Targhee
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Research Report
Evaluation of OFDA2000 Fleece Measurements in NSIP Targhee Ewes

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Summary

A project funded by the American Wool Council analyzed OFDA2000 fleece measurements on fleeces of 186 yearling and 847 adult Targhee ewes from flocks enrolled in the National Sheep Improvement Program. The project yielded the following conclusions:

- Effects of ewe age on OFDA measurements were often significant. Adjustment of most measurements would therefore be required in genetic improvement programs. Preliminary adjustment factors were derived.
- Phenotypic correlations among the measurements revealed strong intercorrelations among micron average, comfort factor (the percentage of fibers below 30 microns), and spinning fineness (an index that considers both average fiber diameter and variation in diameter among fibers in the sample). However, the standard deviation (SD) along the staple and the average curvature were only moderately correlated with other measurements, thereby potentially providing new information on fleece uniformity and processing characteristics, respectively.
- Heritability estimates (h^2) were relatively high (>50%) for micron average, spinning fineness, and average curvature, suggesting that these traits would respond rapidly to selection. Estimated heritability was below 0.30 only for SD along the staple ($h^2 = 0.19$).
- Genetic parameters were similar and genetic associations were very strong for measurements of fiber diameter recorded in yearling ewes by NSIP and in adult ewes by OFDA. There appears to be little increase in accuracy of genetic evaluation of fiber diameter from adding information on adult fleeces to the yearling fleece record. A positive relationship also existed between yearling and adult staple length, although the relationship was not as strong as for fiber diameter.
- EPDs for lamb weaning weight and ewe prolificacy were not associated with OFDA fleece measurements, suggesting that these production traits can be improved without negative effects on fleece value. Associations of OFDA measurements with EPDs for yearling fleece traits were consistent with known genetic relationships among these traits.
- The addition of OFDA fiber measurements to NSIP will be straightforward, once the important measurements are identified. Procedures for merging OFDA output spreadsheets with the NSIP date entry spreadsheet have been developed and could be implemented relatively quickly.

Introduction

Enhancement of the competitive position of American wools in international markets requires greater attention to wool quality attributes. This will necessarily involve application of both traditional and innovative measures of quality that address the full range of fiber characteristics that are important in defining final fabric value. Both the sophistication and timeliness of wool quality assessment must be improved, and the use of comprehensive wool quality measures in genetic improvement must be increased. These enhancements to U.S. wool testing procedures will permit better characterization of U.S. wools, support timely value-based marketing, and enhance our understanding of relationships between fiber characteristics and end-product value.

In order to fully capitalize on an enhanced capacity to measure wool quality, we must first identify the quality attributes that are most useful for characterization and improvement of wool value. This knowledge must then be incorporated into programs that can support rapid and sustained genetic improvement of fleece characteristics in order to achieve and maintain the competitive position of American wools in world markets.

NSIP provides a mechanism for the collection and critical analysis of wool quality data. It likewise provides state-of-the-art procedures for estimation of genetic merit for wool production and quality traits, and a mechanism for assessing relationships (including possible antagonisms) among these traits. This research was conducted cooperatively by Virginia Polytechnic Institute and State University and Montana State University, and was funded by the American Wool Council. The objectives were to provide a preliminary genetic analysis of OFDA2000 fleece measurements and to develop methods for incorporation of these measurements into NSIP.

Genetic Analysis of OFDA2000 Fiber Measurements

Data. OFDA2000 data were received on 1,070 Targhee fleeces from six Montana flocks. After removal of a few animals with clearly unreasonable values, the age and sex distribution for the remaining animals is shown in Table 1. Because of the small numbers of observations, data from rams and old (8 yr and older) ewes were excluded from subsequent analyses. Data on yearling and older ewes were analyzed separately. Seventy-three different sires were represented in the adult ewe data, with a median number of 8 daughters/sire and a range of 1 to 52 daughters. Thirty sires had 10 or more daughters.

