FAO ANIMAL PRODUCTION AND HEALTH PAPER 57

The Awassi sheep with special reference to the improved dairy type

FOOD AND AGRICULTURE ORGANIZATION
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by
H. Epstein

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Bedouin women milking Awassi ewes on the Jordanian steppe. (Photograph courtesy of Dr Ilse Köhler-Rollefson)

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Explanatory notes

AI	artificial insemination
DP	digestible protein
FSH	follicle-stimulating hormone
LH	luteinzing hormone
mosm	milliosmoles
osmolality	the cosmotic pressure of a solution expressed in osmoles or milliosmoles per kilogramme of water
PMS	pregnant mare serum
SD	standard deviation
SPG	specific gravity
TDN	total digestible nutrients
YCGF	yolk-citrate-glycine-fructose

Foreword

Effective decision-making in animal breeding and genetics requires accurate knowledge combined with sound experience. FAO has issued a number of publications over the years, which seek to bring together such knowledge and experience in one volume. These publications have often been devoted to the livestock of certain countries or regions. They seek to bring to light information which has been published but which is often inaccessible to potential users because of language barriers or the limited distribution of scientific journals in some developing parts of the world. Additionally, there is often a wealth of information which has never been adequately documented in a formal way.

The Awassi sheep is a widely distributed type in many countries of the Near East Region and is known in other parts of the world. It is an animal genetic resource with special adaptability and performance characteristics which should be even more widely known. This publication seeks first to offer to the person already familiar with the Awassi sheep the integrated knowledge which draws together known facts and experience. Second, it seeks to bring to those unfamiliar with the Awassi the special qualities it offers for specific environments.

The author, Professor H. Epstein, is an internationally known scholar who has published widely on the subject of animal genetic resources, from both the point of view of origin and domestication, and also from the point of view of current distribution and use. He has used the ability of the dedicated scholar to study the extensive publications and unpublished reports on Awassi sheep thoroughly, and has combined this with his own years of experience in this authoritative text. FAO is pleased to publish this book in the interests of international cooperation and believes it will contribute to improving the understanding and use of this valuable genetic resource.

H.A. Jasiorowski
Director
Animal Production and Health Division

Rome, July 1985

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.

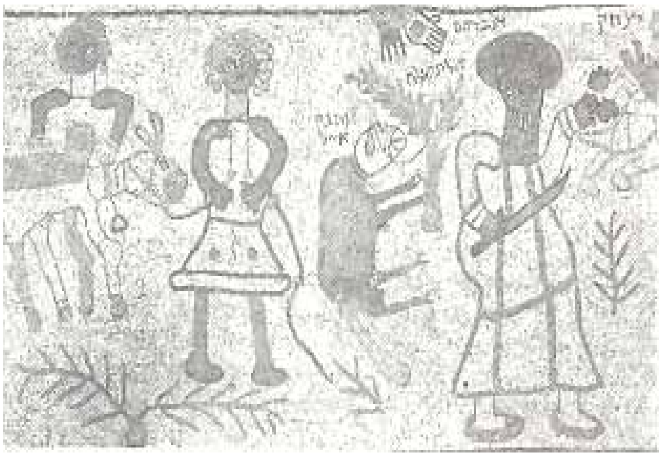


Figure 1-1. Fat-tailed ram from mosaic floor in the synagogue of Beyt Alfa (sixth century AD)

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'.

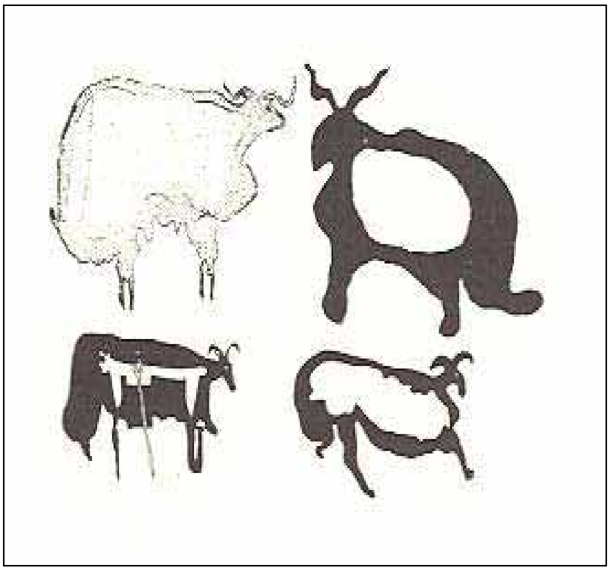


Figure 1-5. Fat-tailed sheep. Rock engravings from central Arabia, second or early first millennium BC. (**Source:** Anati, 1968)

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.)

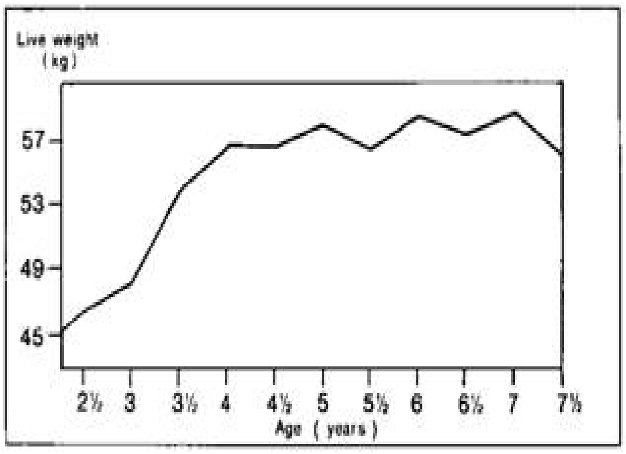


Figure 1-8. Average live weights of Awassi ewes in Lebanon at different ages. (**Source:** Rottensten & Ampy, 1971a)

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

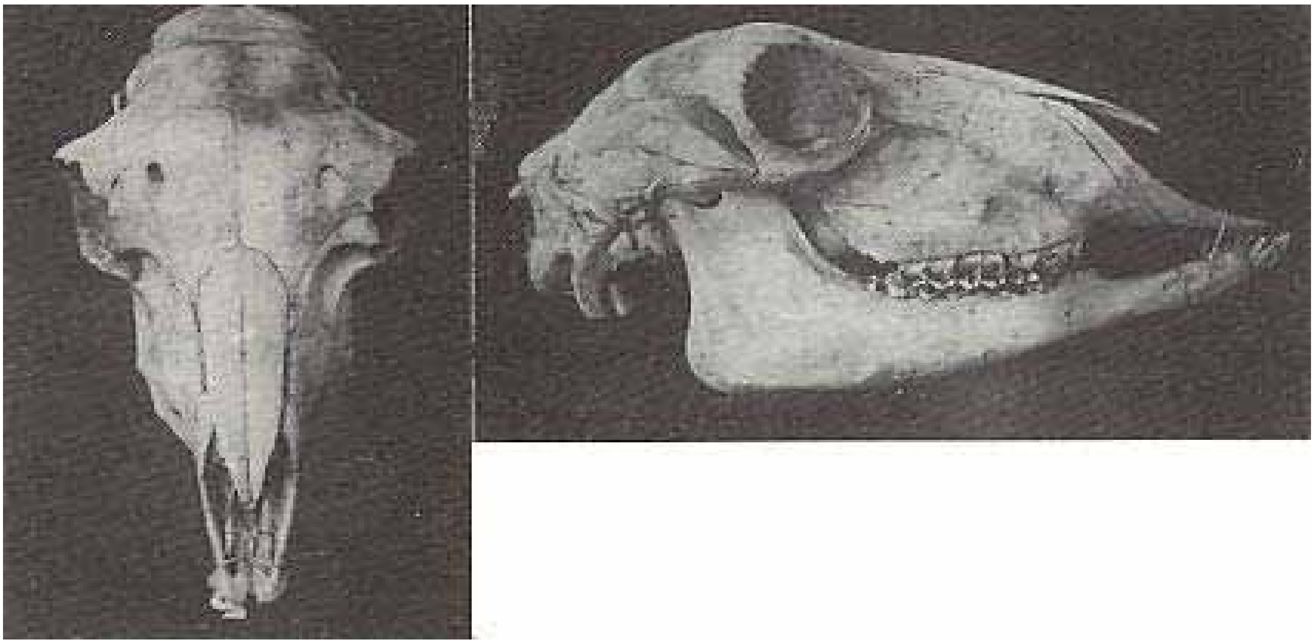


Figure 1-12. Skull of a polled Awassi ewe. Frontal and lateral views

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

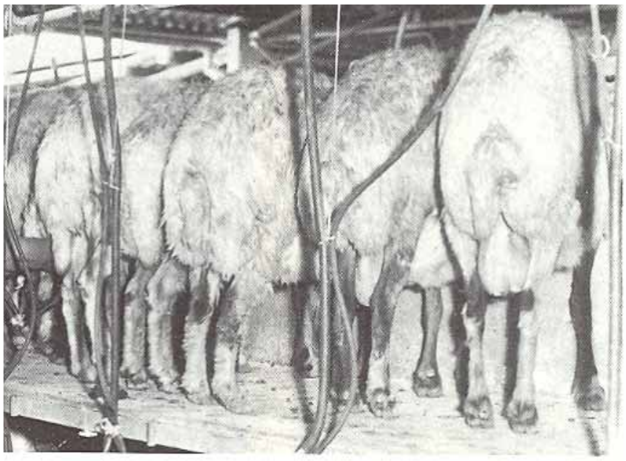


Figure 1-15. Awassi ewes with fat tails of moderate length

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

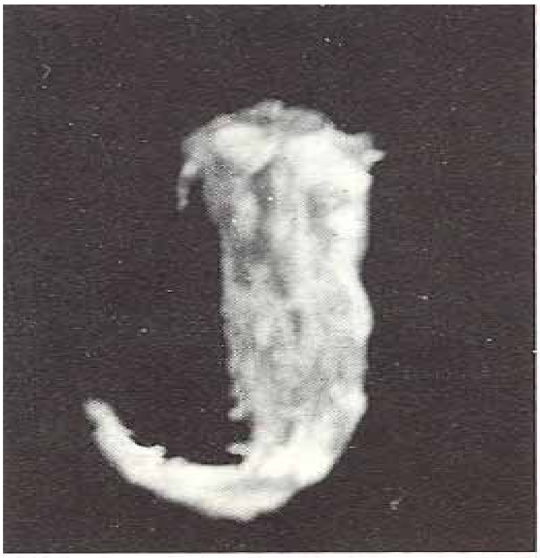


Figure 1-17. Tail of a 3-month-old Awassi lamb after removal of fat cushion

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.)

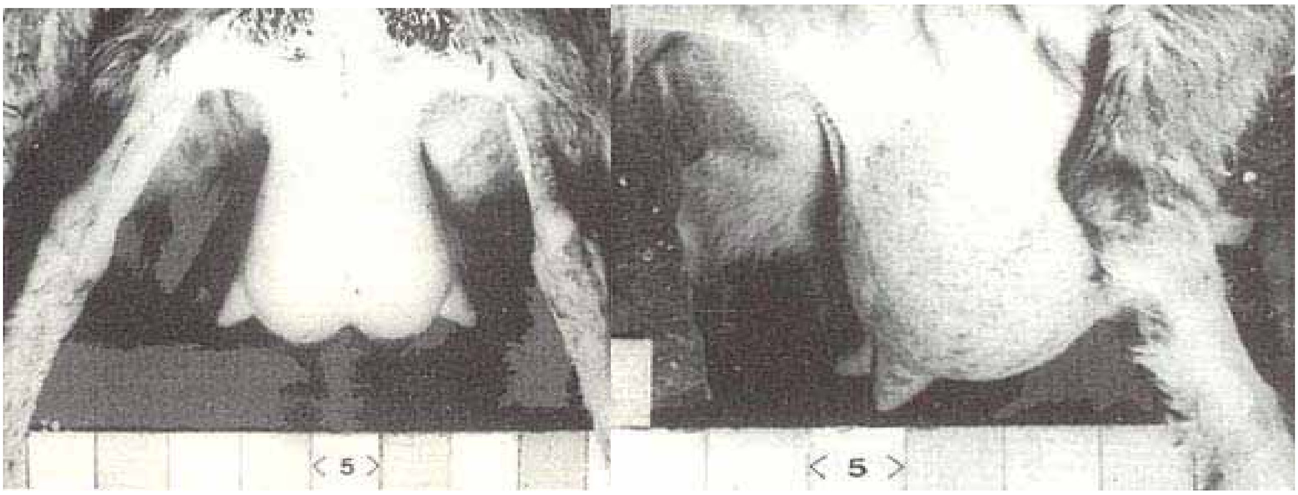


Figure 1-19. Pendulous udders of old Awassi ewes. Caudal and lateral views. (Measure in cm)

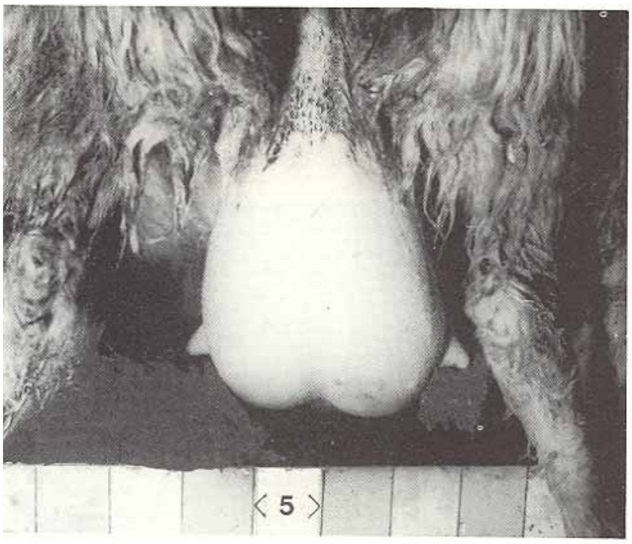


Figure 1-20. Well-shaped udder of an Awassi ewe, but teats too high-set and projecting laterally. Caudal view. (Measure in cm)

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

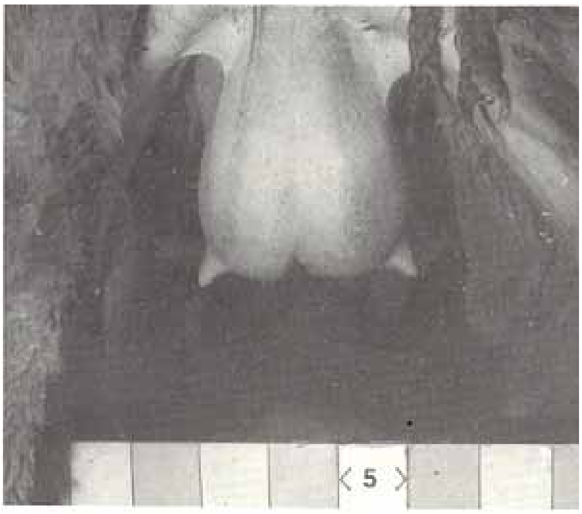


Figure 1-27. Typical udder of an improved Awassi ewe. (Measure in cm)

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.

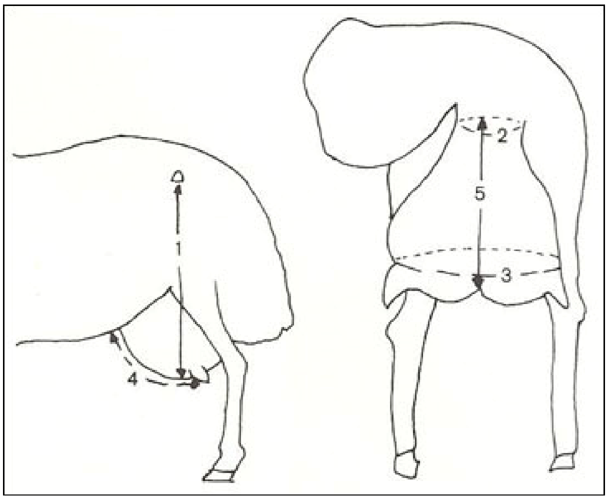


Figure 1-28. Sketch of measurements taken before and after milking

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

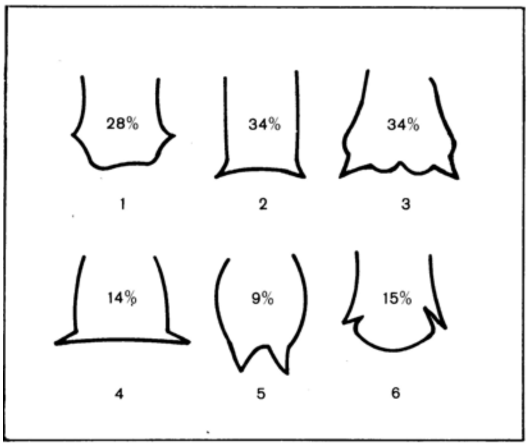
As for the teats themselves, four main types can be distinguished on the basis of either their high or low setting-on, combined with a horizontal or oblique direction (Sharav, 1959; Sharav, Volcani & Eyal, 1962). Eyal, Volcani and Sharav (1958) subdivided the percentage of low-set and obliquely directed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

Measurement	Before milking	On entering cup	In cup at end of milking	After milking
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,

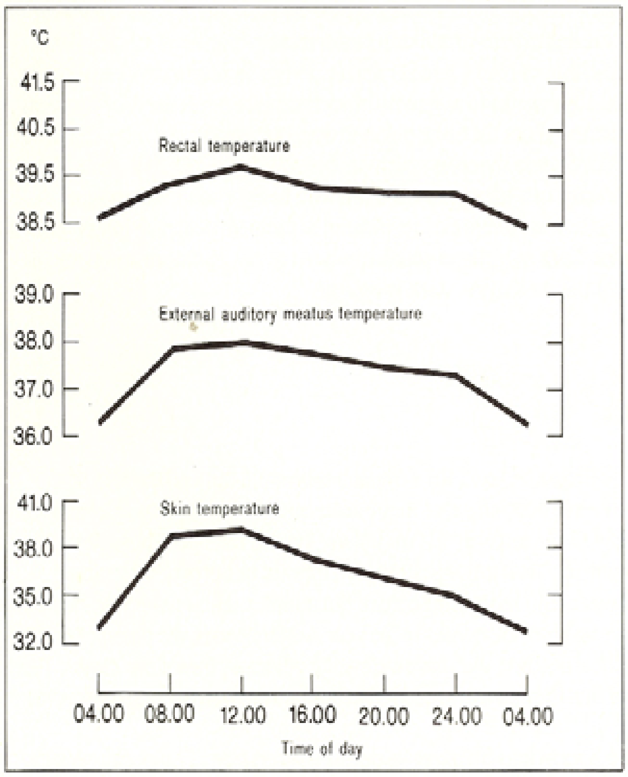


Figure 1-30. Mean rectal, external auditory meatus and skin temperatures of eight penned Awassi lambs at different hours of the day. (**Source:** Degen, 1977c)

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

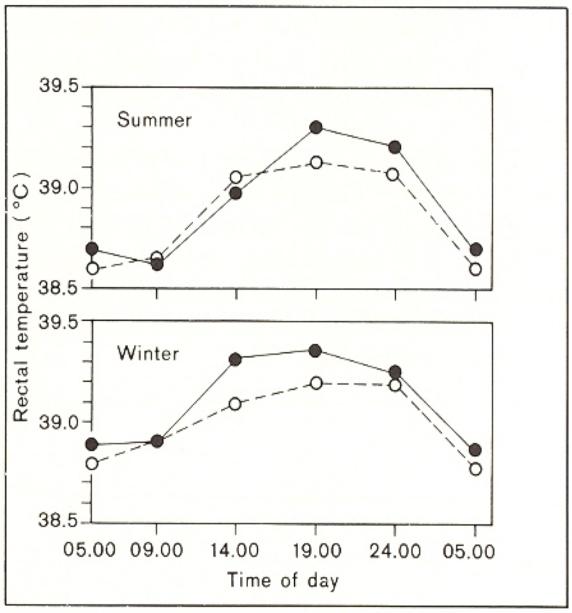


Figure 1-31. Average diurnal trends of body temperature of Awassi sheep kept in the shade. (**Source:** Eyal, 1963a)

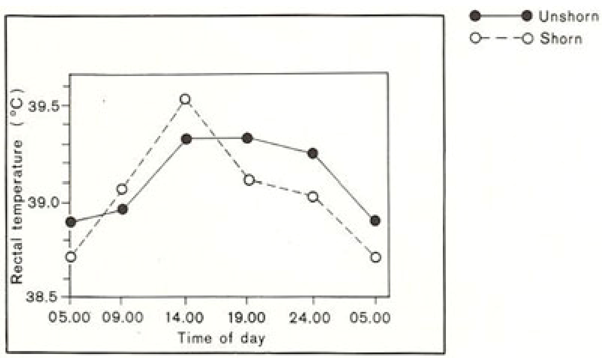


Figure 1-32. Diurnal trends of rectal temperature of Awassi sheep kept in the sun. (**Source:** Eyal, 1963a)

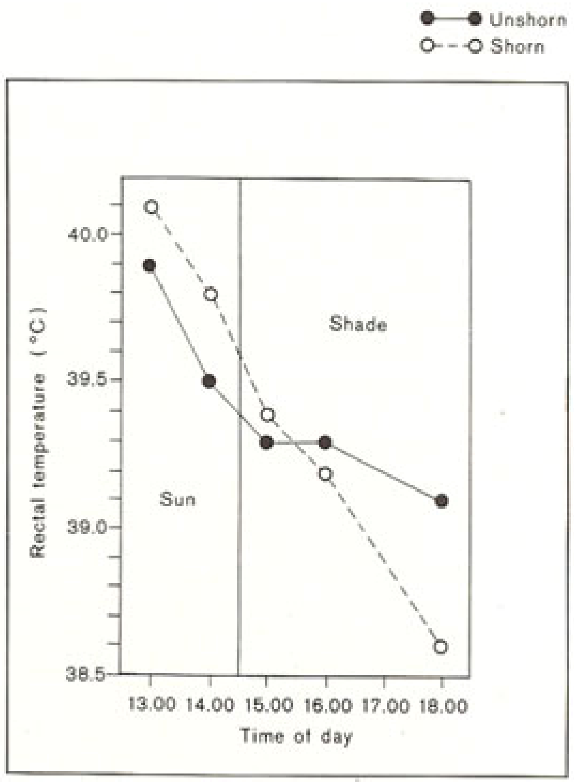


Figure 1-33. Fall in body temperature of Awassi sheep after return from pasture at noon. (**Source:** Eyal, 1963a)

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.

