

# An Assessment of Omani Native Sheep Fiber Production and Quality Characteristics

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## تقييم لإنتاجية وخصائص صوف الضأن العماني

عثمان محجوب وعصام كاظم وأحمد الذهب وريناaldo بيلو وعيسي العماري وعائشة أمبو علي وسميرة خلف

الخلاصة: تم إجراء قياسات منهجية لتقدير إنتاجية وخصائص الصوف على مئة من إناث الضأن العماني ، متوسط وزنها  $38.6 \pm 5.5$  كيلوجرام وتراوحت أعمارها بين ٤٨٨ إلى ٩٩٣ يوم. تم إيواء الضأن في حظائر نصف مظللة وتمت تغذيتها حسب الشبيهة على دريس حشيشة الرويس (٨,٨٣٪ بروتين خام) إضافة إلى ٢٠٠ جرام من العلف المركز (١٦,٥٪ بروتين خام) يومياً. تم جز الضأن مرة واحدة في العام وأخذت عينات من منطقة منتصف الجانب الأيسر لدراسة خصائص الصوف والألياف. يستخدم المجهر الإلكتروني الماسح لدراسة الخصائص الدقيقة لالياف الصوف. تم جمع عينات من الجلد لدراسة توزيع الحويصلات الأولية والثانوية. تراوح وزن جزء الصوف الخام في الضأن العماني بين ٠,٥ و ٢,٦٥ كيلوجرام (متوسط قدره  $1.12 \pm 0.43$  كيلوجرام) وكان وزن الصوف الخام متسوباً إلى وزن الحيوان الحي  $1.0 - 7.6$  بمتوسط قدره  $2.9 \pm 1.16$ . تراوح وزن الصوف النظيف بين ٥٧ و ٨٨,٤٪ بمتوسط قدره  $76.4 \pm 7.6$ ٪. احتوى صوف الضأن العماني على خصل ذات أشكال مختلفة كان متوسط طولها  $22.9 \pm 1.16$  سم، لها متوسط  $4.3 \pm 0.8$  تموجات للخصلة، بينما كان متوسط سماكة الليفة  $46 \pm 12$  ميكرون. أوضحت دراسة المجهر الإلكتروني وجود ثلاثة أنواع من الألياف: ذات الحراشيف الملقنة والممسنة والمنبسطة الطويلة. أوضحت هذه الدراسة أن هناك تباين كبير في خصائص صوف الضأن العماني، مما يقتضي الانتباه إلى إمكانية استخدام الانتخاب الوراثي لتحسين إنتاجية ونوعية الصوف فيه.

**ABSTRACT:** Wool production and quality measurements were carried out on 100 Omani native female sheep (body weight  $38.6 \pm 5.5$  kg; age  $993 \pm 488$  d). Sheep were kept in partially shaded pens and fed *ad libitum* Rhodes grass hay (crude protein 8.83%) plus a daily amount of 200 g general ruminant concentrate (crude protein 16.5% DM). Animals were shorn once a year and samples were taken from the left mid-side site to determine fleece and fiber characteristics. The scanning electron microscope (SEM) was used to study the fine appearance of the wool fibers. A skin sample was used to study the histological arrangement and number of secondary and primary follicles. The greasy fleece weight (GFW) in Omani sheep ranged between 0.50- 2.65 kg (mean  $1.12 \pm 0.43$  kg) and the GFW expressed as a percentage of BW ranged between 1.0-7.6 with a mean of  $2.9 \pm 1.16$ . Clean wool yield in Omani sheep fleece ranged between 57.1 and 88.4% with a mean of  $76.4 \pm 7.6$ . Omani sheep fleece contained various staple shapes and had a mean staple length of  $22.9 \pm 1.16$  cm,  $4.3 \pm 0.8$  crimps per staple; and a mean fiber diameter of  $46 \pm 12$   $\mu\text{m}$ . Electron microscopy revealed three types of fibers; wrap-around, angled type and polygonal and elongated scales. This study indicated a wide variation in the wool characteristics of Omani native sheep fleece, which suggested that selection may be employed to improve wool production and quality in these sheep.

Keywords: Oman, sheep, wool, fleece, assessment.

