	58.5
	empty	44.00	34.0	53.0
Anterior udder length	full	15.60	9.0	23.0
	empty	15.10	7.5	23.0
Posterior udder length	full	23.20	18.5	30.0
	empty	21.60	14.0	28.0
Basal width of right teat	full	2.68	1.5	4.2
	empty	2.53	1.6	3.9
Basal width of left teat	full	2.60	1.4	4.4
	empty	2.58	1.7	4.2
Length of right teat	full	4.12	2.4	6.4
	empty	3.54	2.3	5.5
Length of left teat	full	3.95	2.3	6.6
	empty	3.64	2.4	5.8

As for the teats themselves, four main types can be distinguished on the basis of either their high or low setting-on, combined with a horizontal or oblique direction (Sharav, 1959; Sharav, Volcani & Eyal, 1962). Eyal, Volcani and Sharav (1958) subdivided the percentage of low-set and obliquely directed teats according to an oblique and a nearly vertical downward direction (Table 1-16).

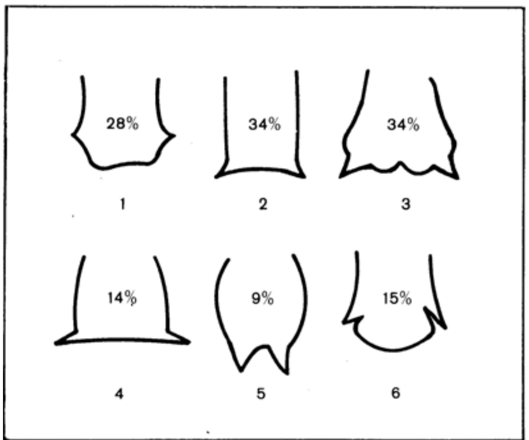
TABLE 1-16. **Setting-on and direction of teats in Awassi ewes (%)**

Setting-on	High	Low	Total
Direction			
Horizontal	28	14	42
Oblique	15	34	49
Vertical	—	9	9
Total	43	57	100

TABLE 1-17. **Length and thickness of teats in relation to their situation and direction (mm)**

Situation of teats	High	Low	
Direction of teats		Horizontal	Oblique
Mean length	36	38	42
Mean diameter	25	26	26

There appears to be a connection between the placement of the teats and their direction, for most of the highly placed teats have a horizontal direction, whereas the majority of the low-set ones are oblique or vertical (see Fig. 1-29). A connection also exists between the position of the teats and their length and thickness; as indicated by the measurements given in Table 1-17, low set-on teats, more especially low-set oblique ones, are commonly longer and thicker than teats set on higher on the udder (Sharav, Volcani & Eyal, 1962). The location of the teats affects the quantity of milk remaining in the udder on completion of the first stage of the milking process (primary milking) (see Fig. 4-3 and Table 1-15) (Eyal, Volcani & Sharav, 1958).



1. Cylindrical udder, teats set high and horizontal
2. Cylindrical udder, teats set low and oblique
3. Pear-shaped udder, teats set low and oblique
4. Pear-shaped udder, teats set low and horizontal
5. Udder with teats projecting downwards
6. Udder with high-set, oblique teats

Figure 1-29. Sketch of different Awassi udders and teats with percentage of occurrence

Sharav (1973a) recorded the changes in the length and thickness of the teats of 24 Awassi ewes in the course of the milking process. The length of the teats was measured with a caliper from the base to the tip and the diameter at the base before and after machine milking. In addition, the length of the teats was measured in a transparent liner and the teat cup under a pulsation vacuum at the beginning and end of milking. Table 1-18 gives the mean data recorded.

TABLE 1 -18. **Measurements of Awassi teats (mm)**

Measure ment	Before milking	On entering cup	In cup at end of milking	After milkin g
Length	35.0	66.3	72.3	38.1
Diameter	25.5	—	—	22.1

Additional teats, up to a total of eight, are quite common in the Awassi (see Fig. 1-22). Usually their canals are separated from those of the main teats. Supernumerary teats have been considered by Wassin (1929) to be a dominant hereditary characteristic. However, they provide no indication of increased milk production in Awassi ewes, although some breeders regard them as such. Rather, they are an obstacle to milking and may contribute to the uncleanliness of the milk.

On each side of the attachment of the udder there is an opening of a large sebaceous gland, analogous to those near the attachment of the scrotum. These glands serve to keep the skin of the udder oily and pliant.

In an examination of the anatomy of the circulatory system of the Awassi ewe's udder, Perk and

Epstein (1959) found the udder halves separated by a well-defined, longitudinal groove which extends upwards as the median connective tissue septum. Each half has an arterial system, derived from a single source, the *Arteria pudenda externa,* which emerges from the inguinal canal to the base of the udder, entering it nearer to its posterior than to its anterior attachment and descending in a solid stem down to the centre of the udder with several smaller branches projecting forwards and backwards. Half-way between its entrance into the udder and the milk cistern, the mammary artery divides into a major branch which continues the medial descent downwards with a moderate forward inclination and into a weaker offshoot. The latter turns backwards and downwards, and then curves forwards at an angle of approximately 90°, continuing its way above the milk cistern to the lower anterior margin of the udder, where it runs at a short distance from, and parallel to, the terminal section of the *Arteria mammaria medialis* before the latter enters the subcutis in the central part of the abdomen. Fine lateral, upward and downward ramifications of the principal arteries, which with constant branching diminish in size, supply the mammary parenchyma, milk sinus, teat and derma. A dissection of Awassi ewes' udders did not reveal any arterial anastomoses between the halves such as are found in the udders of goats and cows.

The venous branches of the Awassi ewe's udder merge into a major medial vein which accompanies the main medial artery and its cranial branch and is deeply embedded in the udder parenchyma. Cranially the mammary vein drains into the large *Vena subcutanea abdominalis,* and dorsally into the *Vena pudenda externa. A* perineal vein, such as is characteristic of the udders of goats and of the rear quarters of those of cows, is absent in the Awassi ewe so that there is no drainage from the internal pudic vein through the udder. Similarly, no anastomotic branches are found between the mammary veins in the basal portion of the udder. While venous blood can thus flow from every part of the Awassi ewe's udder forwards or upwards through the most suitable vein, it cannot flow across to the opposite half (as in goats and cows).

Skin and coat. The skin of the Awassi is moderately thin and elastic, unpigmented and very senstive (Eyal, 1963c). In aged animals it loses its fineness and softness and becomes thicker and coarser. There are no folds on the neck or body, but a thin dewlap extends from the throat down to the brisket.

The head and ears of the adult Awassi are covered with short, stiff hair and the back and sides of the body and posterior part of the fat tail with wool. Until the age of 12-15 months, Awassi sheep also have the entire neck, including the throat, covered with wool. In the large majority the wool disappears from the throat at a later stage, and in many of them the neck also becomes short-haired, save for its top ridge on which a thin cover of wool occasionally remains. In the ram a fringe of longer and coarser wool extends from the throat along the dewlap to the lower part of the brisket, a remnant of the mane characteristic of wild male sheep and unimproved hairy, domesticated sheep. In Awassi lambs, wool grows on the belly, although this is shorter and less dense than on the upper part of the body. As the animals grow older, the wool on the belly is replaced by fairly long, coarse hair, sparser even than the wool on the belly of the lamb. The forelegs are usually short-haired and devoid of all wool, while the hindlegs may also be woolless or, more rarely, be thinly covered with short wool down to the hocks, in some animals as far down as the fetlocks. A coarse-haired tassel of variable length emerges from the thin upturned end of the tail. As in all fat-tailed and fat-rumped breeds of sheep, the inner surface of the fat tail of the Awassi is naked.

Generally, Awassi sheep have a light fleece owing to the low density of wool follicles and the limited surface area covered with wool fibres (Sharafeldin, 1965). For Awassi rams and ewes from Israel, Lebanon, Syria, southern Turkey, Jordan and Iraq, Mason (1967) gives an average annual fleece weight of 0.2-2.5 kg and 1.75 kg, respectively.

In Israel the fleece weight of unimproved Awassi rams ranges from 2.0 to 3.0 kg, with an average of 2.25 kg, and of ewes from 1.0 to 2.5 kg, with an average of 1.75 kg. The fleece weight of four- to five-month-old lambs varies between 0.4 and 0.7 kg, with an average of 0.5 kg, and that of yearling lambs between 1.0 and 2.0 kg, with an average of 1.4 kg.

In 1931 the following mean fleece weights were recorded in three Jewish communal settlements in Palestine: 13 rams, 2.45 kg; 116 ewes, 1.73 kg; 21 four- to five-month-old lambs, 0.6 kg; and 56 yearlings, 1.46 kg (Hirsch, 1933). Thirty years later (1960-63), Goot (1966) recorded a mean fleece weight of 2.5 kg in 100 improved Awassi yearling ewes, an increase of more than 70 percent. In 1966-68 the average weight of 259 fleeces from adult Awassi ewes, imported from Israel into Iran or descended from imported stock, was 2.66 kg (Wallach & Eyal, 1974). Four hundred and three Israeli Awassi lambs born in Yugoslavia yielded 2.63 kg of greasy wool per head, while 1 561 ewes imported into Yugoslavia from Israel had an average fleece weight of 2.85 kg at the first shearing and 2.71 kg at the second shearing, as compared with 2.96 kg in the pedigree flock in Israel whence the ewes had come (Todorovski, Ristevski & Popovski, 1973b,c,d). Hence, improved feeding, increased milk yields and increased body size in the course of 35 years of improvement have led to an increase of over 50 percent in the average fleece weight of Awassi ewes in Israel.

Throughout the period of improvement of the Awassi, first in Palestine and subsequently in Israel, wool prices have been low, more especially in relation to milk and mutton (lamb). For this reason breeders have not cared to introduce fleece weight and quality into their selection programme. However, when this is done, achievement is fairly rapid. Thus an improved flock with high milk yields belonging to a communal settlement (Sarid) was selected for heavier fleeces—in addition to milk and conformation — from 1938 on, with the result that 434 fleece weights, recorded in the years 1948, 1949,1950 and 1952 from ewes of all ages registered in the flock book, showed a mean of 2.97 kg, or 70 percent above the breed average of 1.75 kg (Finci, 1957). The maximum fleece weight in a ram of this flock was 6.8 kg and in a ewe 6.5 kg (Becker, 1958). In comparison, in Syria, one ram of the improved Awassi flock at Wad-al-Azib produced 9.96 kg of wool in a year (Gadzhiev, 1968).

In Lebanon, 391 yearling ewes from six different regions yielded 1.89 kg of wool of one year's growth per head after lambing (Fox *et al.*, 1971). At the experimental farm of the American University of Beirut, Awassi ewes derived from stock of Syrian nomads produced 1.67 kg of greasy wool on average annually during four years (McLeroy & Kurdian, 1958). Later, 407 ewes of the same flock averaged 2.2 kg of machine-sheared wool per year (Rottensten & Ampy, 1971a).

