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Newsletter of the European Network for Increased competitiveness of high quality European Animal fibres by improving fibre quality

Editorial

by Claire Souchet, Project Administrator

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The Thematic Network - Increased Competitiveness of High Quality European Animal Textile Fibres by Improving Fibre Quality, FAIR3 CT96 1597 - is arriving at the end of its second year of existence, with still one year to go. The activities of the Network, since the last EFFNnews issue, have been varied and fruitful.

The third EFFN workshop, held in Belgium, close to the German border, in September, was very successful, with great enthusiasm being shown from the participants. This workshop, on "*Quality assessment and the requirements of the fibre manufacturing industry*" was hosted by Dr K-Ho Phan (DWI, Germany), in Kelmis, on 4 and 5 September 1998. Thirty participants were present, mainly from the fibre manufacturing industry. The discussions were fruitful and allowed the implementation of the fibre manufacturers' points of view regarding fibre quality. More information is given in this newsletter and a full report has been published (*Quality Assessment and the Requirements of the Fibre Manufacturing Industry, Report of an EU workshop held in Aachen, Germany*. Available from the EFFN administrator).

The preliminary results of the Round Trial, on fibre quality measurements, using the OFDA method for cashmere and mohair, were presented during the third workshop by Dr K-Ho Phan (DWI) and Ms Claire Souchet (MLURI). A complete analysis of the results is now being prepared.

The last workshop of the EFFN workshops series will take place in 1999, probably in September, in Portugal. It will be on "*Development of breeding schemes for European-produced speciality animal fibres*" and will conclude the themes and discussions of the three previous workshops.

Finally, after the great response following the publications of the earlier newsletters, we hope that this fourth issue will continue to be of interest and we look forward to hearing further from those who will receive it. Articles are welcome; do not hesitate to contact the network administrator, Ms Claire Souchet.

Inside this volume:

The Quality of Fine Wool in Portugal-Preliminary Results

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Presented to the Fine Wool session of the 3rd EFFN workshop on "Quality assessment and the requirements of the fibre manufacturing industry".
4 - 5 September, Kelmis, Belgium.

Introduction

Sheep are bred in Europe essentially for the production of meat and/or milk. Today, wool produced represents a liability for the breeder, as the selling price does not cover the expenses of shearing, which is a physiological necessity for the animal (Gallico, 1994).

In the last few years, wool prices have been decreasing, due to world crisis within the sector, and most of the wool produced in the EU´s countries is of moderate to poor quality, which cannot properly be classed as "fine fibre". However fine wool of high quality has been "rediscovered" by the fashion industry in recent years in many European countries and there has been an increase on the international markets for such garments. In Europe, wool merchants and textile processors import large lots of wool, which have been rigorously graded and meet rigid specifications. They are reluctant to buy small batches of locally grown wool, which are of variable quality and often heavily contaminated with vegetable matter (Russel, 1998). It is therefore relevant to re-evaluate the present situation and try to improve, or at least maintain, the wool quality of some flocks.

It is also necessary for breed societies to redefine and reintroduce "wool quality" into genetic selection criteria, so that improved breeding stock for more traits may be identified. This objective fits into the national policy of conservation of genetic resources of indigenous breeds. Therefore, it is important to carry out an objective and directed survey of wool quality and to identify the best genetic basis, in order to set up an initial fine wool flock with a fibre diameter of < 20 µm.

The objectives of this work were to describe the quality of fine wool produced in Portugal (taking fineness as the basis for the evaluation), and to identify the existent correlation between the current classification, based on a manual grading scheme and laboratory evaluation.

Materials and Methods

This work was done on the basis of samples graded by the graders as fine wool samples (AA Extra). This was based on the Portuguese official wool grading system classification, which comprises five classes (Table 1)

Table 1 -The Portuguese official wool grading class

AA	**Extra** - Merino Extra **Fino** - Merino Fino	**19 - 22 µ** **21 - 23 µ**
A	**Corrente** - Merino Corrente	**22 - 25µ**
B	**Primas** - Primas **Primas** - X Médio **Cruzados** - X Médio **Cruzados** - X Comum **Cruzados** - X Lustroso	**25 - 29 µ** **29 - 32 µ** **28 - 30 µ** **30 - 35 µ** **28 - 36 µ**
D	**Merinos Defeituosos (E,F,C)** **Cruzados Defeituosos (P,X)**	**DM** **DX**
Aninhos	**Lamb wool (1st shearing)**	
Peças	**Belly and head wool**	

The wool grading was carried out in three different places (Castelo Branco, Évora and Beja). The samples were taken randomly from the classes AA and A, which correspond to the Subclasses Extra Merino (ME) (n = 42), Fine Merino (MF) (n = 54) and Current Merino (MC), (n = 51). Within each subclass, samples have been collected from each one of the three grades of yield.

A significant part of the wool production of interior Centre and South Portugal are centralised in these three locations, where the two breeds of Merino prevail. In the Centre, the Beira Baixa Merino (Castelo Branco) is present and in the South, it is the White Merino (Alentejo) which represents the highest proportion in the sheep population (1.300.000 animals).

Yield grading was based on an individual fleece evaluation (tactile and visual assessment of the content of grease, vegetable matter, mineral matter and other material other than wool fibre) and was divided into three different grades: Grade 1 (62%), Grade 2 (57%) and Grade 3 (53%).

Samples have been taken from the mid-side (4.5 cm^2), based on the proposed measurement procedures from the EFFN (1997).

Laboratory analysis for Yield and Fibre Diameter (using the OFDA, according the IWTO 47-95) was carried out at the Macaulay Land Use Research Institute (UK).

Results and Discussion

Fineness:

The average fineness, evaluated by OFDA, of the samples classified as ME and MF, and of the samples classified as MC showed significant differences (22.0 µm & 22.7 µm *versus* 25.3 µm) (Table 2).

Table 2 - Fineness diameter and Yield in the three regions of wool and for the three grading classes.

	n	Diameter - OFDA (µ)	Yield (%)
Grading Class			
ME (19-22µ)	42	22.0 [a]	58.6
MF (21-23µ)	54	22.7 [a]	60.3
MC (22-25µ)	51	25.3 [b]	60.6
Region			
CB	50	23.2	57.1 [a]
E	49	23.4	60.4 [ab]
B	48	23.4	61.8 [b]
Total/Mean	147	23.3	59.8
SD	na	1.65	8.50
S Grading	na	*	NS
S Region	na	NS	*

Nota: S - Significance for $P < 0.05$; a and b - Indexes that, when similar, indicate that averages are not significantly different; n - number of samples; OFDA - Optical Fibre Diameter Analyser; CB- Castelo Branco; E- Évora; B- Beja; ME - Extra Merino; MF - Fine Merino; MC - Current Merino; SD - Standard Deviation; SRegion- Significance for Region; SGrading- Significance for Grading; *- Significant Differences; NS - Non significant.

