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Corresponding Author: Dr. Joaquin Pablo Mueller, Ph.D.

Corresponding Author's Institution: INTA

First Author: Farhod F Kosimov

Order of Authors: Farhod F Kosimov; Matazim A Kosimov; Barbara Rischkowsky, PhD; Joaquin P Mueller, PhD

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Abstract: Mohair quality of Angora goats in the Sogd Province of Tajikistan was assessed in spring and autumn 2007 and 2008 by inspecting and sampling a total of 797 goats of both sexes, different ages and several coat colors from 15 randomly selected flocks. Fiber fineness was assessed visually on the Bradford scale, staple length was measured with a ruler. Midside fleece samples were analyzed with an OFDA instrument to determine average fiber diameter, standard deviation, coefficient of variation (CVFD), comfort factor, fiber curvature and fiber length. On a subset of 153 goats, kemp and med fiber percentage was determined inspecting 300 fibers of each goat with a projection microscope. Mixed model procedures were used to analyze the data. Residuals of the model were used to calculate correlations. The random flock effect was significant for all traits and the fixed sex, age, and color effects were significant for most traits. In spring shearing data, fiber diameter of males were 2.7 µm coarser than females and increased with age: 27.3 µm (one year old), 31.3 µm (two years old), 34.6 µm (three to five years old) and 37.0 µm (six years and older). Mohair fiber length ranged 137.3-174.7 mm between ages. Six month old kid mohair (autumn shearing) was finest (24.4 µm) and shortest (95.1 mm). White mohair was approximately 3 µm coarser than brown and grey mohair. CVFD was not affected by sex and age but related to color with white mohair having a lower CVFD. Comfort factor and visual Bradford count decreased with age. Average med and kemp percentages were 0.88 and 0.34. Almost 20% of goats had 2% or more medullated fibers. The phenotypic correlation between fiber diameter and med percentage was 0.40 and between fiber diameter and kemp percentage -0.08. On average, visual Bradford count underestimated fiber diameter by about 4.1 µm. The correlation between fiber diameter and Bradford count was -0.28. Thus, visual assessment of fiber diameter is imprecise and reduction of fiber diameter through selection would therefore require analysis of fleece samples. The correlation between staple length and fiber length was 0.78. Thus, ruler determination of staple length measured on the live animals is a good estimator of fiber length measured on the fleece sample. In comparison with South African mohair, Tajik mohair is not only white, has long fibers, is rather coarse and medullated. Given the high variation between and within flocks in fiber diameter and medullation there is room for culling inferior animals and improve current mohair quality.

Revision Note - Rumin-D-12-4712

09/01/2013

This manuscript has been considerably improved in relation to the reviewers comments. However the discussion needs to be revised to place the findings into the currently accepted view that mohair fibre diameter increases with body size and that age is not a determinant of fibre diameter. In this context the limitations of the work need to be clarified given the absence of body size measurements. Discussion revised, limitations clarified and an additional reference included (lines 154-157, 205-206 in red)

Some other minor revisions are required as follows:
In various places in the text there are too many significant figures for fibre diameter, one decimal is sufficient. Corrected, one decimal left (in red)

Abstract. CV of FD or FDCV needs to be clear throughout the text. Corrected, CVFD used throughout the text (in red)

L113. Proportion or %, a proportion would be 0.85 for example. Corrected "percentage" instead of "proportion" (in red)

Insert into table caption what the plus/minus signs refer too. Inserted and clarified (in red)

Evaluation of mohair quality in Angora goats from the Northern dry lands of Tajikistan

Kosimov, F.F.[1], Kosimov, M.A.[1], Rischkowsky, B.[2] and Mueller, J.P.[3]

