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Variability of fibre quality on Chinese Alashan Left Banner White Cashmere goat

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ABSTRACT
The heritability and the phenotypic and genetic correlations of down weight (DW), down fibre diameter (DFD), and coefficient of variation of the down fibre diameter (CVDFD) of Chinese Alashan Left Banner White Cashmere goat were estimated on 1375 one-year-old animals, born in 2009, 2011 and 2013 and bred at the Station for Livestock Improvement of Alashan (Left Banner, Inner Mongolia, P.R. China). For all traits, significant effects were for sex, cohort and sex–cohort interaction ($p < .001$). The heritability for DFD and CVDFD was high, 0.41 ± 0.08 and 0.52 ± 0.06, respectively. Heritability for the DW was low (0.12 ± 0.03). Phenotypic correlation calculated by Pearson's coefficient showed that DFD is positively correlated with both CVDFD (0.29 ± 0.07) and DW (0.20 ± 0.05). The phenotypic correlation between CVDFD and DW was negative (-0.11 ± 0.06). The genetic correlations between DW and CVDFD and between DFD and CVDFD were both high and positive (0.63 ± 0.16 and 0.39 ± 0.1, respectively) while the DW showed a negative genetic correlation with DFD (-0.27 ± 0.2). Our results suggest that the selection for reducing DFD and its CVDFD is possible and a genetic progress can be achieved quickly in the Chinese Alashan Left Banner White Cashmere goat.

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Cashmere; Alashan; goat; heritability; genetic correlation

Introduction

Cashmere is the fine downy-soft winter undercoat found on many goats. Cashmere has a fine texture, and is light yet strong. When it is made into garments, cashmere is extremely warm, much warmer than the equivalent weight in sheep wool.

The U.S. Wool Products Labeling Act of 1939, as amended (U.S.C. 15 Section 68b (a) defines cashmere as the fine (dehaired) undercoat fibres produced by cashmere goat (*Capra hircus l.*). The average diameter of the fibres must not exceed 19 microns and must contain no more than 3% (by weight) of cashmere fibres with average diameters exceeding 30 microns (Cashmere and Camel Hair Manufactures Institute, 2008).

China is the world's main source of cashmere goats, and has recently become the leading purchaser and processor of cashmere produced in other Asian countries.

In the Domestic Animal Diversity Information System hosted by FAO (http://dad.fao.org/), four Chinese cashmere goat breeds are described (Inner Mongolian Cashmere, Liaoning Cashmere, Hexi Cashmere and Shanbei White Cashmere) reared in Liaoning, Inner Mongolia, Xinjiang and Tibet provinces. For the Inner Mongolia cashmere breed, many subpopulation are described (Di et al. 2011), which differ for colour (pure white or coloured) and quality of cashmere (Li et al. 2004). Generally, these types are bred without genetic relationship between them in isolated areas.

In the past years, the genetic admixture with breeds like Liaoning and Inner Mongolia Arbas cashmere selected for increase in body weight and down weight (DW) of the animals has led to the loss of fineness and homogeneity of fibre.

Nowadays, one of the more genetically preserved populations is the Left Banner Alashan White, which produced a very fine cashmere (Bai et al. 2006).

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Nevertheless the influence of Liaoning and Arbas goats is now in progress also in Banner, leading a reduction in fibre quality, in fact fibre diameter is becoming coarser.

A genetic project coordinated by the Station for Livestock Improvement and supported by the Chinese Agricultural University of Jilin and some Italian public and private institutions (University of Camerino, ENEA and the Loro Piana S.p.A. textile industry) started in 2009 in Alashan Left Banner. The purpose of this project was to estimate the genetic parameters for the production traits of the Left Banner Alashan White Cashmere goat. The traits included were: DW, down fibre diameter (DFD) and coefficient of variation of down fibre diameter (CVDFD).

Material and methods

From 2009 to 2013 data were collected from 1375 one-year-old goats, born in 2009 (1st cohort), 2011 (2nd cohort) and 2013 (3rd cohort). The structure of the sample is given in Table 1. The herd was located in the Station for Livestock Improvement of Alashan (latitude 38°24′ N and longitude 104°42′ E), Left Banner, a semi-desert steppe area of the Inner Mongolia (P.R. China). Fleece samples from the mid side of each animal were collected during the first combing. The samples were dehaired, washed and analysed in the Loro Piana Metrology Laboratory in Beijing, certified according to the international requirements of the WTO. Analysis of the DFD and the CVDFD were carried out using an OFDA 100, measuring thousands of fibre for each sample. The DW was recorded directly by the laboratory assistants.

Software package SPSS 12.0 was used to determine the effect of sex, cohort and their interaction on the traits. The same software was also used for the computation of phenotypic correlations calculated by Pearson's correlation coefficient. Heritability and genetic correlation were estimated using the MTDFREML programme (Boldman et al. 1995) with a criterion for convergence set at 10^{-6} and sex and age included as fixed effect for each trait. Standard errors of heritability were estimated using the VCE6 package (Neumaier and Groeneveld 1998).

Table 1. Sample structure.

Sex	Year	Cohort	Number of animals
Bucks	2009	1	270
	2011	2	185
	2013	3	79
Does	2009	1	341
	2011	2	312
	2013	3	188

Results and discussion

Basic statistical analysis

As showed in the Table 2, the average DW values for bucks of the 1st, 2nd and 3rd cohorts was 501.72 g, 514.49 g and 424.11 g, respectively. Lower DW values were recorded for does with a value of 436.69 g, 487.74 g and 404.47 g for the 1st, 2nd and 3rd cohort, respectively.

