Heritability of Fiber Diameter in Corriedale Suckling Lambs

By
Akira Katada

(Animal Breeding Laboratory, Hokkaido National Agricultural Experiment Station)

It is highly desirable in raising farm animals to analyse the heritability of any important character, since it would be useful to have such knowledge in drawing up breeding and selection plans. The fiber diameter is one of the valuable qualitative characters in sheep. The present author has attempted some statistical studies on the estimates for heritability of the fiber diameter in the Corriedale lambs. The present paper describes some of the results of observations though the studies have not been completed as yet.

The author's cordial thanks are due to Prof. S. Makino, Hokkaido University, who has been interested in the problem.

Material and methods

The data for this study were accumulated as a part of the breeding program in the Hokkaido National Agricultural Experiment Station. All Corriedale lambs were raised to weaning age within the years 1952 to 1954. Practically no culling took place before weaning age. The lambs were offspring between 17 sires and 247 dams. The data were obtained from 292 lambs. The fiber diameter records at shoulder, middle side, back and rump were not adjusted for age of lambs; the measurements were made at the age of 60.2 ± 9.3 days. The average inbreeding coefficient of all lambs was not higher than 0.016 percent. Obviously the latter percentage does not materially affect the heritability estimations, and therefore the estimations of heritability were not adjusted by the inbreeding coefficient.

The total variance in each sample was separated into components according to Fisher (1950) and Snedecor (1950). If Y_{ijk} denotes the k^{th} lamb sired by j^{th} sire in the i^{th} year, the following linear mathematical equation can be written:

$$Y_{ijk} = u + y_i + s_{ij} + e_{ijk}$$
$$i = 1, 2, \cdots\cdots, a$$
$$j = 1, 2, \cdots\cdots, m_i$$
$$k = 1, 2, \cdots\cdots, n_{ij}$$

In the equation, u designates the population mean, y_i an effect due to the i^{th} year, s_{ij} an effect due to the j^{th} sire within j^{th} year, and e_{ijk} a random error associated with the individual measurement.

Jour. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. 13, 1957 (Prof. T. Uchida Jubilee Volume).

Table 1. The partitioning of variance for the determination of heritability

Source of variation	Degrees of freedom	Sum of squares	Expected sum of squares	Interpretation variance components
Total	$N-1$	$\sum_{ijk} Y_{ijk}^2 - Y_{...}^2/N$		
Year	$l-1$	$\sum_{i} Y_{i..}^2/n_{i\cdot} - Y_{...}^2/N$	$\sigma_e^2(l-1)+\sigma_s^2(K_1-K_3)+\sigma_y^2(N-K_2)$	
Sire within year	$m-l$	$\sum_{i}\{\sum_{j} Y_{ij\cdot}^2/n_{ij} - Y_{i\cdot\cdot}/n_{i\cdot}$	$\sigma_e^2(m-l)+\sigma_s^2(N-K_1)$	$\sigma_s^2=\frac{\sigma_{(r)}^2}{4}$
Error*	$N-m$	$\sum_{ijk} Y_{ijk}^2 - \sum_{ij} Y_{ij\cdot}^2/n_{ij}$	$\sigma_e^2(N-m)$	$\sigma_e^2=\frac{3}{4}\sigma_G^2+\sigma_{e'}^2$

* Within sire and within years.

N, total number of progeny records analyzed. l, number of years. m, number of sire by year subclasses.

$$k_1=\sum_i \frac{\sum_j n_{ij}^2}{n_{i\cdot}} \qquad k_2=\frac{\sum_i n_{i\cdot}^2}{N} \qquad k_3=\frac{\sum\sum_{ij} n_{ij}^2}{N}$$

The form of analysis used in the study is shown in Table 1. The variances within years were used to estimate heritability by means of the paternal half-sib correlation method according to the suggestion of Lush (1949). The estimations of heritability can be approximated from the following formula :

$$h^2 = \frac{4\sigma_s^2}{\sigma_s^2+\sigma_e^2}$$

The standard errors in the heritability estimations which were obtained following the paternal half-sib correlation method were examined in reference to the formulae given by Hazel and Terrill (1945). The standard errors obtained through this method are not unbiassed estimation values, since the sires have been used for breeding for several years. The actual standard errors would be somewhat higher than the estimated values here presented.

Table 2. Analysis of variance for fiber diameter

Source of variation	Degrees of freedom	Sum of squares				
		shoulder	middle side	back	rump	average of four parts
Total	291	2951.57	3060.01	2896.25	3393.29	3102.51
Year	2	1110.33**	1258.61**	1205.66**	1430.74**	1245.88**
Sire	25	221.17	169.63	154.92	140.96	145.32
Error*	264	1629.07	1631.77	1535.67	1821.59	1391.20

* Within sire and within years.

** Significant at 1 percent level.

Results and discussion

The fiber diameter was observed in the following four parts; shoulder, middle side, back and rump. The results are summarized in Table 2. The differences in the mean square by years for the fiber diameter of four parts are highly significant in 292 lambs examined, while the differences in the mean square by sires within years are insignificant. The estimates for the variance components in the fiber diameter of the four parts studied are presented in Table 3.

Table 3. Estimates of variance components

Characters	σ_y^2 Year	σ_s^2 Sire	σ_e^2 Error	
Fd* of Shoulder	0.12	0.29	6.17	
Fd of Middle side	0.08	0.07	6.18	k_1 50.0
Fd of Back	0.07	0.04	5.82	k_2 114.3
Fd of Rump	0.05	−0.13	6.90	k_3 16.4
Fd of Average	0.07	0.06	5.27	

* Fiber diameter.

The estimation value of heritability for fiber diameter at shoulder, midldle side and back ranged from 0.180 to 0.030. The value for fiber diameter at shoulder is largest of all, as shown in Table 4. The heritability value for fiber diameter at rump is zero; that is, negative (-0.076). The heritability for fiber diameter of four parts was 0.045 in average value.

Table 4. Heritability estimations of fiber diameter by obtained paternal half-sib correlation method

	Schoulder	Middle side	Back	Rump	Average of four parts
Heritability	0.180	0.045	0.030	−0.076	0.045
Standard Error	0.066	0.033	0.029	0.002	0.033

The estimation values of heritability for fiber diameter reported by previous authors range from 0.2 to 0.57 (Tunner 1951 c, Kyle and Terrill 1953, Shelton *et al.* 1954), whereas the heritability estimation obtained in this study is very much smaller than that reported by previous workers. The reason may be the fact that the data in the author's report were obtained from very much younger lambs.

Based on the results here obtained it is possible to state that, when the heritability value of fiber diameter in four parts is actually low in the breed, phenotypic selection seems not to play any important role in promoting genetic improvement.

As indicated above, the progeny testing method will be more useful in planning improvement than phenotypic selection, when the selection of fiber diameter is made at suckling age.

Summary

The estimation value of heritability was observed for fiber diameter at shoulder, middle side, back and rump of lambs at suckling age, based on data taken in the breeding flock of the Hokkaido National Agricultural Experiment Station. The data consisted of records taken from 292 Corriedale suckling lambs (60.2± 9.3 days) during the year from 1952 to 1954.

The method of estimation was subjected to the paternal half-sib correlation after Lush. The estimation values of heritability for fiber diameter at shoulder, middle side and back were 0.180±0.066, 0.045±0.033 and 0.030±0.029, respectively. The fiber diameter at rump was zero in heritability value. The heritability value for fiber diameter at four parts was 0.045±0.033 in average.

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