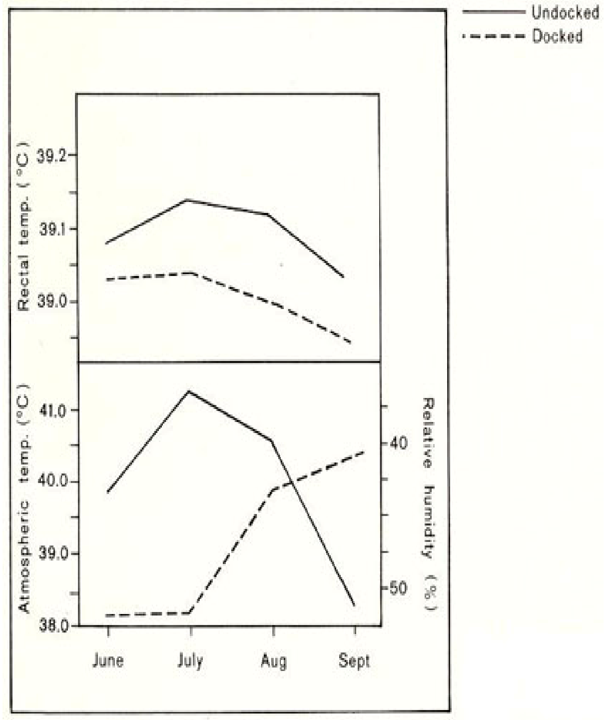


Figure 1-34. Monthly variation in rectal temperature in docked and undocked Awassi rams. (**Source:** Juma, Gharib & Eliya, 1971)

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.

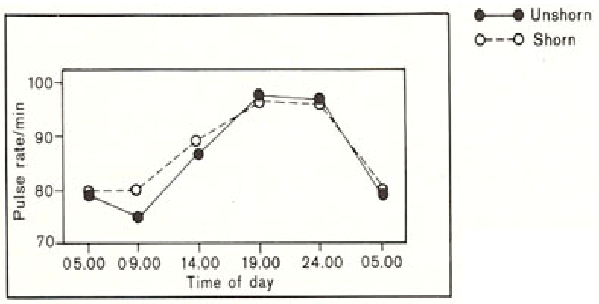


Figure 1-35. Average diurnal trends in pulse rate of Awassi sheep at all seasons in the shade. (**Source:** Eyal, 1963b)

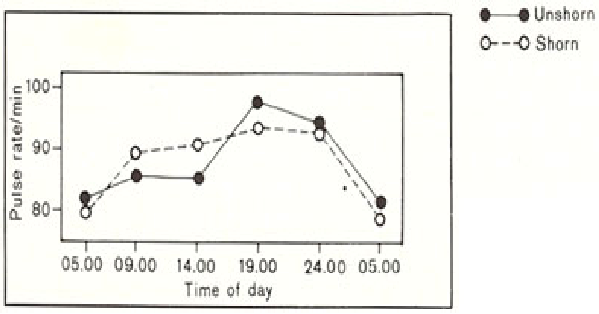


Figure 1-36. Average diurnal trends in pulse rate of Awassi sheep at all seasons in the sun. (**Source:** Eyal, 1963b)

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).

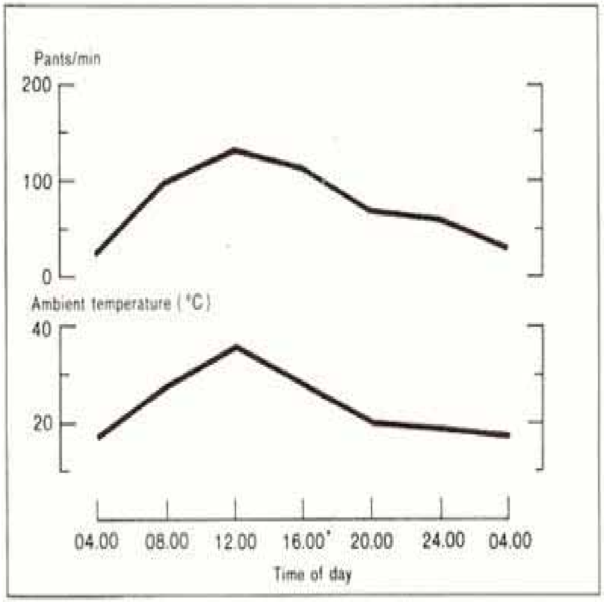


Figure 1-37. Panting rate per minute of eight penned Awassi lambs at different hours of the day. (**Source:** Degen, 1977c)

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.)

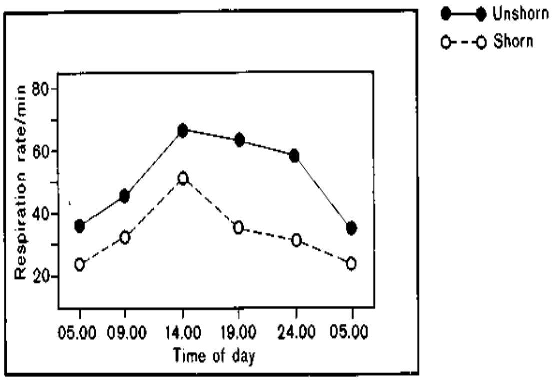


Figure 1-38. Diurnal trends of respiration rate in Awassi sheep in the shade. (**Source:** Eyal, 1963c)

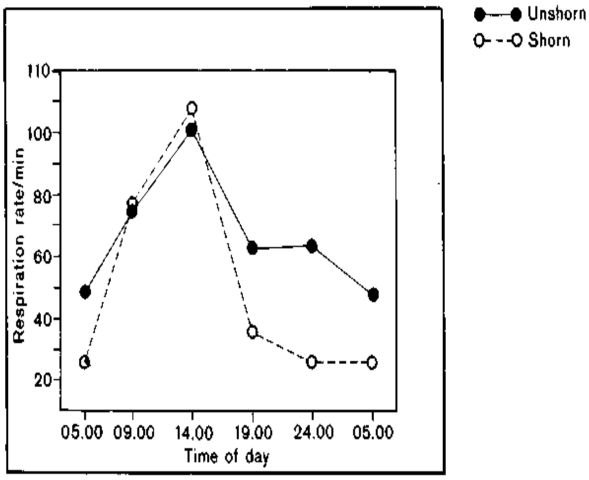


Figure 1-39. Diurnal trends of respiration rate in Awassi sheep in the sun. (**Source:** Eyal, 1963c)

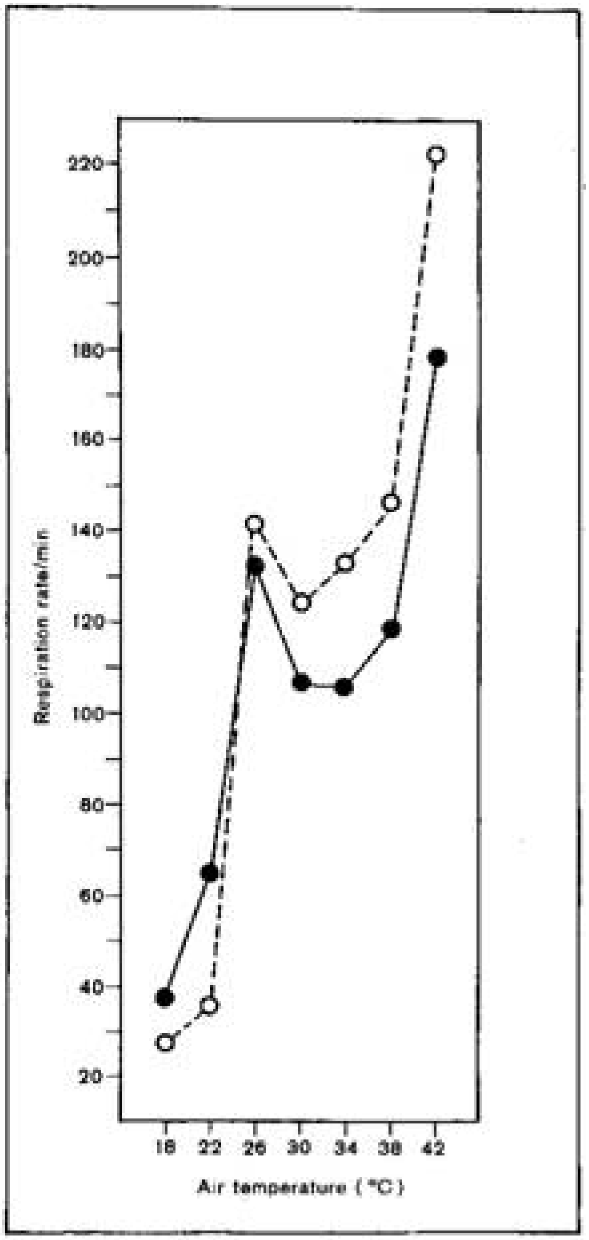


Figure 1-40. Rise in respiration rate with increasing air temperature in Awassi sheep standing in the sun.
(**Source:** Eyal, 1963c)

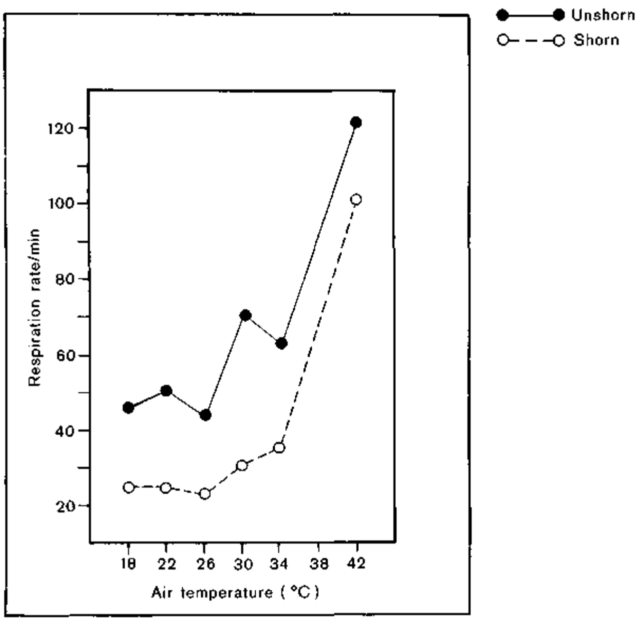


Figure 1-41. Respiration rate of Awassi sheep at different ambient temperatures in the evening after standing in the sun during the day. (**Source**: Eyal, 1963c)

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

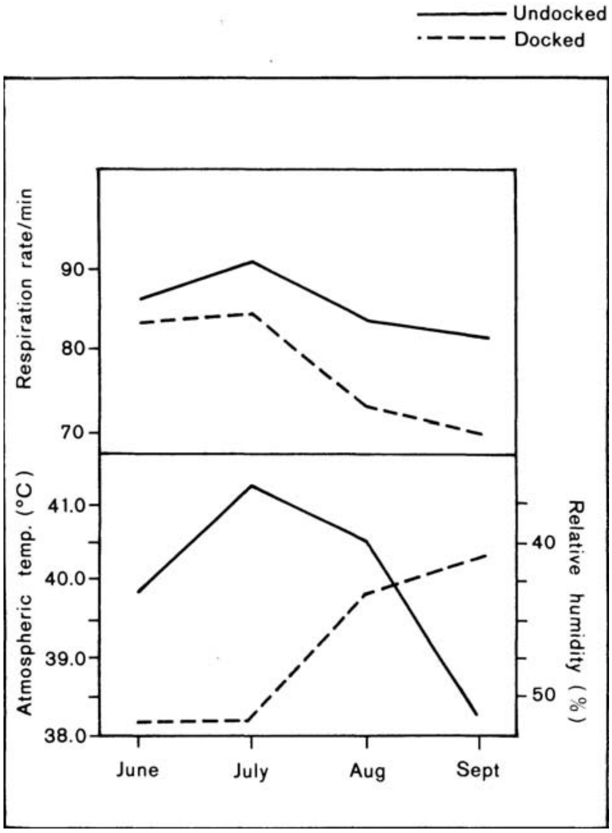


Figure 1-42. Monthly variation in respiratory rate in docked and undocked Awassi rams. (**Source:** Juma, Gharib & Eliya, 1971)

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 (I)	(% of body weight)	Water turnover in 24 hours (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.)

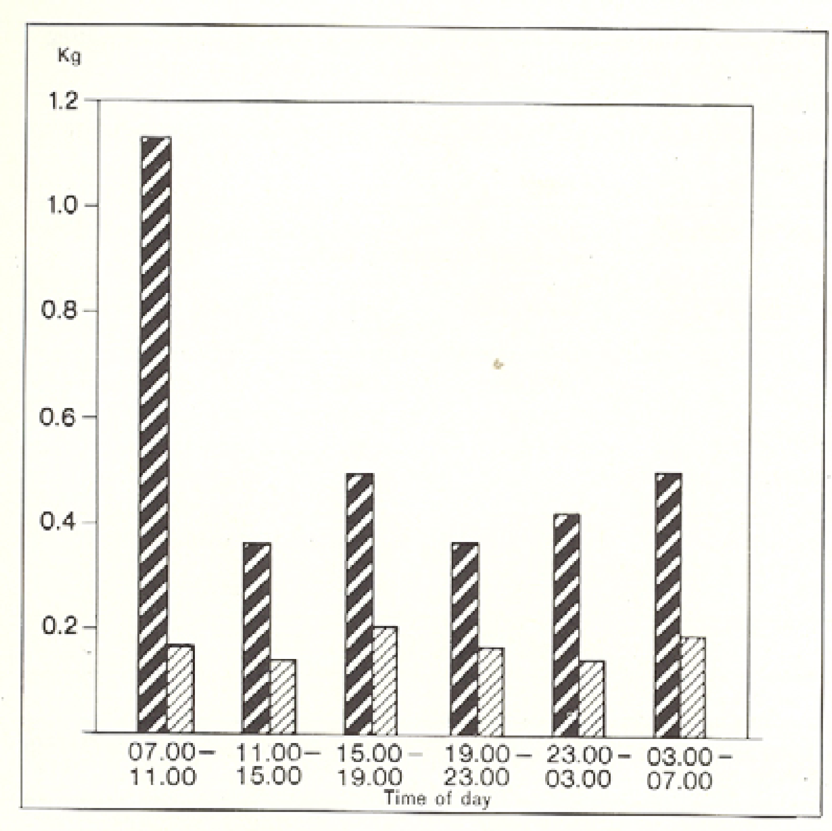


Figure 1-43. Water and feed (dry matter) intake of adult Awassi ewes at different hours of the day. (**Source:** Chen, 1976)

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.

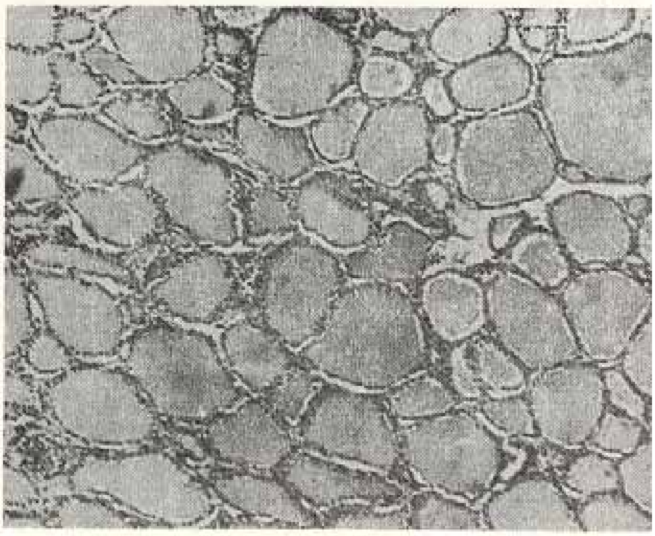


Figure 1-44. Section of thyroid gland of male Awassi sheep in summer. (**Source:** Injidi, Kassab & Rollinson, 1968)

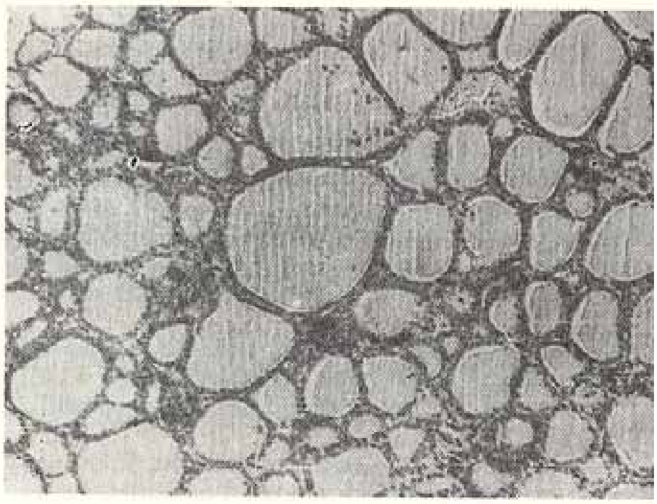


Figure 1-45. Section of thyroid gland of male Awassi sheep in winter. (**Source:** Injidi, Kassab & Rollinson, 1968)

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).

2. Flock management

Shepherding of bedouin and fellahin flocks

In large parts of the subtropical semi-arid Awassi breeding area the sheep depend for their sustenance throughout the year solely on natural pasture growth. In the winter and spring they enjoy the new grazing that sprouts up after the rains. When the winter rains have been plentiful, the bedouin do not water their flocks as these obtain sufficient moisture from the young juicy plants. In summer the sheep live on weeds and the stubble, gleanings and fallen grains on the harvested fields of the fellahin. In autumn and early winter they have to content themselves with the meagre herbage found on hillsides or in valleys. This is the time of scarcity of nourishment when the Awassi sheep use up the fat stored in their tails during the months of plenty. In the season of scanty grazing or during violent rain storms fellahin flocks may be given some tiben — straw crushed and torn by primitive threshing methods.

In some parts of the breeding area the Awassi flocks are not stationary but travel with their nomad owners over large distances and customary grounds in search of pasture. Stationary Awassi flocks owned by fellahin are commonly pastured in the neighbourhood of the villages. When the ewes are in milk, they are taken to the tents of the bedouin or the villages of the fellahin in the evening to be milked and rest in the vicinity for the night. During the season when the ewes are dry, they remain in the field at night together with the shepherds and their dogs.

In Syria, flocks belonging to fellahin are usually taken by shepherds to mountain pastures in the spring. They return to the villages for the winter when temperatures at high altitudes are very low and the mountains are covered with snow. In the plains there is ample grazing during the rainy winter season.

The Awassi sheep of the bedouin of Syria are entirely migratory. In winter numerous flocks move deep into the Syrian desert, often as far as the Euphrates, where pasture growth is fairly satisfactory at this time of year. As soon as the steppe and desert flora dries up early in the summer, they return to the western parts of the country where the winter rains are more copious and the pastures provide grazing until well into the dry season. In the hot months of the year bedouin flocks may be found grazing on the stubble and fallow lands of the fellahin. On their annual migrations from west to east and east to west they cover hundreds of kilometres (Hirsch, 1932).