Abstract

Mohair quality of Angora goats in the Sogd Province of Tajikistan was assessed in spring and autumn 2007 and 2008 by inspecting and sampling a total of 797 goats of both sexes, different ages and several coat colors from 15 randomly selected flocks. Fiber fineness was assessed visually on the Bradford scale, staple length was measured with a ruler. Midside fleece samples were analyzed with an OFDA instrument to determine average fiber diameter, standard deviation, coefficient of variation (CVFD), comfort factor, fiber curvature and fiber length. On a subset of 153 goats, kemp and med fiber percentage was determined inspecting 300 fibers of each goat with a projection microscope. Mixed model procedures were used to analyze the data. Residuals of the model were used to calculate correlations. The random flock effect was significant for all traits and the fixed sex, age, and color effects were significant for most traits. In spring shearing data, fiber diameter of males were 2.7 µm coarser than females and increased with age: 27.3 µm (one year old), 31.3 µm (two years old), 34.6 µm (three to five years old) and 37.0 µm (six years and older). Mohair fiber length ranged 137.3-174.7 mm between ages. Six month old kid mohair (autumn shearing) was finest (24.4 µm) and shortest (95.1 mm). White mohair was approximately 3 µm coarser than brown and grey mohair. CVFD was not affected by sex and age but related to color with white mohair having a lower CVFD. Comfort factor and visual Bradford count decreased with age. Average med and kemp percentages were 0.88 and 0.34. Almost 20% of goats had 2% or more medullated fibers. The phenotypic correlation between fiber diameter and med percentage was 0.40 and between fiber diameter and kemp percentage -0.08. On average, visual Bradford count underestimated

[1] Tajik Livestock Institute, Khojand, Tajikistan
[2] International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
[3] National Institute for Agricultural Technology, EEA Bariloche, Argentina. Corresponding author: mueller.joaquin@inta.gob.ar

fiber diameter by about 4.1 µm. The correlation between fiber diameter and Bradford count was -0.28. Thus, visual assessment of fiber diameter is imprecise and reduction of fiber diameter through selection would therefore require analysis of fleece samples. The correlation between staple length and fiber length was 0.78. Thus, ruler determination of staple length measured on the live animals is a good estimator of fiber length measured on the fleece sample. In comparison with South African mohair, Tajik mohair is not only white, has long fibers, is rather coarse and medullated. Given the high variation between and within flocks in fiber diameter and medullation there is room for culling inferior animals and improve current mohair quality.

Key words: fiber, fiber diameter, medullation, selection, kemp, correlation

Introduction

Mohair producing goats in Tajikistan consist of 233,000 head (Karakulov, 2008); most are in the Northern Province of Sogd (84%) and the remainder in the Eastern Province of Badakhshan (16%). Tajik mohair producing goats were developed by breeding native does to Angora bucks in different periods. In the period between 1936 and 1962, native Central Asian coarse hair goats were crossbred to Angoras imported from Texas, creating the so called "Soviet coarse wool goat breed". Bucks of this breed eventually reached and were used in Tajikistan. Further improvement period started in 1982 under the guidance of the Tajik Livestock Research Institute and involving breeding farms like Kushatova, Tuychi Ergiyshtov, Kalinin, and Gafurov. In 2004, the Tajik Angora goat genotype was formally registered as a new breed (Karakulov, 2008). The breed is well adapted to distant range grazing. In summer, flocks are taken to pastures in mountain ranges and in winter grazed on the lower flatland areas. During the coldest period in winter, animals are housed and provided feed. Goats are shorn once a year in spring. In autumn, only those animals intended for slaughter were shorn. Little information is available on the characteristics of its fiber. Notable for Tajik Angora flocks is the high proportion of colored animals. Sogdian Branch of Livestock Institute of the Tajik Academy of Agricultural Sciences, (2011,) recorded 30% of colored goats (2827 out of a total of 9420) distributed in 47 flocks in the Asht and B. Gafurov regions of the Sogd Province. The Tajik Livestock Research Institute (1985) and Farsikhanov et al. (1985) reported some fleece measurements in the early days of breed improvement. They reported that fleeces contained mainly hair and an insignificant quantity of thin, elastic top hair. Fiber diameter was 30-35 µm and clean yield was 70-80%. Average fleece weight of yearlings was reported to be 0.6-1.0 kg, in 2-year-old animals it was 1.4-2.0 kg, and in older animals it was 1.8-3 kg. The same reports indicated that fiber length was 15-18 cm. To our knowledge, no further information on fleece quality has been published. In 1991, after the collapse of the Soviet Union, all major state and public livestock farms (sovkhozes and kolkhozes) were dismantled and goats distributed to private farmers and households, where no further systematic genetic improvement has been conducted (Kosimov et al., 2012). However, the production and marketing of mohair has remained very active, contributing substantially to the livelihood of a large number of goat herders.

