ABSTRACT
Previous studies have shown that cashmere production (CP) is related to fibre length (FL), mean fibre diameter (MFD) and live body weight (LWT) in Inner Mongolia cashmere goats (IMCGs). However, the correlation magnitudes of these relationships have not been determined to date. The production year, herd, age, birth status, sex, cashmere production, fibre grades, fibre length, mean fibre diameter and live body weight were obtained for IMCGs from yearlings to 5-year-olds. A multilevel mixed model was constructed to discern the impact factors affecting CP. It was concluded that the production year, herd, age, sex, FL, MFD and LWT had highly significant effects on CP ($p < .01$). Birth status had no influence on CP ($p > .05$). The restricted maximum likelihood method (REML) was used to estimate the relationship of CP to all impact factors. Positive correlations were observed between CP and other important economic traits. The regression coefficients for FL, MFD and LWT were 26.50 g/cm, 31.67 g/mm and 2.26 g/kg, respectively. The model fit is relatively good, and the adjusted R-squared value is 0.43. Using a similar method, the relationship of CP to these impacting factors within each fleece grade was analysed. The results showed that LWT had no significant effect on CP in superfine and coarse cashmere grades. Additionally, MFD was not related to CP in coarse cashmere. However, FL, MFD and LWT had highly significant effects on CP in all other FD grades. The regression coefficients of cashmere production for other economic traits varied based on fleece grade.

HIGHLIGHTS
- Cashmere production was positively correlated with live body weight for Inner Mongolia Cashmere goats (IMCGs), which can facilitate indirect selection and reduce the cost of measurement.
- The fibre diameter should be considered to maintain good quality by establishing a nucleus herd, thereby increasing economic income and protecting a variety of resources.

Introduction
Cashmere is the most superior product made from wool fibre. Cashmere’s soft texture gives a garment elegance and distinction. The amount of cashmere from China exported to foreign countries was large, according to the quantum index of world trade. Many countries have performed genetic breeding research on cashmere goats since the 1980s, which has helped improve cashmere production and the quality of fibre (Ponzoni and Gifford 1990; Allain and Roguet 2006; McGregor et al. 2013; Elham et al. 2015; Xuewu et al. 2017). Although the cashmere produced by Inner Mongolia cashmere goats (IMCGs) is well known for its brightness, elasticity, thin diameter and softness, the mean fibre diameter of IMCGs has become coarser in recent years (Wang et al. 2013; Zhang et al. 2014). Some studies explain that the cashmere production of IMCGs is exhibiting a clear upward trend after numerous years of breeding studies (Bai et al. 2006; Wang et al. 2014). According to statistics on production performance provided by our research team, the CP of IMCGs increased 400 g from 1990 to 2017, the fibre
length increased 1.5 cm, and the mean fibre diameter remained 14.5 μm. Additionally, the live body weight of IMCGs significantly improved through genetic breeding. Some studies have reported a genetic correlation between cashmere production and fibre length, mean fibre diameter and live body weight in IMCGs based on a genetic evaluation (Zhou et al. 2002; Bai et al. 2006). However, few studies have used regression analysis to determine the impact of fibre quality and growth traits on cashmere production. McDonald (1988) used linear regression to determine the impact of cashmere production on fibre length. McGregor and Bulter discussed the relationships between cashmere production and the fleece attributes and animal growth of Australian cashmere goats (McGregor and Butler 2008b; McGregor et al. 2013). Wudubala et al. (2015) performed a correlation and regression analysis of the economic traits of Erlangshan cashmere goats, including animal growth and cashmere traits. All these studies demonstrated that cashmere production has a certain relationship with other economic traits.

The impacts of the production year, herd, age, birth status and sex on cashmere production in IMCGs have been determined by previous studies (Zhou et al. 2003; Yue-Jun et al. 2009; Wang et al. 2013). However, the effects of fleece grade on the cashmere production of IMCGs have not been studied. There are three categories of cashmere in China, namely, superfine (≤14.5 μm), fine (14.5 μm–16.0 μm) and coarse (≥16.0 μm) (Liu et al. 2009). The price of cashmere in some countries is closely associated with fibre quality. Terrill (1953) showed that fleece grade significantly affected the price of wool in three sheep breeds. In China, cashmere has gradually begun to be judged by fibre quality. Additionally, in some flocks, nucleus herds with fine fibre diameter have been established. Therefore, it is also necessary to discuss the fleece grade. The purpose of this study is to determine how fibre quality and animal growth influence cashmere production and how the magnitude of this relationship varies within fleece grades. The results of this study will help to inform the establishment of nucleus herds and the effective design of breeding programmes.