The average fleece weight of Syrian Awassi sheep amounts to 1.8-2.0 kg, and under superior conditions of management to 2.5-3.0 kg (Gadzhiev, 1968). According to Erokhin (1973), the annual wool yield of adult Syrian Awassi rams averages 4.35 kg, of adult ewes 2.58 kg and of 15- to 16-month-old Syrian yearling ewes, 3.49 kg. At the Hofūf Agricultural Research Centre in Saudi Arabia, the average annual fleece weight of Awassi ewes of Syrian derivation was 2.03 kg. Pritchard, Pennell and Williams (1975) note that the fleeces of these sheep are heavier than those of the desert-bred Awassi in the north of Saudi Arabia. At the Ras El-Hekma Desert Research Station in Egypt, Awassi yearling ewes of Syrian origin, first shorn at the age of 16 months, had an average fleece weight of 2.37 kg (Fahmy *et al.*, 1968). At the Bahtim Experiment Station in Egypt, the weights of 165 greasy fleeces of six months' growth from fifty 9-, 15-, 21-, 27- and 33-month-old Awassi ewes, derived from stock imported from Syria in 1960, ranged from 0.84 to 1.56 kg according to age, with a total average of 1.285 kg (Ghoneim *et al.*, 1968).

High variability in the annual fleece weight of Awassi sheep is also encountered in Turkey. Sönmez (1955) recorded an average fleece weight of 1.35 kg, ranging from 0.59 to 2.63 kg annually, while Yarkin and Eliçin (1966) reported an annual yield of 2.19 kg, varying between 1.0 and 3.7 kg, in Turkish Awassi sheep. Two hundred and twenty-five Awassi ewes of different coat types, belonging to three Turkish village flocks, yielded 1.9 kg of greasy wool per head; fleece weights declined with increasing age (Sidal, 1973). Imeryüz, Müftüoğlu and Öznacar (1970) recorded an average greasy fleece weight of 2.5 kg and a clean fleece weight of 1.67 kg in adult Awassi sheep in Turkey. At the Ereğli Animal Breeding Research Station in central Anatolia, the greasy fleece weight of Awassi sheep averaged 2.9 kg in 1967 and 2.1 kg in 1968 (Yalçin & Aktaş, 1969).

In Iraq, as Williamson (1949) has noted, Awassi rams and ewes produce not more than 1.0-1.5 kg of wool annually. In 1963, Sharafeldin (1965) recorded an average greasy fleece weight of 1.71 kg in 268 Awassi ewes in Iraq. Of 626 ewes that were weighed at the first five shearings carried out at yearly intervals beginning at 16.9 months of age, 1 456 fleeces averaged 1.37,1.55, 1.53, 1.51 and 1.46 kg, respectively, with a total average of 1.46 kg (Asker & Juma, 1966). At the Hammām Al'Alil Experiment Station in northern Iraq, the greasy fleece weight of adult Awassi rams averaged 2.46 kg, and of ewes 2.00 kg during the period 1965-71 (Ghoneim *et al.,* 1973). The relatively high fleece weights obtained at Hammām Al'Alil are attributed to selection practised in the experimental flock for increased wool production for a period of six years. The heaviest fleeces were obtained at the first and second shearings. The average fleece weights of rams and ewes at different ages were as shown in Table 1-19.

Several factors influencing the fleece weight of Awassi sheep have been studied. The fleece weight of one year's growth differs considerably between lactating and dry, yearling and adult ewes (see Table 1-20). Goot (1972) weighed unskirted and uncrutched fleeces from yearling and adult ewes often Awassi flocks in Israel immediately after machine shearing in May, 12 months after the previous shearing. The average lactation yield of the ewes was 311 kg, varying between 91 and 645 kg.

The statistically highly significant data ($P < 0.001$) show that dry females grow heavier fleeces than lactating ones and that dry yearlings have heavier fleeces than dry adult ewes.

In their investigation over a period of five years into the effects of non-genetic factors on the weight of 756 fleeces from 336 Awassi sheep at the College of Agriculture, University of Mosul, Iraq,

TABLE 1-19. **Average fleece weights of Awassi rams and ewes in northern Iraq at different ages**				
Age (months)	Male		Female	
	Number	Weight (kg)	Number	Weight (kg)
18	69	2.33	187	2.10
30	13	3.15	135	2.08
42	8	2.47	127	1.93
54	3	2.57	89	1.92
66	1	2.36	55	1.81
78	—	—	41	1.91
90	—	—	28	1.87
Total	94	2.46	662	2.00

TABLE 1 -20. **Fleece weights of yearling and adult, dry and lactating Awassi ewes**

	Yearlings		Adult ewes	
	Dry	Lactating	Dry	Lactating
Number of fleeces	276	26	134	1 220
Fleece weight (kg)	2.35 ± 0.57	1.85 ± 0.52	2.12 ± 0.66	1.90+ 0.69

Ghoneim *et al.* (1974) observed that rams grow heavier fleeces than ewes at all ages (see Table 1-19). The mean difference was 0.46 kg and the largest 1.07 kg (3.15 vs. 2.08) at the age of 2½ years. Yearly variations in fleece weight, ranging from 1.68 to 2.35 kg, mainly reflected differences in feeding, management and health of the flock. In the two years of the investigation, singles exceeded twins in fleece weight, while the reverse obtained in the three other years. There were significant correlations between fleece weights at the first shearing and those of the second and third shearings. Estimates of heritability and repeatability showed that sires had a highly significant effect on the fleece weight of their offspring at the first shearing and less so on the second and third shearings when the ewes were either pregnant or lactating and hence influenced by non-genetic factors.

Asker and Juma (1966) found a highly significant correlation between the fleece and live weights of Awassi ewes in Iraq. With an increase in the average body weight from 40.1 kg at the first shearing to 47.9 kg at the fourth, the average fleece weight increased from 1.38 to 1.52 kg. With a fall in the average body weight of ewes to 45.8 kg at the fifth shearing, the fleece weight decreased to 1.47 kg. When the ewes were divided according to their body weights into eight groups with class intervals of 4.54 kg, the maximum average weight of fleeces (1.67 kg) was obtained from ewes weighing 57.2-61.2 kg. Yearly fluctuations in average fleece weight owing to environmental factors ranged from 1.08 to 1.65 kg during the five years of observation (1959/60-1963/64).

Two shearings per year increase the total annual wool yield of Awassi sheep as compared with one shearing. Al-Aubaidi *et al.* (1968) examined the influence of autumn and spring shearings on the weight of fleeces washed before shearing of 19 male and 19 female Awassi lambs in Iraq, with equal numbers of lambs, shorn only in spring, as the control group. The male lambs, which suffered from lice and scabies, yielded 1.73 kg of wool annually in two shearings vs. 1.30 kg in one shearing, and the female lambs, which were healthy and free of lice, 2.30 kg in two shearings vs. 1.78 kg in one. Twice-a-year shearings therefore increased the yield of wool by 0.43 kg (or 33.1 percent) in the male lambs, and by 0.52 kg (or 29.2 percent) in the females.

Colour. Typically, the wool of the Awassi is white with a yellowish hue. The head, ears and anterior part of the neck are brown, while the legs may be wholly or partly brown. Some animals have a white blaze on the head. Lambs born with a light brown, same-coloured or spotted coat frequently grow white fleeces after the first shearing. In unimproved flocks a fair number of animals deviate from the typical pattern .Often brown spots or patches occur in the fleece, and some animals are wholly light or dark brown or red. In Iraq about 10 percent of Awassi sheep have coloured fleeces (Ghoneim *et al.*, 1973). Ewes with black heads are also encountered. Among the İvesi sheep of Turkey two colour varieties are distinguished, one black-headed and the other yellow-headed; there is no significant difference between them in body measurements or milking performance (Yarkin & Eliçin, 1967). Sheep with a black head are called Karabaş (black head) (Yalçjn, 1979). In improved Awassi dairy flocks black-headed animals are usually culled and rams with black heads are never used for breeding. Black-fleeced sheep are rare; in such instances the black pigment does not usually extend to the tassel of the tail which remains white. While white sheep in which the head and ears are also white occur, they are not favoured by breeders since in a subtropical climate with intense solar radiation a pigmented mucosa of the eyes, mouth, nostrils and ears is essential as protection against injury and the diseases connected with these areas, such as bighead which is related to the photosensitivity of an unpigmented mucosa. The hoofs of the Awassi are dark in colour.

Physiological characteristics

Hardiness. In the course of several thousand years the Awassi has become fully adapted to the subtropical environment of its extensive breeding area in the semi-arid or arid regions of southwest Asia. The flocks of the bedouin and of the majority of fellahin are kept in the open throughout the year, day and night, and depend entirely on natural pasturage. They are not protected by their masters against torrential rains in winter nor the blazing heat of the summer. Their natural protection against the strong solar radiation during the hot months of the year is their fleeces, the pigment of their heads and their habit of keeping their heads in the shade below the bellies of their flock mates. It is only from the cold storms of winter that they may be sheltered behind stone walls or hedges of cactus or thorns.

However, the hardiness of the Awassi may break down during a succession of rainy days during the cold season when they remain without feed and have used up the fat reserves accumulated in their tails and bodies in the previous spring and early summer and have become completely emaciated. At such times the death rate from exposure and starvation may be extremely high.

Body temperature. The adaptation of Awassi sheep to their subtropical environment is to a considerable degree a result of their physiological ability to regulate the heat balance of their bodies at different seasons of the year, different diurnal temperatures and humidity conditions, in both the shade and under direct solar radiation. Epstein and Herz (1964) reported that the average body temperature of Awassi sheep in Israel was 0.9°C lower than that of imported Romney Marsh, Dorset Horn and Suffolk sheep of the United Kingdom kept in the same place and conditions.

In a study of the nychthemeral changes in the body temperature of Awassi sheep made by Degen (1976, 1977c), six male and two horned female six-month-old, unshorn lambs were exposed to the summer heat in the semi-arid Negev region of Israel under nearly natural conditions, albeit deprived of their behavioural cooling mechanism at pasture. During the trial the lambs were kept in small individual pens with slatted floors in an open yard with no shade or shelter. The feed consisted of a pelleted concentrate-roughage mixture and water was freely available. The trial began after a preparatory period of two weeks in the pens and lasted for 21 days in August, the hottest month of the year. In this period the site of the test has a mean minimum temperature of 20.2°C, a daily mean of 26.8°C, and a mean maximum temperature of 33.5°C. During the experimental period the mean relative humidity at 8.00 h was 63 percent, at 14.00 h 38 percent, and at 20.00 h 71 percent. At the beginning of the trial the average body weight of the eight lambs was 31.4 kg and at its conclusion 36.8 kg.

The changes in thermoregulatory responses during a 24-hour cycle were established every third day. On these seven days of the test period, the rectal, external auditory meatus and skin temperatures were measured every four hours, starting at 4.00 h (see Fig. 1-30).