Other bedouin flocks are taken in winter to pastures in the southern parts of Syria, where the vegetation begins to grow in October and November. Later the flocks return to the north, their movements closely following rainfall distribution. From October to July the majority of the sheep of the bedouin are pastured in steppe, semi-desert and desert areas. During this period the main events of the annual cycle occur, that is, lambing, milking, shearing and fattening. With the advent of the summer heat, the vegetation fades and the flocks move on to more promising regions. But in many areas of the Syrian steppe the natural flora of valuable pasture plants has been largely destroyed by overstocking and has given way to coarse and thorny vegetation. During droughts the dearth of fodder causes serious weight loss in the sheep of the bedouin and great numbers of them perish (Gadzhiev, 1968). (See Fig. 2-1.)

In Iraq the difference in the grazing system between fellahin and bedouin flocks is similar to that practised in Syria. The fellahin flocks subsist for more than six months of the year on the rich grazing of the winter wheat, the summer stubble and weeds of the arable land, and fortuitous grazing on

Figure 2-1. Awassi sheep following their shepherd on the Syrian steppe. (Courtesy of Dr D.E. Faulkner, FAO)

common ground or the nearby desert. For the rest of the year the flocks are sent under the care of shepherds into the desert for spring and early summer grazing. The distance traversed by the fellahin flocks in search of pasture depends on the year's rainfall, but in general is relatively small.

The Awassi flocks of the bedouin of Iraq are required to obtain their sustenance by foraging over vast distances. This level of management is prevalent in all areas, in the mountains, plains, marshlands and forests. Yet during November and December supplemental feed is often required for the survival of the sheep until after the rainfall (Kazzal, 1973). In winter and spring the bedouin move with their flocks along the depressions in the desert as the grass becomes available. When the wells dry up they go back to the fringes of the irrigated land and the fallows along the canals and rivers. To the east of the Tigris there is adequate summer grazing for the Awassi flocks along the foothills of the frontier with Iran. In the spring and autumn the desert provides sufficient pasturage and in winter the flocks graze on the edges of the marshes and the river bank. The hill bedouin move up to the mountains or down to the plains as the weather dictates. On their annual migrations the bedouin of the Dulaim tribe may traverse some hundreds of kilometres. The daily distance covered in the desert is about 6-8 km when the grazing is fairly good. While 16 km is considered to be a fair rate of progress when migrating to more distant pastures, if pressed, flocks may be driven for as much as 35 km in 24 hours (Williamson, 1949).

In many parts of the breeding area of the Awassi, flocks comprise sheep as well as goats in varying ratios depending on the climate and topographical conditions of each region. The Awassi sheep, which are rather slow of movement during the summer, are stimulated by the goats to greater activity. (See Fig. 2-2.)

Bedouin or fellahin shepherds know nothing of tents or houses but live entirely in the open together with the flocks under their care. They work 365 days a year, from 13 to 16 hours a day. Their work includes shepherding, watching the sheep at night, the care of sick animals, training bellwethers, shearing, weaning lambs, and tying the ewes up for milking, an activity usually performed by the women. (See Fig. 2-3.)

Before dawn, while the sheep and the dogs are still at rest, the shepherds — who have slept in

Figure 2-2. Bedouin flock ot Awassi sheep and Negev goats

Figure 2-3. Bedawi shepherd with full paraphernalia

their clothes on the ground—begin to awaken. Some dry dung or twigs, collected the evening before, are piled up in a small heap and kindled. Each shepherd brings a handful of flour along, one of them mixes it with salt and water, kneads the dough and forms it into flat cakes which are baked in the hot ashes. While the shepherds have their morning meal of bread and onions and a drink of cool water, the sheep slowly get to their feet. When ready to move, the experienced shepherd sounds a sharp cry and the whole flock moves after him, one animal after the other. The shepherd then allows them to pass and, leaning on his staff, counts their number.

While the ground is still wet from the night's dew, the shepherd turns the flock to pastures sparsely covered with dry wilted plants. When the rising sun has dried the dew, the flock moves on to lusher pastures or stubble fields. Progress is slow as the animals move forward while feeding, without much spreading out as Awassi sheep have a close flocking instinct.

When the sun is at its height in the summer, the sheep approach the place of watering. First to rush to the water are the dogs. As soon as they have taken their fill they look for a place in the shade to lie down. As the sheep come up to the water, the shepherd encourages them to drink with suitable cries. After the whole flock has been watered, it may rest for about two hours, ruminating, lying down or standing in a cluster, each sheep with its head below the belly or tail of its neighbour, until the greatest heat of the day has passed. Before moving on, some of the sheep return to the water for another drink. Then the flock goes on to new pastures, feeding with ever greater appetite as the cooler evening approaches. Before sundown the flock is gathered at the night's resting place; the shepherds collect fire material for the preparation of the evening meal and for the following morning. Again fresh bread is baked and eaten with onions or some sour milk or cheese, and the dogs, which serve to guard rather than herd the flocks, get their share.

Awassi flocks of the bedouin and fellahin are commonly accompanied by rams throughout the year. Hence, a ewe in oestrus is served several times. Ewes coming into heat very early in the season may lamb when there is still a shortage of grazing before the rains. In order to prevent this, bedouin owners of large flocks sometimes separate the rams from the ewes before the onset of the breeding season and send them to pasture with the last season's lamb crop. The number of ewes for each ram varies between 25 and 35 in bedouin flocks and between 40 and 50 in those belonging to fellahin.

During the lambing season lambs born in the field and still too weak to follow their dams are carried by the shepherds to the tents or villages where they remain for a few days until strong enough to join the dams at pasture. The suckling period lasts for two to three months, depending on the state of pasture, time of birth, and development of the lamb. After weaning, the lambs are pastured in separate flocks away from the ewes and have to subsist solely on natural grazing.

Neither bedouin nor fellahin castrate male lambs. Only a very few destined to become bellwethers leading the flock may be castrated, either by biting through the spermatic cord or tying a string tightly around the upper part of the scrotum. Such lambs are taken from their dams on the day of birth and fed milk from a small vessel. Their attachment to the shepherd takes place within the first ten days of life, the period of imprinting. Later they are trained to eat grain from the hand of the shepherd. Their training as flock leaders may include the tying of a long cord to the lamb, which is held by the shepherd. The cord is untied as soon as the lamb is accustomed to follow him. The shepherd may also raise his arm and throw a small stone at the lamb, and when it tries to run away, pull it by the cord toward himself. In this way the lamb learns to come to the shepherd whenever he raises his arm.

Milking commences when a sufficiently large number of ewes have suckled their lambs for at least two months. During the first three or four months of the milking season the ewes are milked twice a day, and during the following month only once until they go dry. As the bedouin have no enclosures for milking, the ewes have to be milked in the open. The animals are placed in two rows along a long rope to which they are tied by their heads in opposite pairs.

In some parts of the breeding area Awassi sheep are shorn once a year, in others twice. Shearing is usually done in a rough manner by hand shears or with simple scissors while the sheep are lying on the ground. Wounds caused by the shearers are common. A shearer may shear 20-30 animals a day. Often the wool is sold before shearing, by number and not by weight.

Wherever possible, Awassi sheep are washed once during the summer. After washing the animals are dyed red, green, blue or violet on the back and tail root. Rams are often dyed red all over the body. The reasons given for dyeing vary: distinction between flocks, protection from the intense radiation of the subtropical sun, or aesthetics. Slaughter sheep are dyed on the flanks to make them appear fatter and broader (Hirsch, 1933).

Nutrition of the Awassi dairy flock

In improved Awassi dairy flocks in Israel the Scandinavian (Hansson's) feed-unit system of evaluation of the nutritive value of feedstuffs is used, which considers the value of protein in relation to milk production rather than in relation to energy (therms) or body-fat-producing capacity (starch equivalent) on which other systems are based. The value of digestible protein for fat production in bullocks is considered to be 0.94 of the value of one starch equivalent for this purpose (Kellner, 1971), or 1.0 in the energy evaluation of total digestible nutrients (TDN) (Morrison, 1959), while the relative value of digestible protein for milk production is considerably higher, namely 1.43 (Hansson, 1929). In other words, the energy utilization efficiency of protein for milk production is superior to that for fattening, and to some extent (15-20 percent), this also applies for carbohydrates and fats.

The nutrition of improved Awassi dairy flocks is composed of pasture and stall feeding. The ratio between these components depends on the availability of pasture in the vicinity of the sheds at different seasons of the year and on the milking standard of the flock. The higher the latter, generally the smaller is the part of pascual feed in the provision of the annual nutritional requirements of ewes, being less than one-third in some flocks.

In the subtropical semi-arid breeding area of the Awassi the natural pasture consists of green grasses and plants and of dry plants, according to the season. These should supply the ewes with about 120 feed units annually, that is, ten in December, 15 in January, 30 in February, 30 in March, and 15 in April. During the remaining months of the year the dry pasturage may provide another 20 feed units in all (Becker, 1958).

Farms with improved Awassi flocks usually include agricultural and horticultural areas which may provide the sheep with additional pasturage at certain periods of the year. Among these are vineyards, citrus and deciduous fruit plantations, and carob and olive groves.

After harvesting grain crops, cotton, green fodder or hay, Awassi sheep are pastured on the fields during the short interval between harvesting and ploughing. For a few days they may also graze on the grain fields when the plants have reached a height of 20-25 cm, without detriment to the future grain crop. The same holds for fields sown with green manure, of which clover, horse beans and fenugreek are the most common. However, fenugreek is unsuited for ewes in milk as it imparts an unpleasant flavour to the milk.

On farms with flocks of improved Awassi sheep, it is also common practice to set aside areas of arable land for annual winter pastures sown with barley, oats, wheat or Italian rye-grass, annual summer pastures of maize or Sudan grass, and also perennial pastures of lucerne, Rhodes grass or paspalum. In addition to these more commonly available types of pasturage, there are various other crops and plant residues that are utilized by Awassi dairy ewes on different farms.

Awassi dairy flocks should have watering facilities at pasture even during the season of fresh plant growth when bedouin flocks are not usually watered. Improved Awassi dairy ewes need much larger quantities of water than unimproved sheep because they consume considerable quantities of concentrates and some hay or straw in addition to the pasture grass, and high-yielding ewes, when in full milk, may excrete 4-5 1 of water a day with the milk.

In the composition of feeding rations for Awassi sheep three main factors have to be considered: total feed units, digestible protein and dry matter. The quantities and ratio of these components depend on requirements for maintenance, growth, milk yield, pregnancy, preparation for a new lactation, service of the ram, and wool production. The ration must also supply the necessary minerals and vitamins.

The requirements for maintenance depend on the weight of the sheep. Animals of lighter weight need absolutely less, but relatively more, feed units and digestible protein than those of heavier weight (Loew, Dori & Kali, 1972). (See Table 2-1, based on Kellner & Becker, 1971.)

The daily feeding ration for improved Awassi dairy ewes of an average weight of 60-70 kg should

TABLE 2-1. **Daily maintenance including wool growth requirements of Awassi sheep of different live weights**

Weight (kg)	Feed units (number)	Digestible protein (g)
35	0.45	40
40	0.49	44
45	0.52	47
50	0.56	50
55	0.59	53
60	0.62	56
65	0.66	59
70	0.69	62
75	0.72	64
80	0.75	67
90	0.79	72
100	0.86	77

TABLE 2-2. **Feed unit, digestible protein and dry matter requirements of Awassi ewes in milk**

Milk yield/day (kg)	Feed units (number)	Digestible protein (g)	Dry matter (kg)
0.5	1.5	110	1.8
1.0	1.5	150	2.2
1.5	1.9	190	2.6
2.0	2.4	230	2.8
2.5	2.8	270	3.2
3.0	3.2	310	3.5

Source: Loew, 1980

contain 0.7 feed units and 60 g of digestible protein for maintenance. According to recommendations of the Council on Sheep and Goat Nutrition of the Israel Ministry of Agriculture, larger feed-unit amounts should be allotted for the maintenance of Awassi ewes: 0.8 feed units with 70 g of digestible protein for ewes weighing 60-70 kg and 0.9 feed units with 75 g of digestible protein for those weighing 70-80 kg (Loew, 1980). The ration must also include 1.6-1.9 kg of dry matter which is essential for the proper working of the digestive organs and satiation.

No additional nutrients are required for pregnancy during the first three months as the foetus increases very little in weight in this period. But the plane of feeding during the last two months of pregnancy has a marked influence on the birth weight and vigour of the lambs, and more especially of twins. The pregnancy period is also the time when dairy ewes with high milk yields have lost condition in the course of the lactation period; preparation for the following lactation requires restoration of their weight and accumulation of fat in the tail. Therefore, pregnant Awassi ewes are given 0.3 feed units a day in addition to those allowed for maintenance. The daily digestible protein ration in this period is increased by 50 g so that the pregnant ewe receives 110 g of protein for maintenance, pregnancy and steaming up. The pregnant Awassi ewe also has a greater appetite and requires an addition of 11 percent of dry matter in her daily feeding ration. This brings the total weight of dry matter in the ration up to 1.8-2.2 kg. The daily feeding ration of Awassi ewes during the last months of pregnancy comes, then, to 1 feed unit, 110 g of digestible protein, and 1.8-2.2 kg of dry matter. These are minimum requirements for high-yielding Awassi ewes lambing single lambs once a year. Loew proposes a ration of 1.2 feed units with 120 g of digestible protein and 2.0 kg of dry matter for Awassi ewes in the fourth month of pregnancy, and 1.4 feed units with 120 g of digestible protein and 1.8 kg of dry matter during the fifth month. Ewes with twins, and especially ewes lambing three times in the course of two years, require additional nutrients, and only large ones can cope with such increased quantities of feed.

Awassi yearling ewes receive the same amounts of feed units and digestible protein as pregnant adult ewes. However, they require not more than 1.6 kg of dry matter in their daily ration.

Pregnant Awassi yearling ewes require larger amounts of nutrients than pregnant adult ewes, for in addition to their maintenance and pregnancy requirements they also need nourishment for their own growth. But in view of the lower mean birth weights of lambs of yearling ewes, they require only 0.2 feed units and 40 g of digestible protein on account of pregnancy. The total nutrient requirements of pregnant yearlings are therefore 1.2 feed units, 150 g of digestible protein and 1.6 kg of dry matter.

Ewes in milk require additional nutrition in addition to their needs for maintenance, according to the quantity and fat content of the milk they produce. The production of 1 kg of Awassi milk requires 0.6 feed units and 75 g of digestible protein. An Awassi ewe in milk also needs an increased quantity of dry matter in her daily ration, namely 2.0-2.7 kg. A ewe yielding 3 kg of milk a day should therefore obtain at least 2.5 feed units, 285 g of digestible protein and 2.0-2.7 kg of dry matter to cover her maintenance and production needs. Recently, Loew postulated still larger quantities for Awassi ewes in milk (Table 2-2).

For ewes yielding 4 or 5 kg of milk a day, the necessary feed units and protein increase accordingly, but few of them are capable of consuming such large amounts of feed. The majority lose weight, and foremost the weight of the fat tail, when at the height of production.

The growth of the Awassi ewe's fleece of an average weight of 2.75 kg requires not more than 9 feed units annually, a quantity so small that it can be neglected in the daily ration of a well-managed Awassi flock.

Improved Awassi stud and flock rams require, in conformity with their live weight, 1.0-1.2 feed units, 80-90 g of digestible protein, and 2.5 kg of dry matter in their daily ration during the season of anoestrus or reduced sexual activity of the ewes. In the breeding season their daily ration is increased to 1.2-1.8 feed units and 120-200 g of digestible protein, depending on the number of daily services performed. The dry matter content of the ration is reduced to 2.2 kg a day because of the undesirability of too heavy a load on the ram's digestive system during the season of sexual activity.

The part of natural grazing in the total nutritive requirements of ewes in milk or in lamb can only be estimated roughly. Becker (1958) considers that a dry ewe should consume 1.6-1.9 kg of dry matter at pasture, a pregnant ewe 1.8-2.1 kg, and a ewe in milk 2.1-2.5 kg. In reality, however, pregnant ewes or ewes in milk generally will not consume more than open and dry ewes, that is, about 12-14 kg of pasture plants. If the natural or sown pasture is of a high quality and the ewes can graze to satiation, they should obtain 1.0-1.2 feed units from a day's grazing. But poorer pastures may supply only one-half or one-fourth of this amount. The balance between the estimated consumption of the ewes at pasture and the actual nutritive needs of dry and open, in milk or pregnant Awassi ewes has to be provided by the stall-fed ration.

The necessary quantities of minerals and trace elements are contained in the concentrate mixture. In addition, the sheep have free access to salt licks in every pen.

On days of heavy rainfall when the animals do not go out to pasture or in the absence of grazing for other reasons, the dairy flock has to be entirely stall-fed. Becker gives examples of rations for the stall-feeding of improved Awassi sheep (Tables 2-3 to 2-7).

TABLE 2-3. **Dry ewes, open or in early stages of pregnancy** (0.7 feed unit, 60 g digestible protein, 1.6-1.9 kg dry matter)

	Feed	Kg
	Vetch hay	0.75
	Barley straw	0.70
(a)	Legume hay	0.75
(b)	Cereal grass hay	2.20
	Maize silage	2.00
	Legume hay	1.00
(c)	Barley straw	0.50
	Cereal or other grass hay	1.20
(d)	Maize husks	1.00
	Screenings	1.00
	Cereal grass hay	0.50
(e)	Barley straw	0.50
	Oat-and-legume silage	2.00
	Screenings	0.50
(f)	Barley straw	1.00

Source: Becker, 1958

TABLE 2-4. **Dry ewes in later stages of pregnancy** (1.0 feed unit, 110 g digestible protein, 1.8-2.2 kg dry matter)

	Feed	Kg
	Vetch-and-oat hay	1.00
(a)	Screenings	1.00
	Barley straw	0.25
	Vetch-and-oat hay	1.25
(b)	Maize silage	2.00
	Barley straw	0.50
	Clover hay	0.75
(c)	Screenings	1.00
	Barley straw	0.50
	Clover hay	1.00
(d)	Citrus peel	2.00
	Barley straw	0.75
	Green clover	3.00
(e)	Screenings	1.00
	Barley or legume straw	0.80
(f)	Vetch-and-oat hay	1.50
	Maize husks	1.00
	Clover hay	1.25
(g)	Chopped wintersome	2.00
	Barley straw	0.50
	Clover hay	0.50
(h)	Screenings	1.00
	Green oats	2.00
	Barley straw	0.50
	Cereal or other grass hay	1.50
(i)	Cereal qrass-and-legume silage	2.00
	Screenings	0.50

Source: Becker, 1958

TABLE 2-5. **Yearling ewes, open** (1.0 feed unit, 110 g digestible protein (DP), 1.6 kg dry matter)

	Feed	Kg
	Vetch-and-oat hay	1.00
(a)	Screenings	0.50
	Concentrates (10% DP)	0.30
	Clover hay	1.00
(b)	Silage	1.50
	Concentrates (10% DP)	0.35

Source: Becker, 1958

TABLE 2-6. **Yearling ewes, in lamb** (1.2 feed units, 150 g digestible protein (DP), 1.6 kg dry matter)

	Feed	Kg
	Vetch-and-oat hay	1.00
(a)	Screenings	0.25
	Concentrates (10% DP)	0.60
	Clover hay	1.00
(b)	Silage	1.50
	Concentrates (10% DP)	0.50

Source: Becker, 1958

TABLE 2-7 **Ewes yielding up to 1 kg milk** (1.3 feed units, 135g digestible protein (DP), 2.0-2.7 kg dry matter)

	Feed	Kg
	Vetch-and-oat hay	1.00
(a)	Screenings	1.00
	Concentrates (10% DP)	0.20
	Straw or maize husks	0.50
	Clover hay	1.00
(b)	Chopped wintersome	2.50
	Concentrates (10% DP)	0.30
	Straw or maize husks	0.75
	Clover hay	1.00
(c)	Citrus peel	2.50
	Concentrates (10% DP)	0.20
	Straw or maize husks	1.00
	Vetch-and-oat hay	1.00
(d)	Maize silage	2.50
	Concentrates (10% DP)	0.30
	Straw or maize husks	0.50
	Cereal or other grass hay	1.50
(e)	Green clover	3.00
	Concentrates (10% DP)	0.30
	Straw or maize husks	0.75

Source: Becker, 1958

These examples of feeding rations for Awassi ewes yielding up to 1 kg of milk a day are also recommended for ewes with daily yields of 1.0-1.5 kg, with the difference that in this case the concentrate component in the rations is increased by 0.1 kg a head and the concentrate mixture contains 15 percent instead of 10 percent digestible protein (Tables 2-8 to 2-10). Ewes that yield 5 kg of milk a day cannot cope with more feed units and dry matter than those yielding 4 kg. It is, however, possible to raise the digestible protein content in the concentrate mixture up to 20 percent.

In general, the feedstuffs given in the rations may be exchanged for others according to availability. For example, dry clover may be replaced by vetch-and-oat hay, and green clover by green cereal grasses along with an increase in the digestible protein content of the concentrate mixture. Straw and maize husks are also interchangeable. Again, 'wintersome' *(Sorghum vulgare* Pers. var. *caffrorum,* a grass of South African origin), citrus peel or green cereal grasses may be substituted for silage, and hay for screenings. The ration for rams off the breeding season is given in Table 2-11. If the rams are pastured, no additional feed is required during the off-season.