Materials and methods

General management

The modes of management and production among Inner Mongolia Arbas goat flocks have been described by Zhou et al. (2002, 2003) and Wang et al. (2013, 2014). IMCGs graze on pasture year-round and are kept in southwestern Inner Mongolia in China. The identification number, birth status, sex, birth weight and date of birth for all kids are recorded. Detailed and complete pedigree information on IMCGs from 1990 to 2018 is also on record. All kids are weaned at 4 months of age. Moulting cashmere is harvested in mid-May every year. The live body weight and cashmere production are determined immediately after combing the cashmere and are close to 0.1 kg and 1 g, respectively. Patch samples of 10 cm² from the sides of the shoulder are obtained by shaving the area when beginning combing. Then, the fleece samples are returned to the Wool Analysis Laboratory of the Inner Mongolia Agriculture University. The samples are first washed with petroleum ether to remove contaminants such as soil and grease. Then, lab assistants separate hair from the sample carefully; the remainder is cashmere. The fleece samples were measured with an optical fibre diameter analyser (OFDA) and standard rulers. The fibre properties of each individual goat were assessed from when the goats are yearlings until elimination from the flock or death. The mean fibre (MFD) diameter was obtained directly with the OFDA after pre-treatment of samples. The fibre length (FL) was measured 50 times with a standard ruler. The MFD and FL were measured to the nearest 0.5 μm and 1 mm, respectively. The date of combing, cashmere production (CP), live body weight (LBW), fibre length (FL) and mean fibre diameter (MFD) for the goats were documented and archived.

Data set

Data were collected from 7756 repeated records of individuals one to five years of age in the IMCGs flock from 2008 to 2017. Due to errors in identification numbers, the number of records for fibre properties was less than 7756. Statistics on important economic traits, including cashmere and growth personality, are shown in Table 1. According to Chinese Cashmere Standard, the raw cashmere is classified three levels. However, our research team aimed to establish a nuclear flock with a mean fibre diameter less than 13 μm. As such, four levels of cashmere were

| Variables                      | N  | Mean  | SD   | Minimum | Maximum |
|-------------------------------|----|-------|------|---------|---------|
| Fibre length, cm              | 7304 | 10.49 | 1.76 | 4.02    | 17.50   |
| Mean fibre diameter, μm       | 6357 | 14.33 | 1.02 | 10.84   | 18.77   |
| Live body weight, kg          | 7556 | 39.15 | 9.85 | 21.00   | 88.50   |
| Cashmere production, g        | 7556 | 837.70 | 191.40 | 80     | 1573    |
considered in this study, including superfine ($\leq 13\,\mu m$), median-fine (13 $\mu m$–14.5 $\mu m$), fine (14.5 $\mu m$–16.0 $\mu m$) and coarse ($\geq 16.0\,\mu m$).

**Statistical analysis**

To discern the relationship between CP and other economic traits in IMGGs, a multilevel mixed model that analysed fixed and covariate effects was constructed (Singer 1998; Davidian 2003). Convergence was achieved after four iterations of the entire computing process. Random regression slope coefficients of CP for other economic traits were obtained with the restricted maximum likelihood method (REML). The production year (2008–2017), herd (1–12), birth status (single or twins, 1–2), sex (male or female, 1–2) and age (1–5) were considered fixed effects, and the live body weight (LBW), fibre length (FL) and mean fibre diameter (MFD) were considered covariate variables. The multilevel mixed model included the calculation of fixed and covariate effects, as follows:

$$y_{ij} = \gamma_0 + \gamma_{10} Year_{ij} + \gamma_{12} Herd_{ij} + \gamma_{13} Bs_{ij} + \gamma_{14} Sex_{ij} + \gamma_{15} Age_{ij}$$