Maximum readings were obtained at the hottest time of the day (12.00 h) and minimum readings at the coolest time (4.00 h). The lambs had a fairly stable rectal temperature with a range of 1.1°C. The external auditory meatus temperature was lower than the rectal temperature, the range of nychthemeral fluctuation being 2.1°C. Hence, the hypothalamic temperature was maintained cooler than that of the body. The skin temperature showed the highest fluctuation, namely 6.4°C, but on average was only 0.2°C lower than the rectal temperature.

The Awassi does not use thermolability as a physiological adaptation to heat stress (Degen & Morag, 1974). This applies to normal conditions throughout the range of the breed. But in an investigation of the responses of Awassi sheep to dehydration (see pp. 33, 37-38), Degen (1976,

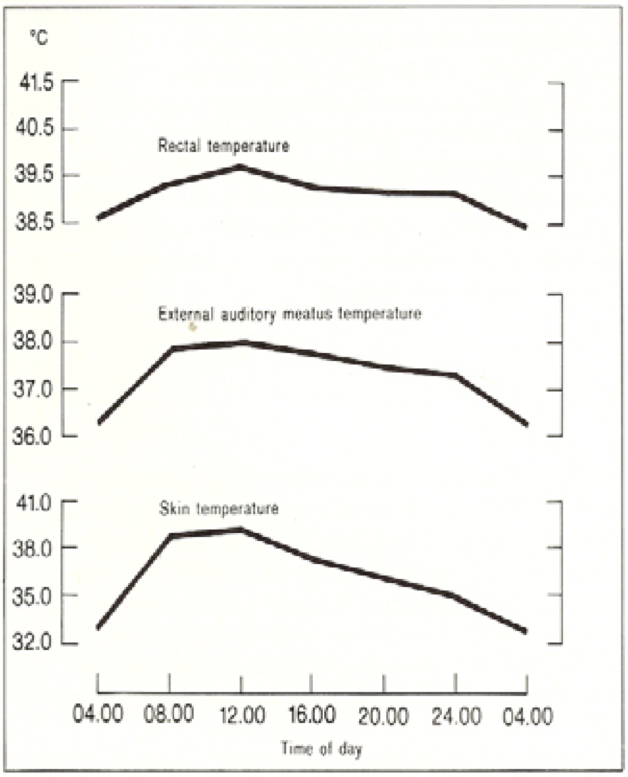


Figure 1-30. Mean rectal, external auditory meatus and skin temperatures of eight penned Awassi lambs at different hours of the day. (**Source:** Degen, 1977c)

1977d) found that with a reduction in the quantity of drinking water offered to the animals, the maximum daily rectal temperature did increase (Table 1-21).

The ability to regulate the heat balance, as expressed by body, skin and fleece temperatures and pulse and respiration rates, has been investigated by Eyal (1963a,b,c,d) in shorn and unshorn three-to five-year-old improved Awassi ewes with an average lactation yield of 240 kg and a live weight ranging from 55 to 65 kg, and in parallel groups of unimproved ewes.

A group of five ewes were shorn every month for a year and then left unshorn. The ewes of another group were left in fleece for one year, after which the two groups were switched. Two parallel investigations were conducted in this manner, one in the coastal region in the centre of Israel with improved ewes, and the other with unimproved ewes in the southern desert where the differences in temperature between day and night and between summer and winter are far greater than in the coastal area. The feeding and management of the sheep were similar in both trials. The rectal temperatures of the animals were taken five times a day.

An increase in ambient temperature is accompanied by an increase in body temperature in shorn and unshorn sheep. In sheep kept in the shade the increase in rectal temperature is steeper in shorn than in unshorn animals. At temperatures above 30°C, shorn sheep have rectal temperatures higher than, or equal to, those of unshorn sheep (see Fig. 1-31). As ambient temperatures decrease, the differences in mean body temperature between shorn and unshorn sheep become larger. At ambient temperatures below 30°C the body temperature of shorn sheep is lower than that of unshorn sheep by an average of 0.16°C.

In spite of great differences in ambient temperatures, there is no significant difference in body temperature between winter and summer. At equal environmental temperatures the mean rectal temperature is higher in winter than in summer. This seems to be because of the fact that Awassi sheep commonly produce milk during the winter, but are dry in the summer. Their thermoregulatory system at equal ambient temperatures is therefore under a greater thermal stress in winter than in summer, and their rectal temperatures correspond to the increased winter stress.

On exposure to direct sunlight, save for the winter months, shorn sheep reach a higher body temperature than unshorn animals (Fig. 1-32). However, when the sheep are transferred from the sun to the shade, or after sunset, the rectal temperature of the shorn animals drops at a faster rate than that of the unshorn ones. This is most conspicuous in sheep returning from pasture (Fig. 1-33). Again, during the cool hours of the day shorn sheep have a lower body temperature than sheep in fleece.

The smallest differences in body temperature between shorn and unshorn Awassi sheep are found when the humidity is at its lowest. A rise in relative humidity at ambient temperatures above

TABLE 1-21. **Mean rectal temperature of 6-month-old Awassi lambs at different rations of drinking water**

Water ration (litres)	Bodytemperature (°C)		
	6.00 h	13.00h	Variation
Free	38.6	38.8	0.23
4.5	38.7	39.0	0.30
3.0	38.7	39.1	0.36
2.5	38.9	39.7	0.80
2.0	39.7	40.4	0.73
1.5	39.7	40.5	0.80
1.0	40.0	40.8	0.83

Source: Degen, 1977d

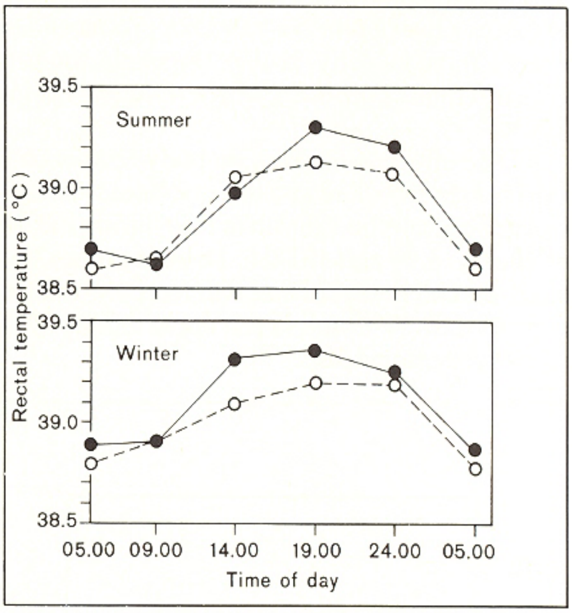


Figure 1-31. Average diurnal trends of body temperature of Awassi sheep kept in the shade. (**Source:** Eyal, 1963a)

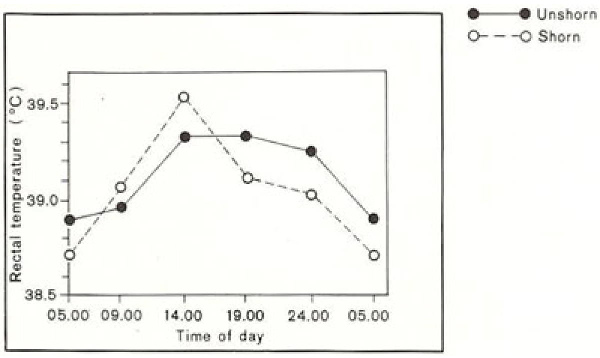


Figure 1-32. Diurnal trends of rectal temperature of Awassi sheep kept in the sun. (**Source:** Eyal, 1963a)

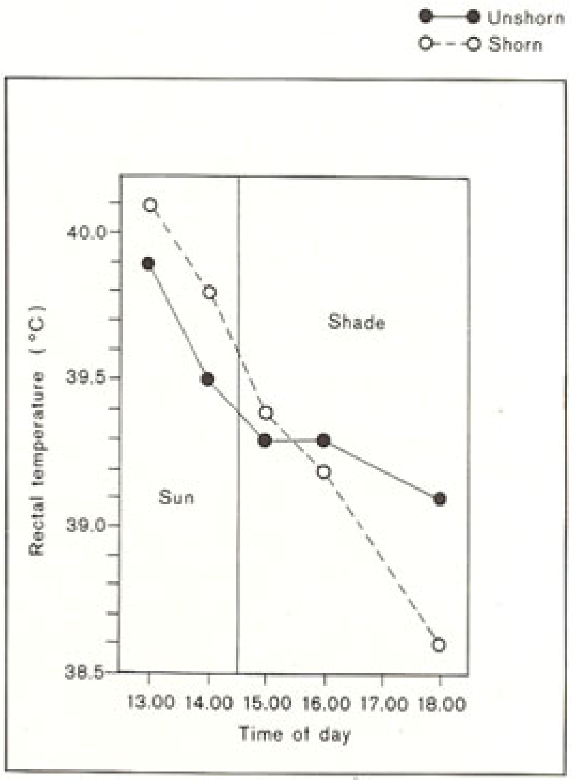


Figure 1-33. Fall in body temperature of Awassi sheep after return from pasture at noon. (**Source:** Eyal, 1963a)

25°C causes a rise in body temperature, particularly in sheep in fleece. In a hot, dry environment the body temperature of shorn sheep exceeds that of unshorn ones. It therefore appears that a rise in ambient temperature brings about a higher rate of increase in the body temperature of shorn sheep, whereas a rise in relative humidity produces a higher rate of increase of body temperature in unshorn sheep. Wind velocity, both in the shade and in the sun, has a greater effect on the body temperature of shorn than of unshorn sheep, reducing the impact of direct solar radiation on shorn animals (Eyal, 1963a).

The effect of docking on body temperature has been investigated by Juma, Gharib and Eliya (1971) in five docked and five undocked Awassi rams, approximately 19 months old, that were kept in open sheds at Abu-Ghraib in Iraq during the four hottest months of the year. The data were recorded at 10.00, 14.00 and 18.00 h. In both groups the monthly variation in rectal temperature displayed a similar trend to that of ambient temperature (Fig. 1-34). In the undocked rams the rectal temperature averaged 39.10°C and in the docked rams 39.03°C, the effect of docking on body temperature being statistically significant.