## Introduction

Sheep are important animals worldwide for the provision of animal protein and wool. Their other products such as fiber, milk, skins or dung are also important as a source of income for small holders in the less developed parts of the world. Oman has 361,000 sheep, 1,018,000 goats, 320,000 cattle and 118,000 camels (Anonymous, 2005) with an estimated 3% annual increase in animal numbers. There is one major breed of sheep in Oman kept in small flocks by nomadic and semi-nomadic pastoralists as well as by smallholder in settled

villages. Under almost all these conditions, sheep graze poor-quality range grass and browse acacia shrubs and other trees, or they are feed Rhodes grass hay, dates, dried fish sardines, banana stems and household leftovers. Omani sheep, which are found over most of the northern parts of the country, are predominantly black but white sheep are not uncommon. They are thin-tailed (with slightly thicker base), small in size and unthrifty in appearance; males are mostly horned and females polled (Anonymous, 1978). The average adult live

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weight of Omani sheep raised under traditional systems range between 22 and 25 kg (Anonymous, 1978). Under intensive management, Omani sheep showed improved performance in the form of high growth rates and good carcass composition compared to those raised under traditional systems (Al-Nakib *et al.*, 1996; Mahgoub and Lodge, 1994a, b).

In Oman, meat is the major product of sheep. Little milk is consumed but their fiber is used by Bedouins to make rugs, artifacts for household and racing camels. The local sheep are described as having coarse wool (Anon, 1978) although no studies have been carried out to determine their skin cover fiber quality. The objective of this study was to evaluate the production and quality characteristics of Omani sheep fiber.

## Materials and Methods

### Animals

Experimental measurements were carried out on 100 Omani native female sheep kept in the Agricultural Experiment Station of the College of Agricultural and Marine Sciences, Sultan Qaboos University. The sheep ranged in body weight between 29-51 kg (mean  $38.6 \pm 5.5$  kg) and age between 285-2072 d (mean  $993 \pm 488$  d). Sheep were kept in partially shaded pens and fed *ad libitum* Rhodes grass hay (DM 93.4%; with CP 8.83% DM, crude fiber 41 %DM, crude fat 1.8 %DM and ash 9.4 %DM) plus a daily amount of 200 g general ruminant concentrate (DM 92.7%; with CP 16.5% DM, crude fiber 2.26% DM, crude fat 3.34 %DM and ash 5.9% DM). Water and mineral salt blocks were available *ad libitum*. Animals were subjected to routine animal health procedures including regular vaccination and deworming. Animals were weighed monthly.

### Fleece Measurements

Sheep were shorn once a year using an electrical commercial shearing device with a hand piece. Greasy fleece weight was determined by weighing the fleece of sheep immediately after shearing on a digital scale. Prior to shearing, a sample was taken from the left mid-side site, over the last rib, using the same shearing device. The wool yield was determined by weighing a sample from the mid-side site in an aluminum tray. The sample was then hand-washed thoroughly using a commercial detergent then dried in an oven at 70°C for 24 hours. The tray plus sample were reweighed and the yield was computed as the difference in weight between greasy fleece weight and dry clean weight.

### Staple and Fiber Characteristics

Mid-side site samples were used to study the fiber attributes in Omani sheep. Staple length was measured by carefully spreading the staple on a board and measuring it to the nearest mm from the cut base to the point at the tip where the bulk of fibers end using a ruler. The number

of crimps was counted on each staple without maximum stretching.

Fiber diameter was determined using a microscope equipped with a caliper in the eyepiece, which was calibrated to a slide measure. A sub-sample of fibers was taken randomly and fitted to a microscope slide and fixed with a tape. The width of twenty fibers from each sample was measured at the middle of the fiber.

### Histology

Skin samples were taken from the right mid-side site (over the last rib) from 16 Omani sheep to study follicle structure while the sheep were controlled in the lateral recumbence position. The wool was clipped and the area disinfected with a multipurpose disinfectant. A shot of a local anesthetic was given and a circle of 5 mm diameter was made using a circular stainless steel cutter. Scalpel blade and forceps were used to remove the skin sample, which was fixed in 10% buffered formalin for histology. Blocks were prepared, sectioned and stained with haematoxlin/eosin stain to enable studying the arrangement of primary and secondary follicles.

### Electron Microscopy

The scanning electron microscope was used to study the cuticle scale pattern of wool fibers. About 10-15 fibers of about 1 cm length from each sample were cleaned in graded ethanol dilutions (25, 50, 75, 90 and 3×100%, 10 min each). They were blotted dry in filter paper then mounted in stubs. The fibers were placed in Sputter coater, coated with gold particles for 1 min, and viewed with JEOL JSM-5600LV Scanning Electron Microscope.