New challenges and opportunities for these herders relate to an increased demand for goat meat and to a niche market for high quality mohair. Thus, in order to orientate selection emphasis, detailed information on current mohair quality is needed. In the framework of an IFAD funded development project aimed at improving livelihoods of small farmers and rural women through value-added processing and the export of mohair and other fibers (ICARDA, 2012), therefore a Tajik mohair quality assessment was performed.

Materials and Methods

Sampling and field data

Three data sets corresponding to fiber samples and field records were analyzed. The data sets are labeled according to the sampling season ('S' for spring and 'A' for autumn) and calendar year as S07, S08 and A08. A total of 797 animals from a total of 15 private, cooperative and state owned flocks were studied in an area covering most of the Sogd Province of Tajikistan (Map 1, one flock could not be geo-referenced). The flocks sampled are run on rangelands at 500-1500 m above sea level with average daily minimum temperature for January of -3.5° C and a maximum in July of 35.5° C. The region is rather dry with an average annual rainfall of 167 mm.

Within transport accessible areas, flocks were selected at random and animals within flocks were sampled irrespective of sex and age. About 73% of samples were white. Fleece samples were collected before the regular spring shearing, except for the A08 data set were samples were collected in early autumn. Samples were coded for flock, sex, age and color. Sex was coded as female or male (both intact and castrated). Age at shearing was coded in 5 categories: 0.5 years (only in A08 data set), 1 year, 2 years, 3-5 years and 6 or more years. Four colors were coded: white, gray (including black & white and light gray), brown (including dark brown and red) and black. Staple length (SL, cm) was measured placing a ruler on the skin at the upper midside of the animal. McGregor and Butler (2009) recommended measuring mohair staple length at the hip or at mid-back sites within flock and genetic selection due to their low sampling variability, moderate heritability and ease of location. Visual assessment of fiber fineness was based on the Bradford count system (Brad, counts) which Tajik scientists are familiar with. Bradford counts were used in the past for grading wool and are defined as "the number of 560-yard hanks of single strand yarn that could be made by a good spinner from a pound of cleaned combed wool". The finer the wool, the higher the Bradford counts. Fiber style was assessed visually by inspecting the whole fleece and animals were classed as 1. "homogeneous" if fibers were uniform by length and fineness, had no medullated fibers in more than one site and had cylinder shaped staples; or 2. as "heterogeneous" when fibers were uneven by length and fineness, had down fibers and/or medullated fibers and had cone shaped staples; or 3. "average" style for intermediate fleeces. Fiber samples of about 25 g were taken before shearing from the midside of the animals following the findings of Taddeo et al. (2000) in that the midside site fairly represents the average fiber characteristics of an Angora goat fleece. Fiber samples were identified and stored in plastic bags.

Fiber analyses

Samples were analyzed in the Laboratory of the Alrun Textile Company located in Almaty (Kazakhstan). Samples were divided in two subsamples. On one subsample fiber length (FL, mm) was measured by stretching staples on a graded pad and averaging at least 3 staples. Thus, FL refers to the length of fibers in the shorn sample whereas SL refers to the length of fibers from the skin of the animal. The second subsample was scoured and minicored to obtain 2 mm fiber snippets which were measured with an OFDA4000 instrument. Fiber diameter was measured on approximately 2000 fiber snippets per sample yielding an average fiber diameter

(FD, µm), its standard deviation (SDFD, µm), coefficient of variation (CVFD, %) and the percentage of fibers below 30 µm or comfort factor (CF, %). In addition, the instrument provides a measurement of fiber curvature (Curv, °/mm). A subset of the S08 samples (n=153 out of 671) was also analyzed for medullation in the Animal Fiber Laboratory of Argentina's National Institute for Agricultural Technology (INTA) located in Bariloche (Argentina). In this Laboratory, the proportion of medullated fibers was measured by inspecting 300 fibers in subsamples with a projection microscope. Medullated fibers were classified as being med or kemp fibers. Med fibers (med, %) are those where the diameter of the medulla is less than 60% of the diameter of the fiber and kemp fibers (kemp, %) are those where the diameter of the medulla is 60% or more of the diameter of the fiber (ASTM D2698, 2001). A few outliers in CF (5), Curv (2) and FL (3) were removed from the analyses. The field and laboratory information recorded in each campaign is summarized in Table 1.