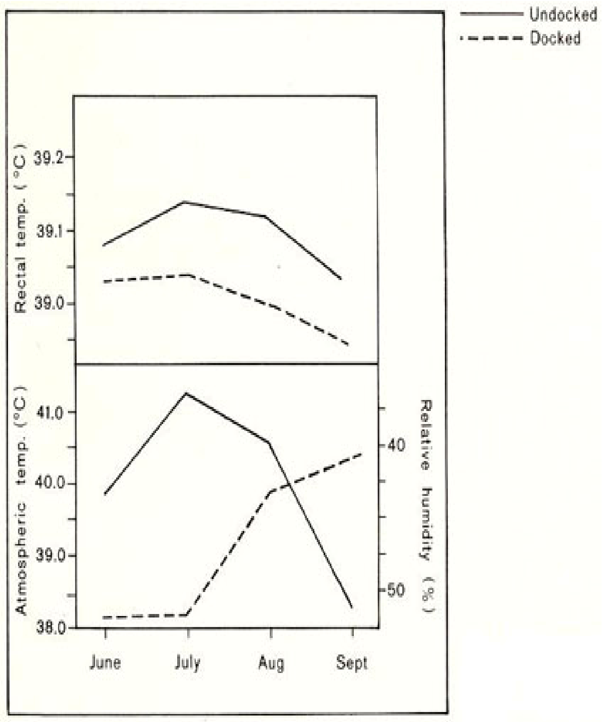


Figure 1-34. Monthly variation in rectal temperature in docked and undocked Awassi rams. (**Source:** Juma, Gharib & Eliya, 1971)

There was a highly significant diurnal variation in the rectal temperature of both groups; the lowest temperatures were recorded at 10.00 h (undocked rams 39.02°C and docked 38.91°C) and the highest readings at 18.00 h (undocked rams 39.28°C and docked rams 39.21°C).

The positive correlation between rectal and ambient temperatures indicates that the heat produced and accumulated in the body exceeded the heat lost. Docking resulted in a greater efficiency of heat regulation, as shown by the lower rectal temperatures in the docked animals. The authors suggest that this may be because of the thicker layer of subcutaneous fat, greater air circulation around the hindquarters and the improved heat-regulating capacity of the scrotum.

Skin and fleece temperatures. Fleece provides shade for the sensitive unpigmented skin of the Awassi and encloses a layer of still air which forms a thermal barrier between the epidermis and the environment. Eyal (1963d) has estimated that the Awassi sheep traps approximately 80 1 of air in its 8-cm-long winter fleece and 501 in the 5-cm-deep summer fleece. This layer of air has a microclimate of temperature and humidity that is governed by the physiological activity of the skin and by changes in the ambient macroclimate. The changes occurring in the microclimate always lag behind environmental changes. Shorn sheep are entirely affected by the macroclimate and respond to changes in ambient temperature more quickly than unshorn sheep. The skin temperature, as well as the humidity and temperature within and on the surface of the fleece during various seasons of the year, at different ambient temperatures, in the shade and under direct sunlight, has been studied by Eyal (1963d) in shorn and unshorn Awassi ewes.

A rise in ambient temperature in the shade from 10 to 43°C is accompanied by an increase in skin temperature from approximately 34 to 40°C in unshorn sheep, and from 28 to 40°C in shorn ones. At the same rise of ambient temperature the surface temperature of the fleece increases from 13 to 42°C in unshorn sheep and from 16.5 to 39.5°C in shorn animals. (See Table 1-22.)

TABLE 1 -22. **Skin and fleece surface temperatures of unshorn and shorn Awassi ewes in the shade (°C)**

Air temperature	Skin temperature		Fleece surface temperature	
	Unshorn	Shorn	Unshorn	Shorn
10	33.9	28.1	12.9	16.6
15	35.0	30.5	17.9	17.8
20	36.7	34.1	23.1	23.6
25	37.6	35.3	26.7	28.3
30	37.4	34.9	31.8	31.7
35	37.9	36.1	36.4	34.9
40	39.0	39.5	40.1	37.9
43	39.7	39.9	42.4	39.5

Source: Eyal, 1963d

TABLE 1 -24. **Skin temperatures of Awassi sheep standing in the sun at various air temperatures (°C)**

Air temperature	Exposed part		Shaded part	
	Unshorn	Shorn	Unshorn	Shorn
19-22	39.4	38.3	38.9	33.3
31-34	41.0	40.7	39.0	39.3
39-42	45.5	45.7	43.4	43.3

Source: Eyal, 1963d

TABLE 1 -23. **Skin and fleece surface temperatures of shorn and unshorn Awassi sheep at various winter and summer temperatures in the southern desert (°C)**

Season	Air temperature	Skin temperature		Fleece surface temperature	
		Shorn	Unshorn	Shorn	Unshorn
Winter	12	32.5	27.8	13.3	15.9
	18	35.5	32.2	19.3	21.2
	25	38.9	35.6	28.5	27.9
Summer	30	37.0	35.1	32.0	31.9
	36	38.1	36.5	37.0	35.5
	42	39.2	39.6	41.8	39.0

Note. Height of fleece in unshorn sheep, 7 cm in winter and 5 cm in summer; in shorn sheep, 0.5 cm in all seasons.
Source: Eyal, 1963d

The changes in the skin temperature of shorn sheep in the course of the day are similar to the changes of the ambient temperature, while the decrease in the skin temperature of sheep in fleece sometimes lags behind a fall in environmental temperature. Skin temperatures rarely exceed rectal temperatures, even at ambient temperatures above the latter. The relation between the rise in skin and ambient temperatures shows a step-wise pattern with breaks at similar environmental temperatures for shorn and unshorn sheep, namely at 15 and 33°C, although shorn sheep have a lower skin temperature than unshorn ones. Eyal (1963d) suggests that the breaks in the rise of skin temperature may be due to a rise in the thermal conductivity of the fleece at these points.

At very high environmental temperatures, the fleece surface temperature may be lower than the air temperature, more especially in shorn sheep in which it may sometimes fall below the skin temperature, suggesting moisture evaporation at the surface of the coat (Table 1-23).

Although only part of an animal's body is exposed to direct solar radiation at one time, an additional heat load is imposed from direct radiation as well as from that of the sky and ground on sheep standing in the sun. In such conditions the skin temperature of shorn and unshorn sheep rises markedly and may reach 47°C (see Table 1-24).

The fleece temperature of unshorn Awassi sheep also increases greatly upon exposure to the sun, with a maximum of 55°C and occasionally of over 60°C midway between the skin and the fleece surface. Eyal attributes the lower temperature at the loose wool surface rather than within the fleece of unshorn Awassi sheep exposed to direct sunlight to convective cooling at the surface (Table 1-25).

TABLE 1-25. **Skin and fleece temperatures of Awassi sheep standing in the midday sun at an airtemperature of 41 °C in the southern desert**

Group	Side of body	Temperature (°C)		
		Skin	Middle of fleece	Fleece surface
Unshorn	Exposed	45.0	55.4	49.4
	Shaded	42.3	48.2	46.9
Shorn	Exposed	46.0	—	46.3
	Shaded	45.3	—	45.5

Source: Eyal, 1963d

The vapour pressure close to the skin of unshorn Awassi sheep in the shade at ambient temperatures of 30-35°C varies between 35 and 40 mm Hg, while in shorn animals in the sun or shade it is similar to that of the environment. In Awassi sheep exposed to direct sunlight, the vapour pressure in the fleece and near the skin may increase up to 80 mm Hg. Sometimes small drops of secretion appear on the skin. In the southern desert a rise in vapour pressure close to the skin is observed when the ambient temperature increases to 40-43°C. This rise in humidity is paralleled by a rise of vapour pressure throughout the fleece. In unshorn Awassi sheep subjected to direct solar radiation in the southern desert at an ambient temperature of 40°C, the skin may become profusely covered with fluid, apparently sweat (Eyal, 1963d).

Pulse rate. Changes in the muscular or metabolic activity of an animal are reflected in the cardiac output and pulse rate. Eyal compared the pulse rates in shorn and unshorn Awassi sheep kept in the shade or in direct sunlight during different seasons of the year (Figs 1-35 and 1-36). Generally, the variability of the pulse rate during the day corresponds to the daily changes in body temperature and metabolic level. In unshorn sheep the fluctuations are greater than in shorn ones.

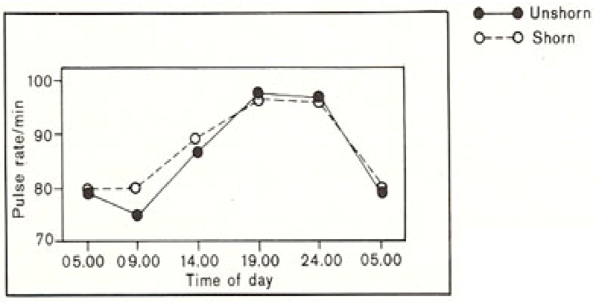


Figure 1-35. Average diurnal trends in pulse rate of Awassi sheep at all seasons in the shade. (**Source:** Eyal, 1963b)

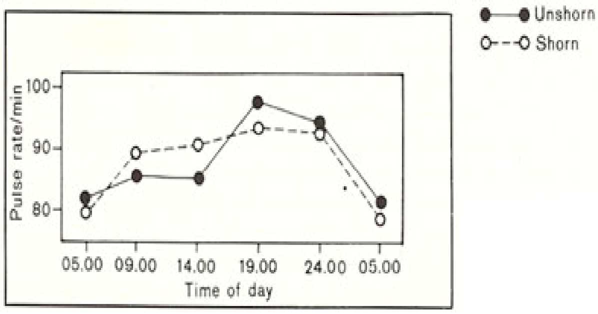


Figure 1-36. Average diurnal trends in pulse rate of Awassi sheep at all seasons in the sun. (**Source:** Eyal, 1963b)

During the summer the pulse rate is lower than during the winter, namely 60-100 per minute for unshorn and 63-100 for shorn sheep as against 90-130 for unshorn and 90-115 for shorn animals. This phenomenon is attributed to lactation during the winter months. With a rise in ambient temperature, especially during winter and spring, the pulse rate tends to increase. In summer, on the other hand, a rise in environmental temperature is accompanied by a lower pulse rate, with the lowest of 42 per minute on hot dry summer days in the southern desert.

With a rise in rectal temperature, particularly at low ambient temperatures (10-14°C), the pulse rate increases in shorn and unshorn sheep. At the same rectal temperatures shorn sheep have a higher pulse rate than unshorn animals during winter and spring and on cool summer days. At high ambient summer temperatures equal rectal temperatures in shorn and unshorn sheep are paralleled by equal pulse rates.

Since the rectal temperatures of shorn sheep at high air temperatures or in the sun exceed those of sheep in fleece, the pulse rate of the shorn sheep is correspondingly higher. Eyal (1963b) suggests that the differences in pulse rate between shorn and unshorn Awassi sheep reflect the combined effects of metabolic rate, body temperature and vaso-motor activity, all of which vary with season and environmental temperatures.

Respiration rate. Sheep generally increase their respiration rate as ambient temperatures rise. Panting on hot days suggests an insufficiency of other cooling mechanisms. Although the respiration rate cannot be used as the sole criterion in estimating heat resistance in sheep, a breed with a slower respiration rate upon exposure to heat is generally better adapted to a hot climate than sheep prone to panting on hot days. This is illustrated by a comparison of the Awassi sheep of Israel with imported mutton breeds from the United Kingdom. During the hot hours of summer days the average number of breaths per minute recorded in Romney Marsh sheep was 170, in Dorset Horn 150 and in Suffolk sheep 128, as against 64 in Awassi sheep kept in the same place and conditions. The high rate of breathing in the foreign breeds continued even during the night and before the break of day when ambient temperatures were generally lower. In consequence their lungs gave in and mortality from lung troubles was exceedingly high in the imported animals and their offspring (Epstein & Herz, 1964).