Table 1. Age and sex distribution for Targhee animals contributing OFDA fleece data

Sex	1	2	3	4-5	6-7	8+	Total
Ewes	186	261	221	284	81	7	1040
Rams	0	5	4	8	2	5	24

OFDA measurements included in the analysis are shown in Table 2. Means, standard deviations, and ranges for each variable are shown for yearlings and for older (2 to 8 yr old) ewes in Tables 3 and 4, respectively.

Age effects on OFDA measurement. Ewe age effects on fleece measurements are shown in Table 5. Among adult ewes, significant effects of ewe age were observed for micron average, micron SD, comfort factor (% of fibers < 30 microns), spinning fineness, staple length, and curvature. Differences in measures of fineness (micron average, comfort factor, spinning fineness) among 2- to 5-yr-old ewes were small, but 6- and 7-yr-old ewes had substantially coarser fleeces.

Variation in fiber diameter was least in 3-yr-old ewes, and increased in both older and younger ewes. Conversely, the mean curvature was highest in 3-yr-old ewes. However, a different pattern was observed for staple length, which was longest in 2-yr-old ewes and declined with increasing ewe age. These results suggest that adjustment of OFDA measurements for ewe age will be required in genetic evaluation programs and provide preliminary estimates of the necessary adjustment factors.

Means for OFDA measurements in yearling ewes are also shown in Table 5 but were not statistically compared to values for older ewes. Yearling ewes are usually managed differently from older ewes, so differences in fiber characteristics between them represent combined effects of age and management. Still, as expected, fleeces from yearling ewes were finer, less variable (although similar in coefficient of variation), shorter, and had less curvature than fleeces from older ewes.

Table 2. OFDA2000 measurements included in this study

Measurement, units	Definitions
Micron average, microns	Average fiber diameter in the sample.
Micron SD, microns	The standard deviation (SD) of fiber diameter within the sample.
Micron CV, %	The coefficient of variation (CV) of fiber diameter within the sample.
Comfort factor, %	The percentage of fibers that are less than or equal to 30 microns. The percentage of fibers >30 microns (the "prickle factor") is associated with the scratchiness of the fabric.
Spinning fineness, microns	A measure of the performance of the fiber when spun into yarn that considers both the micron average and the uniformity (micron SD) of the sample.
Staple length, mm	Length of the staple.
SD along the staple, microns	The standard deviation (SD) of fiber diameter along the staple, a measurement of uniformity of fiber diameter during the growth of the wool fiber.
Curvature average, degrees/mm	A measure of fiber structure that is related to crimp frequency. Higher values for curvature indicate more crimps/inch.

Relationships among OFDA measurements. Phenotypic correlations among OFDA measurements in fleeces from adult ewes are shown in Table 6. Several of the OFDA measurements are indicative of the fineness of the fleece (micron average, comfort factor, and spinning fineness) and, as expected, these variables were strongly intercorrelated, with absolute values for the correlations ranging from 0.81 to 0.98. Uniformity of the fleece is indicated by the micron SD and CV and by the SD along the fiber. The correlation of 0.60 between micron average and micron SD confirms that coarser fleeces are also more variable; however, the micron CV (which measures variation relative to the mean fiber diameter) was only slightly related to micron average ($r = 0.06$). The SD along the staple was not strongly associated with other OFDA measures. The staple length and curvature of the fibers were likewise not closely associated with the micron average or with measures of variation in fiber diameter. Curvature, which is associated with the number of crimps per inch, tended to be a little lower in longer and coarser fleeces (correlations of –0.44 and –0.23, respectively), but the value of curvature as a predictor of fleece quality independent of other measurements remains questionable.

Genetic parameters for OFDA2000 fiber measurements. The use of OFDA2000 measurements in genetic improvement programs requires knowledge of the heritabilities of the measurements and of their genetic correlations with one another and with other measures of animal growth, maternal ability, reproductive capacity, and fleece production. The current data set is adequate to provide preliminary estimates of heritabilities of OFDA measurements. Estimation of genetic correlations requires larger amounts of data (generally ≥5,000 records/trait). However, most of the animals evaluated already had EPDs for a variety of performance traits, and these EPDs were used to assess relationships between OFDA measurements and other measures of genetic merit.