Statistical analyses

Data were edited on spreadsheets and analyzed using mixed linear model procedures of the SAS (2008) package. Age, sex and color of animals were taken as fixed effects and flocks and animals (residual) were taken as random effects. The full statistical model used for all traits was:

$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + F_l + \varepsilon_{ijk}$, where

Y_{ijk}: represents the dependent variable analyzed;

μ: the overall mean;

α_i: the effect of sex (i= female or male);

β_j: the effect of age (j= 0.5, 1, 2, 3-5 and 6);

γ_k: the effect of color (k= white, gray, brown and black);

F_k: the random flock effect assumed N (0, σ_F^2);

ε_{ijk}: the residual random error assumed uncorrelated and N (0, σ_ε^2);

Note that data sampling campaign is not included in the model because autumn and spring data were analyzed separately and because only one flock was sampled in 2007. This flock was taken as an additional randomly selected flock instead of a sample flock of a particular (fixed) year. The significance of including this flock as a random effect in the model was tested by comparing the differences of the residual log-likelihoods of models with and without the random effect, with the corresponding Chi^2 (Molenberghs and Verbeke, 2007). Fixed effects estimates are expressed as least square means ± standard errors. Significance of fixed effects was tested with F tests and significance of estimated differences between least square means was tested considering adjusted Bonferroni probabilities. Probabilities below 5% are considered to be statistically significant in all analyses and probabilities below 1% are highlighted.

Results and Discussion

Sex, age and color effects on mohair quality

Table 2 shows significance of effects in the model for the various traits. The random flock effect was significant for all traits and the three fixed effects were significant for most traits. Tajik mohair fiber diameter follows the same pattern observed elsewhere that males have coarser fibers than females (about 2.7 µm), and that fiber diameter increases with age (up to 10 µm). As shown by McGregor et al. (2012), age *per se* is not a substantial determinant of mohair fiber diameter, once fleece-free live weight is taken into account. The lack of live weight records in our study does not allow us to confirm this finding and the large age effect mentioned may simply indicate large differences in body weights between ages. Visually assessed fiber fineness pattern, in terms of Bradford counts, was in accordance with FD measurements. As would also be expected, the standard deviation of fiber diameter follows the same pattern as fiber diameter and the comfort factor and curvature follow the opposite. The coefficient of variation of fiber diameter is the same in both sexes and across ages (about

31%). Fiber length, as well as staple length, is similar in both sexes and increased with age until 3 or 5 years, getting shorter in older animals (Table 3).

White fleeces were significantly coarser than gray and brown fleeces (about 3 µm, Table 3) and CV of fiber diameter was considerably lower in white fleeces than in colored fleeces (about 4% points, Table 3). This result has no obvious explanation, although it has been observed that some Tajik Angoras, in particular colored animals, have fine down fibers (cashmere) in addition to the regular mohair fibers (Kosimov, unpublished). The presence of such fibers would reduce the average fiber diameter and would increase its relative variation (CVFD) compared to white fleeces. Kosimov (2010) also observed that white fleeces have coarser fibers than gray and black fleeces. In 12 month old females fiber diameter of black, gray and white fleeces was 27.0, 26.3 and 28.1 µm, respectively. The higher fiber and staple length and the lower comfort factor in white animals may be explained by higher selection emphasis for fleece weight (related to staple length) and fleece evenness (related to CVFD). In fact, Kosimov (2010) observed higher fleece weights in white animals than in gray and black animals.