At the height of the breeding season, 0.5 kg of concentrates may be added to the rations given in Table 2-12. In consequence, the rams will consume less hay. If the rams are pastured during the breeding season, they should receive 0.7-1.0 kg of concentrates containing 15 percent digestible protein, in addition to grazing.

In improved Awassi dairy flocks, lambs already weaned at the age of 60 days because their dams were mated again shortly after lambing should have free access to high-quality hay and crushed barley or a concentrate mixture containing 18 percent total and 16.5 percent digestible protein until they reach a weight of 25 kg. Then the total protein content of the concentrate ration may be reduced to 14 percent and the digestible protein content to 11.5 percent. This mixture is also recommended for lambs weaned at three or four months. If pasturage is available not farther away from the barn than 1 km, female lambs may be pastured after weaning. They will consume about half a feed unit at pasture and on return to the barn for the night should obtain their additional needs from concentrates. After being mated at the age of eight to ten months, their ration during the first three months of pregnancy need not exceed that of unmated lambs; during the last two months of pregnancy it should be increased by the addition of half a feed unit including 50 g of digestible protein a day in order to meet the requirements of the growing foetus and to prepare the young ewe for lactation (Loew, Dori & Kali, 1972).

From the time of weaning to the age of ten months female Awassi lambs require 1 feed unit, 130 g of digestible protein and 0.9-1.2 kg of dry matter a day, and male lambs 1.2 feed units, 150 g of digestible protein and 1.1-1.3 kg of dry matter. The rations given in Table 2-13 for the stall-feeding of female Awassi lambs during this period are recommended (Becker, 1958).

On many dairy farms larger rations than these are given to stall-fed female lambs from three to eight months of age, namely 1.25 feed units, including 750 g of concentrates, 500 g of hay and 2.0 kg of green fodder a day. On this ration lambs weighing 30-35 kg at the age of three months attain a weight of 50-55 kg at eight months and are fit for breeding at nine months.

For the stall-feeding of male Awassi lambs raised for breeding, the same rations are recommended with the addition of 0.2 kg of concentrates a day. Male Awassi rams for stud breeding

TABLE 2-8. **Ewes yielding 1.5-2.0 kg milk** (1.6 feed units, 210 g digestible protein (DP), 2.2-2.7 kg dry matter)

	Feed	Kg
(a)	Vetch-and-oat hay	1.50
	Concentrates (10% DP)	0.40
	Screenings	1.25
(b)	Vetch-and-oat hay	1.20
	Silage	2.50
	Concentrates (10% DP)	0.70
(c)	Cereal grass hay	1.50
	Green clover	3.00
	Concentrates (12.5% DP)	0.80
(d)	Vetch-and-oat hay	1.75
	Concentrates (10% DP)	0.85
(e)	Clover	1.00
	Silage	2.50
	Concentrates (15% DP)	0.50
	Straw or maize husks	0.75

TABLE 2-9. **Ewes yielding 2.25-3.0 kg milk** (2.0 feed units, 285 g digestible protein (DP), 2.2-2.7 kg dry matter)

	Feed	Kg
(a)	Vetch-and-oat hay	1.75
	Concentrates (12.5% DP)	1.25
(b)	Clover hay	1.50
	Green oats	2.00
	Concentrates (12.5% DP)	1.20
(c)	Vetch-and-oat hay	1.75
	Green clover	3.00
	Concentrates (10% DP)	1.00
(d)	Vetch-and-oat hay	1.25
	Silage	2.50
	Concentrates (15% DP)	1.00
(e)	Clover hay	1.50
	Citrus peel	2.00
	Concentrates (15% DP)	1.00

TABLE 2-10. **Ewes yielding 3.25-4.25 kg milk** (2.6 feed units, 385 g digestible protein (DP), 3.0-3.3 kg dry matter)

	Feed	Kg
(*a*)	Vetch-and-oat hay	2.00
	Green clover	5.00
	Concentrates (10% DP)	1.25
(b)	Lucerne or clover hay	2.00
	Silage	2.00
	Concentrates (13% DP)	1.40

Source: Becker, 1958

TABLE 2-11. **Stud and flock rams, off the breeding season** (1.0 feed unit, 80 g digestible protein (DP), 2.5 kg dry matter)

	Feed	Kg
(*a*)	Hay	1.0
	Green maize	3.0
	Straw	1.5
(*b*)	Barley	0.5
	Green clover	4.0
	Straw	1.5
(*c*)	Hay	1.0
	Silage	3.0
	Straw	1.0
(*d*)	Green oats	10.0
	Straw	1.5
(*e*)	Screenings	1.0
	Green clover	4.0
	Straw	1.5
(*f*)	Hay	3.0

Source: Becker, 1958

TABLE 2-12. **Stud and flock rams during the breeding season** (1.5 feed units, 160 g digestible protein (DP), 2.2 kg dry matter)

	Feed	Kg
(*a*)	Concentrates (15% DP)	0.5
	Hay	1.5
	Green maize	4.0
(*b*)	Concentrates (15% DP)	0.5
	Green cowpea	4.0
	Green maize	4.0
	Hay	0.7
(*c*)	Green lucerne	3.0
	Crushed barley	0.7
	Hay	1.2

Source: Becker, 1958

TABLE 2-13. **Female Awassi lambs from weaning to 10 months of age** (1.0 feed unit, 130 g digestible protein (DP), 0.9-1.2 kg dry matter)

	Feed	Kg
(*a*)	Concentrates (10% DP)	0.60
	Green clover	1.00
	Vetch-and-oat hay	0.60
(*b*)	Concentrates (10% DP)	0.60
	Silage	0.75
	Lucerne or clover hay	0.60
(*c*)	Concentrates (10% DP)	0.60
	Green lucerne or clover	3.00
	Vetch-and-oat hay	0.25

Source: Becker, 1958

TABLE 2-14. **Male Awassi slaughter lambs during the 3rd month of age** (1.2 feed units, 150 g digestible protein (DP), 1.1-1.3 kg dry matter)

	Feed	Kg
(*a*)	Crushed barley or maize	0.30
	Concentrates (10% DP)	0.30
	Hay	0.75
(*b*)	Crushed barley or maize	0.30
	Green clover	3.00
	Hay	0.25

Source: Becker, 1958

receive a ration of 1.5 feed units a day composed of good hay, green fodder and 1.0 kg of concentrates from the age of five months on, making them fit for service at seven to eight months of age.

For male lambs destined for slaughter, Becker proposes the rations given in Table 2-14 during the third month when the lambs still obtain one or two daily residue sucklings of short duration.

The feeding ration of stall-fed slaughter lambs at this age may include 0.5 kg of silage along with a reduction in the quantity of hay or clover. Should green oats be fed in the place of clover, the digestible protein content of the ration should be increased by the substitution of a suitable concentrate mixture for barley or maize.

After weaning, male slaughter lambs should receive 350-500 g of hay a day and an unlimited quantity of concentrates containing 11.5 percent digestible protein. From the age of four to five months the digestible protein content of the concentrate mixture may be reduced to 8.5 percent. The mixture should include 8-10 million IU of Vitamin A a tonne (Loew, Dori & Kali, 1972).

A day's work with a large, high-yielding dairy flock

The information given in this section was recorded once a month, beginning with the commencement of the main lambing season in October, in a highly improved Awassi dairy flock of about 1 000 adult and yearling ewes and rams belonging to a communal settlement in the Plain of Esdraelon ('Emeq Yizre'el) in northern Israel. The economy of this flock is based on the supply of milk to a central dairy and of fat lambs and culled ewes for slaughter, in addition to the sale of male and female breeding stock in Israel and abroad. The grazing at the disposal of the flock includes 10 ha of arable land sown with different pasture plants according to season and approximately 100 ha of natural hill pastures and cultivated fields after harvesting. In view of the aim of maximum milk yields and early maturity of the flock, and owing to the scarcity of grazing land and the high costs of irrigation water, green fodder, silage and hay, a considerable part of the feed consists of concentrates.

October. In October, work in the shed starts at 05.00 h. During this month the shed is prepared for the coming winter season. The lambing season also begins and by the end of October about 20 percent of the ewes have lambed.

At the time of morning milking one of the sheepmen attends to the lambs born during the night. He disinfects their navels with iodine, cleans the udder and thighs of the ewes, sees to it that the lambs are owned and suckled, and marks their ears with the numbers of their dams. He also performs the daily cleaning and disinfection of the lamb sheds and pens.

Female lambs born late during the last lambing season are bred with or without hormone treatment as soon as they attain a weight of 50 kg.

The ewes fresh in milk obtain 1 kg of pelleted concentrates at milking and 500 g of good hay. During the night when they stay with their lambs they have free access to concentrates, but generally they do not consume more than a total of 2 kg of concentrates a day. The ewes that are to lamb in November receive 750 g of pelleted concentrates with 14 percent protein a day in addition to grazing; those that are to lamb in December receive 500 g of the same mixture.

During October the flock is pastured in two groups. One includes dry ewes soon to lamb and the few that lambed late in the last lambing season and that still give more than 200 g of milk a day, and the other one of dry ewes and last season's lambs. The grazing consists of dried up natural hill pasture

Figure 2.4. Before parturition of the second twin

which should provide the animals with sufficient roughage. For about an hour a day they are also pastured on vidan (sorghum x Sudan grass) and toward the end of the month on rye-grass sown for winter grazing. As long as the sown grass is still short, only the ewes soon to lamb or in milk are pastured on it; as it grows longer, the dry ewes and lambs follow. If the grazing is insufficient, maize silage is added to the daily ration.

The sheep return to the shed at about 17.00 h, before darkness sets in. The sheepman responsible for this work enters the day's new data in the flock diary and the birth and service registers. At 18.00 h the work in the shed comes to an end.

November. Work in the shed begins at 05.00 h. First the young lambs that stayed with their dams during the night are separated from them and the milk still left over in the udders of the ewes is milked. The ewes fresh in milk receive 2 kg of high-quality maize silage and 500 g of hay; those shortly due to lamb are given only silage. In addition to this ration, both groups are pastured together on rye-grass from 09.00 to 15.00 h. They are accompanied by the rams at pasture. On their return to the shed the ewes in milk are milked again and then join their lambs for residue suckling, remaining with them throughout the night. The ewes in milk have free access to a concentrate mixture at night, while those that are shortly due to lamb are limited to a concentrate ration of 800 g. The rams receive 1 kg of concentrates in the evening. In the course of November the percentage of ewes with lambs at foot rises from about 20 to 50.

The second group, consisting of yearling and pregnant ewes due to lamb later in the season, has already left the shed at 06.00 h to be pastured on harvested cotton fields. Most of the yearlings that have been served in August, September and October, either without or following hormone treatment, are in lamb. However, since a very few may not yet be pregnant and may still come into heat, a selected ram accompanies this flock so that the sire of the few future late-born lambs is known with certainty. This flock returns from pasture only at 17.00 h when the ewes in lamb receive 700 g of concentrates a head and the yearlings 750 g.

After the onset of rain, the flock is no longer sent to pasture but remains in the shed where the animals are fed legume straw, 2 kg of maize silage and 700 g of concentrates a head; the ewes in milk are also given hay. The rams receive hay, silage and 1 kg of concentrates.

The work in the shed ends at 18.00 h, but a responsible sheepman may remain in the shed for another few hours to look after the ewes that lambed during the day and those due to lamb during the night.

December. Work in the shed begins at 04.00 h. First to be milked are the ewes with lambs less than one month old which are suckled for 12 hours each night until they weigh about 12 kg. The ewes with older lambs, which are suckled for eight hours a day, are next to be milked. This leaves enough time for the lambs to remain with their dams for four hours after milking in the morning before the ewes leave for pasture. Then follows the milking of the ewes suckling their lambs for four hours, two hours or one hour a day, and finally of the ewes with lambs less than eight days old which remain with their dams in the stalls all the time but are incapable of coping with the whole quantity of milk these produce. Milking of the flock in the rotary parlour is completed at 07.00 h.

At the milking the ewes are given 1 kg of pelleted concentrates a head irrespective of their yields. During the first two months of lactation they also have free access to pelleted concentrates in self-feeders after evening milking, but they make little use of this and on average do not eat more than a total of 2 kg of concentrates a day. The ewes with lambs less than eight days old receive unlimited quantities of concentrates and vetch hay in their separate box stalls, but again they do not consume more than 2 kg of concentrates.

The dry, yearling and last season's late-born females obtain their day's ration of 750 g of pelleted concentrates, containing 14 percent digestible protein, before leaving for the pasture grounds. The ewes in lamb receive 700 g and the stud rams 1 kg of concentrates. Lambs older than two months are given the same concentrate mixture in self-feeders in addition to 200-300 g of hay and 300 g of straw a day. Lambs less than two months old receive a concentrate mixture containing 18 percent digestible protein *ad libitum,* and also an unlimited quantity of good hay.

Before going out to pasture, the ewes in milk that lambed early in the lambing season are joined by a teaser ram furnished with an apron. Those found to be in oestrus are served by one of the stud rams in accordance with the mating plan. They are not tried again in the afternoon after return from pasture, but if still in heat next morning they are served once more. Ewes in milk that do not come into heat naturally within two months after lambing are given hormone treatment as the flock-master aims at three lambings in two years.

At 10.00 h the flock is taken by the shepherds in two or three separate groups to the pastures, which are situated near the shed, while the lambs remain at home. The rams, save one, join the group of pregnant ewes at pasture. The small percentage (about 5 percent) of adult ewes that remained barren in the previous breeding season and the yearling ewes are pastured together with a single stud ram by which those ewes coming into heat naturally or after hormone treatment are served. The shepherd makes a note of the ear numbers of such ewes for later entrance in the service register of the flock.

The pastures consist partly of wild grasses and plants and partly of sown rye-grass and oats. After the flock has left the shed, the sheepmen distribute the feed for the ewes returning from pasture in the afternoon and are then free to rest for four hours.

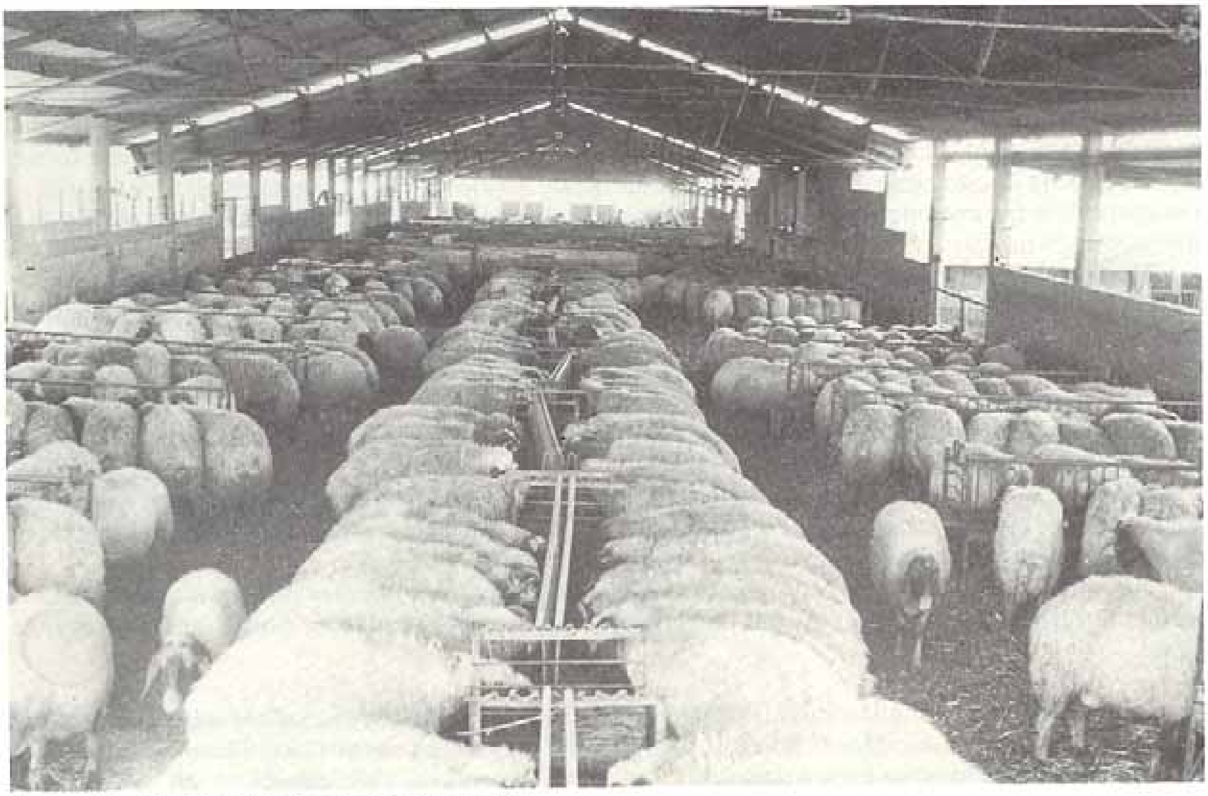


Figure 2-5. Shed feeding of Awassi ewes in winter

January. In January work in the shed begins at 04.00 h. Toward the end of the month the lambing season of the 13- to 16-month-old yearling ewes commences. In general flock management in January, there is one marked difference from December. In January (as well as in February and March) ewes are not bred, although many of them that are in milk may still come into heat. This measure is taken to prevent lambings in June, July and August, the hottest months of the year, for lambs born in the heat of summer develop more slowly than those born in cooler months. Also, the high ambient day temperatures depress the milk yields of the ewes when they should be at their highest. During the hot summer months the sheepmen also wish to avoid the additional work involved in the care of new-born lambs and in freshening ewes.

Ewes in milk that were served in December continue to be tested by a teaser ram every morning, not, however, to be bred if not in lamb but in order not to be dried up prematurely after three months of lactation in preparation for the following lactation, as in the case of the ewes that lambed before the end of the year and are again pregnant.

The flock is pastured in three separate groups from 10.00 to 16.00 h. One consists of adult ewes in milk, the second of ewes due to lamb within two months, and the third of ewes in the first three months of pregnancy, yearlings in lamb, and stud rams. The pastures consist of natural grazing in the hills and areas sown with pasture grasses. The afternoon milking begins at 14.00 h. The ewes are turned in in batches and return to the pasture grounds as soon as they are milked; only the last batch coming in at 16.00 h remains in the shed. The rations of concentrates are similar to those given in the previous month. Work in the shed ends at 18.00 h.

February. Work in the shed begins at 04.00 h. Owing to its large size, the flock is again pastured in three separate groups, two of which comprise ewes in milk and the third ewes and yearlings due to lamb and rams. The pastures consist of natural hill grazing and fields sown with pasture grasses. As the days grow longer and day temperatures are somewhat higher, the whole flock returns from grazing not at 16.00 h, as in December and January, but at 17.00 h.

In addition to pasture, ewes in milk receive 400 g of hay, 400 g of straw and concentrate rations according to the quantities of milk they produce. Only ewes in the first two months of lactation have free access to concentrates at night. The dry ewes and yearlings are given 600 g of concentrates in the morning and 400 g of straw at night. The lambs are not yet pastured in February, but remain in the shed and receive 400-500 g of hay and an unlimited quantity of concentrates with 14 percent protein.

During February the ewes in milk are no longer tested by a teaser ram. At the end of the month the male lambs born in October and November are sold for breeding or slaughter.

March. As during the last three months, work in the shed begins at 04.00 h and afternoon milking at 14.00 h. But as the days grow longer, the sheep return from pasture after 17.00 h and the day's work in the shed ends at 18.30 h.

The flock continues to be pastured in three separate groups, two of ewes in milk and one composed of adult and yearling ewes still to lamb, stud rams, female lambs, and male lambs selected for the replacement of culled rams. In the morning the flock leaves the shed as soon as the dew has been dried by the rising sun at about 10.00 h. Before coming back to the shed for afternoon milking the sheep are rather sluggish, grazing more eagerly on their return to pasture and especially in the late afternoon. The pastures are now less juicy than in winter. They provide the lambs and ewes with sufficient nourishment for maintenance. At milking times the ewes are given additional concentrate rations for milk production or pregnancy, the rations corresponding to yields. At night they receive straw. On return from grazing, male and female lambs have free access to concentrates in order to fit them for early breeding. The lambing of yearlings and of those adult ewes that lamb late in the season owing to two lambings the year before continues. Ewes that lambed early in the lambing season and that are due to lamb again in April or May are dried up. Male lambs born in October or November are sold in this month at a live weight of 50-60 kg according to market demand.