In a trial to examine the responses of Awassi sheep to heat stress, six male and two female six-month-old unshorn Awassi lambs were exposed to summer heat without shade (Fig. 1-37). The minimum and maximum ambient open air temperatures during the trial were 16 and 45°C, respectively. The mean panting rate of the lambs increased fourfold from the coolest to the hottest part of the day, namely from 35 to 135 per minute. German Mutton Merino lambs kept in identical conditions increased their panting rate from 41 to 199 at the same hours, while their pantings were shallower than those of the Awassi lambs (Degen & Morag, 1974; Degen, 1976, 1977c).

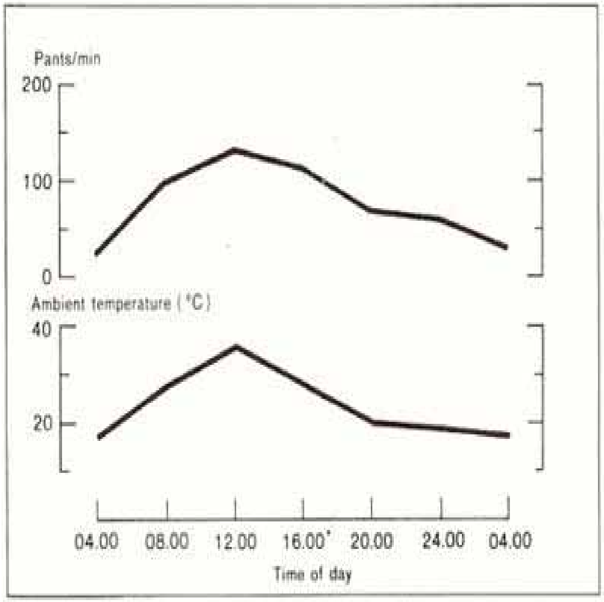


Figure 1-37. Panting rate per minute of eight penned Awassi lambs at different hours of the day. (**Source:** Degen, 1977c)

In a study of the respiration rate of shorn and unshorn Awassi sheep in the shade and in direct sunlight during various seasons of the year and at different hours of the day, Eyal recorded a mean respiration rate throughout the year of 55 per minute in sheep in fleece and 32 in shorn sheep (Figs 1-38 and 1-39).

The diurnal trends of respiration rate follow the ambient temperature more closely than the body temperature, the maximum of which is reached in the evening. However, shorn sheep respond to the cooler air toward evening more quickly than unshorn sheep, returning to their basal respiration rate of 20-30 per minute within a short time. Shorn sheep, therefore, are more efficient in dissipating heat than unshorn ones in which the reduction of the respiration rate during the cooler evening hours is delayed. At ambient winter temperatures of 8-25°C the increase in respiration rate is steeper in sheep in fleece; at ambient temperatures of 22-42°C the increase is steeper in shorn animals. (See Figs 1-40 and 1-41.)

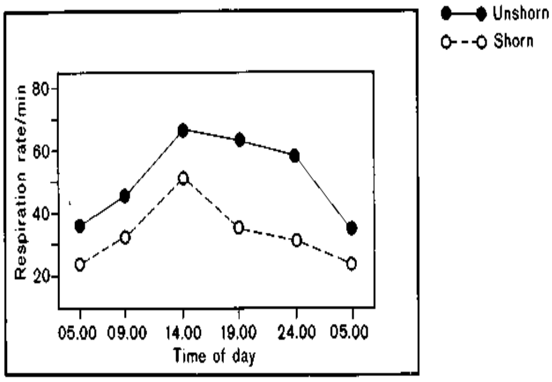


Figure 1-38. Diurnal trends of respiration rate in Awassi sheep in the shade. (**Source:** Eyal, 1963c)

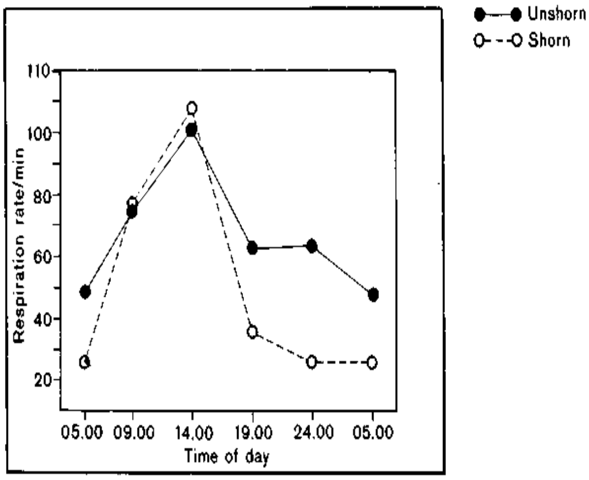


Figure 1-39. Diurnal trends of respiration rate in Awassi sheep in the sun. (**Source:** Eyal, 1963c)

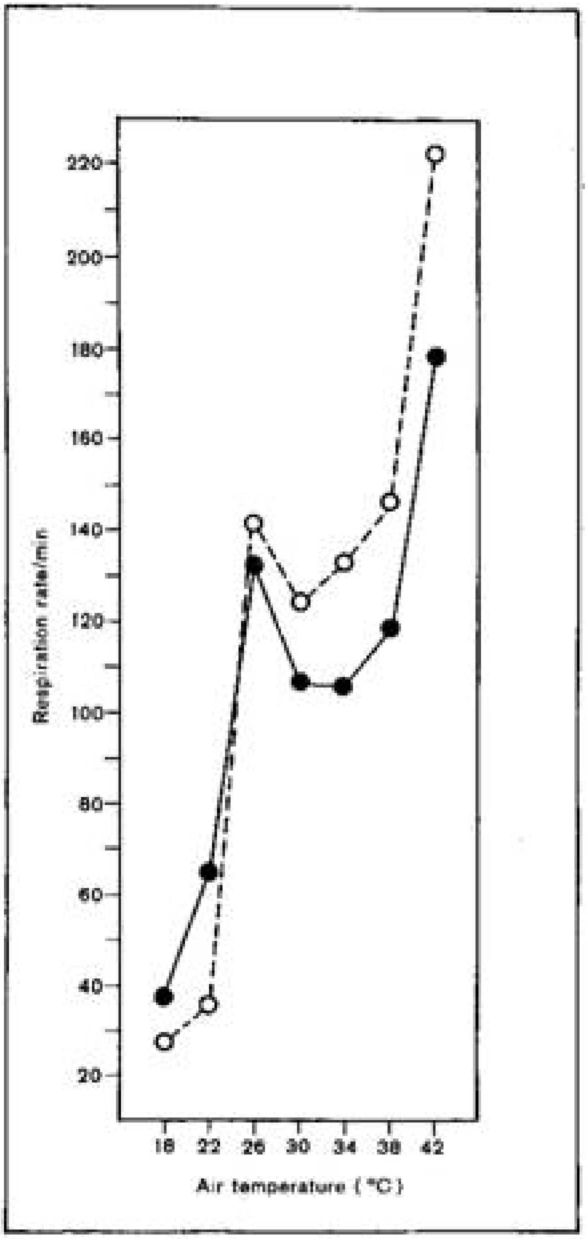


Figure 1-40. Rise in respiration rate with increasing air temperature in Awassi sheep standing in the sun.
(**Source:** Eyal, 1963c)

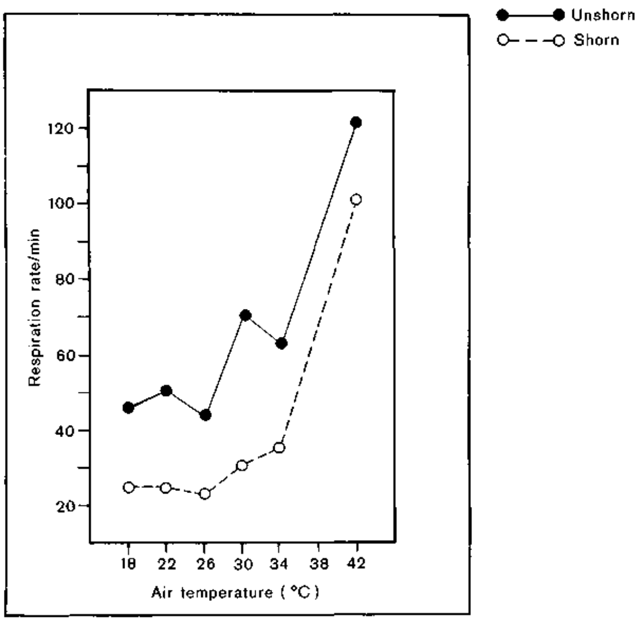


Figure 1-41. Respiration rate of Awassi sheep at different ambient temperatures in the evening after standing in the sun during the day. (**Source**: Eyal, 1963c)

In the shade the critical temperature for the increased respiration of Awassi sheep is 22°C for unshorn and 26-30°C for shorn animals. Under direct sunlight the critical ambient temperature for an increase of the respiration rate is 15-18°C for unshorn and 18-22°C for shorn sheep. During the hours of greatest heat the respiration rate of shorn sheep exceeds that of unshorn ones, owing (as Eyal, 1963c, suggests) to the reflection of part of the direct solar radiation by the fleece and the loss of heat by long-wave radiation. Yet the overall average respiration rate of the shorn sheep is 74.1 as against 83.5 per minute for those in fleece, for the respiration rate of shorn sheep decreases very rapidly on the return of the animals from the sun to the shade.

With similar rectal temperatures on cold winter or very hot summer days, the respiration rates of shorn and unshorn Awassi sheep are similar. But at moderate ambient temperatures unshorn sheep have a higher respiration rate than shorn sheep with identical rectal temperatures.

There is hardly any difference in the humidity effect on the respiration rate of shorn and unshorn Awassi sheep at ambient temperatures below 26°C. However, at air temperatures of between 27 and 34°C, increasing relative humidity is accompanied by the higher respiration rate of unshorn sheep in the shade and a lower one for shorn animals. The opposite obtains in sheep exposed to direct sunlight. With rising relative humidity the respiration rate of shorn sheep here not only increases but does so at a steeper rate than in animals in fleece.

The differences in respiration rate between shorn and unshorn sheep increase on a windy day. At ambient temperatures above 18°C the respiration rate of shorn sheep is reduced by wind, but at lower air temperatures the effect of wind on the respiration rate of shorn sheep is negligible.

Eyal (1963c) concludes that the differences between the respiration responses of unshorn and shorn Awassi sheep stem from the differences in their thermal balance, which again are the result of differences in the insulating characteristics of the body surface and between the macroclimate and the microclimate in the fleece.