The correlation found between the subjective grading and the laboratory evaluation of the diameter (OFDA) was not particularly high (0.6182). That could be due to the fact that, in the range of variation of the fineness of the classes, there was an overlapping among adjacent classes. This meant that wool, that can be identified as 22.0 µm, was, on the basis of the tactile grading and other subjective components, classified as ME or as MF.
Nevertheless, it should not be forgotten that the subjective evaluation was done on the whole fleece, while the laboratory evaluation was done on samples taken at a specific site (mid-side of the animal).

The mean fibre diameter evaluated by OFDA were not significantly different ($P > 0.05$) according to the regions where the samples of fine wools were obtained (23.2 µm, 23.4 µm & 23.4 µm in the areas of Castelo Branco, Évora and Beja respectively). A high homogeneity of the wool produced in the three areas of the interior Centre and South of Portugal was observed (Table 2).

Yield:

Concerning the yield, no significant differences were observed ($P > 0.05$) among the averages of the yield of each class. The yield varied from 58.6% in the ME (19 µm - 22 µm) to 60.6% in the MC (22 µm - 25 µm). However, this parameter, varied from region to region, with significant differences between the regions of Castelo Branco and Beja (57.1% and 61.8%) (Table 2).

These results could be due to the handling system and also to the purpose of production. In the region of Beja and Évora, where the highest yield was observed, the flocks are essentially kept in a purely extensive system, based on grazing, and directed to meat production. In the region of Castelo Branco, where the yield was lower, the flocks of Beira Baixa Merino are bred for milk purposes; the animals are kept in an intensive production system, based on grazing, and are daily subjected to a high stocking density, because of the need for milking. The animals were either confined (during winter) or outdoors (end of winter and spring). Confinement can last from the beginning of the night milking to the end of the next day morning milking. This leads to a higher degree of wool contamination and to the consequently lower yield.

Grades of yield:

The yield averages of the three lots by OFDA showed significant differences to each other (55.5% *versus* 59.1% *versus* 63.6% for the lots 3, 2 and 1 respectively) (Table 3); this confirmed

the difference between the lots obtained by the graders. It can be seen that the yield obtained in the laboratory was about 2% higher than the expected yield assessed by the graders.
It was necessary to point out that, between each grade of yield, there was a difference of about 4%, which lead to a difference of 8.1% between lot 1 and lot 3. This has consequences in terms of marketing and industry.

Table 3- Comparison between the yield of wool grading by the technicians and the laboratory results

Yield grading	n	**Yield (%)**
1(62%)	53	63.6 [c]
2 (57%)	53	59.1 [b]
3 (53%)	41	55.5 [a]
Total/Mean	147	59.8
SD	na	8.03
S	na	*

Future of fine wool produced in Portugal:

The distribution in classes of the mean diameter of the samples, determined by OFDA, showed that 36.1% (53/147) of the analysed wool was fine, with less than 22.5 µm of diameter. Only 4.1% of the samples showed diameters lower than 20 µm. However 32,0% of the samples showed diameters that vary between 20 µm and 22.5 µm.
These results, obtained by random sampling, and the fact that wool samples were found with 18.1 µm, suggest that there is sufficient variability to allow the improvement of the fineness characteristic.
This work is timely since it implies that an increase of the fibre diameter, with a decrease of animals with diameters lower than 20 µm, has been happening. Work done by Morais (1938) sixty years ago showed that, in some regions in the South of Portugal, it was still possible to find 20% of animals with wool diameter lower than 20 µm.

Table 4- Evaluation of the percentage of fine wool

	<20µ	[20 - 22.5µ[	[22.5 - 25µ[	>=25µ	Total
n	6	47	60	34	147
%	4.1	32.0	40.8	23.1	100.0

Conclusions

The results obtained by the evaluation of the fineness by OFDA revealed a reasonable correlation with the subjective grading based on tactile and visual assessment.

The continuation of this work within the project “Evaluation of fine wool in Portugal” is essential. However, the preliminary results obtained and presented are enough to conclude that more than 35% of the wool produced in Portugal (from 1.3 million animals of the breed Merino) can be classified as fine wool, with a diameter less than 22.5 µm. It seems that genetic variability exists within the population, which allows the real possibility of improving the wool fineness characteristic.

The homogeneity of the wool obtained in each subclass and the differential of the found yield, allows to conclude about the real advantages of the marketing and industry of these classified wool. For example, the 8.1% of yield loss, between lots 1 & 3, would lead to a great economic loss, when dealing with large quantities of raw material.

The results obtained emphasise the quality of the work done by the graders, who act as protectors of the quality of the product offered to the market.

In Portugal, the maintenance of the wool grading systems is recommended. However, it is necessary to associate the vocational and objective training of new technicians, in order to accomplish this task. If this aim can be reached, it would be possible to be less dependent on the importation of high quality raw materials and from the preservation of international markets. The added value, lost in the import process, would be retained in the production area (Russel, 1994).

At the European level, a labelling system could protect the European fine wool (Corcoran, 1994). It would have an impact at the production level (increasing income from sheep production, settling rural population in LFAs), at the industry level (availability of fine wool produced in the EU suitable for the market demands), at the consumer level (providing a certified product) and at the research level (which must provide answers to the needs of the whole chain).

It would be, however, necessary to establish a quality grading for European wool and a standardisation of the classification methods, in order to establish quality-related price scales (Pinto de Andrade *et al.*, 1997), as well as the creation of an European wool marketing infrastructure (Russel, 1998), which would be responsible for grading and marketing and could guarantee a high standard of presentation and quality of fine wool, and thus, to assure a higher added value to wool production.

Note 1: The authors thank the invaluable support of Dr. M. Martins Abrantes, and Eng$^{os.}$ J. Chabert, A. Ramalho and A. Amarelo who integrated the team of wool classifiers in Portugal.