April. As the warmer weather during April dries the dew of the night sooner than in March, the sheep have already gone to pasture at 05.00 h. Again the flock is divided into three groups, two of which consist of ewes in milk. Some of the ewes have already been milked by 05.00 h; those that have not yet been milked return in batches to the milking parlour after an hour or so of grazing. This is possible because some of the pastures are situated near the shed. Generally the flock grazes on the hills in the morning as there the dew dries earlier than on the plains. As the day advances the sheep are moved to the juicy green sown pastures.

From 14.00 h on the ewes return in batches to the shed for milking, as in the morning. The last group — consisting of the dry adult and yearling ewes still due to lamb, the stud rams and the lambs — returns between 18.30 and 19.00 h. The day's work in the shed ends at 19.00 h.

The lambing of those adult ewes that did not lamb earlier in the season and of those that had already lambed in October or November but had again become pregnant continues in April, as does the lambing of yearling ewes.

Preparations are made for the shearing of the flock, which takes place at the end of April if the weather does not suddenly turn cold and rainy. The dry and pregnant ewes are shorn first, then the rams, and finally the ewes in milk. The lambs are shorn three weeks later. The sheep to be shorn remain in the shed and are fed on hay while waiting their turn. Once shorn, they leave for the pasture grounds.

Shearing begins at 04.00 h and ends at 12.00 h and is done by the sheepmen themselves who are assisted by additional workers on the days of shearing. Three shearers work with three shearing machines while four workers prepare the sheep, placing them on hydraulic tables which lift them to a convenient height. Each shearer finishes approximately ten sheep an hour, or 80 in an eight-hour working day. The shearing of an adult flock of nearly 1 000 sheep therefore takes three to four days.

The wool is put into bags to be dispatched collectively by the Sheep Breeders' Association for export to the United Kingdom.

May. The flock leaves the shed for pasture at 04.00 h in two groups, a larger one consisting of ewes in milk and a smaller one comprising dry ewes, lambs and the remaining ewes in milk. The rams are left in their shed as the mating season commences at the beginning of the month. Before going out, the adult and yearling ewes are tested by a teaser ram for oestrus. Two-year-old females that failed to lamb as yearlings receive a hormone treatment. As each of the stud rams in the flock serves three females a day, the hormone treatment is restricted to a corresponding number.

The dew of the night is no longer a hindrance to early morning grazing as the plants of the natural pasture begin to go to seed and dry up and the dew makes them tastier to the sheep. In addition to the natural hill pastures, the flock is also taken for a few hours to the sown rye-grass and fodder beet in succession. During the early hours of grazing the ewes are returned to the shed in groups for milking and concentrate feeding and return to pasture as soon as they are milked. Between 09.00 and 10.00 h the whole flock returns to the shed for watering and rest. Milking begins again at 13.00 h. At 16.00 h the flocks are once more taken to graze on the natural hill pastures until 19.00 h, just before darkness, when they are returned to the shed for the night.

The concentrate feeding of rams, ewes, yearlings and lambs continues on the same levels as before. Small lambs, born in April or May, join their dams at 19.00 h on the latters' return from pasture, until they are separated from them at 04.00 h. At 06.00 h the ewes are milked in order to relieve their udders of the milk remaining from the night's suckling with which the lambs could not cope, and the renewed production during the two hours since their separation from the lambs. They then return to pasture. Aften the noon milking, which is completed at about 15.30 h, the small lambs are again suckled for half an hour and then separated from their dams which join them after their return from grazing at 19.00 h. Work at the shed ends at 17.00 h, except for the shepherds who return from the pasture two hours later, distribute the sheep into their compartments in the shed and admit the young lambs to their dams for the night.

Toward the end of May the female lambs and the males retained for breeding are shorn.

June. There are no lambings in June. Ewes whose daily milk yields have fallen to 750 g or less are now milked only once a day, at midday. They are dried up as soon as their yield drops to below 200 g a day.

All other activities are similar to those of May, save that at pasture vidan is now available in addition to fodder beet.

July. A large number of ewes are dry by July. About one-fourth of them are again in lamb. Those that lambed in February, March or April and are not again pregnant and do not come into heat naturally because of their high milk yields receive hormone treatment in order to induce oestrus and a second lambing in the same year.

The flock is pastured in two groups. One group comprises dry ewes, ewes that are milked only once a day, yearlings and female lambs, and the other group consists of ewes in milk. Lambs born in February are also sent to pasture in July, joining those born since October. The flocks graze on sown pasture for one hour a day and on dry natural pastures for the rest of the time. The lambs receive an additional ration of 700 g of concentrates a day in the shed. Lambs born after February continue to remain in the shed where they obtain their standard rations.

August. In August work at the shed begins at 04.00 h. Nearly two-thirds of the flock are dry or are milked only once a day. The rest, consisting of ewes that lambed late in the season or for the second time in addition to the yearlings ewes, are milked twice a day. The dry ewes and those that are milked only in the afternoon leave for pasture at 04.00 h. Those ewes that are milked twice a day follow as soon as their morning milking is completed. The flock is pastured in two groups, the first comprising the ewes which are to lamb in October and the second those due to lamb at a later date. The pasture consists of sown vidan and fodder beet and of dried up natural pasture plants. The ewes that are due to lamb in October receive an additional concentrate ration of 500 g a day containing 14 percent digestible protein to prepare them for freshening and to provide sufficient nourishment for the growth of the foetuses into strong and vigorous lambs.

Before leaving for pasture the ewes are tested for oestrus by a teaser ram and those found to be in heat are bred in accordance with the mating plan. The stud rams remain in the shed. Female lambs that have attained a weight of not less than 50 kg are now also bred so that they may lamb as yearlings. If they do not come into heat naturally, they are given a hormone treatment.

The afternoon milking begins at 13.00 h. In view of the high midday temperatures in August, the flock is returned to pasture only at 16.30 h and taken back to the shed for the night at 20.00 h.

September. In September, as in August, work at the shed begins at 04.00 h. The hours of midday milking, grazing and return from pasture for the night are also the same as in August. A large part of the flock is now dry; only yearlings and the adult ewes that lambed for the first or second time late in the season are still in milk.

Again the flock is pastured in two groups, one comprising the ewes that are to lamb in a month or two and the few still in milk, and the other group the ewes that are due to lamb later and the female lambs born during the last lambing season. The grazing consists of vidan and dry natural pasture; fodder-beet grazing is coming to an end. Annual rye-grass is now sown for winter grazing.

The concentrate ration of the ewes due to lamb in October is increased to 750 g a day, while ewes that are to lamb in November receive 500 g in addition to grazing. The rams do not go to pasture but are fed in the shed.

The testing of the ewes for oestrus and the breeding of lambs that have reached a weight of 50 kg continues. Those that do not come into heat naturally receive hormone treatment.

Diseases, parasites, poisoning and hygiene in Awassi flocks

There is a marked difference in the incidence of several ovine diseases and parasites between unimproved Awassi flocks maintained on natural grazing and improved dairy flocks which obtain the major part of their nutritional requirements from high-plane stall-feeding and only a relatively small share from natural or artificial pastures. Thus, mastitis, ketosis, hypocalcaemia, virulent foot-rot, vaginal and uterine prolapse and lamb dysentery occur more frequently in improved Awassi dairy sheep than in unimproved flocks. The latter are more prone to tetanus, anthrax, sheep pox, brucellosis and scab as a consequence of their contact with carrier flocks or other sources of infection in pastures.

Some infectious diseases, such as foot-abscess, arthritis, infectious pneumonia, botulism, listerella and salmonella infections, necrotic hepatitis and malignant oedema, are generally rare or absent in Awassi sheep. But several non-infectious diseases are fairly widespread, some of them in improved dairy sheep and others in unimproved stationary or migratory flocks maintained solely on pasturage.

Diseases due to photosensitivity of the exposed mucous membrane of the mouth, nostrils, ears and eyelids do not occur in Awassi sheep owing to the pigmentation of the head.

The following infectious and non-infectious diseases are of rather common occurrence in Awassi sheep throughout their range.

Adenomatosis. Histologically pneumonia occurs in two different forms in Awassi sheep, one chronic and progressive (Maedi-Visna, Montana disease) and the other adenomatic (jaagsiekte). Both are caused by the same virus, which in a climate suitable to its development and in animals under stress, is transferred from sick to healthy sheep by the air. The susceptibility of sheep to the infection varies. In affected Awassi flocks it rarely exceeds an incidence of 5 percent, but one improved dairy flock had to be disbanded because of heavy financial losses due to adenomatosis.

The disease mainly strikes sheep three to five years of age or older, but may also occur in younger animals, although rarely in those under one year. The interval between infection and the appearance of the first symptoms lasts from six to eight months. Usually the disease is first observed when the sheep have to walk long distances to and from pasture, to ascend hills or are driven at a fast pace. Adenomatic animals show difficulty in breathing and discharge from the nostrils and lag behind at the end of the flock. In spite of a normal appetite, they continuously lose condition until the fatal outcome two to three months after the outward appearance of the first symptoms.

Post-mortem examination shows a cancerous enlargement of the lungs which are sometimes three times their normal weight. Large parts are hard and of a greyish-white colour, occasionally accompanied by secondary congestion and abscesses caused by microbes or lung-worms. The cancerous character of the disease is indicated by metastases in the lymph system connected with the lungs and in some instances also in the heart, liver, spleen and kidneys, in voluntary muscles, on the peritoneum in the abdominal cavity and in the pelvic basin.

There is no efficient remedy, and affected sheep should be slaughtered at once to prevent infecting other sheep and to preserve the value of the carcass. Close confinement and the overcrowding of sheep in small compartments aids the spread of infection.

Anthrax. Anthrax is an infectious disease caused by *Bacillus anthracis,* to which sheep are highly susceptible. In several parts of their range Awassi sheep are infected on natural pasture. The greatest source of the disease is the carcass of an animal that has died of anthrax. When its blood is exposed to the air, large numbers of spores are formed from the bacilli. The spores, which are very resistant to heat and dryness and retain their vitality for years, may either be swallowed or inhaled or gain access to the body through scratches or wounds. On entering the bloodstream, the bacilli, freed from the spores, multiply rapidly and discharge their toxins. Infected sheep may drop down suddenly and die in convulsions, displaying a blood-stained discharge from the nostrils, mouth and anus. Occasionally death is preceded by grinding of the teeth, rapid breathing and pounding of the heart. In the early stages penicillin and oxytetracycline (terramycin) have proved effective in combatting the infection. Prophylactic measures consist of the burning or deep burial of the carcasses of animals that have fallen prey to the disease and the annual vaccination of Awassi flocks in which anthrax occurred during the previous decade.

Bluetongue. Bluetongue is a non-contagious disease of sheep and, to a lesser degree, of cattle. It is caused by a virus transmitted by biting gnats of the genus *Culicoides,* which are active at night. The virus occurs in different strains, some of which are more virulent than others. Sheep two to four years old are more vulnerable than younger and older ones, and in rams the disease usually appears in a particularly severe form. Suckling lambs may obtain temporary or permanent immunity from the antibodies in the milk of their dams.

In Awassi sheep bluetongue is rare; its symptoms are commonly light and seldom fatal. It is a seasonal disease that occurs only in summer when the insect host is active. It is more widespread in low-lying, swampy areas than on hills or high plateaus. The symptoms include a rise in body temperature of up to 41°C, loss of appetite, rapid loss of weight, a reddened mucous membrane of the mouth which later turns blue (cyanosis), frothing of the saliva, formation of lip and tongue ulcers, discharge from the eyes and nostrils, the appearance of a red band at the top of the hoofs (coronitis), and a loss of wool. Breathing becomes difficult and congestion of the lungs and intestines may follow. Sick animals stop walking and lie down most of the time. In light cases recovery follows in a short time, but in severe instances death may occur in six to seven days after the first symptoms, or recovery may be very slow.

There is no specific cure, but antibiotics are used in order to prevent additional infection. Sheep that have recovered from bluetongue are often attacked by scabies and worms. Flocks threatened by bluetongue are vaccinated. Immunity commences eight to ten days after vaccination, reaches its height after one month, and lasts for about nine months. In regions where the disease is prevalent in summer, vaccination is repeated every year before the onset of the breeding season. Ewes should not be vaccinated during the early stages of pregnancy as they may give birth to still-born or defective, dummy lambs (hydranencephalus). Flocks in which bluetongue has already struck a few animals should be vaccinated to protect those that are still healthy. Barns should be sprayed with a 0.5 percent solution of a phenol compound.

Brucellosis. Brucellosis has repeatedly been observed in Awassi flocks. It is caused by a strain of bacillus bang (*Brucella ovis*), which differs from those attacking cattle, goats and pigs. Many flocks have been found to be infected with *Brucella melitensis* Biotype 1 (Kamal, 1981). When a number of abortions and retained afterbirths, combined with lowered milk production, occur in a flock without apparent cause in feed or management, brucellosis should be suspected. After one or two abortions infected ewes usually become immune and carry out their lambs, although remaining carriers. The placenta and genital discharge and their milk may contain large numbers of the organisms.

Often *B. ovis* infection is transmitted by rams in which the bacillus causes epididymitis, orchitis and impaired fertility. It may be spread during the mating season when a clean ram serves a ewe previously served by an infected ram which has shed *B. ovis* bacteria with semen.

Sheep may be immunized by vaccination with one of the vaccines prepared from *B. abortus* Strain 19 or *B. ovis* or *B. melitensis.* The live vaccine Rev. 1 is used for lambs from July to December and for ewes from April to June when most of them are not in lamb. It confers immunity for at least four years, which is the major part of a ewe's productive life. Rams are not vaccinated with the live vaccine Rev. 1 (Kamal, 1981). Streptomycin and chlortetracycline used together have proved effective in promoting a bacteriologic cure for brucellosis (MVM, 1973). Once a few animals in a flock have been infected by spreader sheep introduced from outside or on common pastures, the disease can sometimes be eradicated only by destruction of the entire flock or, at least, by culling the reactors traced by a blood or milk test.

Contagious agalactia. Agalactia occurs throughout the breeding area of the Awassi and is prevalent in Awassi flocks of the fellahin and bedouin. Improved dairy flocks are known to have been infected by goats, animals in which agalactia occurs in a particularly severe form. It is an infectious disease, characterized by the sudden, rather painless cessation of the milk flow and degeneration of the udder tissue. Temporary side-effects, such as swollen leg joints and eye troubles, occur in about 10 percent of affected sheep. In rams agalactia is characterized by inflammation of the joints.

The causative agent, *Mycoplasma agalactiae,* is intermediate between a microbe and a virus. It resembles a virus in its filtering capacity and a microbe in its capability of multiplying in a culture medium without the presence of live cells. Infection occurs by way of the alimentary canal.

Typically, in an infected flock a number of ewes show a marked decline in milk yields and the milk changes in consistency and content. Firstly, it is more viscous than normal Awassi milk; in a few days it turns to a watery and flocky fluid. This is followed by a hardening of the udder tissue and a cessation of milk production. Usually both halves of the udder are affected at the same time. The appetite of agalactic sheep remains normal. The disease is rarely fatal in adult ewes, but may cause serious damage through loss of milk. Infected lambs may die or be retarded in their growth.

If accompanied by conjunctivitis and inflamed leg joints, agalactia is readily distinguishable from mastitis. Otherwise laboratory examination of the milk is necessary for diagnosis. Sheep that have recovered from the disease may remain carriers for a considerable time, spreading the organism with their milk, urine and droppings. Infected flocks can be immunized by vaccination. The daily intramuscular injection of tylosin, instituted early, has been reported to be beneficial.

In an improved Awassi dairy flock of 450 ewes, 150 animals were severely attacked by agalactia, in addition to others in which the disease passed in a light form. Fifteen percent of the infected ewes also had swollen joints. This symptom was particularly harsh in lambs and yearlings, which also suffered from severe eye troubles, some of them being struck by blindness. Aureomycin application to the eyés successfully cured these yearlings. The infected ewes continued to be milked irrespective of whether or not their udders contained any milk. In doing so, 60 percent of the infected ewes in milk recovered their production, although on a considerably reduced scale; the rest went dry for the year. Sheep that could not go to pasture owing to inflammation of the leg joints were kept in the barn for a few weeks until they recovered. In the following years the flock remained free of agalactia (Becker, 1958).

Contagious ecthyma. Contagious ecthyma, also called pustular or labial dermatitis or scabby mouth, is an infectious disease of sheep and goats, occasionally also of man, caused by a highly epitheliotropic virus which produces hard, wart-like scabs about the lips, nostrils and udder, sometimes also around the coronet of the legs, between the toes and on the naked side of the fat tail. Lesions also appear inside the mouth.

The disease is transmitted through feed and water as well as by direct contact between animals, spreading speedily throughout a flock. Once a flock has been infected, new outbreaks may occur in young lambs every year or two, or the disease may flare up two to three years after a previous outbreak. Awassi dairy flocks are rarely attacked, but in flocks of the fellahin and bedouin which come into contact with other flocks in pasture, the disease is common. In the breeding area of the Awassi it appears in the winter and spring but very seldom in the summer.

The virus contained in scab particles fallen to the ground is resistant to dryness and may penetrate the skin of sheep through small abrasions caused by thorns or rough grasses. The incubation period varies between two and eight days when small vesicles make their appearance. The scab reaches its maximum development in eight to ten days and is shed after about another week when the underlying skin has healed.

In adult sheep the disease usually passes in a light form, but lambs are very sensitive. If a large area of the lips and muzzle is involved, feeding becomes difficult and young lambs may cease sucking and feeding. Feed should be nourishing and easy to pick up so that the lambs do not die from starvation. Dams that have passed the disease may be allowed to suckle their offspring, but those that have not yet acquired immunity should be milked and the lambs bottle-fed since the udders may become infected by the scab of the lambs, commencing as a black scab on the teats and extending over the skin of the udder. Sheepmen should not touch scabs with hands that have abrasions or small wounds as these may become infected. In humans the disease passes within three weeks and provides immunity.

The lesions of contagious ecthyma may be washed with a solution of 2 percent potassium permanganate, 10 percent lysol, and 5 percent copper sulphate or 1-2 percent argentum, followed by the application of iodine, Chloromycetin tincture or a boric acid, salicylic acid or sulphanilamide ointment to the dry scabs. In endangered flocks or areas, prophylactic vaccination with a living virus should be practised once a year or at outbreaks. Animals of all ages may be vaccinated, ewes at the last stages of pregnancy. In many flocks only the lambs are vaccinated on the assumption that older sheep have already acquired immunity. In areas free of the disease or in improved dairy flocks that do not come into contact with diseased sheep or infected pastures, there is no need for vaccination as it may actually introduce the disease to a hitherto clean flock.

Dysentery in Awassi lambs. Diarrhoea in lambs occurs in different forms, that is, normal diarrhoea in the new-born, bacterial dysentery during the first weeks of life, and coccidiosis in lambs three to four weeks of age and older.

Diarrhoea is normal in lambs on the first day of life owing to the laxative effect of colostrum on the meconium. Sometimes the meconium sticks the broad tail to the anus so that excrement cannot be discharged and, if not cleaned in time, the lamb will die a painful death.

Meconium discharge may be followed — usually after an interval of a few days but rarely after the first week — by bacterial dysentery or scours of a yellow, grey, greenish or white colour that may be tinged with blood. This is a highly fatal disease caused by enteropathogenic strains of *Escherichia coli,* occasionally also by the toxins of *Clostridium perfringens* Types B and C, which are usually introduced into the intestines of lambs with the milk from contaminated teats and udders. In an infected flock a yearly increasing number of lambs may fall victim to the disease. Sick lambs are weak, depressed, show a rise in temperature and no inclination to suck. The disease takes its course in from a few hours to three to four days, varying with the strength of the lamb and the severity of the attack. Post-mortem examination shows small ulcers crowded into comparatively large ulcerated areas on the inside of the bowels and also an enlarged liver.

Prevention of lamb dysentery consists of rigorous stall hygiene, clean feed, water and troughs, dry and clean bedding, and the cleaning of the udder and teats of the ewes before milking and suckling. The bacteria causing dysentery require moisture for their propagation and are killed by dryness.

The lamb creates antibodies to bacterial dysentery in its body, but its immunization system begins to work only a few days after birth. Until then the lamb depends on the antibodies contained in the colostrum. But these can enter the bloodstream of the lamb only during the first day; thereafter the intestines are no longer permeable to the antibodies which leave the intestines with the excrement. If the quantity of colostrum sucked on the first day is sufficient, the antibodies will help the lamb to withstand infection for several days until it can defend itself with its own antibodies. If the lamb is insufficiently provided with antibodies by the colostrum, the disease gains an upper hand. The same holds true if the lamb is incapable of sufficiently developing its own system of antibodies owing to a low birth weight, weakness, poor nourishment, cold, or unhygienic conditions. Disowned or orphaned lambs are particularly susceptible to scours. They should be fed bottled colostrum milked from their dams or from other ewes, which has been frozen as a reserve for this purpose.