In a trial on the effect of dehydration on the physiological responses of Awassi sheep (see pp. 37-38), it was found that with a reduction in the daily water ration offered to six-month-old lambs, the panting rate decreased. Degen suggests that this may indicate a reduced amount of respiratory water loss, such as is observed in the Australian Merino and also in Sinai and Syrian mountain goats and in Grant's and Thompson's gazelles (Table 1-26).

In an investigation of the effect of docking on the respiratory rate of Awassi rams carried out by Juma, Gharib and Eliya (1971) in five docked and five undocked, approximately 19-month-old rams at Abu-Ghraib in Iraq during the hottest months of the year, it was found that the monthly variation in respiratory rate was significantly related to variations in atmospheric temperature (Fig. 1-42). The docked rams maintained lower respiratory rates than the control sheep; the average rate of respiration in the undocked rams was 86.2 per minute and in the docked animals 78.4. The maintenance of lower respiratory rates by the docked rams, along with lower rectal temperatures (see Fig. 1-34), indicates that docking in Awassi sheep results in greater heat-regulatory efficiency.

TABLE 1-26. **Average panting rate of 6-month-old Awassi lambs at different rations of drinking water**

Water ration (litres)	Panting rate per minute at 13.00 h
Free	147
4.5	141
3.0	150
2.5	151
2.0	110
1.5	108
1.0	112

Source: Degen, 1976

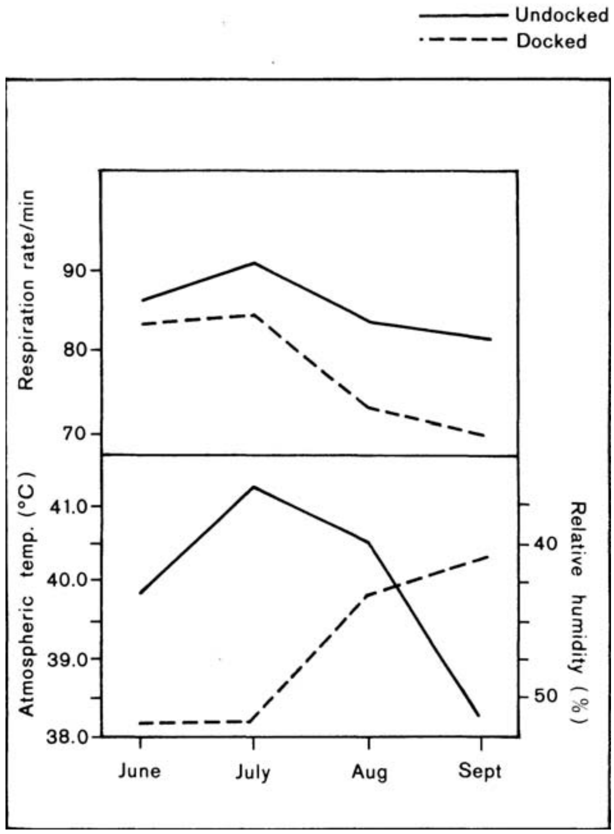


Figure 1-42. Monthly variation in respiratory rate in docked and undocked Awassi rams. (**Source:** Juma, Gharib & Eliya, 1971)

TABLE 1 -27. **Total body water in Awassi sheep grazing on dry summer and lush winter pastures**

	Summer	Winter
Body weight (kg)	34.8	36.6
	25.7	25.3
Total body water (% of body weight)	73.9	69.1

Source: Degen, 1976

Water economy and feed intake under different conditions. Sheep adapted to arid and semi-arid conditions are characterized by a low water turnover which enables them to exploit scanty pasture growth in seasons of drought over a relatively wide distance from the source of water.

In the range of the Awassi the grazing is generally scarce and poor during summer and autumn so that sheep maintained solely on natural pastures have to mobilize their fat reserves during the dry season. During and shortly after the rainy season the animals increase their body solids and gain weight. These differences affect total body water and its distribution (see Table 1-27).

The seasonal changes in these respects have been examined by Degen (1976) in four female Awassi yearlings grazing on the dry pasture of abandoned cropland vegetation with a water content of less than 10 percent during October and November, and on shrub (mainly the saltbush species) during December and January, and in four other yearlings grazing on lush native pasture with a water content of 70-85 percent in February and March (see Table 1-28). In December and January the sheep received an additional ration of 500 g of concentrates and 250 g of groundnut straw a day, and in

January also an unlimited quantity of onions. The animals had free access to water and shade at the grazing grounds. At night they were penned up. Again, in August nine Awassi sheep were pastured in a paddock with a uniform stand of the legume *Medicago polymorpha* with a relatively constant water content of less than 10 percent.

TABLE 1-28. **Mean water turnover of Awassi sheep grazing on native pasture, shrub and legumes in different months of the year**

Type of pasture	Number of sheep	Body weight (kg)	Water turnover in 24 hours	
			(i)	(ml/kg body weight)
Native pasture				
October	4	37.4	3.86	103.2
November	4	36.4	3.07	84.3
February	4	45.5	5.80	127.5
March	4	48.6	6.60	135.8
Shrub				
December	4	35.0	6.47	184.9
January	4	35.4	4.26	120.3
Legumes				
August	9	40.5	5.61	138.5

Source: Degen, 1976

The animals turned over more water when grazing on lush plants than on dry plants. However, they more than doubled their water turnover when moved to saltbush characterized by a high mineral content. When onions were offered, the water turnover decreased at a similar rate as the saltbrush intake.

In a study carried out for the purpose of estimating the water turnover and dry matter intake of Awassi sheep under winter grazing conditions, Degen examined five yearling ewes which were kept in fenced paddocks of sown barley pasture for 24 hours a day (Table 1-29). The animals did not have access to free water, which in any case is rarely taken by Awassi sheep pastured on luscious grazing in winter. The trial lasted for five days in February and was repeated for six days in March when the barley had a higher dry matter content, namely 32.8 percent as against 18.5 percent in the previous month.

Estimated from the water turnover, the sheep on average consumed 0.82 kg of dry matter per day in February, and 1.51 kg in March (see Table 1-30). Based on a field estimate, the mean dry matter intake per animal was 0.74 kg a day in February and 1.28 kg in March. The total water intake per sheep in 24 hours was 3.61 in February and 3.11 in March.

In a trial carried out for the purpose of determining the water and feed intake of Awassi sheep under summer grazing conditions, Degen (1976) kept seven eight-month-old ewes and two rams with a mean body weight of 40.5 kg on a dry pasture of *Medicago polymorpha* during two periods of ten

TABLE 1-29. **Total body water and water turnover in five Awassi yearling ewes pastured on green barley in February and March**

Month	Body weight (kg)	Total body water		Water turnover in 24 hours	
		(I)	(% of body weight)	(I)	(ml/kg live weight)
February	36.1	25.7	71.2	3.6	99.7
March	36.3	25.5	70.2	3.1	85.1

Source: Degen, 1976

TABLE 1 -30. **Daily feed intake by five Awassi yearling ewes pastured on green barley in February and March, as estimated from water turnover**

Month	Green matter intake (kg)	Dry matter intake (kg)	Dry matter intake per kg live weight (.9)
February	4.42	0.82	22.7
March	4.60	1.51	41.6

Source: Degen, 1976

days each from 6.00 to 19.00 h a day. Weighed water was offered to the animals every morning and the remaining water was weighed at 19.00 h. The evaporation loss was determined separately.

Another Awassi ram, of similar age and body weight, was placed outdoors in a metabolic cage near the grazing paddocks and was offered weighed herbage collected from the field and weighed water at 6.00 h each day. The remains of the herbage and water were weighed at 19.00 h. The animal was provided with shade at the same times at which the grazing sheep were observed to be in the shade.

The water turnover was estimated for the pastured sheep and the caged ram and the difference between the daily mean of the total water turnover and water drunk was used to estimate the mean daily herbage intake (Table 1-31).

In three tests with Awassi sheep in the Negev desert of Israel during the hot month of August, Chen (1976) found that differences in age, ambient temperature and feed did not appreciably alter the water-to-feed ratio of 3:1 in total feed and water consumption, although actual intakes of water and feed were changed by temperature, age and feed to a greater or lesser extent (Table 1-32). Seven six-month-old lambs were tested in each of two trials and in the third trial seven 2- to 2 ½-year-old ewes. The animals were kept in separate boxes during the tests. In the first test the boxes were placed under the roof in a well-ventilated shed. In the second test the boxes were exposed to direct sunlight. In the third test with adult ewes, which were kept in the shade of a screen cover for part of the day, the effect of differences in age and feeding ration from those of the lambs on feed and water intake was tested. The lambs were fed *ad libitum* a balanced ration of concentrates and cotton-seed hulls containing 15.9 percent protein, while the adult sheep received, also *ad libitum,* dry natural pasture herbage, finely chopped, with a protein content of 4.8 percent.

TABLE 1 -31. **Mean dry matter and oxidative matter intake of pastured Awassi sheep during 24 hours in summer**

Tritiated water turnover (l)	5.61
Water intake (l)	4.57
Feed water (l)	1.04
Dry matter (kg)	1.31
Oxidative matter (kg)	1.11

Source: Degen, 1976

TABLE 1 -33. **Mean feed intake and body weight with different rations of drinking water**

Water ration (l)	Feed intake (kg)	Water-feed ratio	Body weight (kg)
Free	1.43	3.20	37.8
4.5	1.44	3.13	39.7
3.0	1.03	2.91	40.4
2.5	0.85	2.94	39.8
2.0	0.55	3.63	38.0
1.5	0.36	4.17	35.6
1.0	0.23	4.35	32.6

Source: Degen, 1977d

TABLE 1 -32. **Mean water and feed intake of Awassi lambs and ewes in three tests**

Test no.	Mean maximum air temperature (°C)	Mean live weight during test (kg)		Water intake (l/day)	Feed (dry matter) intake (kg/day)	Water-feed ratio
		Beginning	End			
I	32	31.0	36.5	5.38	1.95	2.8
II	37	30.6	35.9	5.71	1.94	2.9
III	33	51.4	49.7	2.65	0.85	3.1

Source: Chen, 1976

The water and dry matter intake of the adult sheep was approximately 60 percent lower than that of the lambs, while the ratio of water to feed was similar. The water intake of the lambs kept in the sun was slightly greater than that of those kept in the shade, but the difference was not statistically significant.

The mean water intake of the adult ewes markedly differed between six four-hour periods of the day. Thirty-five percent of the day's total water consumption was drunk during the early hours of the day, from 7.00 to 11.00 h. The feed intake, on the other hand, showed only slight differences in the six four-hour periods (Chen, 1976). (See Fig. 1-43.)