$$+ \gamma_{16} FL_{ij} + \gamma_{17} MFD_{ij} + \gamma_{18} LBW_{ij}$$

where $y_{ij}$ is the vector of observations of the $j$th animal at the $ith$ age. $Year_{ij}$, $Herd_{ij}$, $Bs_{ij}$, $Sex_{ij}$ and $Age_{ij}$ are the fixed effect levels of the $j$th animal. $FL_{ij}$, $MFD_{ij}$ and $LBW_{ij}$ are the covariate variables for the $j$th animal at the $ith$ age. The observation unit for analysis is an individual goat. $\gamma_0$ is an intercept, which was also used as the over mean. $\gamma_{10}$, $\gamma_{12}$, $\gamma_{13}$, $\gamma_{14}$, $\gamma_{15}$, $\gamma_{16}$, $\gamma_{17}$ and $\gamma_{18}$ were the slope coefficients of $Year_{ij}$, $Herd_{ij}$, $Bs_{ij}$, $Sex_{ij}$, $Age_{ij}$, $FL_{ij}$, $MFD_{ij}$ and $LBW_{ij}$ on CP, which explained the incremental change in CP for each unit of change in the fixed effects and covariate variables.

The above model was also used to analyses the relationship between cashmere production and other economic traits within fleece grades. All of the fixed effects and covariate variables were determined by mixed procedure by using SAS software (SAS Institute 2009).

**Results**

**Statistics of important economic traits in IMCGs**

The basic statistics of cashmere and growth traits are shown in Table 1. The variation in each trait is large, particularly for live body weight and cashmere production. After years of breeding, these two traits have clearly improved in terms of phenotype and genetics, though these qualities were poor in some individuals. The cashmere production and live body weight are 837.7 g and 39.15 kg, respectively. The average fibre length from ages of 1 to 5 years is as high as 10.49 cm, which is highly advantageous for cashmere processing. The mean fibre diameter from one to five years is 14.33 $\mu m$, and the coefficient of variation of MFD is relatively small.

**Parameter estimates with the multilevel mixed model**

The results of the regression analysis are shown in Table 2. The production year, herd, age, sex, FL, MFD and LWT had significant effects on CP ($p < .01$). Birth status had no effect on CP ($p > .05$). Additionally, there was a marginal significance in CP among the individuals ($\gamma_{100}$) ($p = .06$). The regression coefficients for FL, MFD and LWT were 26.50 g/cm, 31.67 g/µm and 2.26 g/kg, respectively. Except for age and sex, other explanatory variables positively affected cashmere production. The trend in CP in terms of age is shown in Figure 1. CP increased and then decreased with age. The maximum MED value was reached at 2 years old. Finally, CP was considerably higher in males than in females (Figure 2).

The relationship between CP and other economic traits for each fleece grade are shown in Table 3. The slope coefficients of fibre properties and animal growth on cashmere production within fleece grades were inconsistent. The effect of live body weight on CP was not significant in the superfine and coarse fleece grades. Fibre length and live body weight had positive effects on CP for all fleece grades. Mean fibre diameter was not significantly related to CP in coarse cashmere. Cashmere production exhibited a rising trend with fleece grade (Figure 3). However, the mean fibre diameter was negatively correlated with cashmere production in the coarse fleece grade.

Table 2. The parameter estimates of the fixed effects and covariate variables in the multilevel mixed model.

| Parameters | Effects Estimate | SD | t Value | p       |
|------------|------------------|----|---------|---------|
| $\gamma_0$ | Intercept        | 89.7800 | 47.6200 | 1.8800 | .0616** |
| $\gamma_{10}$ | Year            | 8.2900 | 1.9100 | 4.3500 | <.0001** |
| $\gamma_{12}$ | Herd            | 6.8900 | 1.6700 | 0.5300 | <.0001** |
| $\gamma_{13}$ | Bs              | 3.5700 | 4.2800 | 0.8300 | .4040** |
| $\gamma_{14}$ | Sex             | 34.3100 | 6.6900 | 5.1300 | <.0001** |
| $\gamma_{15}$ | Age             | 14.6800 | 8.2500 | 1.7200 | .0866* |
| $\gamma_{16}$ | FL              | 26.5000 | 13.1000 | 2.0500 | .0200** |
| $\gamma_{17}$ | MFD             | 31.6700 | 3.0700 | 8.6400 | <.0001** |
| $\gamma_{18}$ | LBW             | 2.2600 | 0.3400 | 6.7200 | <.0001** |

Bs: birth status; FL: fibre length; MFD: Mean fibre diameter; LBW: live body weight; ns: fixed effect or covariate variables have no effect on cashmere production.