## Results and Discussion

### Wool Production Characteristics

The GFW in Omani sheep ranged between 0.50-2.65 kg with a mean of  $1.12 \pm 0.43$  kg (Table 1). This weight is within the range for tropical and sub-tropical sheep reported by Gatenby (1986) but is well below that of specialized wool-producing breeds with GFW of about 4-5 kg. Tabbaa *et al.* (2001) reported a GFW of 2.1 kg in 53 kg Awassi sheep and a range of 1.2-1.9 kg GFW for other Middle East carpet wool sheep. Awassi is a major multipurpose sheep in the Middle East and, in Jordan fleeces were estimated to represent about 2.5% of the value of products from its commercial production beside meat and milk.

The frequency distribution of the GFW is presented in Figure 1. It represents a normal distribution bell curve slightly skewing to the left. The curve indicates that it is possible to improve wool yield in Omani sheep by exploiting the elite group at the right end (with more than 2 kg GFW) to improve the average through selection because of the high heritability score for the GFW. Ghoneim *et al.* (1974) reported that the heritability score for fleece weight in Awassi Iraqi sheep was 0.47 by paternal half-

**Table 1.** Omani sheep wool production parameters.

Statistical Function	Body weight (kg)	Age (days)	Greasy fleece weight (kg)	Yield (%)	Greasy fleece weight/body weight
Mean	38.63	993.29	1.12	76.41	2.94
SD	5.49	488.30	0.43	7.56	1.16
Maximum	51.00	2072.00	2.65	88.42	7.79
Minimum	29.00	285.00	0.50	57.14	1.04
Median	38.00	956.50	1.03	77.18	2.70
Mode	39.00	300.00	0.70	NA	2.70

sib correlation and 0.16 by regression of offspring on dam. Repeatability was 0.32 by intraclass correlation and 0.36 by correlation between pairs of records. The authors recommended that for improvement of fleece weight, breeding stock should be selected for fleece weight at first shearing when they are 18 m old.

To overcome the effects of the wide range of body weight in animals used in the present study, GFW was expressed as a percentage of BW and it ranged between 1.04 and 7.56 with a mean of  $2.94 \pm 1.16$  kg (Figure 2). This is higher than 2.2 kg GFW adjusted for BW in yearling Awassi sheep (Tabbaa *et al.*, 2001). There was a trend of fleece weight in kg or as a percentage of body weight, to increase with age with a maximum of 1.5 kg in 1267 d old sheep then slightly decreased to about 1.0 kg by the 1908 d group of age (Figure 2). Similarly, Tabbaa *et al.* (2001) found that GFW was higher in yearling Awassi sheep than in lambs but there was no difference between yearling and mature sheep in GFW. Ghoneim *et al* (1974) reported that sex, age, year of shearing and type of birth

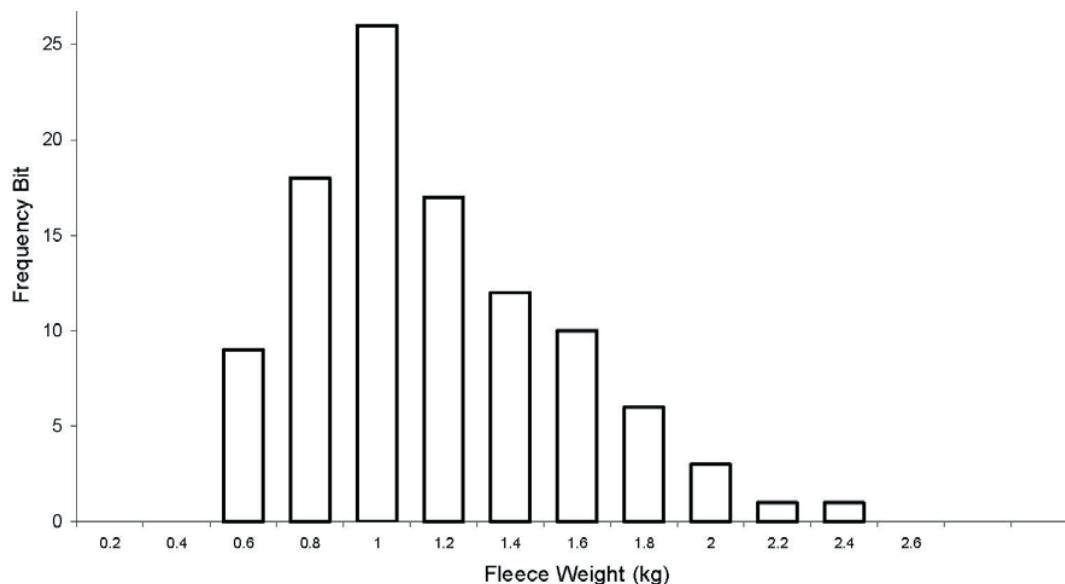
significantly affected fleece weight. The fleece weight was the highest at the first and second shearings.