Vaccination of the ewes with a vaccine prepared from the dysentery bacillus at mating time and one week before lambing provides a sufficent quantity of antitoxin in the colostrum to protect the lamb during the period of susceptibility. Injection of the lamb with a potent antitoxin serum soon after birth has also been recommended in certain circumstances, immunity lasting for three to four weeks. The remedies for scours are based mainly on antibiotics. However, the bacteria responsible for an outbreak may acquire immunity to the antibiotic used in a relatively short time, necessitating the use of another type.

From the age of one month the lamb is usually immune to bacterial dysentery, but may henceforth be attacked by coccidiosis which produces scours differing in colour and smell from those of lambs suffering from bacterial diarrhoea.

Coccidiosis is a parasitic disease, caused in animals and birds by protozoa which destroy the cells of the intestinal lining of their hosts. Each class of animal harbours a specific type of coccidia. In sheep one or several species of *Eimeria* may be responsible for an outbreak of coccidiosis. Awassi dairy lambs,.often crowded together in small enclosures for long periods, are more prone to the infection than are unimproved sheep kept in the open. Lambs in poor condition owing to worm infestation are particularly susceptible. Infection with the oöcysts of the coccidia occurs by way of the mouth. In the stomach and duodenum sporozoites are liberated from the oöcysts by the digestive juices and enter the epithelial cells of the mucous membrane where they multiply, invading and destroying additional cells. After a time this acute stage ceases; new oöcysts are formed and expelled with the faeces, ready to infest another host. The coccidia abound in wet, dirty conditions and are resistant to freezing and ordinary disinfectants, being viable outside the body for up to two years, but are readily destroyed by direct sunlight and complete drying.

The symptoms displayed by lambs suffering from coccidiosis are a stiff gait, partial paralysis of the hindquarters, nervousness and accelerated breathing. Scouring is brown or black, blood-stained and bad-smelling. The lamb weakens and may eventually die from exhaustion. Those that survive the acute stage of the disease remain unthrifty and coccidia carriers for months. Treatment consists mainly of good nursing and relief of the symptoms. Sulphonamide drugs, such as sulphaguanidine, sulphamerazine, sulphamethazine or sulphaquinoxaline, are employed for treatment, 2 g of sulpha-guanidine being recommended for young lambs once a day for four to six days. Favourable results have also been obtained from nitrofurazone. The principal means of prevention are the avoidance of overcrowding, worm infestation, insufficient or low-quality feed, and wet, dirty bedding.

Enterotoxaemia. Infectious enterotoxaemia, also called pulpy kidney disease, is caused by the organism *Clostridium perfringens* Type D (*Bacillus Clostridium Welchii D*). It is rare in unimproved Awassi flocks maintained mainly on grazing, but frequent in improved dairy flocks where it particularly strikes young stock in the pink of condition.

The disease is due to a very powerful toxin produced in the intestines by the bacillus and absorbed into the bloodstream, causing either sudden death or death after a few hours of acute sickness. Sheep in which enterotoxaemia assumes a more chronic form, with listlessness and foetid diarrhoea as the only symptoms of the disease, may recover. A predisposing condition for the proliferation of the bacillus present in the intestines seems to be a digestive disturbance connected with a change in the feed. The disease strikes male and female sheep of all ages, being particularly frequent in single lambs — but rare in twin lambs — and in adult sheep in poor condition.

The post-mortem examination carried out a few hours after death indicates an acute toxaemia. The intestines are distended with gas and the kidneys are dark red or grey in colour and soft or pulpy owing to large quantities of blood retained in the kidney vessels. The liver is also congested and the heart sac full of fluid.

Antitoxin serum, prepared in horses by the injection of the toxin of *C. perfringens* Type D, confers almost immediate protection for a short period. Given intravenously in a large dose, it also has some curative effect at an early stage of the disease. Lambs in improved Awassi dairy flocks are regularly vaccinated against enterotoxaemia with an inactivated formolized and potassium alum-precipitated culture of the microbe. This confers immunity from ten days after the vaccination on. The vaccination is performed on lambs three to four weeks of age or older, along with that against tetanus. Ewes are vaccinated during a late stage of pregnancy to confer immunity to their lambs during the first few weeks of life. Rams are vaccinated once a year. Unimproved flocks are vaccinated only at an outbreak of the disease.

Enzootic virus abortion. Enzootic abortion occurs fairly widely in Awassi dairy flocks and is responsible for the loss of up to 5 percent of lambs, which may be either aborted, still-born, premature and dying soon after being expelled, or may rot in the womb. Typically, abortion occurs at a late stage of pregnancy. Of twins, one may be born alive and the other one dead. Some lambs are normal to outward appearance, but die during the first month.

The causal virus, which is transmitted by the afterbirth of infected ewes, belongs to the psittacosis-lymphogranuloma group (*Miyagawanella ovis = Chlamydia psittaci*). It infects mature sheep, yearlings and young lambs, causing them to abort one or two years later. Once a ewe has aborted or lambed prematurely owing to the enzootic virus, she will remain immune and not abort a second time.

The disease can be controlled by proper sanitation, the culling of infected animals in flocks in which the disease has been diagnosed, and the vaccination of unexposed females from six months on prior to their first mating. A single vaccination gives lasting protection (Fraser & Stamp, 1961). Tetracycline compounds have been used in the control of enzootic abortion (MVM, 1973). Secondary bacterial infection is prevented by the administration of sulphonamide drugs and antibiotics.

Foot-and-mouth disease. Foot-and-mouth disease, caused by a rhinovirus that exists in seven distinct strains, occurs from time to time in every part of the range of the Awassi. Generally the disease passes in a light form, but in one outbreak in bedouin flocks about 40 percent of the lambs died, while there was no mortality among mature animals. If flocks are attacked before the onset of the breeding season, many ewes may fail to get in lamb in the early oestrous periods but may become pregnant later. In flocks struck during the lactation period there is usually a moderate fall in milk yield and some ewes may develop congestion of the udder, refuse to eat for a number of days or have difficulty in standing on their legs.

If an outbreak of foot-and-mouth disease occurs in the vicinity of a flock, it can be successfully vaccinated against the relevant strain. In some improved Awassi dairy flocks it is common practice to vaccinate all animals of more than three months of age against the various types of the disease each winter. If foot-and-mouth disease strikes a flock that has not been immunized, simultaneous infection of the entire flock with the saliva of a sick sheep is recommended so that the disease may pass in the shortest possible time. Daily intramuscular injections of antibiotics assist in a speedy recovery. The sheep should be kept on dry ground or litter to avoid a secondary infection of the claws with contagious foot-rot.

In a number of Awassi flocks lameness (paraplegia), muscular rigidity or paralysis due to lymphomatic congestion of the brain has been observed four to six weeks after vaccination with an inactivated African Type 1 strain of foot-and-mouth disease. In typical instances, 10-15 percent of the animals in a flock were affected with a mortality rate of 0.5-1.0 percent.

Hypocalcaemia. Hypocalcaemia, also called parturient paresis or milk fever, occurs from time to time in improved Awassi dairy flocks at or shortly after lambing, more rarely before. This distinguishes hypocalcaemia from pregnancy toxaemia which always strikes before lambing. In unimproved flocks, where the disease sometimes occurs in outbreaks, it may also affect dry ewes, yearlings and rams after a sudden change in grazing conditions.

The earliest signs of hypocalcaemia are a weakness in the hindlegs and loss of appetite. Later the animal goes down and rests on its chest and belly, and finally on its side in a state of coma until it dies in a day or two.

The examination of the blood of hypocalcaemic ewes shows a level of 6-7 mg of calcium in 100 cc of serum instead of a minimum of 9 mg in healthy sheep. This calcium deficiency also distinguishes hypocalcaemia from pregnancy toxaemia in which the blood is deficient in glycogen. The calcium deficiency may be caused by grazing on lush green pastures deficient in calcium or by intestinal congestion that prevents the absorption of Vitamin D, essential for the production of the parathyroid hormone that regulates the calcium concentration in the blood.

An intravenous injection of calcium borogluconate leads to a speedy recovery from the disease. If the injection is made subcutaneously, recovery is slower. Only in rare instances is a second injection required. In high-yielding ewes inflation of the udder, as practised in cows, is also effective.

Mastitis. Mastitis, also called bluebag or garget, is the most destructive infectious disease in Awassi dairy flocks. It is caused chiefly by two organisms, *Staphylococcus aureus* and *Pasteurella mastidis* (*haemolytica*). Occasionally other staphylococci, streptococci, *Escherichia coli* and *Corynebacterium* pyogenes are involved, some causing only congestion and others the speedy development of gangrene. Infection enters through the teats and slight wounds on the udder and breaks out suddenly. It may be facilitated by many factors, such as chilling or injury by the teeth of suckling lambs, sharp stones or thistles, manure sticking to the entrance of the teat canal, milking without previously cleaning the udder, prolonged milking, changes in the vacuum pressure of the milking machine, or roughness of the rubber facing of the cups. It is commoner in wet winter weather than in dry summer.

The infection is accompanied by a hot and painful swelling of the affected half of the udder, lameness on its side, a rise in temperature to 40.5-42.0°C, and refusal to eat and suckle. The udder becomes congested, red and hard, and secretion from the teat is thin, watery and blood-stained or thick, creamy, lumpy, of a yellowish colour and foul odour. After about six hours the udder may become gangrenous, the gangrene beginning at the teat and spreading to the base of the udder which turns blue, then on to the belly and the other half of the udder. At this stage the disease may be fatal owing to blood poisoning by the microbes and gangrenous parts of the udder. The acute stage of the disease usually lasts 24 hours and rarely more than 48 hours; in fatal cases death occurs within three days from the onset of the disease.

Affected ewes should be separated from the flock as a precautionary measure. Treatment is of little avail in saving the affected half of the udder. Extension of the infection to the other half may be prevented by injection of 3 million units or 1 cc Procaine penicillin G in oil, which is effective against *Staphylococcus aureus,* together with 5 g dihydrostreptomycin, effective against *P. mastidis.* Aureomycin and antibiotics of the tetracycline group may also be used. The antibiotics may be injected either into the rump muscle or into the udder close to the gangrenous part, or syringed into the udder by way of the teat canal. The oral administration of sulphamerazine and sulphamethazine has also been recommended. Abscesses should be syringed out with a weak antiseptic solution. Hot fomentations, ointments and massaging of the udder with fat mixed with some turpentine should help to alleviate congestion, while the pus should be gently stripped from the teat.

Prevention of mastitis consists of hygienic measures, washing of udders with a 1 percent hypochloride solution before milking, and disinfection and treatment of small scratches and wounds of the udder.

If gangrene has destroyed the tissues of one-half of the udder, the ewe is usually culled. Many sheepmen slaughter the ewe the moment the udder is attacked to prevent the spoiling of the meat by the toxins of subsequent gangrene. Valuable Awassi breeding animals with one udder half intact after an attack of mastitis may, however, be retained, for they may still produce more than 200 kg of milk per lactation, a quantity sufficient to raise a lamb and cover the feeding expenses of the ewe.

In a trial with 40 Awassi and 229 East Friesian-Awassi cross-bred ewes kept under the same conditions, Jatsch and Sagi (1979) found that ewes with hard tissue lumps in their udders, following a previous staphylococcus infection, yielded 188 g more milk a day on average than those with healthy udders. The authors suggest that the larger yield from ewes with lumpy udders may either be owing to the rarer culling of high yielders after an attack of mastitis or to the greater susceptibility of superior dairy ewes to udder infections.

Ophthalmia. Ophthalmia or pink eye, caused by the organism *Rickettsia conjunctivae,* is a common infectious disease in Awassi sheep. It occurs more frequently during the hot months of the year, sometimes taking the form of an epidemic, rather than in winter. However, in at least one improved Awassi dairy flock, ophthalmia was particularly troublesome in winter owing to a predisposing cause, namely, the feeding of clover straw containing a large amount of dusty particles which penetrated into the eyes of the sheep. Other factors favouring outbreaks of the infection are dust on the roads over which the sheep travel on their way to pasture, fine chaff or straw, small seeds, flies and mosquitoes, glaring sun and strong winds. However, the disease may also appear in the absence of any pre-disposing condition. Close contact between infected and healthy sheep in the barn or at pasture favours the rapid spread of ophthalmia throughout a flock.

The incubation period of ophthalmia lasts three to five days. Early symptoms are inflammation of, and a watery discharge from, one or both eyes. The discharge may subsequently change to pus and the animal may partly or completely close the affected eye. Mild cases may recover in a fortnight, but in more serious cases the cornea is covered with a whitish film, with a temporary loss of eyesight. In such instances recovery may take many weeks. If an ulcer develops on the cornea, blindness may be permanent without possibility of a cure. On recovery the animal is immune to ophthalmia for a period lasting up to one year, but may remain a carrier infecting healthy sheep with the secretion from its eyes when conditions for a new outbreak are favourable. In a dried state the organism remains infective for not more than two days.

Sheep suffering from ophthalmia should be isolated from healthy ones, although this cannot completely prevent their infection, for flies may transfer the disease or pastures may be infected with the secretion from the eyes of sick sheep. In a shady, dustless place the disease often passes without complication. Washing of the infected eyes either with a boric acid, zinc sulphate or copper sulphate solution three or four times a day, and the application of an ointment containing penicillin, aureo-mycin, sulphathiazole or mercuric oxide will assist in curing more severe outbreaks of ophthalmia.

Paratuberculosis. Paratuberculosis and tuberculosis are two entirely different diseases. Tuberculosis is very rare in sheep, while paratuberculosis, which is caused by *Mycobacterium paratuberculosis,* is fairly widespread in Awassi flocks maintained on a high plane of nutrition and management. It is an intestinal disease not transferable to humans. Healthy flocks are usually infected by the introduction of outwardly healthy animals from an infected flock, the manure of infected animals and its ingestion being the primary source of infection. The latter occurs at a young age, but the disease develops slowly and its first symptoms commonly appear only after the first lambing at lambing and suckling time (from December to June), the majority being in sheep from three to five years old.

Paratuberculous sheep lose condition for weeks and months, with alternating diarrhoea and constipation, until there results a total loss of strength. However, their appetite, body temperature, breathing and pulse rate appear normal until the end.

Sheep suspect of the disease should be isolated and if the microcomplement fraction test of the faeces and blood shows the presence of paratuberculosis, they should be culled at once. However, not all carriers can be detected by laboratory examination, for the microbes are not always present in the intestinal contents, and such seemingly healthy sheep are liable to spread the disease after all detected carriers have been removed.

In the 1950s a dead culture vaccine providing permanent immunity was developed in Iceland where paratuberculosis was introduced from Germany with imported sheep. The vaccination of newborn lambs has proved a success in infected Awassi flocks so that the disease has now become rare. Immunization of female lambs is practised at the earliest age, not later than at two months, while male lambs are vaccinated only if destined for breeding.

Pregnancy toxaemia. Pregnancy toxaemia or twin-lamb disease occurs sporadically in nearly every improved Awassi dairy flock. It is a nutritional disease in ewes carrying twin lambs and appears within the two weeks before lambing when the foetuses grow at a high rate. It often follows a feed supply, more especially a carbohydrate intake, that is inadequate for the needs of the ewe and her two lambs, or a change in feed or weather at the critical time. Since twinning has become increasingly frequent in improved Awassi dairy flocks, pregnancy toxaemia occurs much more often in these than in unimproved flocks. The disease is associated with a marked lowering of the glycogen level of the body, resulting in a disturbed metabolism and auto-intoxication.

Early symptoms are loss of appetite, a staggering gait and semi-consciousness. As the disease progresses, severe ketosis and acidosis may develop (MVM, 1979). Finally, the ewe can no longer stand on her legs and dies within a few days. If the disease appears shortly before lambing, the ewe quickly recovers after parturition or removal of the young by Caesarean section. At an early phase of pregnancy toxaemia, it is possible to assist the ewe in overcoming the disease by an intravenous injection of a glucose solution or drenching her twice a day with calcium and sodium lactate, propylene glycol or sugar, or molasses dissolved in water.

Pseudotuberculosis. Pseudotuberculosis, also called caseous lymphadenitis or cheesy glands, is a moderately widespread bacterial disease in Awassi flocks. It is caused by *Corynebacterium pseudotuberculosis* which produces abscesses in the superior and inner lymph glands of the body, more especially in the lymph glands situated below the mandibles, between these and the maxillaries, below the ears, and in the supramammary, groin, shoulder, flank and thigh glands. Diseased glands are also found in the thoracic and abdominal cavities after slaughter. Ripe abscesses break and discharge a thick greenish-yellow pus which has no particular smell. The pus contains the bacteria which multiply in the tissues of infected sheep and are arrested by the lymph glands. They may also lead a saprophytic existence in the intestinal contents of both infected and healthy sheep and pass out in the faeces, remaining alive outside the animal body in conditions of shade and moisture for as long as two years.

The bacteria enter the sheep through small skin wounds, cuts or abrasions, usually in the course of shearing. The disease is more common therefore in older sheep that have been shorn several times than in younger stock. In order to avoid infection, it is recommended that young lambs be sheared first — as these are rarely infected — and the older sheep last, and that cuts caused during shearing as well as the shears, combs and blades of the shearing machine be disinfected.

Abscesses should be treated with ichthyol and when coming to a point and breaking be cleaned with permanganate of potash or another antiseptic solution, followed by the application of penicillin-streptomycin ointment.

Losses caused by pseudotuberculosis in Awassi flocks are generally small. Only occasionally do the abscesses render breathing and swallowing difficult, and if the disease lasts for a number of months, the lungs, liver, spleen and kidneys may be affected. After slaughter, portions of the carcass must be condemned as unsuitable for human consumption or for aesthetic reasons.

Sheep pox. Pox, caused by the virus *Variola ovina*, is one of the most dangerous infectious diseases of Awassi sheep. In Syria it is widespread (Gadzhiev, 1968). It mostly strikes flocks on pastures where infected sheep have previously grazed or it is introduced into a clean flock by purchases of sheep from an infected flock. The incubation period ranges from four to seven days. The symptoms of the infection are a loss of appetite, a rise in body temperature to 42°C, a swollen head and large pustules all over the body, but especially on the head, inner side of the toes, the pits of forearm and thigh, the naked side of the fat tail and on the udder. In winter the disease generally occurs in a more dangerous form than in summer. Many ewes die or abort, and even in a lighter form of the disease milk production is markedly reduced. In suckling lambs sheep pox is particularly fatal. Secondary afflictions, such as congestion of the lungs, lesions in the alimentary tract, chronic diarrhoea, foot-rot, spoilt udders, blindness or a destroyed nasal septum, are frequent. Animals that have overcome the disease are permanently immune. Permanent or long immunity is also acquired by lambs carried by ewes struck by the infection during pregnancy.

The pustules of sheep pox differ from those of contagious ecthyma in that they do not form large areas but remain separate from one another, a condition particularly apparent on the lips. Again, sheep suffering from pox show a rise in temperature and feel very ill, contrary to those attacked by scabby mouth.

Sheep infected by pox should not go to pasture but remain in the barn in isolation and be fed well. Suckling lambs should be assisted in suckling or be bottle-fed until recovery which is accelerated by the administration of multiple vitamins. Infected or endangered flocks are immunized by a sensitized or formalized virus vaccine once a year either in autumn or at outbreaks. The protection is extended by the addition of aluminium hydroxide.

Tetanus. Tetanus is caused by the bacillus *Clostridium tetani,* the spores of which may be preserved in sunlight for up to 12 days and in the darkness of soil, manure and dust for several years. The organism is anaerobic, growing only when air is excluded. In cuts caused by shearing, in thorn or nail pricks or ear-tag wounds which heal quickly, the bacilli, freed from the spores introduced by contamination, multiply and excrete a powerful poison which reaches the central nervous system causing tonic spasms of the voluntary muscles of the head, neck, trunk and limbs. The disease, which has an incubation period of four to ten days and sometimes longer, is nearly always fatal in sheep. Infected lambs lie on their sides in a state of complete paralysis. Large doses of tetanus antitoxin injected subcutaneously may save an infected sheep, but the result is uncertain after the symptoms have developed.

Tetanus in Awassi flocks is controlled by the removal of scurfy and gangrenous matter from wounds and their disinfection and by other measures of hygiene. Passive immunity lasting from one to four weeks may be conferred by antitoxin administration; lasting immunization may be achieved by doses of 100 units of tetanus antitoxin and 1 cc of tetanus toxoid for lambs, followed by the injection of 1 cc of tetanus toxoid each year for the following two years.

Urinary calculi. Urinary calculi are mainly formed in two- to six-month-old male Awassi lambs that are being fattened on grain rations with a high phosphorus content or those that for various reasons do not drink enough water. The disease may appear in a number of lambs simultaneously. It also occurs in adult rams, but in female lambs the affection is very rare because their urinary passage is wider and shorter than the male urethra. The principal points at which calculi are formed are at the glans penis, the volutions of the urethra — more especially the sigmoid flexure, that is, the S-shaped curve just behind the scrotum — and the exit of the urethra from the bladder. The *processus urethrae* is of practical importance in relation to urinary calculi, because sometimes a small calculus becomes wedged in the 'worm', preventing the animal from urinating. The formation of calculi takes several weeks or months.