Note 2: This study is part of the output from the project "Evaluation of Fine Wool in Portugal" INTERREG II nº 98.09.5050.5

Bibliography

CORCORAN, K. (1994). Opportunities and Constraints for a European Fibre Industry. Fine Fibre News, 3. 24-29.

EUROPEAN FINE FIBRE NETWORK (1997). "Development of European Standard for Objective Measurement of Genetic Selection Parameters Based on Quantity and Quality". Workshop Report 1. 20-21.

GALLICO, L. (1994/95). The importance of wool and speciality fibres for European rural development. Fine Fibre News, 4. 1-4.

LANNER, (1995). Report on "The importance of the wool industry for rural areas in difficulty". Presented to the Parliamentary Assembly of the Council of Europe on 10th July 1995.

MORAIS, M.C. (1938). Estudo Zootécnico das lãs Nacionais. Separata do Boletim da Estação Zootécnica Nacional. III (3): 28-29.

PINTO DE ANDRADE, L., ALBERTO, D., VARZEA RODRIGUES, J. and CHABERT, J. (1997). " Typical Livestock Products and Rural Development- The study case of Fine Wool". 2th European Worshop of the LSIRD network.- "Improving market integration and value-adding in domestic livestock enterprises in disadvantaged regions- the implications for future research:" University of Kassel, Witzenhausen, Alemanha. 27-29th September.

RUSSEL, A.J.F. (1994). The role of fine fibre producing animals in European agriculture. European Fine Fibre Network, 1: 3-10.

RUSSEL, A.J.F. (1998). Fine Wool: Design of a common database and common recorded traits. European Fine Fibre Network, Worshop Report 2: 34-37.

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Characterisation of fibre diameter profiles

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1. Introduction

Fibre fineness and fibre length are among the most important characteristics of staple fibres, with respect to their spinnability and the performances of the products. The mean values of these characteristics are essential, but so are the variance or other parameters from the corresponding distributions, especially for wool or other natural fibres.
The existing instruments, for the measurement of fibre length distribution and fibre diameter distribution, give such information. However, as the length and diameter measurements are performed on separate instruments, no detailed relationship (i.e. for each fibre from a test specimen) between length and diameter characteristics of individual fibres can be obtained in this way. Moreover, for diameter characteristics, the existing instruments perform the measurement on a single fragment for each fibre. Thus, no information is obtained on the diameter variability along the fibres.

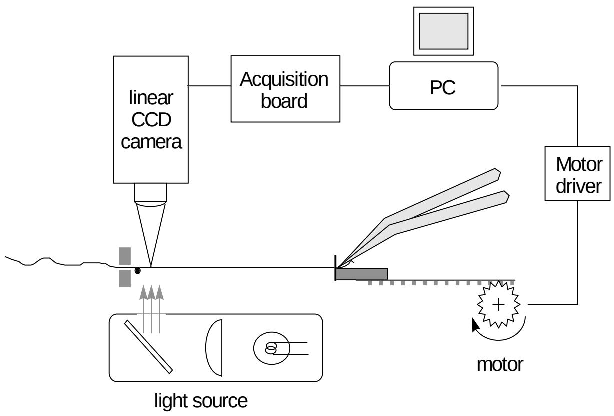
In view of studying these characteristics, we developed a prototype instrument - the *Fibre Profile Meter* - which measures semi-automatically the diameter variation along single fibres. Several relevant characteristics, regarding the diameter variation, are computed thereafter, as well as the length of each individual fibre.

2. Principle of the instrument

A schematic representation of the instrument is given on Figure 1. Its principle is to move a single fibre at constant speed under a high magnification electronic CCD camera which observes the image of a narrow line, perpendicular to the fibre axis. By sliding the fibre from one end to the other, slightly tight, under the camera, the extended length (i.e. uncrimped) of the fibre is measured. Simultaneously, the transverse dimension of the fibre is computed by analysing the video signal from the camera. Successive signals, corresponding to successive sections of the same fibre, are analysed at a high rate. In this way, short-term, as well as long-term, variations in the diameter along the fibre can be observed, and corresponding parameters are computed.

The instrument operates in a semi-automatic mode: the fibre is drawn manually from a sample and held at one end by means of tweezers. The measurement then proceeds automatically, by pulling the fibre at a constant speed under the camera until the fibre end is detected.

Figure 1- Principle diagram of the Fibre Profile Meter



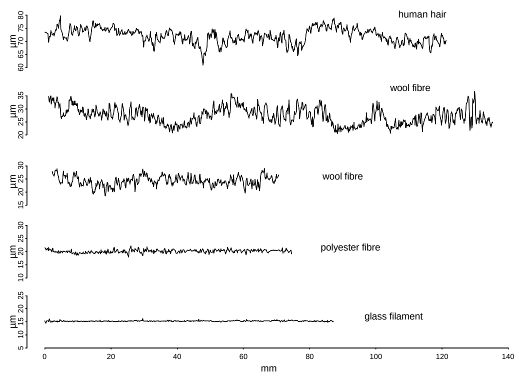
3. Performances

The complete cycle for a single fibre measurement is about 16 seconds, including the selection of the fibre, its introduction in the instrument, the measurement itself and the computing of the relevant parameters.

Practically, this present instrument allows the measurement of fibres whose length and diameter are greater than about 20 mm and 10 µm respectively. These lower limits are not strictly fixed by the instrument but more by the ability of the operator to handle very fine or short fibres.

During the measurement on a single fibre, successive individual diameter measurements are performed every 150 µm along the fibre. The corresponding individual data can be stored in a file; this procedure allows the plotting of the full profile of the fibre. Examples of such plots are given in Figure 2, which corresponds to a human hair, two wool fibres, a polyester fibre and a portion of a glass filament. The short-term variations observed specially on wool and human hair may appear intriguing, but are in fact due to the presentation of the data with the abscissa and ordinate scale in a ratio of about 1000. The observed variations are rather smooth when observed with equivalent scales. Repeated profile measurements have, however, been performed on the very same fibres; they show a very good reproducibility.

Figure 2- Typical fibres profiles



The precision of the length measured for a single fibre is evaluated to ± 1 mm and is mostly due to the uncertainty in gripping the end of the fibre with the tweezers. For diameter measurements, the precision is much more difficult to determine; on the basis of the experiments conducted until now, the precision for the mean diameter measured on a single fibre, which depends on many parameters, is evaluated to be typically ± 0.2 µm.