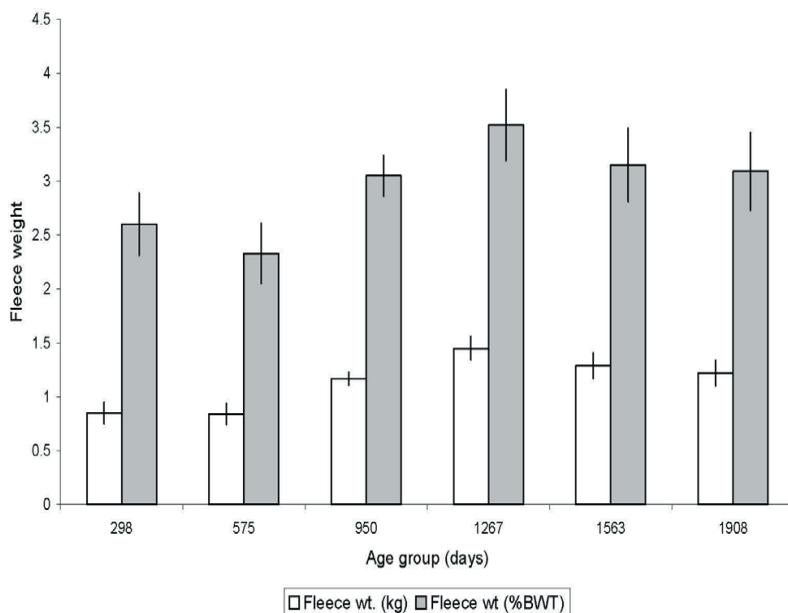
Yield in Omani sheep fleece ranged between 57.14 and 88.42% with a mean of  $76.4 \pm 7.56$  (Table 1). This yield is comparable to that of 74-62% reported for tropical and subtropical sheep by Gatenby (1986).

The majority of Omani sheep are black since black is a dominant color in Omani sheep. However, some white Omani sheep are also available and there are breeding programs for their improvement in breeding stations in the country (Dr Tag Elsir Issa, personal communications). Such programs would be beneficial for improvement of Omani sheep wool production.

#### Fleece Characteristics

The mid-side site position over the last rib was reported to be closely representative of both follicle and wool characteristics and therefore, much used in sampling (Gatenby, 1986). This site has been used for assessing Omani sheep fleece characteristics in the present study.

**Figure 1.** Frequency distribution of the greasy fleece weight in Omani sheep.



**Figure 2.** Fleece weight (kg) and fleece weight as percentage of body weight expressed on various age groups of Omani sheep.

There were different staple shapes in Omani sheep fleece (Figure 3) ranging from rectangular aggregate of small staples to oval, but most had pointed tips. Sheep producing coarse wool usually have more tippy staples.

Staple length in Omani sheep fleece ranged between 12-37 cm with a mean of  $22.86 \pm 4.31$  cm (Table 2). This indicates that fleece from local sheep is longer than that reported for most tropical and subtropical sheep (Gatenby, 1986). Tabbaa *et al.* (2001) reported a staple length of 14 cm in Awassi sheep. The number of crimps ranged between 2-6 (mean  $4.30 \pm 0.80$ ) indicating that the fleece of native Omani sheep is more straight than curly. Because

of its crimp, or curl, wool has considerable resilience and with its high tensile strength and elasticity, gives fine woolen fabrics the ability to retain shape better than cloth made from other natural fibers. The length of Omani sheep wool is much longer than that reported for carpet wool breeds (4-12 cm) and more similar to that of English long lustrous wool (Dr. M. Salehi, personal communication, 2008).