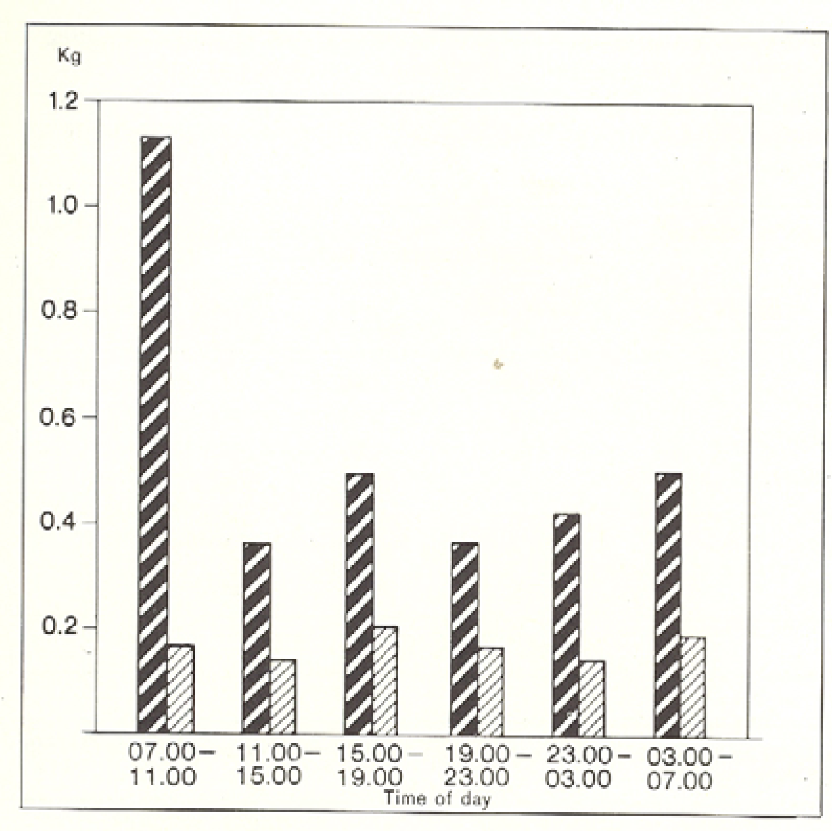


Figure 1-43. Water and feed (dry matter) intake of adult Awassi ewes at different hours of the day. (**Source:** Chen, 1976)

In eight Awassi lambs individually penned in the Negev desert of Israel in the hot summer sun without shade, the mean ratio of feed (dry matter) to water intake, which with normal feeding and watering was 1:2.9, changed after a 24-hour starvation period to 1:3.7 (Benjamin, Degen & Vachnich, 1974).

In a study of the physiological responses of Awassi sheep to a restricted water supply under semi-arid summer conditions, Degen (1976,1977d) kept three six-month-old male lambs in individual pens in a shadeless place during the hot dry summer months of May and August. Before the beginning of the trial the animals were adjusted to these conditions for a fortnight. During the first ten days of the test they were allowed to eat and drink *ad libitum* in order to determine their normal feed and water intake, the latter being 4.67 1 a day. The daily feeding ration during the trial consisted of 1.8 kg of concentrates and 0.2 kg of straw, while the water was rationed to 4.5, 3.0, 2.5, 2.0, 1.5 and 1.01a day for 9-12 days at each level. The feed and water remains were weighed daily and the sheep were weighed every two days. At the end of the experiment the animals again had free access to water.

With free or 4.51 of water a day offered in the morning, the lambs took most of it in one drinking. When offered 3.01 or less, they drank all the water at once. With a reduction in the water ration the feed intake decreased, but the ratio of water to feed remained constant at approximately 3:1 until the water ration came down to 2.01 a day. At this point the lambs ceased eating almost completely and the ratio of water to feed widened.

The lambs gained weight as long as water was freely available or a 4.5-1 daily ration was offered. They began to lose weight when the water ration was reduced to 2.51. Most of the loss in body weight consisted of water. The total loss was 7.8 kg, or 19.3 percent (Table 1-33).

Following dehydration and a loss of 19.3 percent in body weight, the lambs, upon again having free access to water, drank 7.11, or 21.8 percent of their last weight, which represented 91 percent of their weight loss of 7.8 kg.

At the commencement of the trial the water content of the faeces was 65 percent. This gradually decreased to 45 percent with a reduction of the water ration to 1.01 a day (Table 1-34).

The faeces, which normally formed small smooth pellets, became increasingly irregular in shape during the course of dehydration.

With a reduction in the water ration the concentration of the urine increased to an osmolality of 3 230 mosm per litre of H_2O, and the ratio of urine to plasma from 2:5 to 8:3 (Table 1-35).

In a study of the changes of total body water and water turnover of Awassi ewes during the third, fourth and fifth months of pregnancy and the first month of lactation, Degen (1976,1977b) observed six pregnant and four unbred animals, maintained on natural pasture (Tables 1-36 and 1-37). During the fifth month of pregnancy the ewes received an additional ration of 500 g of concentrates and 250 g of groundnut straw, and during lactation a further addition of unlimited quantities of onions. At pasture, water and shade were within easy reach. At night the ewes were penned up. In the course of the test period the mean daily air temperature decreased from 22.7 to 11.1°C, while the mean relative humidity rose from 61.3 to 69.4 percent.

TABLE 1-34. **Water content of faeces at different rations of drinking water**

Water ration (l)	Water content of faeces (%)
Free	65.1
4.5	58.9
3.0	57.9
2.5	51.8
2.0	49.0
1.5	47.5
1.0	45.0

Source: Degen, 1977d

TABLE 1-35. **Osmolality of urine and plasma at different rations of drinking water**

Water ration (l)	Urine (mosm/1l$H_2$0)	Plasma (mosm)	Urine-plasma ratio
Free	769	311	2:5
4.5	884	314	2:8
3.0	1 305	322	4:1
2.5	1 914	350	5:5
2.0	1 809	360	5:0
1.5	2 139	384	5:6
1.0	3 230	387	8:3

Source: Degen, 1977d

TABLE 1 -36. **Mean weights and total body water (kg) of Awassi ewes in last 3 months of pregnancy and 1st month of lactation, and of unbred ewes during same months**

Month of pregnancy or lactation	Pregnant or lactating ewes		Unbred ewes	
	Weight	Total body water	Weight	Total body water
3rd pregnancy month	56.3	41.9	37.4	26.7
4th pregnancy month	56.9	43.1	36.4	26.8
5th pregnancy month	54.9	41.6	35.0	25.5
1st lactation month	44.8	32.2	35.4	25.8

Source: Degen, 1977b

TABLE 1 -37. **Mean water turnover (l and % of body weight) of Awassi ewes in last 3 months of pregnancy and 1st month of lactation, and of unbred ewes during same months**

Month of pregnancy or lactation	Mean water turnover per ewe in 24 hours			
	Pregnant (l)	Unbred (l)	Pregnant (% of body weight)	Unbred
3rd pregnancy month	5.36	3.86	9.6	10.3
4th pregnancy month	4.88	3.07	8.5	8.4
5th pregnancy month	10.37	6.47	19.2	18.6
1st lactation month	6.91	4.26	15.3	12.4

Source: Degen, 1977b

The ewes of both groups, pregnant and unbred, lost weight during those months in which Awassi ewes are generally in lamb because at this time of year pastures are dry and of low nutritive value. At parturition the loss of weight (fluids, lamb and foetal membranes) amounted to 18.2 percent of the mean body weight; most of this consisted of water. The percentage of total body water increased during the test period in both groups, save for the fifth month during which it remained constant in the non-pregnant ewes. During the fourth month, when grazing on saltbush, all ewes more than doubled their water intake. During the lactation period the suckling ewes increased their water turnover by 29 percent.

Seasonal changes in the thyroid gland and trachea. The seasonal changes in the thyroid gland of one-year-old unimproved Awassi rams have been studied in central Iraq where the climate is characterized by a long, very hot and dry summer season and cold, humid winters. In summer, temperatures in the shade may rise to 50°C, and in July and August the mean maximum temperature exceeds the body temperature of sheep each day. During the coldest months the mean minimum temperature is approximately 4°C. In summer the relative humidity is usually below 20 percent, but in winter it may reach 100 percent.

A hundred thyroid glands were examined in summer and the same number in winter (Injidi, Kassab & Rollinson, 1968). The mean weight of the glands was 1.78 g (0.95-3.61 g) in winter and 2.28 g (1.05-3.10 g) in summer, the seasonal difference being statistically highly significant. The mean diameter of 20 follicles from five glands each, examined in winter, was 152.1 μ (80.0-201.4 μ), and from the same number in summer 87.6 μ. (52.8-140.7 μ), the seasonal difference being statistically significant.

Microphotographs of sections of the thyroid gland show marked differences in the colloid within the follicles. In the hot season the colloid is of a uniform consistency (Fig. 1-44), whereas a marked tendency to cross-striation artefacts is observed in colloids from glands in winter (Fig. 1-45). Further, in the hot season there is a widespread and pronounced tendency to vacuole formation in the periphery of the colloid, while in winter such vacuole formation is negligible.

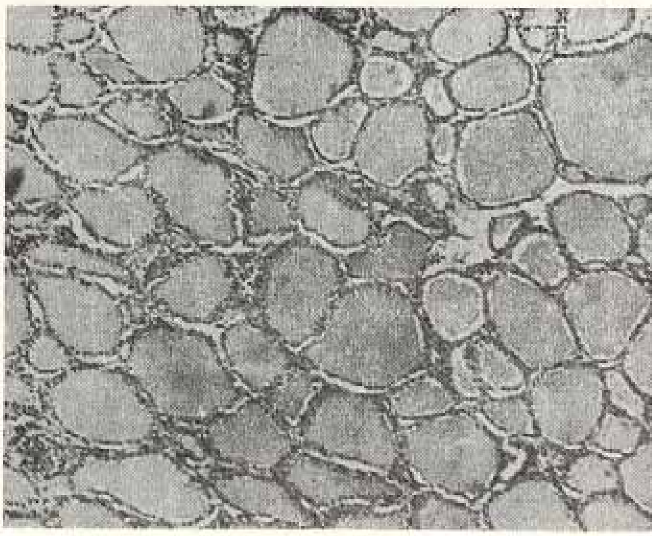


Figure 1-44. Section of thyroid gland of male Awassi sheep in summer. (**Source:** Injidi, Kassab & Rollinson, 1968)

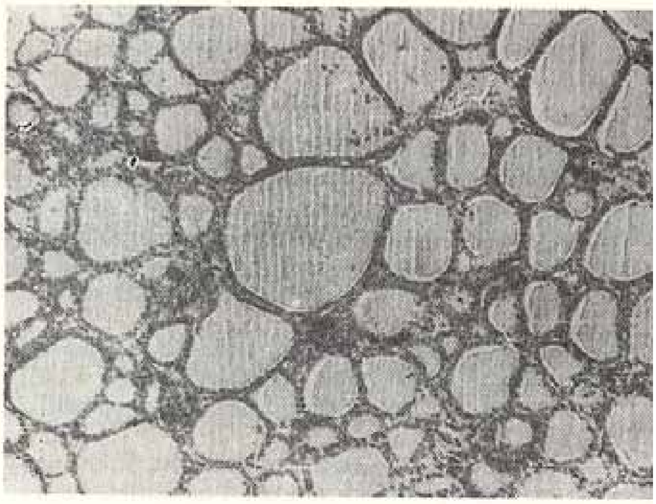


Figure 1-45. Section of thyroid gland of male Awassi sheep in winter. (**Source:** Injidi, Kassab & Rollinson, 1968)

The authors suggest that in Awassi rams (which have lower thyroid activity than females), the larger size of the thyroid gland in summer may indicate increased thyroid activity. Again, the greater size of the glandular follicles in winter may be a result of an increased use of the products of the gland in summer and increased storage from reduced activity in winter.