However, one limit of the described equipment has to be mentioned. This equipment measures the transverse dimension of the projected image of the fibre. For fibres with a circular cross-section, it corresponds to the fibre diameter. For a non-circular cross-section, the measured dimension is the apparent width of the fibre. In that case, the measured dimension can be some form of average between the minimum and maximum width, but it can also be biased if the fibre has a tendency to lie with a preferred orientation with respect to the camera axis.

4. Presentation of the results

Several parameters relating to each individual fibre are evaluated and displayed after each single fibre measurement. The most relevant are the following:

- extended length (i.e. uncrimped)
- mean diameter (along a single fibre)
- coefficient of variation (CV) of diameter (along a single fibre)
- maximum diameter and its position along the fibre
- minimum diameter (weak point) and its position along the fibre
- maximum absolute gradient of diameter and its position along the fibre

When performing the profile measurements on a collection of fibres (e.g. fibres sampled from one staple or fibres drawn from a test specimen), statistical data are easily computed, such as:

- mean extended length and CV of extended length
- other length distribution statistical parameters (quartiles, percentiles)
- overall mean diameter (mean of the individual mean diameters)
- overall CV of diameter (CV of the individual mean diameters)

5. Discussion

Numerous applications of the *Fibre Profile Meter* can be found, which could be of interest for woolgrowers, topmakers, spinners, etc.

A first possible application is the characterisation of wool staples at the fibre level. As most of the fibres within a staple have a similar behaviour during the fibre growth, it is possible to determine a number of important characteristics of the staple (length, mean fibre diameter, minimum of diameter along the staple, position of minimum diameter) from the measurement of the fibre profiles on a limited number of fibres drawn from the staple. The determination of the staple profiles, i.e. the variation of the mean fibre diameter along staples, can be an effective approach in the study of wool growth effects arising from the times of shearing and lambing. This is of potential interest not only for woolgrowers, but also for topmakers, by providing additional information for the prediction of topmaking performance.

Another possible application of the *Fibre Profile Meter* is in the prediction of the prickle properties of apparel fabrics. Studies have shown that the perception of "prickle", when wearing next-to-skin garments, is due to the presence of coarse fibre ends protruding from the fabric surface. A critical parameter in the prediction of prickle is the percentage of coarse fibres in the fibre diameter distribution (coarse edge). In a more realistic approach, the diameter distribution of fibre ends is essential to consider. In this respect, the *Fibre Profile Meter* can easily provide the relevant information, through the measurement of single fibre profiles.

It is likely that other interesting applications of the *Fibre Profile Meter* can be found for fibres other than wool and even in other fields, such as the study of human hair properties.

6. Conclusion

This instrument has been developed to allow the simultaneous measurement of length and diameter characteristics on individual fibres. The fibre diameter profile can be obtained as well as other detailed dimensional characteristics of the fibres.

This makes this instrument a unique tool for laboratories involved in the study of fibre characteristics. The *Fibre Profile Meter* is applicable to most of the staple fibres and even for filaments, in view of the study of the diameter regularity. It can also be useful in other fields like, dermatology or cosmetology, where the dimensional characteristics of human hair are of importance.

Soft Rolling Skin: Is it a Watershed for Alpaca Production?

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Alpaca breeders in Australia are increasingly facing the challenge of producing top quality fibre. However, there are misconceptions as to most suitable methods to use.

It is curious to observe how methods for selecting superior sires in the showring are imposing the law in the Alpaca industry in Australia, despite such methods having proven to be of little genetic value in other industries. Furthermore, it is interesting to realise that, within alpaca judging in Australia, there are no defined standards of assessment, but mainly a set of judges' personal preferences. Judges' interpretations range from selection of nice standing animals ("since champions stand by themselves", as was one judge's comment) to borrowed and erroneous ideas from the wool industry (e.g. "the wool must look [crimp] fine to test fine"). If personal preferences and assumptions are to be the benchmarks, the usefulness of the showring is in question. Show competitions should then likely be seen as a marketing tool and as an opportunity for social interaction amongst industry people, and not as a place for improving the quality of the livestock.

Historically, no clear correlation has been established between show prizes and the genetic potential of an animal to improve the economic characteristics of its offsprings. Consider the alpaca fleece as an example. Fine crimp and solid lock are often favoured by judges. Such an animal lacks the density of wool follicles in its skin to generate high fleece weights of fine and uniformly grown fibres. Instead, the fleece is composed of unevenly grown and entangled fibres that break more readily during processing. It is the opposite, i.e., bold and deep crimp on thin locks, composed of highly aligned fibres bundles, that are required. Consequently, some sires crowded with show-ribbons produce poor breeding results. Some are also disseminating genetic faults.

What is the solution? Is the objective identification of performance of an animal using individual characteristics of economic importance (such as fleece weight and fibre diameter) in index selection schemes the best way to go? Watts J. and Ferguson W.K. (1998, pers. com.) argue that Merino breeding experiments, based on clean fleece weight and fibre diameter selection, which led to the formulation of an index system called WOOLPLAN, did not and could not deliver the results anticipated. Their argument is that, like many methods embodied in traditional practices, it does not tackle the central issue of maximising the development of secondary wool follicles in the animal's skin, which is essential for elite fibre production combined with high fleece weight.

The question that the Australian alpaca industry should face is: "what is then the way to go?". Is there a simple and accurate method of identifying alpacas, whose fleece structure is indicative of the quantity and quality of fibre they are capable of producing and transmitting to their offspring?
This paper endeavours to evaluate, from a critical farming systems perspective, a method that encompasses a multiple set of practical components of on-farm functional selection of superior animals, recognised as the *Soft Rolling Skin*ò approach (Watts J.J., 1992, 1996).

SRSò had its start in Merino research. It is the outcome of comparing selection programs based on quantitative genetics of individual characteristics and on a holistic visual selection method developed in the course of advisory work, at the farm level, based on observations of fleece structure and its correlation with the underlying skin histology and fine structure of the fibres (Watts J.J., 1992).

It was obvious (Watts J., 1998, pers. com) that this visual method, encompassing traditional characteristics of wool quality, in a systematic manner, (i.e. softness, crimp definition, crimp frequency, uniformity of crimp and bundling over the body) was producing an animal of better qualitative and quantitative wool characteristics, the ultimate objective of the selection process.

The principles of SRSò are supported in Carter (1943, 1968), Carter and Hardy (1947), Hardy and Lyne (1955), Moore et al. (1989) and Watts (1992, 1996).