Heritability estimates for OFDA measurements (Table 7) were greater than 0.50 for micron average, spinning fineness, and average curvature, suggesting that these measures would respond rapidly to selection. Heritabilities for several measures of fleece uniformity were also substantial (0.49 for micron SD and 0.32 for micron CV), indicating that genetic improvement in fleece uniformity is likewise possible. However, the heritability of micron SD along the fiber was low relative to other OFDA measurements ($h^2 = 0.19$) indicating less opportunity to improve uniformity along the fiber by selection and suggesting that variation in diameter along the wool fiber mainly reflects nongenetic influences of nutrition and physiological state during the year. In comparison, the heritability values used for yearling fleece weight, fiber diameter, and staple length in NSIP are .37, .57, and .42, respectively. Measures of micron average in

Table 3. Means, standard deviations, and ranges for OFDA measurements from 2- to 8-yr-old ewes (n = 847)

Measurement	Mean	Std Dev	Min	Max
Micron average	21.87	1.63	17.10	29.10
Micron SD	3.81	0.50	2.60	5.40
Micron CV	17.46	2.22	12.80	26.80
Comfort factor	97.01	3.14	62.40	100.00
Spinning fineness	20.70	1.51	16.70	27.40
Staple Length (OFDA)	72.81	15.23	35.00	130.00
SD along the staple	1.07	0.42	0.16	2.62
Curvature average	97.00	11.34	61.30	136.00

Table 4. Means, standard deviations, and ranges for OFDA measurements from yearling ewes (n = 186)

Measurement	Mean	Std Dev	Min	Max
Micron average	20.82	1.27	18.00	24.50
Micron SD	3.65	0.47	2.70	5.20
Micron CV	17.52	1.75	14.30	24.60
Comfort factor	98.43	1.71	88.30	100.00
Spinning fineness	19.72	1.28	17.00	23.80
Staple length	62.20	11.68	35.00	100.00
SD along the staple	0.84	0.37	0.22	2.04
Curvature average	93.74	10.50	68.70	121.20

Table 5. Means for OFDA measurements by ewe age

Measurement	1	2	3	4-5	6-7
Number of observations	186	261	221	284	81
Micron average*	20.8	22.2	22.2	22.3	22.8
Micron SD*	3.65	3.86	3.79	3.81	3.95
Micron CV	17.5	17.4	17.2	17.2	17.4
Comfort factor*	98.4	96.7	96.8	96.6	95.3
Spinning fineness*	19.7	21.0	20.9	21.1	21.5
Staple length*	62.2	81.1	76.1	75.8	73.3
SD along the staple	.84	1.07	1.11	1.12	1.16
Curvature average*	93.7	94.6	97.1	96.6	93.5

*Significant ewe age effect in ewes 2 yr old and older.

Table 6. Phenotypic correlations among OFDA traits in adult ewes

Measure-ment 2	Measurement 1						
	SDMicron	CVMic	Comfort	SpinFine	Staple	SDAlong	Curve
MicAvg	.60	.06	-.81	.98	.01	.26	-.23
SDMic		.83	-.72	.74	-.04	.44	-.16
CVMic			-.33	.24	-.06	.36	-.04
Comfort				-.85	-.02	-.29	.23
SpinFine					.00	.32	-.23
Staple						.13	-.44
SDAlong							-.15

Trait definitions:

MicAvg = Micron average
SDMic = Micron SD
CVMic = Micron CV
Comfort = Comfort factor
SpinFine = Spinning fineness
Staple = Staple length
SDAlong = SD along the staple
Curve = Curvature average

Correlations of ≥0.06 or ≤-0.06 are significant at $P < 0.05$.

these adult ewes were thus very similar in heritability to measurements taken in yearlings. This result suggests that measurement of fiber diameter in adult ewes may not add much to the accuracies of genetic evaluation and the rate of genetic improvement in fiber diameter.