Sheep suffering from urinary calculi show general depression, their belly begins to swell and after a few days assumes the shape of a fluid-filled balloon. An afflicted animal is in great pain which it tries to overcome by kicking against its belly. Urination ceases completely or only a few blood-stained drops are discharged. The tip of the penis becomes covered with blood and pus. When the bladder has become greatly distended with urine, the tubes leading to it from the kidneys or the bladder itself or another portion of the urinary tract may rupture (Belschner, 1951). Before death from poisoning by urine entering the blood stream, the lamb lies in agony on the ground with the smell of urine emanating from its body.

Surgical treatment is possible, but in most cases only expedient if the obstruction is situated in the penial glans or in the urethral process which can be amputated without detriment to the ram's sexual potency.

The disease can be largely prevented by a sufficient supply of fresh drinking water, the addition of 5 percent salt to the concentrate ration of male lambs in order to increase their thirst, and the presence of enough Vitamin A and twice the amount of calcium as that of phosphorus in the concentrate mixture. The addition of 0.5 percent ammonium chloride to the mixture fed to male lambs also reduces the tendency of the urine to form calculi (Rapaport, 1979).

Vaginal and uterine prolapse. Eversion of the vagina and uterus prolapse are rather frequent in well-fed adult Awassi ewes of improved dairy type in which they appear to be caused or promoted by a disturbance in the hormonal balance, estrogen in the feed, or increased pressure in the abdomen by a uterus with twin lambs, a large quantity of feed consumed, and a distended bladder which forces the ewe to strain when urinating. They are rare in unimproved Awassi flocks.

Eversion of the walls of the vagina through the lips of the vulva usually occurs a few days before lambing, but occasionally follows a difficult birth or retention of a dead putrefied foetus. The vagina, turned inside out, appears at the exterior as a red sausage-shaped swelling with a depressed centre. When it occurs after lambing, it is frequently associated with partial or complete eversion of the uterus. If this is not attended to, the ewe may die of gangrene, septicaemia or, if the swollen vagina prevents discharge of the urine, from uraemic poisoning.

Before the beginning of treatment the fat tail is lifted on to the back of the ewe and her hindquarters are raised. The vagina and uterus are cleaned with a weak antiseptic solution and lubricated with paraffin oil or vaseline. Following this, the uterus and vagina are carefully returned into place, and tetracycline pills or a sulpha preparation in tablets or capsules are introduced in addition to Procaine penicillin G and streptomycin in powder form. To prevent another eversion, the vulva is partially closed with a plastic device, silk thread or a few strands of wool from either side across the vulva. In serious cases the intramuscular injection of penicillin and streptomycin and the subcutaneous injection of calcium borogluconate are recommended. The injection of diethylstilbestrol and post-hypophysis hormone will accelerate the contraction of the uterus.

Vibrionic abortion (**ovine genital vibriosis).** Vibriosis has been observed in Awassi flocks for many years. It is caused by the micro-organism *Vibrio foetus intestinalis* which causes inflammation and decay of the foetal membranes and may be responsible for 5-7 percent of the abortions in infected flocks, although considerably greater losses have been reported. Abortion commonly occurs during the last four to eight weeks of pregnancy, but occasionally at an earlier stage. Lambs carried the full term may be stillborn or weak. Ewes aborting once, but later carrying out their lambs, may remain spreaders of the infection. It is believed that the disease is transmitted by the foetus, afterbirth and discharges of aborting ewes — which infect feedstuffs or drinking water — or by infected rams. Freshly aborted foetuses and foetal membranes are used for diagnosis.

The vaccination of ewes with A bacterin shortly before mating, again eight weeks later and annually thereafter is effective, while penicillin and dihydrostreptomycin will control an outbreak. Oxytetracycline (Terramycin) added to the daily feeding ration over the last eight weeks of pregnancy will reduce the incidence of abortion (MVM, 1973, 1979). Measures to prevent the spread of vibrionic abortion consist of sanitation and the isolation of infected sheep. There is no need of the radical measure of complete or partial destruction of flocks as is sometimes necessary in the case of brucellosis.

Virulent foot-rot. Virulent foot-rot is widespread in Awassi flocks. It is caused by an anaerobic microbe, *Fusiformis nodosus,* which, in association with *Sphaerophorus necrophorus,* attacks sheep of all ages, causing pain and lameness and in severe cases may be fatal. In dairy ewes it also leads to a severe reduction in milk yields. In neglected cases foul-smelling, festering wounds appear between the claws, extending to above the level of the horn. If these come into contact with the udder, it may also become infected. The organisms causing foot-rot thrive in moist manure and damp sheds and may survive in the crevices of neglected hoofs for as long as one or two years. As infection usually occurs in the shed, and more rarely in pastures, it is seldom found in the Awassi flocks belonging to bedouin.

Treatment consists of surgery, the medication of infected hoofs and prophylactic measures. Surgery includes the removal of the necrotic parts of the hoof and the opening of the wounds to the ambient air and medicinal substances, such as Formalin, Chloromycetin, Syntomycin (chloram- phenicol), copper sulphate powder, oxytetracycline (Terramycin) ointment, or a sulpha drug. To prevent the spreading of foot-rot from carrier sheep, sick animals should be separated from the flock for ten days following a successful cure. Flocks threatened by infection should be moved slowly through a shallow foot bath containing a 10 percent solution of copper sulphate or 5-10 percent solution of Formalin every three or four days until all the sheep are cured. Before the onset of the rainy season the hoofs should be pared and all overgrown horn removed.

Foot-rot has been differentiated from toe abscess or lamellar suppuration which is caused by a mixed infection of *Sphaerophorus (Fusiformis) necrophorus* and *Corynebacterium pyogenes* and usually affects only a small number of animals in a flock, seldom more than one foot of a sheep, and but rarely lambs. It is favoured by similar environmental conditions to those promoting virulent foot- rot and is also treated by surgery and medication and prevented by the same hygienic measures. Sometimes foot-rot and toe abscesses occur in an Awassi flock simultaneously.

Blowfly (**screwworm).** The blowfly, *Cochliomyia hominivorax,* is well known to every sheepman in charge of an Awassi flock. It is considerably larger than the common housefly and of a greenish-blue colour with a reddish head. Skin wounds caused by shears, thorns or other objects are immediately attacked by the blowfly. Infected wounds are particularly attractive to it. In the range of the Awassi the blowfly is active only from the beginning of spring to the end of summer and not in winter.

The life cycle of the blowfly consists of four stages: egg, maggot, pupa and adult fly. During her lifetime, which lasts about one month, the female deposits more than 2 000 eggs into open wounds. The maggots or screwworms hatch in a few hours, burrow into the flesh and feed for about six days. They then drop from the enlarged wound to the ground, burrow into it and there change into pupae, to emerge one to eight weeks later as adult flies ready for fertilization and new strikes.

Fly-struck sheep should be treated and the maggots destroyed before they mature and drop off to pupate. The wool should be completely removed from and around the struck area and one of the common dressings for fly strike should be applied to the wound. A copper sulphate solution dabbed with a brush in the open wound and on its surroundings and dry boracic acid powder dusted on the struck area have proved efficacious in killing the maggots and protecting the wound against re-strike while it is healing. The copper sulphate solution may be replaced by a benzene hexachloride ointment and boracic acid by a mixture of sulpha and iodoform powder or diphenylamine.

Leeches (**Hirudinea).** Leeches infest Awassi sheep grazing in swampy areas or near river beds. The species *Limnatis nilotica*, which is the most common one in the range of the Awassi, is of a greenish-black, earth colour with yellow lines along the sides. This leech invades the mouth of sheep while they are watered and attaches itself to the mucosa of the mouth, gullet or throat. One or a very few leeches are enough to inconvenience a sheep seriously. With its tongue and jaws the affected animal endeavours to get rid of the leeches, and blood oozes from its mouth because the leeches excrete a substance which prevents clotting of the blood. Sheep infested by leeches may stop feeding.

Shepherds noticing the trouble remove the leeches with a hand covered with a rag because the leeches easily slip from bare fingers. Washing the mouth of infested sheep with a sponge soaked in a concentrated salt solution will also remove the leeches. Those that have taken their fill of blood drop out by themselves.

Nose bot. Another fly parasitic upon Awassi sheep is the nasal fly, *Oestrus (Cephalomyia) ovis,* which is smaller than the blowfly and of a greyish-yellow colour. It attacks its host in spring and early summer during the hot hours of windless days. The fertilized female fly deposits maggots of less than 2 mm long at the entrance to the nostrils of the sheep. The young larvae crawl into the nostrils, feeding on the mucus, and pass up the nasal chambers to enter the frontal sinuses where they stay and develop for nearly a year, growing during this time to a length of about 3 cm, divided into eleven distinct segments. The sheep react to the irritation caused by the bots by snuffling, sneezing, giddiness and, if the number of bots is large, by what is known as 'parasitic nasal catarrh'.

When mature, the bots release their hold on the mucous membrane and return to the nasal passage where they are expelled by sneezing. They then burrow into the ground to pupate, the pupal state lasting for several weeks or months, depending on environmental conditions. At the end of this time the mature flies emerge ready to mate and seek new hosts for their larvae.

Sheep attacked by the bot-fly try to defend themselves by sticking their noses into loose soil or the fleeces of other sheep. Since the fly does not attack in the shade, Awassi sheep kept in the barn during the hot hours of spring and summer days are protected. Also, the fly cannot get at the nostrils of sheep standing in clusters with their heads below the bellies or fat tails of their neighbours. Yet there are few mature Awassi sheep which, after slaughter, will not show some bots in their nasal passages or frontal sinuses. In Iraq where *O. ovis* is widespread, as many as 40 nasal bot maggots have been found in a single sheep (Eichler, 1967).

The intramuscular injection of dimethoate is effective against all larval stages of the sheep bot-fly. The same applies to Ruelene and rafoxanide given orally as a drench (MVM, 1973).

Scabies. Scabies in Awassi sheep is caused by two species of small mites of the order *Acarina,* namely, *Sarcoptes scabiei* and *Psoroptes scabiei.* Psoroptic mange is common in the range of the Awassi; in Iraq 5 percent of the sheep are affected by *P. ovis* (Eichler, 1967).

The *Sarcoptes* mite causes sarcoptic mange, the most severe form of scabies. The mite digs through the epidermis to the corium where it settles down. The females burrow cavities in the skin and lay 10-25 eggs in each of these, while the males remain on the surface of the corium. The larvae hatched from the eggs undergo an additional metamorphosis before developing into mature, 0.2- to 0.5-mm-long mites. The entire process takes two to three weeks.

The parasite attacks mainly the woolless parts of the body, usually beginning in the nostrils and mouth, thence passing to the ears and remaining parts of the head. Sometimes the mites also assault the feet, the naked inner side of the fat tail, the scrotum and those parts of the body where the woolly covering is thin. Sheep attacked by the sarcoptic mite rub the affected parts against walls and fences and the lower part of the forelegs. As a result, the skin loses its flexibility and breaks, and open wounds appear which become covered with thick, hard scales.

Scab mites rapidly pass from sheep to sheep, but at an early stage eradication of the infestation is not difficult. Dipping prevents infestation of unaffected sheep, but as the mites sit in the skin and are often covered wth thick scales, the dipping fluid does not reach them. It is therefore necessary to use medicinal ointments. At the present time benzene hexachloride is successfully employed against scabies of the head. Previously two other ointments were commonly used in Awassi flocks, one compound of 70 percent wood tar, 15 percent yellow sulphur powder and 15 percent methylated spirit, and the second of 40 percent wood tar, 25 percent petroleum, 15 percent sulphur powder, 15 percent methylated spirit, and 5 percent creosote. To these mixtures sheepmen used to add oil, vaseline, soft soap, discarded motorcar oil, or lysol.

The *Psoroptes* mite causes body scab. It is twice as large as the mite attacking the head and is readily seen with the naked eye on a piece of affected skin held against a dark background. *Psoroptes* does not dig into the skin but lives on the epidermis, sucking its food from a deeper layer. It prefers parts of the body thickly covered with wool. The metamorphoses from egg to egg stage are similar to those of the head mite, but the full cycle is completed in half the time.

Affected sheep are restless, rubbing their sides against the ground, walls and fences, and in their endeavour to rid themselves of itching, they pull out staples of wool with their teeth. The wool sometimes gets stuck between the teeth, and in their reaction to this new trouble the sheep may turn round and round while the grazing flock moves on.

The affected areas of the skin show small wounds of a reddish-yellow colour which discharge pus and serum. Mixed with yolk and dandruff this turns into a sticky mass. The wool becomes wet as though perspiring. After a time it is shed, and the infested areas become dry, hard and sore so that the affected sheep may eventually stop eating and lose condition. On cold and wet days sheep infested with scab mites suffer more than in warm sunny weather. After shearing, the infested skin heals outwardly, but the eggs of the mite remain alive and hatch as soon as the wool grows longer.

The mature scab mites and the larvae are sensitive to most dip solutions and easily killed by dipping, but few insecticides also destroy the eggs. Generally, two applications at an interval of ten days are therefore necessary to kill the larvae that have hatched from the live eggs after the first dipping. This applies to arsenical and carbolic dips, lime-sulphur and nicotine sulphate, and to those containing derris root. However, a single dipping or spraying with benzene hexachloride suffices to control psoroptic mange.

Sheep ked. The sheep ked, *Melophagus ovinus,* is a wingless fly about 7 mm long of reddish or greyish brown colour and covered with short bristly hair. Its mouth is adapted for piercing the skin and sucking blood. When feeding, the parasite buries almost buries its whole head with the proboscis into the skin of the sheep. It migrates readily from one animal to another.

During her lifetime the female deposits in the wool of the sheep about a dozen nearly fully developed larvae which are covered with a white membrane. In less than a day the membrane, attached to the wool by a sticky substance, turns brown and hard, containing the pupal stage of the parasite. The young keds emerge from the pupae about three weeks later to work their way through the wool to the skin of the host. In a week's time the keds reach sexual maturity and in another week the female brings forth the first larva, continuing the process about once a week during the three-to-four-month span of her life.

Sheep heavily infested with keds scratch and rub and bite at the itchy parts. Lambs, with their tender skins, suffer most from the intense irritation caused by the blood-sucking insects, losing condition and showing general unthriftiness. In addition, the fleece is damaged by the 'tick stain' produced by the excrement of the keds.

The pupae encased in the hard membrane withstand the destructive action of many dipping fluids, but benzene hexachloride destroys them along with the adult keds.

Sucking and biting lice. Awassi sheep kept in primitive conditions frequently suffer from infestation by sucking lice, particularly of the species *Haematopinus (Linognathus) ovillus.* In Iraqi Awassi sheep blood-sucking lice of the species *L. africanus* are frequent, causing moist itchy lesions of the skin on the back. Toward the end of the dry, hot summer season, sheep in poor and neglected condition are especially vulnerable. Once lice have obtained a footing on one or several sheep, they rapidly spread throughout the flock. Infested sheep scratch and rub the itchy parts of their bodies against walls, fences and trees. Staples of wool, looking like white threads against the darker background of the fleece, sever from the skin. Underneath the loose staples the lice and their numerous eggs or nits are clearly visible. The nits are attached to the wool close to the skin by a viscid substance excreted by the female.

Occasionally Awassi flocks belonging to bedouin or fellahin also suffer from infestation by biting lice, such as the sheep-biting louse, *Damalinia ovis,* and the sheep-foot louse, *Linognathus* (*Ano-plura*) *pedalis.* In Iraq, Awassi sheep have been found infested by the biting louse *Lepikeutron ovis.*

Lice and nits are destroyed by a single dipping in a benzene hexachloride dip or by spraying or dusting with an insecticide, such as methoxychlor or toxaphene.

Tick diseases. The commonest genera of ticks infesting Awassi sheep are *Rhipicephalus* and *Hyalomma.* In flocks in Iraq the species *R. sanguineus* and *H. excavatum* are widespread, especially in spring and summer. Awassi sheep are also attacked by other species of ticks, such as *R. bursa, H. detritum, Boophilus annulatus, Amblyomma punctata, Dermacentormarginatus,* and *Ornithodoros lahorensis.* The last species occurs mainly in the north of the country in sheep that are housed during the night in winter (Eichler, 1967). Three different tick diseases occur in Awassi sheep, namely, babesiasis, theileriasis and anaplasmosis.

Ovine babesiasis is caused by *Babesia ovis* and *B. motasi,* the haemosporids of which invade, and multiply in, the erythrocytes and may lead to serious losses in Awassi flocks. It is transmitted by the tick *R. bursa* which is most active in the summer months from April to June. *B. ovis* is especially prevalent in marshy areas, while *B. motasi* in Awassi sheep occurs mainly in mountainous regions with calcareous soils. The disease is characterized by acute fever and a lack of appetite, followed by anaemia and icterus. In untreated animals mortality is high. Sheep that recover have permanent immunity but remain carriers of the infection. The disease is effectively treated by the intravenous injection of acriflavine, the subcutaneous or intramuscular injection of quinuronium sulphate, or the intramuscular injection of imidocarb dihydrochloride.

Theileriasis in Awassi sheep is caused by *Theileria ovis* or *hirci* and usually occurs in spring. Like babesiasis, it is transmitted by the tick *R. bursa,* but unlike *Babesia, Theileria* does not multiply in the erythrocytes after invasion. The parasites enter the spleen, lymph nodes and liver where they multiply. The haemosporids are released into the bloodstream and again invade the erythrocytes where they remain unchanged until ingested by a tick. Symptoms of the infection are high fever, anaemia and icterus. The mortality rate is high, while recovered sheep are permanently immune. At an early stage of the infection the intravenous injection of chlortetracycline (Aureomycin) or oxytetracycline (Terramycin) inhibits the development of haemosporids in the invaded organs.

Anaplasma ovis in Awassi sheep is relatively non-virulent, but under certain conditions is capable of producing anaplasmosis of mild severity. The infection is transmitted by several species of ticks and also by biting flies. The symptoms include a rise in temperature and a lack of appetite. Aureomycin, Terramycin and Achromycin (tetracycline) have an inhibitory action against the causative agent in the erythrocytes. After recovery the sheep remain carriers.

As in all tick diseases the incidence can be reduced by killing the ticks on the sheep or repelling them with insecticidal sprays in the season of danger.

Worms. Worm infestation in Awassi sheep is widespread throughout the range of the breed. The kind of worms prevalent in different areas varies according to local topographical and climatic conditions. Thus, for example, flocks grazing in semi-desert regions harbour different helminthic populations from those pastured on undrained swampy land. Again, improved Awassi dairy flocks in Israel are relatively free of worms, although at one time some of them became badly infested following the introduction of sheep from southern Anatolia.

The worms found in Awassi sheep belong to two phyla, Nematoda and Platyhelminthes (which includes Trematoda and Cestoda), each of which comprises a number of families, genera and species.

Cestoda. Tapeworms occur in the majority of bedouin and in many fellahin flocks but have become rare in improved Awassi dairy sheep. The reason is that the dogs on farms with improved flocks are not fed the remains of dead sheep, so that the essential link in the life cycle of tapeworms is broken.

The commonest tapeworm in Awassi sheep in *Echinococcus granulosus,* also called *Taenia echinococcus.* This worm consists of a head or scolex and three or four body segments. The mature worm infests the intestines of dogs and other Canidae which excrete the eggs of the worms with faeces. These may be picked up by sheep in grazing. In the intestines of the sheep the shell of the eggs dissolves, the parasite in the onchosphere phase of its metamorphosis bores through the mucosa of the intestine and invades the bloodstream by which it is carried to the lungs and liver. Here it remains and becomes enveloped by a bladder, first a small one and later a larger one, which contains a yellowish mass of variable consistency, fluid, thick or petrified, in which the scoleces are embedded. In the livers and lungs of slaughtered Awassi sheep in Iraq the cysts or hydatids of *E. granulosus* are common (Eichler, 1967). The scoleces can develop into mature fertile worms only after being swallowed, usually with the discarded pieces of infested lungs or livers of slaughtered or fallen sheep, by dogs, jackals, foxes or wolves. The adults of this tapeworm are common in stray pariah dogs.

The spread of the hydatid disease is prevented by keeping infested lungs and livers out of the way of dogs and wild canids and by regularly dosing the sheep-dogs for tapeworm. The cysts are not very harmful to the sheep unless they take up a large part of the infested organ. They do, however, detract from the value of the slaughtered sheep. A copper sulphate drench with the addition of nicotine sulphate or arsenite of soda will kill tapeworms in sheep. A solution of calomel (mercurous chloride) in water has also proved to be efficacious, and the same applies for lead arsenate and niclosamide.