SRSò is being used in the alpaca industry now (Watts, 1996). It is based on recognition of fleece properties that reflect the levels of secondary follicle development in the animal's skin and, as a result, the quantity and quality of fibre the animal produces. In the Merino industry, this breeding system is forcing change to traditional breeding practices that have endured for over 100 years. Naturally, it is having an uncomfortable impact for some sectors.

1-What is the Soft Rolling Skin (SRSò) Approach?

In the skin of every fleece-coated animal, there are wool and/or hair follicles that produce the fibres, which constitute the fleece. Each follicle produces a fibre. The follicles are clustered together into distinct groups that are repeating structural units all over the animal's body. In each group, three primary follicles are found, and many more secondary follicles.

The SRSò approach is concerned with breeding animals with greatly increased numbers of secondary follicles in each group. The purpose is to put more follicles in the follicle group and position each follicle closer to another. In this way, there will be more fibres in the fleece and each fibre will be finer, more evenly grown and aligned. Because the biological limit is three primary follicles per follicle group, the "density" of follicles sought must come from animals with greater number of secondary follicles in each group. This is why sires with superior secondary follicle numbers will play a major role in the improvement of the genetic potential of Australian alpacas.

The average Australian alpaca has seven secondary follicles to each primary follicle (an S/P ratio of 7 to 1 or 21 follicles per mm^2 of skin). This is a low figure, reflecting inadequate numbers of secondary follicles in each follicle group. As a result, there are too few fibres in the alpaca fleece to produce high fleece weights. The fibres are usually strong in fibre diameter, uneven in size and shape, frequently medullated and invariably entangled. By breeding on SRSò principles, the level of secondary follicle development can be raised quickly and permanently.

For example, the S/P ratio of the Australian Merino averages 21 to 1 (or 63 secondary follicles per mm^2 of skin), and forms solid locks of entangled fibres. The SRSò Merino has an S/P ratio above 45 to 1 (or 135 secondary follicles per mm^2 of skin) and with twice the number of fibres (compared with the average Merino), with heavy cutting and fine fleeces composed of long, evenly grown and highly aligned fibres (Watts J., 1998, pers. com.).

The SRSò approach predicts that, if the level of secondary follicle development in the alpaca is improved by a margin similar to that already accomplished in Merinos, then the fleece fibres will similarly become finer, longer, better aligned and more evenly grown. The animals will cut heavier weights of fine fibre that is free of the processor's cruse, the medullated fibre. One of the crucial points of the SRSò system is that the levels of secondary follicle development are accurately reflected in the nature of the fleece surface and fleece structure of the animal. More specifically there are fibre properties, namely softness of handle, bold and deep crimp, lustre and fibre bundle formation, that allow alpaca breeders to systematically identify and rank animals according to the individual's expected levels of secondary follicle development. As a result, breeders adopting this system are able to select the better fleeced animals for breeding with a much greater level of assurance of the breeding outcome than previously has been possible.

The SRSò procedures are subjective in their operational implementation, but emphasise the importance of traditional wool characteristics in a systematic (i.e. inter-related) manner. By comparison to the solely quantitative approach to selection of superior animals, the traditional criteria of wool quality, that the SRSò approach rescued, were bundling (fibre alignment), handling (softness), character (deep and bold crimp definition) with uniformity of crimp and fibre over the body, and fibre lustre.

2-What are the Practical Components of the SRS Approach Applied to Alpacas?

Since the main characteristic of high S/P follicular ratio is visually undetectable, it is necessary to look for outward signs. Watts (1996) states that the fleece surface should look like a "laundry mop" composed of fibres bundles, not staples (fibre bundles are not thicker than a match stick). The fleece looks untidy and shaggy but on careful inspection, it is a most impressive fleece by virtue of the deep even crimp in organised bundles, its soft handle and absence of any hint of two-coatedness.

The components, that are more evident when the structure of the fleece is examined in the parted fleece, namely are:

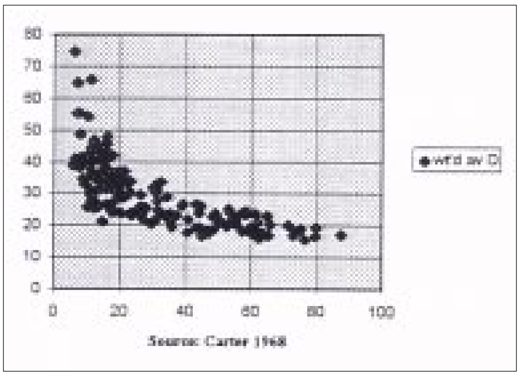
a) Bundling: understood as the organised alignment of fibres that grow from each follicle in the skin. There is virtually no fibre entanglement, so that the boundaries of each closely set bundle are visually discernible.

b) Bold and deep crimp: Boldness of crimp (as opposed to fine crimp) means the distance the peaks of each crimp "wave" are spaced far apart. As wool crimps approximately every seven days, the bolder the crimp, the faster is the growth of the fibres that comprise the fleece. Deep crimp indicates that the amplitude of the crimp is high. It is synonymous with the fleece being said to be "well-marked" or having a "good character". High fibre alignment is essential for the fleece fibres to be collectively deep crimping.

c) Lustre: is the intensity of light reflection from the fleece. It depends, for its maximum expression, on the fleece fibres being highly aligned, cylindrical in shape and smooth surfaced. High levels of secondary follicle development deliver this type of fibre assembly.

d) Softness: which is maximised as fleece fibres become finer, more evenly sized, smoother surfaced and bolder crimped. Carter's results (1968), in Figure 1, show the relationship between total fibres per follicular group and the average fibre diameter of secondary-derived follicles. The slope of the relationship is negative, indicating a negative correlation between the number of fibres per follicular group and the fibre diameter. This suggests that, as practical methods are used to increase the number of secondary derived follicles in the histology of the skin, more fibre will be concentrated in the same skin area, thus giving a lower micron count.