Associations between OFDA measurements and EPDs for NSIP production traits (defined in Table 8) are shown in Table 9. Tabular values are regression coefficients that predict each OFDA measurement from the EPDs for other traits. Thus a significant regression coefficient indicates that a relationship exists between the traits, and the size and direction of the relationship indicates the expected change in adult OFDA measurements associated with a 1-unit change in EPD.

EPDs for yearling fiber diameter were significantly associated with all adult OFDA measurements. In particular, there was a very highly significant relationship with OFDA micron average. Since the OFDA micron average is being measured on the animal itself (rather than on its progeny) the expected value of the regression coefficient is 2.00, which is very close to the observed value of 2.15, providing additional evidence that there is little difference in genetic merit for fiber diameter between yearling versus adult fleeces. The use of records from related animals in calculation of the yearling fiber diameter EPDs increases the accuracy of genetic evaluation of fiber diameter. This increase in accuracy appears to correspondingly reduce the need for measurement of fiber diameter in adult fleeces. Other associations between yearling FD EPD and adult OFDA measurement are generally consistent with the phenotypic associations involving micron average in Table 6. The only exception was that ewes with coarser yearling fleeces had significantly longer staple as adults, whereas there was no phenotypic association between these two measurements in adult ewes.

Across-flock EPDs for yearling staple length were provided to NSIP flocks in 2002. The yearling staple length EPD also had a very highly significant positive relationship with adult staple length, although the observed regression coefficient of 1.31 in/in was less than the expected value of 2.00. Heritabilities for staple length were similar for yearling and adult ewes, but these results suggest that somewhat different sets of genes may be involved in control of yearling and adult staple lengths.

Associations between yearling fleece weight EPD and adult OFDA fleece measurements were consistent with the observed genetic relationship between fleece weight and fiber diameter in yearling fleeces. A genetic correlation of 0.57 between yearling fleece weight and fiber diameter is used in NSIP and appears to be maintained in adult ewes.

Table 7. Estimates of heritability and additive variance for OFDA fiber traits

Measurement	Heritability
Micron average	.62
Micron SD	.49
Micron CV	.32
Comfort fact.	.38
Spinning fineness	.64
Staple length	.43
SD along the staple	.19
Curvature average	.50

Table 8. NSIP EPD traits

Abbreviation	Trait, units	Definition
WW	Weaning weight, lb	Weight at weaning
MM	Maternal milk, lb	An indication of genetic merit for mothering ability that reflects genetic differences in ewe milk production potential as realized in her lambs and expressed in pounds of lamb weaning weight
YW	Yearling weight, lb	Weight at a year of age
FW	Fleece weight, lb	Yearling fleece weight
FD	Fiber diameter, microns	Yearling fiber diameter
SL	Staple length, in	Yearling staple length
PLC	Percent lamb crop	Number of lambs born per 100 ewes lambing

Table 9. Regressions of OFDA fiber traits on current NSIP EPD[a]

	NSIP EPD						
OFDA measurement	WW	MM	YW	FW	FD	SL	PLC
Micron average	.07	-.12	.11***	1.54***	2.15***	2.07***	.012
Micron SD	.03	-.08***	.02**	.38***	.49***	.53**	.003
Micron CV	.09	-.31***	.00	.54†	.48*	.57	.004
Comfort fact.	-.12	.30*	-.17***	-2.56***	-3.39***	-3.01**	-.020
Spinning fineness	.08	-.16*	.11***	1.55***	2.13***	2.14***	.011
Staple length	.73	-.02	.76***	11.43***	5.41***	32.85***[b]	-.164†
SD along the staple	-.01	.00	-.01	.18**	.18***	.31**	.001
Curvature average	.47	1.4*	-.09	-10.73***	-8.19***	-29.31***	.099

[a]Tabular values predict the anticipated change in each OFDA fiber measurement associated with a 1-unit change in EPD. See Table 8 for definition of EPD traits.