Another tapeworm, somewhat less common in Awassi sheep than *T. echinococcus,* though frequent in Iraq, is *T. multiceps.* This worm also infests the intestines of dogs and wild canids. Its eggs are passed out with the faeces of these animals and may fall on grass to be eaten by sheep, their intermediate host. Here the parasite is carried by the bloodstream to the brain and spinal cord where it becomes encysted, the cyst containing the larval stage, called *Coenurus cerebralis.* The cysts may grow to a considerable size and disturb the brain of affected sheep, causing a lack of coordination, loss of sense of direction and progressive paralysis of the limbs. Dogs become infested by eating the worm cysts contained in the brain or spinal cord. The surgical treatment of sheep is possible if the cyst is situated superficially on the brain so that it can be felt through the softening bone (Fraser & Stamp, 1961). As in the case of *T. echinococcus,* the spread of *T. multiceps* is prevented by dosing the farm and sheep-dogs with a mixture of thiabendazole and piperazine adipate and by keeping them away from the carcasses of infested sheep.

Nematoda. The phylum Nematoda comprises a considerable number of different families and genera of round worms, many of which infest Awassi sheep. The occurrence of the following species of sheep nematodes has been established in Iraqi flocks (Eichler, 1967): *Haemonchus contortus, Ostertagia circumcincta, O. trifurcata, O. occidentalis, Camelostrongylus mentulatus, Marshallagia marshalli, Trichostrongylus axei, T. vitrinus, T. colubriformis, T. probolurus, Bunostomum trigonocephalum, Nematodirus filicollis, Strongyloides papillosus, Chabertia ovina, Oesophagostomum venulosum, Setaria labiatopapillosa,* and a *Trichocephalus* species.

Contrary to Trematoda and Cestoda, the majority of which are hermaphroditic, Nematoda are separated into males and females. Their life cycle generally consists of four phases. The female worms infest the stomach and intestines of their host laying large numbers of tiny eggs which are passed out with the faeces and contaminate pastures. Here the eggs develop into small larvae which climb up and down pasture plants. At a further stage the larvae are eaten by grazing sheep which thus become infested or reinfested. Finally, in the gastro-intestinal tract, the larvae develop into mature worms which, if present in large numbers, cause anaemia and loss in condition. The most pathogenic gastro-intestinal nematodes belong to the genera *Haemonchus, Trichostrongylus, Ostertagia* and *Marshallagia.*

In contrast to other countries in the range of the Awassi, in Iraq it is the adult ewes that suffer most from gastro-intestinal nematode infestation, while lambs are less affected and in a better state of health. This is attributed to the fact that the majority of Awassi flocks migrate to the desert after lambing. Hence, the lambs are removed from the areas of heavy parasitic infestation and graze in clean areas during the first six months of their lives (Eichler, 1967).

H. contortus, with a length of 1-2 cm for the male and 2-3 cm for the female, is the largest of the stomach worms. It lives mainly on blood which it sucks from the wall of the stomach, more especially the abomasum, and causes severe anaemia, paleness of the mucous membrane of the eyes and mouth, and whiteness of the skin. The female may lay up to 3 million eggs in the course of 24 hours. The eggs can withstand dryness for months and the larvae may live up to one year under most variable environmental conditions. Sheep are infested by the larvae on pasture grass or in drinking water.

Phenothiazine given as a preventive and curative drench is very effective against haemonchosis. It may be given at any time of the year except to ewes in the last month of pregnancy. The dose for rams and ewes is 25-30 g in 100 g of water, for yearlings 20 g, and for lambs 10 g. It is advisable to repeat the treatment after three months. Of another anthelmintic, thiabendazole, 3 g are given to adult sheep and 1.5 g to lambs; one treatment is sufficient.

Trichostrongylus worms are 6-12 mm long and not thicker than a very fine hair. Although they do not suck blood, they cause irritation of the gastro-intestinal tract and in severe cases acute parasitic gastro-enteritis, dark scour being the most prominent symptom of the infestation. For the prevention and therapeutic treatment of trichostrongylosis, phenothiazine is also used, but as these worms are very resistant to its action, a larger dose than that given for haemonchosis is necessary. Two organophosphates, coumaphos and haloxon, as well as thiabendazole, have proved to be highly effective against *Trichostrongylus.*

Trichostrongylus worms often go together with brown stomach worms of the two species

Ostertagia circumcincta and *O. trifurcata.* Like the twisted stomach worm, *Haemonchus contortus,* these hair-like worms, about 1.0-1.5 cm long, live mainly in the abomasum. The control and treatment of infestation are essentially the same as those for the other worms of the gastro-intestinal tract.

Two other species of Nematoda, *Nematodirus battus* and *N. filicollis,* are occasionally found in Awassi flocks grazing on low-lying pastures. They are 1.5-2.0 cm long and relatively harmless, but a massive invasion in the small intestines of lambs by these parasites at the immature larval stage, burrowing into the lining of the gut, may cause severe irritation and a loss of body fluid. With an acute attack by the larvae the lambs begin to scour and some of them may die of dehydration in spite of an avid intake of water. Nematodiriasis is effectively prevented and cured by bephenium embonate and coumaphos.

Nematoda infest not only the gastro-intestinal tract; some invade the bronchial passages and ramifications of the lungs. The species most common in Awassi sheep is the large or thread lung-worm, *Dictyocaulus filaria,* which ranges up to 10 cm in length and may cause congestion in the lungs, the development of pus and difficult breathing. The development of lung-worms is similar to that of the Nematoda infesting the stomach and intestines. The eggs are coughed up and swallowed; on their passage through the intestines the larvae hatch and are passed out in the droppings of the sheep. In a few days they become infective, and after being swallowed by sheep they burrow through the intestinal wall and are carried by the lymph stream to the aorta and thence by the blood to the lungs where they settle down.

The life cycle of the small or hair lung-worm, *Muellerius capillaris*, includes an intermediate host after passing out of the bowels of the sheep, as the small land snail found in pastures.

The symptoms of heavy lung-worm infestation are an irritating cough, rapid breathing, discharge from the nostrils and progressive loss in condition. The treatment consists of intratracheal injections of various worm-killing liquids, such as tincture of iodine or potassium iodine and glycerine in water, oil of turpentine, oil of creosote and chloroform in olive oil, or picric acid in water, but their effectiveness is not high. Cyanoacetohydrazide is efficacious against adult lung-worms but not against immature lung-worms, while diethylcarbamazine is effective against immature worms but not against adult forms. Methyridine and tetramisole are effective against all stages of lung-worms (MVM, 1973). Against *M. capillaris* the intramuscular injection of emetine hydrochloride is also effective, while dictyocaulus can be combatted by vaccination.

In improved Awassi dairy flocks the use of anthelmintic medicines varies. Some flock-masters worm their sheep once a year in autumn, others in autumn and in spring, while still others worm their flock only when they notice that the sheep actually suffer from worms. However, many well-bred and well-managed flocks are practically clean of worms and do not require vermifuges at any time.

Trematoda. Worms of the class Trematoda are parasites living in the inner organs of sheep. They attack their host by means of special organs which serve for attachment and suction. More than 20 different species of Trematoda are parasitic in sheep, among these *Distomum hepaticum, Dicrocoelium lanceolatum, D. dendriticum, Paramphistomum microbothrium,* and *Schistosoma haematobium (Bilharzia haematobia).*

Liver fluke infestation (distomiasis) of Awassi sheep is common in the northern parts of the range of the breed, especially in southern Anatolia, northern Syria and northern Iraq which have comparatively high rainfall, but it is also prevalent in swamps and irrigated areas in the central and southern regions. Fluke disease usually follows a year of abnormally heavy rainfall. In Iraq the area for grazing appears to be immense in relation to the number of sheep, but actually it is greatly limited by the large barren tracts and scarcity of wells. The more fertile areas are therefore severely overstocked and entozoal parasitism is common. The periodic crowding of sheep on the fringes of marshes and pools causes particularly heavy losses from distomiasis (Williamson, 1949). The common species of liver fluke in Iraq is *Fasciola gigantica* which occurs in all areas, but especially in the central and southern *liwas.* In the hilly regions of the north and northeast, *F. hepatica* is widespread in sheep (Eichler, 1967).

The liver fluke, *Distomum hepaticum (F. hepatica),* is a leaf-like worm nearly 25 mm long which infests the bile ducts of sheep and, in its immature form, the parenchyma of the liver. The eggs discharged with the faeces die if deposited on dry ground, but if dropped on or near water they develop into larvae (miracidia) which bore into the body of a particular fresh water snail that serves as intermediary host. In Iraq, *Lymnaea euphratica* is suspected to be the vector of *F. gigantica.* After further metamorphoses from the sporocyst to the mother redia, daughter redia and cercaria stages, the cercariae are set free from the intermediate host to swim free in the water or to attach themselves to blades of grass or other plants, where the encysted metacercariae may remain viable for months and be ingested by sheep with drinking water or plant feed. In acute attacks by the simultaneous invasion of the liver by a large number of immature flukes, death may occur from haemorrhaging. In chronic cases, resulting from irritation in the bile ducts by mature liver flukes, the sheep become anaemic and progressively weaker until they die in two or three months.

An effective treatment for mature fluke infestation is a drench of hexachloroethane, hexachlorophene, carbon tetrachloride or bithionol mixed with liquid paraffin. The destruction of young flukes requires a considerably larger dose than for adult flukes and repeated treatments are necessary. An improvement on the carbon tetrachloride medication is the intramuscular injection of this compound in combination with other chemicals. Recently a number of compounds have become available, such as clioxanide, oxyclozanide, rafoxanide, nitroxynil, brotianide and menichlopholan, which have increased efficacy against immature and adult flukes (MVM, 1973,1979).

Dicrocoelium lanceolatum and *D. dendriticum* are also widespread in the range of the Awassi. Like *Distomum hepaticum,* they attack the bile duct and liver of sheep, but use different intermediate hosts from those of *D. hepaticum* for their metamorphoses. The eggs of *Dicrocoelium lanceolatum* are spread with the faeces of infested sheep. The larvae (miracidia) are ingested by the first host, the terrestrial snail *Cionella lubrica,* which thrives on dry hill pastures. In the body of the snail they develop into cercariae which are taken up by an ant, *Formica fusca.* The ingestion by grazing sheep of ants infested with encysted metacercariae introduces the latter into the third and final host where the immature flukes migrate through the bile duct to the liver. The anthelmintics used against *F. hepatica* are ineffective against *D. lanceolatum* and *D. dendriticum,* but thiabendazole and two compounds with the proprietary names Hetolin and Hetol have given satisfactory results (MVM, 1973).

Rumen flukes *(Paramphistomum microbothrium)* are present in large numbers of Awassi sheep in Iraq. The young stages, which live in the small intestine, cause enteritis and loss of condition (Eichler, 1967).

Schistosoma haematobium (Bilharzia haematobia) is mainly a human disease, but it also attacks sheep. Iraq is one of the world's two major foci of schistosomiasis. In the past *S. haematobium* has also been responsible for severe losses in several improved Awassi flocks in Israel. In Iraq, *Schistosoma bovis* and *Ornithobilharzia turkestanica* are reported to be the two species mainly responsible for the schistosome infestation of Awassi sheep. As in the other worms of this order, the eggs are discharged with the faeces of the sheep. In conditions of sufficient moisture, the larvae hatch and invade a snail. The vector of *S. bovis* is *Bulinus truncatus* which is common in the central and southern parts of Iraq, while *O. turkestanica* uses *Lymnaea euphratica* as its intermediate host (Eichler, 1967). After the metamorphoses, the parasite leaves the body of the snail and attaches itself to a nearby plant. Along with this it is introduced into the digestive tract of the sheep where it penetrates the bloodstream and infests the walls of the veins and the liver, poisoning the host with its toxins.

Poisoning. Poison may affect a few sheep or destroy an entire flock. The poisons that may strike Awassi sheep are of two kinds, plant and mineral. Some plants in the grazing areas of Awassi sheep are poisonous at all times of the year, while others are only dangerous in certain periods or under certain conditions of their growth.

Unimproved Awassi sheep grazing on their natural home pastures generally avoid poisonous plants, such as *Papaveraceae, Solanum nigrum, Ramunculus arvensis, Ferula communis, Ecballium elaterium* and *Nerium oleander.* It is only in times of prolonged drought when the pastures do not provide enough nourishment and the sheep go hungry that poisonous plants may be eaten and cause diarrhoea or death if the quantities consumed are sufficiently large.

Awassi flocks grazing on grain sorghum fields may be poisoned by prussic acid which often develops in sorghum at an early phase of growth, especially after a rainless period or if deprived of irrigation. Sometimes this also occurs in Sudan grass. Becker (1958) has recorded that sorghum plants sprouted on poultry droppings close to a hen-house poisoned Awassi sheep which fed on them while passing by. The symptoms of hydrocyanic acid poisoning appear within one or two hours: trembling, weakness in the legs, frothy discharge from the mouth, heavy breathing and, finally, paralysis and speedy death.

Grain feeding and the presence of glucose in the stomach counteract the danger of prussic acid plant poisoning to a certain extent. Therefore a drench of molasses or sugar dissolved in water may be administered as a first measure to save the lives of sheep suffering from this poison. At an early phase of prussic acid poisoning a drench of sodium carbonate and iron sulphate dissolved in water may also be helpful. Belschner (1951) recommends the immediate intravenous injection of 20 cc of a mixture of 50 g of sodium nitrite and 200 g of sodium thiosulphate dissolved in 11 of water or the subcutaneous injection of 5 cc of sulphuric ether.

Awassi sheep have also been poisoned by fenugreek straw or grazing on green fenugreek. The seeds of this plant are used in many parts of the range of the Awassi as a condiment and sometimes the plant as green manure.

The symptoms of fenugreek poisoning are weakness of the leg muscles below the knees and later also below the hocks so that the sheep can no longer stand on their legs. In graver cases the neck and rib muscles are also affected, causing difficulty in eating and breathing. Sometimes oedemas develop below the mandibles and subcutaneously at other parts of the body, and serous fluid accumulates in the heart and abdominal cavity. With the cessation of fenugreek straw or green feeding the sheep usually recover, although slowly, and only a few cases are fatal.

At least one instance is known of Awassi sheep having been poisoned by eating yellow lupin seed to which they accidentally had access (Becker, 1958). Bread in quantities of more than 750 g a head has also proved to be fatal to Awassi sheep, especially to ewes in lamb, through excessive lactic acid fermentation in the stomach.

Mineral poisoning seldom occurs in unimproved Awassi flocks belonging to fellahin or bedouin, but it is not rare in improved dairy flocks where it often results from negligence on the part of the sheepmen or others.

Arsenic poisoning may be caused either by the consumption of foliage treated with arsenical herbicides such as sodium arsenite and arsenite trioxide (MVM, 1979); by drinking arsenic dipping fluid; or by absorption through open wounds in the skin, which is much more deadly than drinking dipping fluid. Occasionally the licking of arsenic containers or paint tins, or an excessive dosage of arsenical drenches against worms, are responsible for losses.

Sheep poisoned by arsenic have abdominal pain, foul-smelling and sometimes blood-tinged diarrhoea and difficult breathing. In acute cases the animal may die in a few hours; in chronic poisoning from the repeated intake of small quantities of arsenic over a period of time, death may come in up to one week. Post-mortem examination shows intense inflammation of the mucous membrane of the abomasum and congestion of the intestines and liver.

An antidote for arsenic poisoning is the intramuscular injection of 6 mg/1 kg body weight of 2,3-dimercaptopropanol or a drench of 7-14 g of sodium thiosulphate dissolved in 300 cc of water. In addition, 2 g of sodium thiosulphate in a little boiled water may be injected intravenously. Raw linseed oil should be given as a purgative and the sheep should not be watered for at least one day (Belschner, 1951).

In several improved Awassi flocks poisoning has occurred from eating thallium-poisoned bran or grain used against moles in the fields. Such bran or grain contains 2 percent thallium sulphate. Normally 2.5-3.0 kg of grain are spread for each hectare of land, or five to ten grains are inserted in an exit from the burrows of the moles. The fatal dose of thallium sulphate for sheep is 15-25 mg/1 kg live weight. An animal weighing 50 kg has therefore to consume 37.5-62.5 g of poisoned grain for a fatal dose. It is most unlikely that sheep would pick up such a large quantity of grain in fields treated with the quantities of grain prescribed. Hence, thallium poisoning nearly always results from carelessness on a farm where sheep have access to poisoned bran or grain in bags or to spilled grain.

The symptoms of thallium poisoning are loss of appetite, gnashing of teeth, reddening of the mucosa of the eyes and mouth, discharge from the mouth, weakening of the legs and lying down. Postmortem examination shows congestion and ulceration of the stomach and intestines, ulcers being particularly common in the duodenum. The contents of the omasum usually contain red thallium-soaked wheat.

Thallium-poisoned sheep should be purged with magnesium sulphate or paraffin and drenched with diphenylthiocarbazone oral percent solution of sodium iodide in water. In addition, they should receive an intravenous injection of a 10 percent solution of sodium iodide. Sheep that recover from thallium poisoning continue to have diarrhoea for some time and their wool comes loose.

Copper poisoning has been observed in well-fed Awassi dairy flocks in ewes in milk and in lambs six months of age and older. In unimproved flocks kept on natural pasture such poisoning is extremely rare. Copper is an essential trace element in the nutrition of sheep; a pregnant ewe requires 5 mg of copper a day, while ewes' milk contains 0.15 ppm of copper and wool 5 ppm. On the other hand, sheep are easily poisoned by an excessive quantity of copper.

Two kinds of copper poisoning are distinguished, acute and chronic. The acute form may be caused by the ingestion of copper compounds contained in plant or other sprays, anthelmintic medicines or foot baths. Chronic copper poisoning is due mainly to feedstuffs containing small but excessive quantities of copper which are stored in the liver until it is overburdened. This may happen in dairy ewes or fat lambs that obtain most of their nutritional requirements in the form of concentrate mixtures containing copper in a 10 ppm or higher concentration, and little or none from grazing.

The symptoms of copper poisoning are loss of appetite, diarrhoea, red urine, short breathing, trembling, weakness, prostration and death, in acute cases there is severe congestion of the stomach and intestines, while in chronic poisoning the liver, kidneys, spleen and lungs show abnormal changes and there may be generalized jaundice.

The treatment for acute copper poisoning consists of the administration of potassium ferrocyanide or powdered iron with which copper in the stomach and intestines will form an insoluble compound. This should be followed by the administration of magnesium sulphate or raw linseed oil.

In all cases of mineral or plant poisoning, and in particular if the cause of the affection is unknown, a drench of raw linseed oil or magnesium sulphate and sodium bicarbonate dissolved in water should be administered and the white of eggs, milk and stimulants in the form of alcohol or strong coffee should be given.

Buildings for Awassi dairy flocks

Housing for Awassi dairy flocks includes the shed, adjoining yards and storage facilities for roughage, silage and bedding. The bin for concentrates is located in the shed, the silo usually at a distance of 8-10 m from it, and the storage sheds for roughage and bedding not less than double this distance. The entire complex must fit the general plan of the farm, to save labour and promote the health and production of the flock. In addition, it should be close to the road over which the sheep must travel on their way to pasture grounds. Further, the sheep shed should be situated sufficiently far from the cow sheds and cattle yards to minimize the danger of parasites and infectious diseases passing from one to the other. Topographically the shed and the yards should not be located in a hollow, and land with a moderate declivity is preferable to a level area as yards on a well-drained decline dry up soon after a rainfall.

The shed houses the ewes, yearlings and lambs. Attached to it are the milking parlour, milk refrigerator and tank, and a room and sanitary facilities for the workers. The bin for concentrates may be inside or just outside the shed. The pen for the rams may be situated in the shed or in one of the yards.

The floor of the shed should have a declivity of not less than 1.5 percent and not more than 5 percent. The space required in the shed and yard for Awassi sheep of different ages, sex and condition has been given by Becker (1958) (see Table 2-15). With the increase in the average weights of improved Awassi dairy sheep during the last two decades, about 10 percent should be added to these figures.

Awassi sheep in fleece and good condition suffer little from cold, more especially as ambient winter temperatures are not usually very low in their range. The shed should protect them from rain storms in winter and the burning midday sun in summer. As the cooling sea winds come from the direction of the Mediterranean, sheds for dairy sheep were originally built to extend from north to south so that in summer they lay open to the western winds throughout their entire length. This arrangement, however, is no longer recommended, and modern sheds extend from west to east. The advantage of this direction is in the long southern front of the shed opening into the yard or paddocks which, following a downpour of rain, are soon dried by the rays of the sun. Also, the main direction of winter rains is from the west, to which the modern shed offers only a narrow front (see Figs 2-6 to 2-10).

Table 2-15. **Floor space required by Awaasi sheep in shed and yard (m^2)**

Type of sheep	Shed	Yard
Dry ewe	0.90	1.30
Pregnant ewe	1.00	1.45
Ewe in milk	1.00	1.45
Ewe and lamb	1.25	1.80
Yearling	0.90	1.30
Weaned lamb	0.80	1.15
Ram in rams'shed	2.00	2.85

Source: Becker, 1958