Mohair medullation

It is well known that Mohair quality is downgraded by the presence of medullated fibers. The average med and kemp fiber content of 0.88 and 0.34% (Table 4), respectively, resulted larger than in other Angora goat populations. For example, the Sonora test results for Texan Angora bucks in 2010 showed med and kemp averages of 0.28 and 0.11%, respectively. Total medullation is 1.22%, considerably more than 0.28 and 0.35% reported by Snyman (2002) for South African Angora populations and considerably less than 3.8-10.1% reported by Gifford et al. (1990) for an Australian Angora population. Using the Newman and Paterson (1999) criterion that first class mohair must have less than 2% kemp, the Tajik fleeces would qualify as first class.

However, individual animals in our data set had up to 19.3% of medullated fibers, indicating that these animals are well below standard and their fleeces may contaminate acceptable fleeces. In our data 19.6% animals (30 out of 153) had 2% or more medullated fibers in their mid-side fleece samples. Lupton et al. (1991) observed that neck, shoulder and mid-side samples underestimate whole fleece medullation figures, and therefore our results may underestimate whole fleece medullation in Tajik Angoras. A further indication of fleece contamination in Tajik mohair can be inferred from the visual assessment of style performed on 265 animals of the S08 data set. Only 57.4% of these animals were considered "homogeneous" in style, 27.5% were "average" and 15.1% "heterogeneous" (Chi^2=75.0, $P<0.01$).

Effect of autumn shearing on Mohair quality

Regular shearing of Tajik Angoras is in early spring. A few samples were taken in autumn from animals of different ages, including kids about 6 months of age in order to test Mohair quality at that time. Fiber length and staple length were about 5 cm shorter than in spring (Table 3) as the older animals were shorn in the previous spring, thus the results need to be regarded carefully. Also FD is much larger in autumn than in spring samples. Litherland et al. (2000) studied fibers at 4 seasons finding that summer-autumn mohair was about 2.5 µm stronger than winter-spring mohair. Of interest are the results of 6 month old kid mohair: fiber diameter is 24.4 µm and fiber length is about 10 cm (Table 5).

Correlations

Phenotypic correlations are as expected (Table 6). Fiber diameter is positively correlated with SDFD and negatively correlated with CF and Curv. Of interest is the correlation of ruler measured staple length and the measured fiber length in the shorn sample. The correlation turned out to be high (0.78) indicating that there is no need to take and analyze fleece samples if interest is only in fiber length. Of more interest is the correlation between visual assessment of fiber fineness (Bradford counts) and OFDA measured fiber diameter. The correlation is negative but rather low (-0.28). Using the raw data set the correlation is negative and high (-0.73, analyses not shown). Visual Bradford fineness is largely based on crimp frequency and differences in crimp frequency between kid mohair and adult mohair are easily observable, thus raw data including kid and adult records increase the correlation. This is also verified in the correlation between FD and Curv (related to crimp frequency) which is also negative and much larger in raw data (-0.72, analyses not shown) than in the analyses using the residuals of the model (-0.53, Table 6). The results indicate that visual assessment of fiber diameter based on Tajik mohair classer expertise in Bradford counts may be sufficient to discriminate fiber diameter in mixed age groups but may be insufficient to discriminate fiber diameter within contemporary groups. This is a rather unfortunate result for breeders wishing to reduce fiber diameter through selection without taking fiber samples.

An additional question is whether Tajik mohair classers can predict with reasonable accuracy the actual fiber diameter of mohair. In 1968 the "United States Standards for Grades of Wool" established a relationship between Bradford counts and fiber diameter (USDA, 1968). For example, a Bradford count of 44 would correspond to wool with an average fiber diameter between 34.4 and 36.2 µm and a Bradford count of 64 would correspond to 20.6 and 22.0 µm. Figure 1 shows that in 668 samples the slope of the regression of measured fiber diameter on Bradford count is the same as the slopes of the expected upper and lower bounds of the micron ranges established for each Bradford count. It also shows that the difference between the measured fiber diameter and the fiber diameter predicted by the Bradford counts is about 4.1 µm. Thus, the particular classers underestimated real fiber diameters by about 4.1 µm along the Bradford scale.

Correlations with medullated fibers were calculated on a subset of the spring 2008 data (Table 7). As expected med content is highly correlated with total medullation (0.96) and moderately correlated with FD (0.40). Other correlations with med content are rather low as also observed by Gifford et al. (1991). As expected, kemp content is correlated with total medullation (0.48) and slightly correlated with med fibers (0.22); other correlations are not significantly different from zero.