[b]OFDA staple length is expressed in mm. NSIP staple length EPD is expressed in inches. Tabular value is expressed in mm/in and has an equivalent value of 1.31 in/in.

†P < 0.10.
*P < 0.05.
**P < 0.01.
***P < 0.001.

The weaning weight EPD was not associated with any of the OFDA measurements, suggesting that selection for early growth will not affect adult fleece quality. However, several associations between yearling weight EPD and adult fleece measurements were observed. Ewes that were larger as yearlings had somewhat longer and coarser fleeces as adults. These relationships were consistent with the observed genetic correlations of yearling weight with yearling fiber diameter (0.21) and staple length (0.27).

EPDs for maternal traits (i.e., percent lamb crop and maternal milk) were occasionally associated with OFDA measurements. Percent lamb crop EPD was negatively associated with adult staple length, although the magnitude of the association was small. More prolific ewes may devote more nutrients to reproduction, leaving less to support fleece growth. No other association between percent lamb crop EPD and OFDA measurements was observed. Ewes with high maternal milk EPDs had more uniform fleeces (lower micron SD and CV) and slightly finer fleeces with significantly better spinning fineness and comfort factor, although the magnitude of the associations was small. Again, this relationship may reflect a less-positive energy balance during lactation in higher-milking ewes. No genetic associations were observed between percent lamb crop or maternal milk and fiber diameter in yearling fleeces, providing additional support that the relationships observed in adult fleeces likely reflect competing nutrient demands for reproduction, milk production, and fleece growth.

Integration of OFDA Measurements into NSIP and Development of Breeding Objectives

As access to OFDA evaluations of individual fleeces expands, there will be corresponding opportunities to incorporate these measurements into industry genetic evaluation systems such as NSIP. Three main issues must be addressed in order to appropriately utilize OFDA measures for genetic improvement:
1) The specific measurements that contribute most to the specification of fleece value must be identified;
2) These measurements must be incorporated into NSIP; and
3) The emphasis that should be placed on each of the measurements in selection must be determined.

An assessment of the utility of individual OFDA measurements in defining fleece value is beyond the scope of this project. That assessment will require the active involvement of wool biologists and processors to clarify which of the many OFDA measurements provide information on the value of the finished product and, therefore, on the value of individual fleeces. However, the heritability estimates in Table 7 and the phenotypic associations in Table 6 provide critical input to this assessment. For example, high phenotypic intercorrelations among micron average, comfort factor, and spinning fineness demonstrate that these are all primarily indicators of the fineness of the fleece and will rank individual fleeces similarly. Mean curvature is both highly heritable and only modestly correlated with other traits, suggesting that this measurement provides somewhat unique information, although its economic significance has not been adequately defined.

The incorporation of OFDA measurements into NSIP will be relatively straightforward. The OFDA output files can be directly added as a new page in the NSIP data entry spreadsheet. Animals on the NSIP inventory or lambs from the current lamb crop can be listed from the NSIP database prior to collection of OFDA data to ensure that animal identification is consistent between NSIP and OFDA spreadsheets. Two approaches may then be taken to the integration of OFDA data into NSIP. One approach would be to incorporate the full set of OFDA measurements into the NSIP database as a resource for both selection and further analysis. The second is to identify only the subset of OFDA measurements judged to be most important for selection and to copy and retain only those in NSIP. The decision on which approach to follow will depend on how much OFDA information is collected by the industry and on the assessment of which OFDA measurements contribute most to definition of fleece value. Either approach can be implemented in NSIP quickly and with little additional cost. Changes in NSIP operating procedures would be required only if annual measurements of OFDA fleece traits in adult ewes become common. NSIP currently bases genetic evaluations of fleece traits only on yearling fleeces. Procedures to utilize repeated fleece measurements throughout the life of a ewe are conceptually straightforward but would require some development work and a few procedural changes.

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