The fiber diameter in Omani sheep is presented in Table 2. It ranged between 24-67.5  $\mu\text{m}$  (mean  $45.9 \pm 12.26$   $\mu\text{m}$ ). This ranks it among the carpet wool-producing sheep (Gatenby, 1986). Tabbaa *et al.* (2001) reported a fiber diameter of 36  $\mu\text{m}$ . Shepherd (1959, cited by Gatenby, 1986) indicated that the range of fiber diameter for carpet wool should be 11-90  $\mu\text{m}$  with 85% of the fibers in the range of 21-60  $\mu\text{m}$ . According to Dr Salehi (personal communication, 2008), the diameter range of fibers in carpet wools range between 11-90  $\mu\text{m}$ . The wide range in fiber diameter in Omani sheep indicates a wide variation, which may be exploited using selection to improve the fineness of wool in these sheep. Average fiber diameter is a trait with high heritability score of 0.45-0.60 (Beatson, 1988) renders it rapidly responding for efficient selection programs.

Carpet wools consist of a mixture of true wool, hair, heterotypical and kemp fibers. The morphology, microscopy and dimension of each fiber types in carpet wool are different. The average diameter of carpet wools is between 25-35  $\mu\text{m}$  in unimproved and native breeds in Middle East or Asian countries and between 35-45  $\mu\text{m}$  in improved carpet wool in New Zealand and (Dr M. Salehi, personal communication ,2008). More detailed studies are needed to determine fleece characteristics of Omani sheep



**Figure 3.** Three different types of Omani sheep fleece.

**Table 2.** Characteristics of Omani sheep wool.

Statistical Function	Staple length (cm)	Number of crimps	Number of crimp/cm	Fiber diameter ( $\mu\text{m}$ )	No of Primary follicles	No of secondary follicles	Sec/Prim
Mean	22.86	4.30	0.19	45.9	22.9	12.8	0.6
SD	4.31	0.80	0.03	12.26	8.2	10.5	0.4
Maximum	37.00	6.00	0.29	67.50	43	40	1.6
Minimum	12.00	2.00	0.12	24.00	1	0	0
Median	23.00	4.00	0.18	45.25	22	10.5	0.51
Mode	23.00	4.00	0.17	45.50	22	11.5	0.53

using larger numbers of animals with separation of fibers to determine the percentage of each fiber type.

#### Fiber Structure

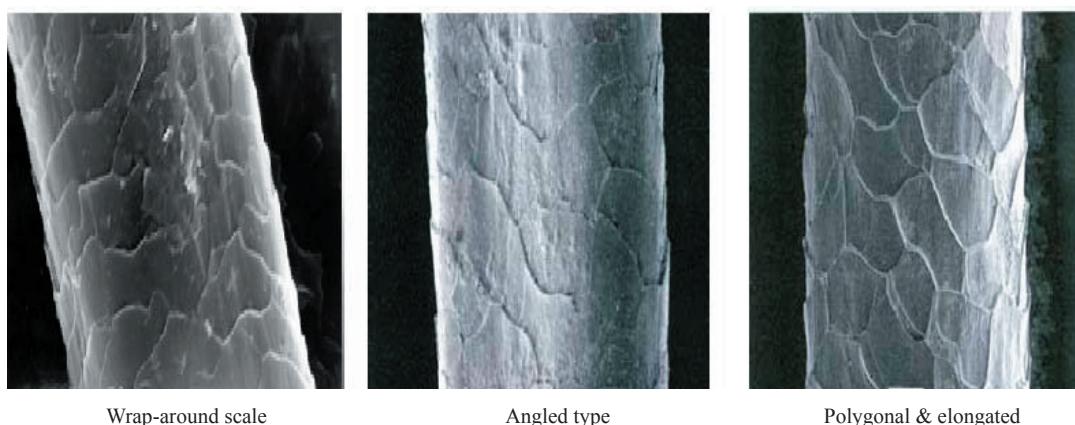
The outer surface of wool fiber enables it to be differentiated from hair mainly by the nature of the scales that cover the fiber. Wool scales are numerous, minute, and pointed and are attached only at their bases causing interlock under pressure. The number of scales varies with the fineness and curliness of the fiber. Accordingly, micrographs taken for the Omani sheep fibers indicate that they look like fairly typical wool rather than hair fibers (Figure 4). The micrographs also showed that there were three different wool fiber types available in Omani sheep similar to those described by Woods and Orwin (1982) and shown in Figure 4. The first type is a wrap-around scale pattern on keratinized wool fiber which is usually seen in fine wool fibers such as Merino (Dr Joy Wood, personal communication). Scales in Omani sheep of this type appears to be more numerous and pointed than in Woods and Orwin (1982) study. The second fiber type is the angled type of scale pattern which occur in medium diameter fibers. The angles of the Omani sheep scales are not as steep as for those reported by Woods and Orwin (1982). The third type of fiber is the polygonal and elongated scale pattern type which usually occurs in