Practical implications

The bulk of mohair offered in the international market is South African. This mohair is graded and priced according to its fiber diameter and fiber length (e.g. WMR, 2012). Maximum prices are paid for mohair of 24-26 µm in diameter and 130-160 mm in length. Other characteristics which also impact on the value placed on mohair are the amount of: style and character; kemp and medullation; staining and vegetable contamination (AG&M, 2012). In comparison to premium South African mohair, Tajik mohair is rather coarse, except for kid mohair shorn in autumn. Given the high variation between and within flocks there is room for culling inferior animals and reduce fiber diameter in current flocks. However, visual assessment of fiber diameter within contemporary groups is not efficient which means that fiber samples need to be taken and analyzed. At present there are no fiber sample analyses facilities in Tajikistan thus selection for reduced fiber diameter will largely depend on the skills of the breeders in detecting fine mohair goats. Selection should also improve future generations if genetic parameters of Tajik Angora populations are similar to other Angora populations (e.g. Gifford et al., 1991 in Australia; Taddeo et al., 1998 in Argentina; Visser et al., 2009 in South Africa). Tajik mohair fiber length is excellent since Angora goats are shorn annually and not twice a year, as is typically done in South Africa. An important drawback of Tajik mohair is its high content of medullated fibers. Almost 20% of goats have 2% or more medullated fibers and many fleeces would qualify as crossbred mohair in the international market. Culling highly medullated goats would improve current flock mohair quality but genetic improvement through selection would be slow if heritability of medullation is low as it is in other Angora goat populations (e.g. Gifford et al., 1990). An option is to reduce medullation through introduction of genetically medullation-free animals (Newman and Paterson, 1999).

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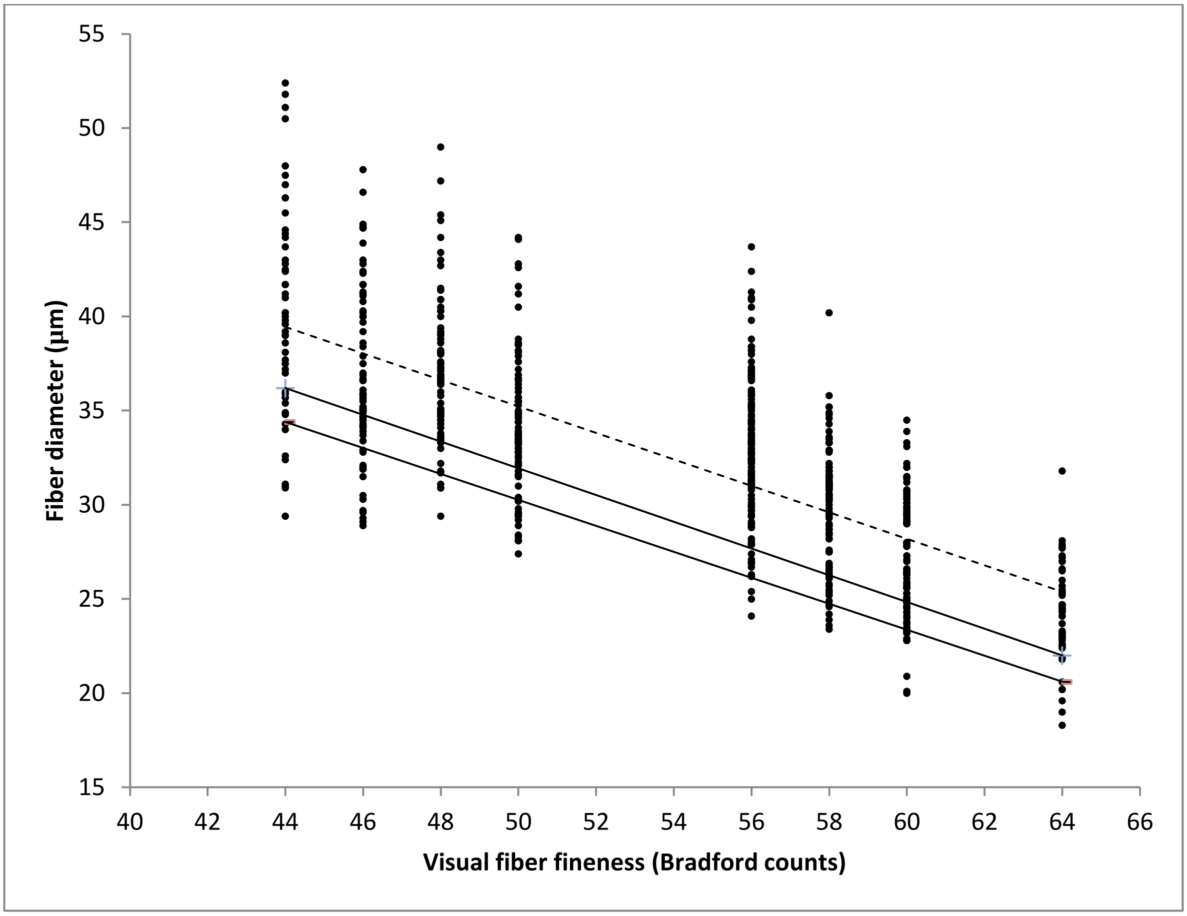