**Fixed effect or covariate variables have highly significant effect on cashmere production.**
Discussion

The fibre length of IMCGs ranged from 4.0 cm to 17.5 cm, with an average value of 10.5 cm. The average fibre length was longer than that of Lori goats (Salehi et al. 2013). Additionally, the ratio of FL longer than 5 cm in the entire IMCGs population reached 99%, which fully satisfied the cashmere processing requirements. In China, cashmere with a fibre length longer than 36 mm is considered ideal for processing (Yan and Long 2009). It was found that the mean fibre diameter among IMCGs is thickening. However, it is finer than in other goat breeds, such as Liaoning cashmere goats and Raeini cashmere goats. The mean fibre diameter of male and female Liaoning cashmere goats is 16.12 μm and 15.97 μm, respectively (Wu 2018). Shamsaddini-Bafti reported that the mean fibre diameter of Raeini cashmere goats is approximately 18.0 μm (Shamsaddini-Bafti et al. 2012). The cashmere production in our study was higher than that found for Long Dong cashmere goats (Xue et al. 2011). Our research team has been contributing to breeding for CP and LBW in this flock for many years. Currently, two economic traits have shown clear improvement. CP increased 400 g from 1990 to 2017, which is relatively higher than that of other goat breeds (Couchman and McGregor 2010; Rischkowsky and Momen 2012; Ansarirenani 2013). Inner Mongolia cashmere goats are a dual-purpose breed, producing cashmere and meat, but they are famous for the high production and good fibre quality of their cashmere. The live body weight in male and females increased by 23.24 kg and 12.15 kg, respectively. The LBW of IMCGs is higher than that of Angora goats (McGregor et al. 2013). However, the live body weight of Liaoning cashmere goats is well known to be high, given their large body size, which is far larger than that of IMCGs. Our investigation of the key cashmere goat flocks in 2018 revealed that the LBW of male and female Liaoning cashmere goats was approximately 75.5 kg and 50.0 kg, respectively.

Many researchers (Zhou et al. 2003; Yue-Jun et al. 2009; Wang et al. 2013) have reported the influence of nongenetic factors on cashmere production of IMCGs. Although all these studies used a generalised linear model with least square means, their results agreed with the results of this study. Clearly, except for birth status, other fixed effects, including the production year, herd, age and sex, significantly affected CP. In the present study, the maximum value of CP was attained at 2 years old and then sharply declined thereafter. This trend may be explained by the fact that some secondary hair follicles lose the ability to produce cashmere fibres as goats age. Similarly, McGregor and Butler observed an increasing trend of CP with age in Australian goats, though the maximum value appeared at six years old (McGregor and Butler 2008a). The CP of males in this study was much higher than that of females, echoing the results of previous studies (Rischkowsky and Momen 2012; Bai et al. 2015; Pallotti et al. 2018; Wani et al. 2018). However, Newman and Paterson (1996) explained that the
cashmere production of males was lower than that of females for New Zealand cashmere goats. Most studies (Ferreira et al. 2014; Visser and Marle-Köster 2014) have demonstrated positive genetic and phenotypic correlations between CP and MFD, which is consistent with the results of this study, in which cashmere production increased 31.67 g per 1 mm increase in mean fibre diameter. Nevertheless, a study performed by Stefano Pallotti showed that CP had a negative genetic correlation and positive phenotypic correlation in Chinese Alashan Left Banner White Cashmere goats, which may be explained by the diverse breeds and data structures (Pallotti et al. 2018).