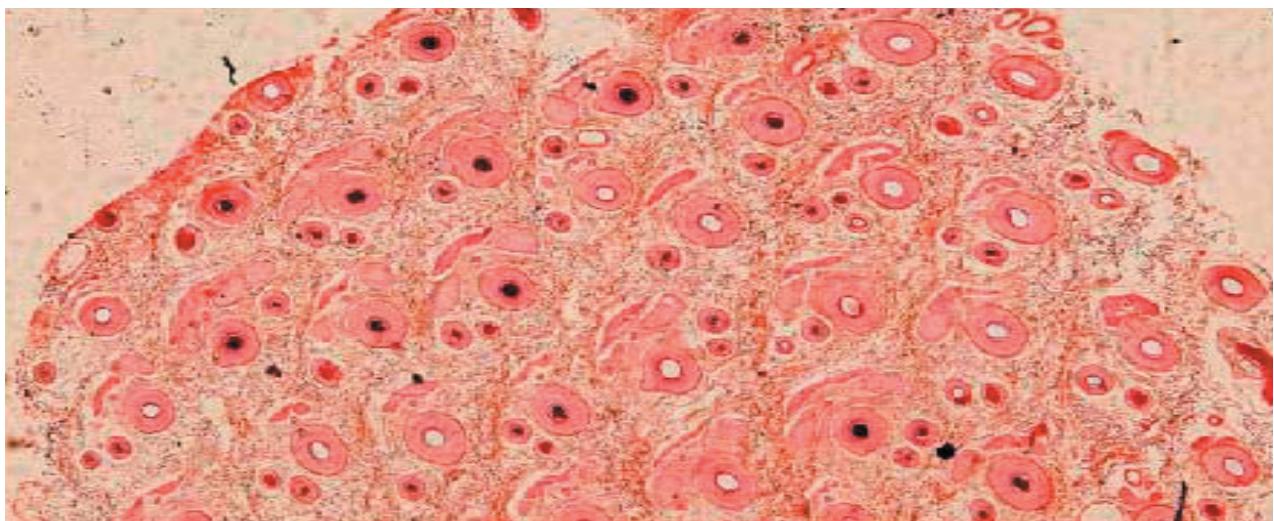
coarse fibers. This is mainly observed in large-diameter fibers as for Woods and Orwin (1982).

Wool follicle arrangement (primary and secondary) determines wool characteristics. Primary follicles give rise to coarser wool whereas secondary follicles give rise to true finer wool. Ratio of primary (occurs in trios) to secondary follicles determines wool density and fineness with Merinos having 15-25 of sec/prim ratio, Omani sheep (Table 2) would therefore have very coarse wool with a minimum number of primary and secondary follicles as well as low secondary/primary ratio. In specialized fine wool breeds such as the Merino, primary follicles are arranged in the form of three "trios". Other arrangements such as line and rectangular, are also observed in coarser wool breeds. Omani sheep follicles are arranged in line with very few secondary follicles (Figure 5).

#### Potential of Wool Production from Omani Sheep

Although it may currently appears to be a product of less significance, wool production from Omani native sheep may be improved as an extra source of income to farmers. Gatenby (1986) pointed out two major economical advantages of wool production in the tropics. First, there is no antagonism between meat and wool production, as the increase in body sizes tends to increase fleece weight. Second, wool production can be economical in arid areas

**Figure 4.** Micrographs showing various types of wool fiber structure in Omani native sheep.



**Figure 5.** Histological section of Omani sheep skin showing the arrangement of primary and secondary fibers.

with meager nutritional resources, as wool can grow even if sheep are losing weight. It is understood that in order to improve the wool industry, attention should be paid not only to genetical improvement of sheep, but also to improved management, nutrition, shearing operations, handling and storage of wool. To improve fleece quality characteristics experts may assess wool on living animals by visual appraisal and without sophisticated methods. Therefore, Omani natives may be trained to do on-farm assessment of promising wool-producing animals. There are some individual sheep selected for their pure white color and finer fibers at Wadi Qurayat Breeding Center (Dr. Tagelsir Ali, personal communication). Such sheep would be more suited for improved wool production in Oman. Improvement of fineness of wool is important but it should be taken into consideration that there is a negative relationship between wool quantity and quality as wool weight per unit of metabolic live weight significantly decreases with decreasing mean fiber diameter (Saul *et al.*, 1993).

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