Figure 1: Relation between visual assessment of fiber fineness (in Bradford counts) and measured fiber diameter (in µm) in 668 Angora goats (black dots). The dashed line is the linear regression of fiber diameter on Bradford counts and the two solid lines are the upper and lower bounds of expected fiber diameter for visually assessed fiber fineness as defined by USDA (1968). For example, goats visually classed as having fiber fineness of 44 counts are expected to have a fiber diameter between 34.40 and 36.19 µm but, when their fleece samples were analyzed, fiber diameter averaged 40 µm. The underestimation of fiber diameter is constant along the visual fiber fineness scale.

Table 1

Number of samples by data set.

Data set	Flocks	FD	SDFD	CVFD	CF	Curv	FL	SL	Brad	Color	Style	Medul-lation
S07	1	61	61	61	61	61	61	0	0	0	0	0
S08	14	668	668	668	663	666	667	668	668	668	265	153
A08	3	68	68	68	68	68	68	68	0	68	0	0

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length, Brad: Bradford count.

Table 2

Statistical significance of factors affecting mohair quality traits.

Effects	FD	SDFD	CVFD	CF	Curv	FL	SL	Brad
Fixed sex effect (F)	71.63**	24.44**	2.01^{ns}	59.08**	15.63**	0.99^{ns}	0.16^{ns}	110.2**
Fixed age effect (F)	142.5**	71.69**	1.21^{ns}	130.0**	64.41**	76.99**	55.81**	464.9**
Fixed color effect (F)	10.64**	2.23^{ns}	11.13**	15.25**	34.42**	23.11**	24.22**	3.21*
Random flock effect (Chi^2)	20.0**	95.2**	56.0**	20.3**	3.7*	36.5**	35.7**	26.2**

^{ns} not significant, *P<0.05, **P<0.01.

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length, Brad: Bradford count.

Table 3

Least squares means (± standard error) of measured and visually assessed fiber quality traits in spring shorn mohair.