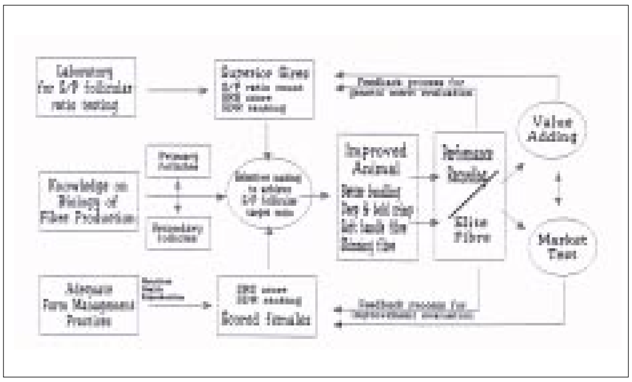
Figure 1- Relationship between Follicular Density (Y) and Fibre Diameter (X).



3- What are the Practical Implications of the SRSò Approach to Alpaca Management?

The SRSò approach is a systematic process to selection of advanced fleece alpacas integrating consumer and processing requirements with the breeding and marketing of the fibre. Figure 2 shows that there are three basic components to undertake a SRSò exercise.

Figure 2- A Farming Systems Perspective of Elite Alpaca Fibre Production



Firstly, it is necessary to have a clear basic understanding about the biology of fibre production, integrated to laboratory testing of secondary follicles to identify the S/P ratio of each stud sire, and proper management practices at the farm level. Secondly, selective mating, using properly S/P ratio tested sires and scored females, will produce the improved next generation of animals in the targeted characteristics of economic importance. Finally, the third component implies an exercise in performance recording, in order to check genetic gain and production increase comparatively between generations of animals. The market test of SRSò fleeces closes the exercise.

SRSò is a simple, but extremely consistent, way to manipulate secondary fibre follicle development indirectly by identifying how many of the components of the "fleece package" (fibre bundle formation, bold and deep crimp, lustre and softness) are present in the fleece of an individual animal. It is a focused breeding pathway that minimises primary follicle development (eliminates two-coatedness), allowing maximum secondary follicle development to be expressed. The skin progressively becomes looser, producing a "soft rolling" blanket cover of high value fibre.

The SRSò approach rejects the concept of the "saddle" as the natural place for locating the highest quality fibre on an alpaca. It brands this as a "transitional stage" in the modern evolution of alpacas, in which vestiges of the primitive two-coatedness produced by over-sized primary follicles, as are typically seen in the vicuna, remain. It emphasises that high quality fibre should extend to the entire fleece-bearing surface of the alpaca, from behind the ears, down the neck and apron and behind the legs. The simple fact is that a SRSò alpaca should have a very high level of secondary follicle development, that allows 100% of the body area to produce elite fibre.

SRSò provides a logical system to visually identify and grade animals, so that appropriate mating pairs can be determined. This is simply done through identifying the strengths and weaknesses in females for both fleece and body size and structure. For example, an observer may choose to allocate a score of the fleece up to one point for each component of the "fleece package" (i.e. bundling, crimp, softness and lustre). Females can be classified clearly into fleece types: "wool", the best fleece expression of high secondary follicle development; "frame", next best fleece expression together with outstanding body size, structure and bone; "flat skin", reflecting low follicle density and lacking crimp definition ("crinkled" fibre or fine crimped), lustre and fibre bundles; and "primitive" in which very low density and two-coatedness of the fleece is evident even throughout the body saddle. Males are not considered for use, unless they have high levels of secondary follicle development coupled with correct conformation and good constitution. Males must definitely be of the "wool" or "frame" type in order to ensure a minimal threshold of genetic improvement.

4-Conclusions:

a) Alpacas are still in a primitive stage, related to their histological constitution, for the production of elite fibre. The current S/P follicle ratio is evidence of this. A fundamental condition for the production of elite fibre is given by the presence of large numbers (as large as possible) of secondary follicles in the skin of the animal. The larger the secondary follicle numbers, the better will be the S/P follicular ratio.

b) Fibre bundles, and not staples (i.e. locks) are the basic unit of fleece structure. The better the bundling, the closer and the deeper the crimp becomes. A high number and density of secondary follicles in the follicle group of the skin forces the fibre to be long and fine. Long fibres are fast-growing fibres and will appear as a bold crimp, as well as a deep crimp. The fibre will automatically be very soft and lustrous.

c) There is the opportunity to adopt a holistic approach to elite alpaca fibre production which has SRSò selection as the central focus. Surrounding it, one can integrate a whole set of possibilities ranging from farm management practices, individual animal assessment, and "typing" for mating for best breeding outcome, diagnostic skin testing, progeny testing and breeding performances, through to value-adding the alpaca fibre according to its enhanced processing performance.

d) Alpaca show judges need urgently to define fleece standards that equate to biological standards. Present evidence is that many judges are unwittingly selecting against the superior fleeced alpaca by not recognising, nor understanding, the significance of the bold deep crimp that forms fibre bundles.

e) Alpaca breeders should also organise a stud sire register and a performance recording system. These initiatives will ensure that reliable public information is available and informed decisions can be made. These are simply starting points of any serious program to produce elite alpaca fibre.

f) Though it is still an early stage to confirm the effectiveness of SRSò methods in the genetic improvement of alpacas, the initial results are indicating that, when superior sires, with strong genetic dominance are used, the SRSò principles are operational in producing superior progeny.

References

CARTER, H. B. (1943). Studies in the Biology of the Skin and Fleece of Sheep. Council for Scientific and Industrial Research, Bulletin 164.

CARTER, H. B. (1968). Comparative Fleece Analysis Data for Domestic Sheep: The Principal Fleece Staple Values of Some Recognised Breed. Agricultural Research Council, n.c.

CARTER, H. B. and HARDY, M. H. (1947). Studies in the Biology of the Skin and Fleece of Sheep: The Hair Follicle Group and its Topographical Variations in the Skin of the Merino Foetus. Council for Scientific and Industrial Research, Bulletin 215.

HARDY, M. H. and LYNE, A. G. (1956). The prenatal development of wool follicles in Merino sheep. Australian Journal of Biological Science, 9: 423-441.

MOORE, G. P. M., JACKSON, N. and LAX, J. (1989). Evidence of a unique developmental mechanism specifying both wool follicle density and fibre size in sheep selected for a single skin and fleece characters. Genetic Research Cambridge, 53: 57-62.

WATTS, J.J. (1992). Breeding Towards Better Sheep and Better Wools., in Proceedings of Michell Sheep Forum, 24 April 1992, Walte Agricultural Research Institute, Adelaïde, pp. 74-84.

WATTS, J.E. (1996). Breeding from Fibre to Fabric. Coolaroo Alpaca Stud, Elite Alpaca Production Workshops, Mittagong.