This is confirmed by a study of the thyroid of unimproved Awassi rams in Israel during different seasons of the year. Volcani (1957) found that the lumen of the thyroid greatly expands from June to September and the colloid increases in quantity and changes from numerous drops to a smooth condition. The height of the epithelium lessens from 6-7 to 2-4 μ, and its cuboidal columniform condition gradually levels down, indicating the absence of activity and the end of accumulation. The nucleus completely fills the cellular space. In June the thyroid still produces a considerable quantity of secretion for partial storage; during July-September accumulation reaches its peak and the thyroid ceases to secrete.

Thyroidal activity coincides with the main breeding season of the Awassi. In June and July the highly active gland utilizes the accumulated colloid. In August and September colloid accumulation increases again and the activity of the epithelium shows signs of slowing down.

In Awassi rams in Iraq the mean internal diameter of the trachea was 16.8 mm in winter and 19.8 mm in summer. Injidi, Kassab and Rollinson assume that the larger tracheal diameter in summer is caused by panting.

Haemoglobin types in Awassi sheep. In adult sheep of different breeds three haemoglobin types occur, namely Hb-A, Hb-B, and Hb-AB, which are distinguishable by paper electrophoresis. The Awassi breed of sheep is overwhelmingly of the haemoglobin type B. In sheep from bedouin flocks in the Beersheba area of Israel, a frequency of 0.06 of Hb-AB was recorded, and in fellahin flocks in the Nazareth area a frequency of 0.08. In an improved Awassi dairy flock of a Jewish communal settlement there were no animals of the Hb-A or AB types (Reshef, 1965), but in another similar flock, Perk, Frei and Herz (1964) found one adult animal of Hb-AB type among 61 lambs and ewes. Evans, Harris and Warren (1958) noted the complete absence of Hb-AB-A in 39 Awassi sheep from Israel and a frequency of 0.05 in 47 animals of the same breed from Iraq. It would appear that sheep with Hb-B are better adapted to the environment of Israel than are animals with Hb-A or AB, and that selection for high milk yields has led to the disappearance of Hb-A from improved dairy flocks (Eyal, 1968). Reshef recorded the particulars given in Table 1-38 of Hb-B in samples from ten improved Awassi dairy ewes.

TABLE 1-38. **Haemoglobin characteristics in Awassi ewes**

Particulars of Hb-B	Mean	Standard deviation
Mean corpuscular haemoglobin concentration	35.3	4.6
Packed cell volume	29	4.9
Haemoglobin (g%)	10.10	1.1

TABLE 1-39. **Mean values of blood serum proteins in Awassi sheep in different seasons**

Month	g/100 ml serum
August	6.79 ±0.23
October	6.40 ±0.53
November	6.35 ±0.77
January	5.72 ±0.50
March	5.45 ±0.74
June	6.73 ±0.39

The paper electrophoretic haemoglobin pattern in sheep shows the existence of two distinct erythrocyte populations, one containing foetal and the other adult haemoglobin, which differ in several chemical, physiological and physical properties. In the blood of new-born Awassi lambs an average amount of 74.8 percent of foetal haemoglobin has been recorded, indicating that the synthesis of adult haemoglobin (Hb-B) commences before birth. With advancing age, foetal haemoglobin diminishes until its complete disappearance after six to eight weeks (Perk, Frei & Herz, 1964).

Blood serum proteins and lipoproteins. The electrophoretic analysis of the blood serum of Awassi yearling ewes reveals the existence of seasonal variation in the composition of serum proteins in this breed. During the hot season of the year the concentration of proteins in the serum is considerably higher than in winter (Table 1-39) (Peeri, 1963).

The higher protein concentration in summer results from an increase in the quantity of albumin in the serum, accompanied by a reduction in the ratio of the other protein fractions. Peeri holds that the larger albumin concentration facilitates the incorporation of fluids with the blood plasma and prevents excessive dehydration, hence increasing resistance to high ambient temperatures. Thus, Awassi sheep bred in the hot Beyt Shean valley, 244 m below sea level, have a higher percentage of albumin in the blood plasma than Awassi sheep of the same sex and similar age and conditions at a place 138 m above sea level (Table 1-40).

TABLE 1 -40. **Mean percentages of electrophoretic protein fractions in the blood plasma of Awassi sheep in two different climatic regions**

Climate	Albumin	Globulins							Total
		α1	α2	α3	β1	β3	γ1	γ2	
Hot	51.5	2.9	3.8	10.1	5.9	5.4	13.9	6.5	100.0
Warm	44.9	3.8	6.0	10.7	4.5	5.5	16.3	8.3	100.0

Awassi sheep possess a higher albumin concentration in their blood serum (44.9 ±3.8 percent) than do German Mutton Merino (42.3 ±4.7 percent) and Corriedale sheep (42.1 ±3.9 percent) in the same environment. This is believed to be one of the factors responsible for the superior adaptation of the Awassi to a warm climate. Yet total protein contents in the blood plasma of the Awassi are lower than those of the imported Corriedale and Mutton Merino breeds, namely 6.18 ±0.75 g% against 6.79 ±0.82 g% and 6.70 ±0.68 g%, respectively.

In an investigation of proteins and lipoproteins in the blood serum of 42 improved Awassi sheep of different age groups and of both sexes, Perk and Lobl (1960) found that total serum proteins increased with age in both males and females. In three-month-old male lambs 100 ml of serum contained 5.65 g of protein, in yearling rams 6.95 g, and in three-year-old rams 7.02 g. In female Awassi sheep the total protein contents in 100 ml of serum rose from 5.78 g in three-month-old lambs to 7.12 g in yearlings and 7.36 g in adult lactating ewes. The increased total protein values result from a rise in the globulins, especially pronounced in lactating ewes. Thus, in males of the above three age groups, the albumin-globulin ratio dropped from 1:85 to 0:91-0:90, and in females from 1:75 to 0:99-0:77, respectively.

The same trend was observed in the paper electrophoretic serum pattern, which consists of seven fractions. A comparison between three-month-old and adult males showed a reduction in the relative value for albumin from about 60 percent of the total to 46 percent. The α3 globulin value also dropped, albeit to a lesser extent. The α2 and β1 globulins snowed no significant differences between the age groups of the males, but β3 was absent in the older rams. In the latter, αl globulin showed a slight rise from 2.3 to 3.1, while the γ-globulin value rose from about 11 percent of the total in the three-month-old male lambs to 23 percent in the older rams. The γ2 fraction was absent in young lambs; in the older rams it represented 6.8 percent of the total value. The female Awassi sheep showed the same trend, but in lactating ewes the changes were more marked. Thus the albumin value dropped from 61 percent in the three-month-old female lambs to 41 percent of the total proteins in the ewes in milk, while the combined γ-globulins rose from 11 to 36 percent. There are, therefore, no significant differences in the values for the protein fractions of both sexes in the three-month-old lambs or the yearlings, but the lactating adult Awassi ewes have lower albumin and higher γ-globulin values than rams of the same age. Perk and Lobl (1960) suggest that these differences are related to the endogenous female hormone secretion.

The authors found no marked differences in the paper electrophoretic protein patterns between adult Awassi and adult Rambouillet, Corriedale, Somali, East Friesian and Romney Marsh rams. In lambs the high albumin-globulin ratio characteristic of the Awassi was also found in Rambouillet and Karakul lambs.

The paper electrophoretic lipoprotein pattern of sheep serum shows four distinct bands, referred to as albumin and α, β, and γ-lipoproteins. With increasing age the lipoproteins from the albumin region decrease, a phenomenon most distinct in lactating ewes, namely from 49.5 percent in three-month-old lambs to 33.4 percent in ewes in milk. In rams there is practically no change with age in the α-lipoprotein, but in lactating ewes a slight increase has been recorded. The most striking differences occur in the β-lipoprotein, where an increase of about 40 percent was found in yearlings and of 100 percent in adult ewes above its value in three-month-old lambs. At the same time, the lipoprotein bound to the γ-globulin decreases in lactating ewes by about 15 percent (Perk and Lobl, 1960).

The analysis by Perk and Lobl of the blood serum of four 91-day-old, male, fat-tailed Awassi lambs and six lambs of the same breed and age that had been docked on the third day after birth showed only very slight and statistically insignificant differences in the protein and cholesterol contents of the blood serum and in the paper electrophoretic distribution of the protein and lipoprotein pattern between the two groups (Epstein, 1961) (see Tables 1-41 and 1-42).

TABLE 1-41. **Chemical analysis of blood serum for proteins and cholesterol from six docked and four undocked male Awassi lambs**

Serum contents	Docked		Undocked	
	g/100 ml serum	SD±	g/100 ml serum	SD±
Albumin	3.83	0.24	3.80	0.18
Globulin	2.08	0.18	2.05	0.25
Total protein	5.91	0.29	5.85	0.43
	mg/100 ml serum	SD±	mg/100 ml serum	SD ±
Total cholesterol	79.8	5.6	80.7	7.2

TABLE 1-42. **Paper electrophoretic distribution of proteins and lipoproteins in blood serum of six docked and four undocked male Awassi lambs**

Proteins	Docked		Undocked	
	% of total proteins	SD±	% of total proteins	SD ±
Albumin	61.16	4.08	61.00	0.94
α_1-Globulin	2.40	0.58	2.37	0.37
α_2-Globulin	3.83	0.69	4.25	0.57
α_3-Globulin	11.83	2.10	10.80	0.47
β_1-Globulin	4.50	1.34	4.59	0.93
β_3-Globulin	3.08	0.29	5.62	0.58
γ -Globulin	13.20	2.56	11.37	1.20
Lipoproteins	% of total lipoproteins	SD±	% of total lipoproteins	SD±
Albumin-bound lipoprotein	47.90	3.22	44.75	2.68
α-Lipoprotein	19.00	2.67	22.00	3.14
β-Lipoprotein	12.00	1.08	12.15	2.15
γ-Lipoprotein	21.10	1.96	21.10	3.47

This indicates that the synthesis of the blood serum proteins and lipoproteins was not affected by the docking of the fat tail and conforms with the almost equal liver weights of both groups as well as with the high rate of body fat accumulation in the docked lambs, which nearly counterbalanced the inhibited fat tail (see also p. 200, paras. 2 and 3, and Table 5-13).