Effect level	FD (µm)	SDFD (µm)	CVFD (%)	CF (%)	Curv (°/mm)	FL (mm)	SL (cm)	Brad (counts)
Female	31.2±0.4B	9.8±0.2B	31.5±0.6A	53.8±1.8A	15.9±0.4A	157.2±3.0A	16.4±0.3A	53.6±0.3A
Male	33.9±0.5A	10.4±0.3A	31.1±0.7A	44.6±1.9B	14.6±0.4B	159.1±3.1A	16.5±0.3A	51.0±0.4B
1 year	27.3±0.5D	8.8±0.3D	31.8±0.7A	68.9±1.9A	19.0±0.4A	137.3±3.2D	14.5±0.3C	59.2±0.4A
2 years	31.3±0.5C	9.8±0.3C	31.2±0.7A	51.2±1.9B	14.8±0.4B	155.5±3.2C	16.4±0.3B	54.6±0.4B
3-5 years	34.6±0.5B	10.6±0.3B	31.0±0.7A	40.7±1.9C	13.6±0.4C	174.7±3.1A	18.1±0.3A	48.8±0.4C
6+ years	37.0±0.6A	11.4±0.3A	31.2±0.8A	36.1±2.4C	13.4±0.6C	165.0±3.9B	16.7±0.4B	46.7±0.5D
Black	32.7±0.9AB	10.5±0.4A	32.0±1.0A	48.8±3.3A	15.2±0.8B	150.6±5.3BC	16.2±0.6B	51.9±0.7AB
Brown	31.0±0.7B	9.9±0.3A	32.3±0.9A	57.1±2.6A	18.6±0.6A	143.3±4.3C	14.2±0.5C	53.4±0.5A
Gray	31.8±0.6B	10.3±0.3A	32.5±0.8A	51.7±2.4A	14.7±0.6B	159.5±3.9B	17.0±0.4B	51.9±0.5B
White	34.7±0.4A	9.8±0.2A	28.4±0.6B	39.2±1.5B	12.3±0.3C	179.0±2.6A	18.2±0.3A	52.2±0.3AB

Different letters between effect levels indicate significant differences ($P<0.05$).

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length, Brad: Bradford count.

Table 4

Mean, standard deviation and range of medullated fiber types in spring shorn mohair.

Fiber type	Mean (%)	Standard deviation (%)	Minimum (%)	Maximum (%)
Med	0.88	2.43	0.00	18.7
Kemp	0.34	0.77	0.00	6.3
Total	1.22	2.71	0.00	19.3

Table 5

Least squares means (± standard error) of measured quality traits in autumn shorn mohair.

Age (years)	FD (µm)	SDFD (mic)	CVFD (%)	CF (%)	Curv (°/mm)	FL (mm)	SL (cm)
0.5	24.4±1.5B	7.7±0.7B	31.6±1.5A	31.6±1.5A	17.0±1.4A	95.1±5.1A	10.7±0.7B
1.5	36.0±2.2A	10.8±0.9A	30.7±2.0A	30.7±2.0A	12.1±1.8B	105.7±7.6A	11.8±0.9AB
2.5	40.7±2.1A	12.2±0.9A	30.3±1.9A	30.3±1.9A	11.3±1.7B	106.9±7.1A	12.6±0.9AB
3.5+	41.0±2.5A	12.1±1.0A	29.8±2.2A	29.8±2.2A	11.3±2.0B	106.3±8.7A	13.3±1.0A

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length.

Table 6

Phenotypic correlations among measured and visually assessed mohair quality traits.

	SDFD	CVFD	CF	Curv	FL	SL	Brad
FD	0.46**	-0.31**	-0.91**	-0.53**	0.14**	0.14**	-0.28**
SDFD		0.67**	-0.32**	-0.09^{ns}	0.03^{ns}	0.04^{ns}	-0.20**
CVFD			0.40**	0.37**	-0.09*	-0.07^{ns}	0.02^{ns}
CF				0.56**	-0.18**	-0.17**	0.28**
Curv					-0.26**	-0.28**	0.22**
FL						0.78**	-0.04^{ns}
SL							-0.06^{ns}

^{ns} not significant, *P<0.05, **P<0.01

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length, Brad: Bradford count.

Table 7

Correlations among types of medullated fibers and mohair quality traits.

Trait	FD	SDFD	CVFD	CF	Curv	FL	SL	med	kemp
med	0.40	0.25	-0.13	-0.32	-0.24	0.17	0.13	1	0.22
kemp	-0.08	-0.04	0.05	0.07	0.00	0.03	-0.04	0.22	1
Total	0.34	0.21	-0.10	-0.27	-0.21	0.16	0.11	0.96	0.48

Correlations below ±0.16 are not significantly different from zero (P>0.05).

FD: fiber diameter, SDFD: standard deviation of fiber diameter, CVFD: coefficient of variation of fiber diameter, CF: comfort factor, Curv: fiber curvature, FL: fiber length, SL: staple length, Brad: Bradford count.

Paper on Mohair quality_map.jpg

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