3rd EFFN Workshop in Kelmis (Belgium)

Claire Souchet

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The third EFFN workshop, *"Quality assessment and the requirements of the fibre manufacturing industry"* was held in Kelmis (Belgium), in September 1998. It was hosted by Dr K-Ho Phan (Deutsches Wollforschungsinstitute, Aachen, Germany). The purpose of this meeting was to involve the manufacturers and have their point of view regarding fibre quality. This would allow to further refine the parameters and recording protocols identified during the two previous workshops.

Dr K-Ho Phan (DWI, Germany) and Ms Claire Souchet (MLURI, UK) first presented the preliminary results of the Round Trial undertaken by the network for cashmere and mohair fineness measurements.

Participants separated into three discussion groups on fine wool, cashmere and angora/mohair. For fine wool, the processors' requirements have been identified, the most important criterion being the fibre diameter. It was concluded that for progress in the development of fine wool production in Europe, the wool quality has to be improved and wool grading and marketing infrastructure have to be developed. This was already outlined during the first two workshops. The British or Portuguese systems could be a basis for further developments. For mohair and angora, only a niche market is accessible to these fibres. The main criteria that would be required by processors have been identified by the processors in the different countries involved. The main requirements were to overcome the problem of measuring and defining medullation, kemp and bristle rate. The OFDA technique could provide a solution for their measurement. For cashmere, the most important criteria for processors have been identified within the group. Other objective measurement methods for traits, such as lustre and colour, will be investigated in the near future by the British and German partners.
A more detailed account is available in the workshop report (Contact the network administrator if you wish to receive a copy of it).

Two field trips enlightened the two days' discussions. The first was a visit to the scouring factory "Traitex", located close to Kelmis. The director, Mr Godin, who participated to the workshop, showed the group around and explained the principles of his factory. Then, participants had the opportunity to visit the Deutsches Wollforschungsinsitute in Aachen (Germany), situated next to the Belgium border. Dr Ho Phan and his colleagues explained the aims and research programs of the institute. A demonstration of the Optical Fibre Diameter Analyser was given and allowed the participants to understand better the technology and results from this equipment.

Mr Godin, from Traitrex, explaining to the group the principles of his scouring factory.

Breeding program for wool traits - The Fine Finnwool Project

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Background

No support was given to Finnish wool producers after Finland joined the European Union. Wool prices are therefore ruled by the spinning mills and they are fairly low (0.75-2.30 US$/kg). The genetic improvement of wool traits is not viable unless the wool is further processed. The Finnsheep wool can be recognised by its special characteristics, such as lustre, softness, lightness and elasticity. The wool is medium fine and has good felting characters. There is a good prospect for the development of Finnsheep wool products, assuming that the production is sufficient, the raw wool quality is uniform and the processed yarns are of high quality. Therefore, some joint efforts are needed to develop a functional and profitable wool chain, through the creation of a network. The same network could be then utilised in creating breeding programs for wool traits.

Project description and objectives

This 3-year breeding study (1997-99) is connected with the Fine Finnwool-project, which belongs to the EU Objective 5b, in the Varsinais-Suomi region. The aim of the first year of the study is to create a regional network of sheep breeders, who are interested in improving wool quality. The network will allow the determination of the recorded traits and criteria for assessment of wool traits, in co-operation with the rural advisory centre. Selection criteria, used in the wool line of Finnsheep nucleus flock, will be utilised in this study. The targets for the second year are to estimate genetic parameters for all considered wool traits, to estimate the breeding values, using animal model BLUP for wool quantity and quality traits, to start analysing wool samples for fibre diameter (measured with OFDA technique), and to work out the method of utilisation of elite sires. The ultimate purpose is to transfer the BLUP-system for wool traits to the national field recording scheme. Although the main breeding objective is to improve wool quality, other production characteristics, such as prolificacy and meat traits, are also considered.

Data recording and evaluation procedure

The first year's data (1997) included 600 Finnsheep lambs, sired by 24 rams from 22 flocks. Half of the animals were white and the other half, coloured. The flocks, with an average size of 27 ewes, belonged to the Finnish Sheep Recording Scheme. Besides identity and pedigree information, birth date, birth-rearing type, sex, age of ewe, 42-day live weight, 120-day live weight and live weight at assessment, were recorded. The following wool characteristics were assessed: staple length, fineness according to grades (60-48), number of crimps per 3 cm, density, fleece uniformity, staple formation and lustre (point scale 5-1). The evaluation of wool quality was carried out by a trained team. Fibre diameter measurements for small amount of wool samples, using Airflow apparatus, were carried out at the Agricultural Research Centre of Finland.

The second year data (1998) consisted of the records from 795 lambs, sired by 27 rams from 18 flocks. 49% of the lambs were white, the rest were black, brown and grey. The wool samples for the OFDA measurements were taken from the flocks of the Fine Finnwool project and, as a comparison, from the Finnsheep nucleus flock and another large pure Finnsheep flock. The samples will be analysed in the Macaulay Animal Fibre Evaluation Laboratory.

The target of the first year OFDA measurement is to determine the fibre diameter (fineness) in white and coloured Finnsheep.

The analyses of the second year of OFDA measurements will cover different sire lines and progeny groups.

Preliminary results

Table 1 shows means, standard deviation and coefficient of variation for each characteristic. The scores of the subjectively assessed fleece characteristics were averages of three values.

The highest variation was in evenness and staple formation. This was expected in this early stage of the project, since no selection for wool traits was carried out yet. Fineness grades, which are based on staple crimp, did not vary very much in the three locations, being somewhat coarser on the britch. The mean value of 53.4 (fineness grade on the mid-side) describes the medium-size curl. The number of crimps per 3 cm was 6.2, with a maximum of 13 crimps. The average length for unstreched staple was 6.7 cm at 5.5 months of age. When comparing white Finnsheep with the coloured ones, it was found that the white ones had higher scores in evenness, staple formation, lustre and crimps per 3 cm. However, the coloured Finnsheep had a higher score for density. The subjective fleece grade corresponds to the number of crimps per 3 cm; the phenotypic correlation was 0.88.

Table 1. Wool quality traits - mean performance data, 1997 (n=599).