The regression coefficient of FL in IMCGs was 26.50 g/cm, which confirms the positive genetic correlation between CP and FL found in previous studies (Zhou et al. 2003; Bai et al. 2006). McDonald (1988) explained that the range in regression coefficients of FL among shearing ages was 11.1 g/cm–20.7 g/cm, which is in approximate agreement with our results. However, few regression analyses of CP on FL have been performed, though some reports suggest a positive relationship between CP and FL (McGregor et al. 2013; Bai et al. 2015), whereas other reports indicate a poor negative correlation between FL and CP in Raeini cashmere goats (Rischkowsky and Momen 2012; Ansarirenani 2013). The variation in results may be due to differences in species and data structures. Similarly, live body weight exhibited a positive relationship with CP. A 1 kg increase in LBW resulted in a 2.26 g gain in CP, implying a relationship between animal growth and cashmere production. The LBW and CP may be improved with adequate nutrition. In addition, our breeding research makes an important contribution to enhancing these two traits. McGregor and Butler illustrated that cashmere production increased with animal size (McGregor and Butler 2008a; McGregor et al. 2013).

Our study is the first to discuss the effect of fleece grades on CP and to estimate the regression coefficients of CP for LBW, FL and MFD in each fleece grade. In this study, cashmere production rose sharply with fleece grade, which indicates a positive correlation between cashmere production and fibre diameter. The results of the regression analysis were consistent with the findings of previous studies in animal models (Zhou et al. 2003; Bai et al. 2006). Fibre length had a highly significant effect on CP for all fleece grades. However, the relationship between CP and MFD at FG-4 was poor, which is explained by the relatively low regression coefficient (−5.68 g/µm). A negative relationship between FL and MFD was observed (Liu et al. 2007). LBW had no significant effect on CP in FG-1 and FG-4, which was due to the data structure and low coefficients of variation. Although the regression coefficients of FL, MFD and LBW varied for different fleece grades, except in the case of the relationship between CP and MFD in FG-4, a positive relationship between CP and the three economic traits in other FGs was observed. Ultimately, it was difficult to promote high cashmere production and a superior fibre diameter simultaneously. However, the positive relationship between CP and LBW will benefit breeding of IMCGs.

### Conclusions

The results of the regression analysis indicate that live body weight, mean fibre diameter and fibre length had highly significant effects on cashmere production. Cashmere production increased with the average values of these three traits. Additionally, cashmere production exhibited an increasing trend with fleece grade. In other words, cashmere production increased as fibre diameter thickened. In summary, it is difficult to improve cashmere production and fibre quality simultaneously. Considering that cashmere in China has gradually begun to be valued based on fibre quality, the two key traits of cashmere production and fibre

### Table 3.

| Statistic | FG1 | FG2 | FG3 | FG4 |
|-----------|-----|-----|-----|-----|
| n         | 650 | 3057| 2279| 371 |
| Mean, g   | 784.40 | 825.10 | 866.60 | 886.80 |
| SD        | 172.60 | 191.50 | 196.60 | 199.20 |
| CV(%)     | 22.01 | 23.21 | 22.68 | 22.47 |
| the change in CP per 1 cm in FL, g | 16.08** | 27.23** | 26.84** | 33.30** |
| the change in CP per 1 µm in MFD, g | 34.25* | 38.49** | 31.90** | –5.86ns |
| the change in CP per 1 kg in LBW, g | 2.21ns | 4.92** | 3.08** | 2.82ns |

FG: fleece grade; CP: cashmere production; FL: fibre length; MFD: Mean fibre diameter; LBW: live body weight; ns: the economic trait have no effect on cashmere production.

**The economic trait have significant effect on cashmere production.

***The economic trait have highly significant effect on cashmere production.
quality should be improved separately by forming two nucleus flocks. The positive relationship between live body weight and cashmere production indicates that nutrition level significantly affects body growth and cashmere production. Therefore, it is necessary to improve live body weight and cashmere production by combining nutrition and breeding work. The cashmere production increased significantly with fibre length. Conversely, increasing cashmere production can improve fibre length, which benefits the textile processing of cashmere.

Acknowledgements
The authors are grateful to the staff of the Inner Mongolia Arbas Cashmere goat stock farm for providing data and assistance.

