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# Heritability of individual fiber medullation in Peruvian alpacas

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#### ABSTRACT

The aim of this research was to estimate for the first time the heritability and genetic relationship between medullation and fiber diameter in each fiber by itself. A total of 21,600 fibers from 36 samples from white fleeces, 600 fibers each sample, from males between 0.4 and 10.4 years old from Pacomarca experimental farm (Inca Group, Puno, Peru) were tested using projection microscope (PM). The individual fiber diameter (FD) and the category of medullation (CM) was recorded in each fiber. CM of each fiber was assigned to one of the five categories established in the literature. The percentage of medullated fiber ranged from 12.33% to 91.67% per sample. The correlation between OFDA 100 \* medullation percentage and PM measurements was 0.79. The statistical model used for estimation of genetic parameters for CM and FD included the age as a linear and quadratic covariate as systematic effect, and the additive genetic and the permanent environmental as random effects. The pedigree that served to predict genetic values was very robust and strong, allowing obtaining reliable and significant parameters. Univariate and bivariate models were used to estimate heritability for CM and DF, as well as its genetic correlation. Different models considering CM as continuous or categorical trait were tested. The highest heritability estimate for CM was  $0.36 \pm 0.13$  obtained using a bivariate continuous model. Using the same model, the heritability estimate for FD was 0.35  $\,\pm\,$  0.15 and the genetic correlation between CM and FD was  $0.93 \pm 0.12$ . These results implied that selection against medullated fiber is feasible while at the same time reducing the FD in alpacas. Since measurement of CM per fiber sample was time-consuming, PM measured by OFDA 100 \* would be useful as an indicator to reduce the number of medullated fiber in alpaca fleeces.

#### 1. Introduction

Alpaca fiber quality is worldwide considered among the best for the textile industry. However its price is still far from other fine animal fibers like cashmere. The main argued reason is the prickle factor associated to alpaca fiber. Big efforts have been made in order to remove this particular issue. Thus, prickling has been linked to fiber diameter, particularly to fibers thicker than 30 µm, and consequently comfort factor has been defined as the percentage of fibers lower than that value (McGregor, 1997; Frank et al., 2006), as an interesting trait to work with. In order to remove prickle factor, selection has been carried out based on the reduction of fiber diameter as selection criterion in Pacomarca experimental farm (Gutiérrez et al., 2011), and a fast reduction has been achieved (Gutiérrez et al., 2014), but prickle factor has not completely been removed. The medullated fiber and type of medullation has alternatively been blamed as responsible for prickle factor (Frank et al., 2014; Frank et al., 2017; McGregor, 1997). They called

them objectionable fiber, appearing to have opacity greater than 94% and a diameter greater than 25 µm (IWTO, 1998). If selection objective in fiber has been traditionally the thinness of the fiber and prickle factor still remains, an alternative would be to move the selection criterion from fiber diameter to fiber medullation to reduce prickle factor. A strong genetic relationship between medullation and thickness seems to exist but it would have to be studied individually in each fiber; working with global parameters as mean fiber diameter and medullation percentage might hide information. Before implementing selection based on medullation, that relationship would have to be firstly carefully studied as it would imply important changes, and the first step is to know how heritable individual medullation would be, as well as the genetic relationship between diameter and medullation within each fiber. Such genetic parameters have never been previously estimated in alpacas. Thus, the objective of this study was to estimate genetic parameters of individual fiber medullation in alpacas, as well as to explore its relationship with fineness in each fiber itself, and the

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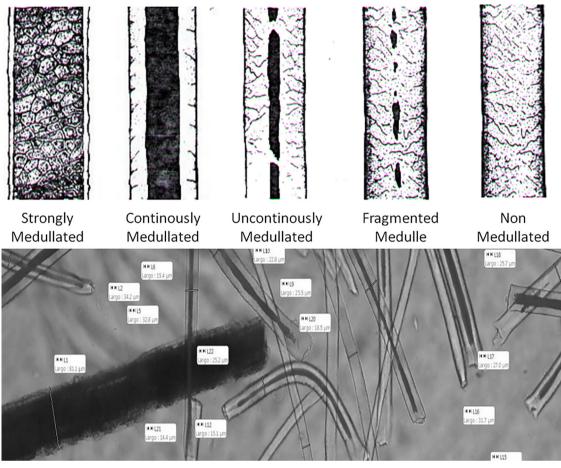


Fig. 1. Categorization of the fibers according to the type of medulla and a picture sample under projection microscope gathering all different categories.

possible ways to model the medullation classification to predict breeding values useful in selection of animals.

#### 2. Material and Methods

A total of 21,600 fibers from 36 samples of white fleeces, 600 fibers each sample, from white Huacaya males between 0.4 and 10.4 years old from Pacomarca experimental farm (Inca Group, Puno, Peru) were analyzed. The fiber samples were prepared and analyzed according to IWTO-8-2011 (IWTO, 2011) procedure at the Universidad Nacional Agraria La Molina (Lima, Perú).

Each individual fiber was considered as one record. Note that this consideration provides 600 records per sample, and the resulting trait differs from the usual trait called fiber medullation which simply addresses, in a unique figure, the percentage of medullation in a sample. Thus, for each of the 36 samples, 600 fibers were randomly chosen and each classified according to their medullation category using microscope projection (Frank et al., 2007; Villarroel, 1963) in to: non medullated, fragmented, uncontinuously medullated, continuously medullated, and strongly medullated (Fig. 1). Fiber diameter was determined for each fiber computing later the mean, the standard deviation and the comfort factor as the percentage of fibers lower than 30  $\mu$ m. Each sample took about one and a half effective working day to be processed, and the analysis required trained staff.

Pacomarca has simultaneously started to register the percentage of medullation by using an OFDA 100  $^{\circ}$  device (Lupton and Pfeiffer, 1998). This device counts total medullated fibers as described in the IWTO–57-98 (IWTO, 1998). The calibration of the OFDA device was certified by the official service called Inter wool labs. The OFDA records were used to correlate with those from PM belonged to the same 36

samples of the analysis, except one that was accidentally lost. On the other hand, as detailed below, in order to correlate breeding values from different models with a reference value, the 1478 samples registered during 2016 in the Pacomarca experimental farm were also used to estimate environmental effects from a fixed model and to deregress those 36 that were finally used as reference. The fiber measurements from PM, with the age of animals and medullation distribution of each of the 36 samples are shown in Table 1, jointly with the percentage of medullation assessed by OFDA 100 ° device. As the influence of animal age on diameter fiber is a well known phenomenon (Gutiérrez et al., 2011) and its influence is also clear on medullation (McGregor, 2006), age of registered animals is also shown in Table 1.

Pedigree of the recorded individuals was tracked back to the founders to complete a pedigree of 121 individuals, with 100% of the parents known as well as 71% of the grandparents, 20% of the great grandparents and less than 1% of the great great grandparents identified. Numerator relationship matrix, computed using Endog v4.8 software (Gutiérrez and Goyache, 2005) showed a strong connectedness between animals as shown in Fig. 3. Despite only the group of males was taken, there was a strong genetic connection among them, justifying their representativeness in the whole population. On the other hand, even when the number of animals is scarce, the high number of records helped to obtain reliable estimates. The final reliability of these analyses can fortunately be known; using the Bayesian approach in the present study helps to properly quantify the levels of uncertainty, once convergence was proofed.

Category and diameter of each fiber were modeled to estimate variance components. Fiber medullation as described here is a categorical trait. Thus, threshold models are indicated to 1 perform the estimation of genetic parameters for this trait (Gianola and Foulley, 1983;

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