The average DFD values for the 1st, 2nd and 3rd cohorts ranged from 14.63 µm to 14.27 µm for the bucks. The does showed slightly thicker fibre with DFD values ranging from 14.49 µm to 15.75 µm.

The average CVDFD values for the 1st, 2nd and 3rd cohorts for the bucks ranged from 27.09% to 29.39% showing less variation compared to does were CVDFD ranged from 27.64% to 41.39%.

The basic statistical analysis results indicating the potential of the Left Banner Alashan White Cashmere goat showed higher results for bucks in terms of yield, fineness and homogeneity of fleece.

Fixed effects analysis

The ANOVA showed a significant effect ($p < .001$) of sex, cohort and the interaction between sex and cohort on the three traits studied (Table 3). As also

Table 2. Average values for the down weight, the down fibre diameter and the coefficient of variation of down fibre diameter.

	Bucks			Does		
Trait	Cohort	Mean	Sd	Cohort	Mean	Sd
Down weight, g	1	501.72	120.50	1	436.69	120.41
	2	514.49	132.62	2	487.74	138.04
	3	424.11	73.02	3	404.47	61.74
Down fibre diameter, µm	1	14.63	0.93	1	14.49	1.09
	2	14.27	0.75	2	15.01	0.77
	3	14.59	0.67	3	15.75	0.95
Coefficient of variation of down fibre diameter, %	1	27.09	3.78	1	27.64	5.84
	2	29.39	4.39	2	41.39	8.51
	3	28.52	5.02	3	36.50	9.28

reported by the basic statistical analysis results, bucks showed highest performance in terms of fibre quality. This differences between the two genders may reflect the physiological mechanisms that affect fleece production performance as proposed by Wang et al. (2013).

The differences in weather condition, rainfall and grazing during the 5 years of the study may explain the effect of cohort in the traits studied. This non-genetic factor affected fibre production in other goat breeds as reported for the Inner Mongolia cashmere goat (Zhou et al. 2003) and for the Angora goats (Allain and Roguet 2003).

Estimates of genetic parameters

As showed in the Table 4, the heritability was low for the DW and high for the DFD with values of 0.12 and 0.41, respectively. Of the three traits studied in this paper, the CVDFD had the highest heritability with a value of 0.59. In our study, the low heritability value for DW differs from those reported for the Inner Mongolia cashmere goat (Zhou et al. 2002) and for the Arbas strain (Bai et al. 2006) where the heritability was found to be moderate with values of 0.28 and 0.30, respectively. A moderate heritability of DW (0.35) was also found for the Liaoning cashmere goat in a study by Ning et al. (2005). For the DFD, we found an heritability value similar to those reported from previous studies on Arbas strain and Liaoning breed (Zhou et al. 2002; Ning et al. 2005; Bai et al. 2006; Wang et al. 2013, 2015) in which the value was moderate ranging from 0.28 to 0.42.

The DW showed negative genetic correlation with DFD (−0.27) while it was highly genetically correlated with CVDFD with a correlation coefficients of 0.63. The genetic correlation between DFD and CVDFD was moderate with a value of 0.39.

The phenotypic correlation of DW was positive for DFD (0.20) and negative and not statistically significant for CVDFD (−0.11) while DFD showed moderate phenotypic correlation with CVDFD with values of 0.29.

The negative genetic and positive phenotypic correlation between DW and DFD from our study are in disagreement with the correlations estimated by Bai et al. (2006) and Wang et al. 2013, 2015), which are both positive.

However, the largest differences between our estimates of genetic parameters and those found in other works may be due to the differences in genetic structure between the breeds. Differences in the sample size, the definitions of the traits, the models used for analysis, and the environments to which the populations are subjected may also contribute to these differences (Zhou et al. 2003).

According to our results, in the Chinese Alashan Left Banner White Cashmere goat, the selection for reducing DFD and its CVDFD is possible and the genetic progress can be achieved quickly. Both traits have high heritability and high positive genetic and phenotypic correlations, therefore selection based on phenotypic values will lead to a genetic improvement of these two traits. Otherwise, the direct involvement of DW on selection appears not useful due to his low heritability.

Conclusions

In Alashan Left Banner White Cashmere goat, the genetic parameters are favourable for selection of homogeneous and fine fleece while the selection for yield in cashmere would lead to a slow genetic improvement of the trait.

Our data make an addition to understanding the genetics of cashmere fibre production in Alashan Left Banner White Cashmere goat and provide a basis for

Table 4. Heritability (diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) for the fibre traits.

Trait	Down weight	Down fibre diameter	CVDFD
Down weight	0.12 ± 0.03	−0.27 ± 0.20	0.63 ± 0.16
Down fibre diameter	0.20 ± 0.05	0.41 ± 0.08	0.39 ± 0.10
CVDFD	−0.11 ± 0.06	0.29 ± 0.07	0.52 ± 0.06

CVDFD: coefficient of variation of down fibre diameter.

Table 3. ANOVA for the down weight, the down fibre diameter and the coefficient of variation of down fibre diameter.

Trait	Source of variation	df	Mean Square	F	*p*-Value
Down weight, g	Sex	1	373731.02	26.74	<.001
	Cohort	2	569320.45	40.74	<.001
	Sex x Cohort	2	67062.43	4.80	<.001
Down fibre diameter, μm	Sex	1	104.26	126.08	<.001
	Cohort	2	37.35	45.16	<.001
	Sex × Cohort	2	48.17	58.24	<.001
Coefficient of variation of down fibre diameter, %	Sex	1	14267.15	327.21	<.001
	Cohort	2	8820.99	202.30	<.001
	Sex × Cohort	2	4488.22	102.93	<.001

the development of the efficient genetic selection plan.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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