Traits	mean	sd	CV %
Fleece uniformity	3.2	0.88	27.5
Density	3.1	0.64	20.5
Staple formation	3.0	0.92	30.5
Lustre	3.3	0.77	23.7
Fineness grade *)			
chest	54.1	1.40	2.6
midside	53.4	1.79	3.4
britch	53.0	1.83	3.5
Staple length (cm)	6.7	1.90	28.4
Number of crimps(/3cm)	6.2	2.19	35.2
Age at assessment (d)	162	17.7	10.9

Uniformity, density, staple formation and lustre; point scale 5-1

*) based on staple crimp type and assessed on three locations

As shown in Table 2, the mean number of crimps per 3 cm was 6.7 and the fibre diameter 23.4 microns, in the fineness grade 54. This grade includes 55 % of the lambs. Correlations between fibre diameter and the fineness grade, as well as the number of crimps, were consistent (about 0.60). The higher the fineness grade and the number of crimps per 3 cm, the lower the fibre diameter.

Table 2. The number of crimps per 3 cm and fibre diameter (µm) by fineness grade

	Crimps			Fibre diameter		
Fineness grade	n	mean	sd	n	mean	sd
46	5	0.4	0.55	1	24.1	-
48	9	1.6	0.53	2	28.4	1.77
50	27	3.0	0.71	1	28.4	-
52	158	4.6	0.63	11	25.4	1.04
54	327	6.7	1.02	16	23.4	1.38
56	56	9.6	1.26	10	23.5	1.37
58	12	12.6	1.24	4	22.3	1.44

Fineness grade , assessment from midside

The average diameter of fibres, measured by the Airflow apparatus, was 24.2 microns (CV 8.0 %). The preliminary results indicated that wool was somewhat coarser in the black and brown types, than in the white ones.

Conclusions

* Well-trained staff is needed to have reliable results for the subjective assessment of wool quality.
* The collection of the assessed data should be carried out at a standardised age of the animal.
* Besides wool quality assessment, the weighing of greasy wool during shearing is also necessary to improve wool quantity in breeding programs of white and coloured Finnsheep.
* A strong emphasis will be put on the objective fineness measurements, using the OFDA methodology.
* The animal model BLUP evaluation for wool traits is now under development, which will allow the sheep breeders to select next year replacements, using BLUP indices.
* The flock size is small among the breeders in the Fine Finnwool project. Therefore, it is important to develop a scheme to utilise the top ranked sired, to ensure the genetic improvement in the most desired wool traits.

Finnsheep wool: subjective measurements of wool quality

Staple formation in Finnsheep: dense and lustrous

Conference Announcements

EAAP annual meeting 1999

Zurich, Switzerland

23-26 August 1999

Programme for the Sheep and Goat Production Study Commission:

Monday 23 August:

9.00-12.30: Session I
Sheep and goat production in wet mountain areas
Chairperson: M. Schneeberger (Switzerland)

14.00-17.30: Session II
Free communications
Chairperson: D. Croston (United Kingdom)

Tuesday 24 August:

08.30-12.00: Session III
Feeding dairy goats under intensive management
Chairperson: P. Morand-Fehr (France)

13.00-22.00: Mid Conference Tour

Wednesday 25 August:

08.30-12.30: Session IV
Genetic Resistance to disease / parasites
Chairperson: M. Stear (United Kingdom)

14.00-17.30: Session V
Economic, genetic and management aspects of fine fibre production
Chairperson: J. Milne (United Kingdom)

Thursday 26 August:

08.30-10.00: Session VI
Free communications/Business meeting/Emerging issues
Chairperson: D. Croston (United Kingdom)

10.30-12.30: General Assembly

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3rd European Symposium on South American Camelids and Supreme European Seminar

Goettingen, Germany

27-29 May 1999

Provisional Programme:

Wednesday 26th May 1999

18.00-21.00-Informal Welcome Reception

Thursday 27th May 1999

09.00-17.00 -Lectures
Opening of the conference
Opening lecture
Session 1-Ecology and sustainability
Session 2- Socio-Economics
Session 3-Breeding and genetics

20.00-21.30- Concert

Friday 28th May 1999

09.00-17.00-Lectures
Session 4 -Reproduction and pathology
Session 6 -Fibre and meat production

17.00-18.00: Round Table 1
EU-politics for the development of Andean regions

19.30: social dinner

Saturday 29th May 1999

09.00-12.00-Lectures
Session 5 - Nutrition
Session 7- Free papers

14.00-16.00- Roundtables 2 and 3
Round Table (2) on Sustainable use of South American camelids in South America
Round Table (3) for Breeders and Keepers

Closing of conference

Sunday 30th May 1999
08.30-19.30
Post-conference excursion (optional)

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Training courses/technical exchange visits

The Network has funds for the provision of a limited number of training visits by Network members -- or their staff and students -- for the purpose of learning about measuring techniques, to institutions in other EC countries. These visits or courses are in the use of OFDA technology in research institutes, extension services, producers organisations and manufacturers. The grants are therefore intended for organisations, who are using OFDA methodology, to run courses and for visits by staff from organisations setting up the new technology in their organisations.

Proposals for funding should include:

1-date of the visits and the outline of the activities that are planned,

2-the full address of the institute(s) to be visited and the contact name(s) there,

3-a description of the applicant's background and current interests and what he/she hopes to gain from the visit,

4-a budget showing all the expenses that will be claimed. The appropriate APEX air fare may be claimed for international travel. Within the destination country, reasonable travel expenses may be claimed. A subsistance allowance to cover hotels and meals may be charged at a rate of up to 75 ECU per day, and

5-an acknowledgment from the host institution that they have been consulted and agree with the proposal.

Following the visit, a short report should be sent to the Project Co-ordinator.

Applications should be sent to "Dr John Milne, EU Project Co-ordinator, MLURI, Craigiebuckler, Aberdeen, AB15 8QH, Scotland, UK". They should arrive not later than 6 weeks before the proposed departure date.

MACAULAY ANIMAL FIBRE EVALUATION LABORATORY

Fibre testing prices

	For 10 or more samples	*For less than 10 samples*
Fibre diameter	£5.00 per sample	£5.50 per sample
Fibre diameter and yield	£10.00 per sample	£11.00 per sample

Samples of **at least 1 g** should be sent to:

Hilary Redden, Macaulay Research and Consultancy Services Ltd,
Craigiebuckler, Aberdeen, AB15 8QH, Scotland, UK. Tel: (+44) 1224 318611

NB: If taken from a live animal, samples should be taken from the mid-side position, and if from a fleece, should be representative of the whole fleece.

All prices are subject to VAT at 17.5%.