Disclosure statement
The authors declare that they have no competing interests.

Geolocation information
The data were collected from a cashmere goat flock in Inner Mongolia located at the Arbas stock farm (latitude 39° 06'E and longitude 107° 59'E) in southwestern Inner Mongolia, China.

Funding
This work was supported by a grant from the Inner Mongolia Agricultural University for second levels of outstanding doctorate [NDYB2016-05], the Young Talents of Science and Technology in Universities of Inner Mongolia Autonomous Region [NJYT-17-A04], the Natural Science for Youth Foundation [31702086] and the Modern Agro-industry Technology Research System [CARS-39-06].

References
Allain D, Roguet JM. 2006. Genetic and non-genetic variability of OFDA-medullated fibre contents and other fleece traits in the French Angora goats. Small Ruminant Res. 65: 217–222.
Ansarirenani HR. 2013. Cashmere quality of Iranian goat breeds. Media Peternakan. 36:1–5.
Bai JY, Jia XP, Wang YQ, Pang YZ. 2015. Path analysis of the main economic characters of the Inner Mongolia white cashmere goats. J Exper Biol Agri Sci. 3(3):269–274.
Bai JY, Zhang Q, Li J, Dao E, Jia XP. 2006. Estimates of genetic parameters and genetic trends for production traits of inner mongolian white cashmere goat. Asian Australasian J. Anim. Sci. 19(1):13–20.
Couchman RC, McGregor BA. 2010. A note on the assessment of down production in Australian ‘cashmere’ goats. Anim Sci. 36:317–320.
Davidian M. 2003. Hierarchical linear models: applications and data analysis methods. Pub Am Stat Assoc. 98: 767–768.
Elham B, Hedayatolah R, Sahrakha Azar RD. 2015. Estimation of genetic parameters for growth traits and fleece production of south khorasan goats. Anim Sci J. 105:11–26.
Ferreira TA, Pereira IG, Gouveia AMG, Pires AV, Facc O, Farah MM, Pessoa MC, Guimarães MPSLP. 2014. Genetic evaluation of Saanen goats born in Brazil from 1979 to 2009. Arquivo Brasileiro De Medicina Veterinária E Zootecnia. 66:1179–1188.
Ke-Bang, X, Bu-Feng, Z, Jian-Jun, Z, Yu-Cheng, Z, Yan-Ling, P, Jia-Long, Li, et al. (2011). Study on breeding of high-quality and high-yield cashmere goat in long dong. Journal of Animal Science and Veterinary Medicine. 30(3):11–14.
Liu GY, Liu Y, Zhang CQ. 2009. Studies on fiber properties of Shanbei cashmere goats. Modern Agri Sci Technol. 9: 243–244.
Liu H, Zhihai J, Chunwang Y. 2007. Research of relation between age and production characters of cashmere in Inner Mongolia white cashmere goats. J Chin Agri Univ. 12:37–40.
McDonald BJ. 1988. Estimation of cashmere production from cashmere fibre length in goats. Aus J Exper Agri. 28: 37–39.
McGregor BA, Butler KL. 2008a. Cashmere production and fleece attributes associated with farm of origin, age and sex of goat in Australia. Aus J Exper Agri. 48:1090–1098.
McGregor BA, Butler KL. 2008b. Determinants of cashmere production: the contribution of fleece measurements and animal growth on farms. Small Ruminant Res. 78:96–105.
McGregor BA, Butler KL, Ferguson MB. 2013. The allometric relationship between clean mohair growth and the fleece-free liveweight of Angora goats is affected by liveweight change. Anim Prod Sci. 53:154–162.
Newman SAN, Paterson D. 1996. Estimates of environmental effects for liveweight and fleece characteristics of New Zealand cashmere goats. New Zeal J Agric Res. 39(3): 379–386.
Pallotti S, Wang J, Tang P, Antonini M, Lou Y, Pieramati C. 2018. Variability of fibre quality on Chinese Alashan Left Banner White Cashmere goat. Italian J Anim Sci. 17:53–56.
Ponzoni RW, Gifford DR. 1990. Developing breeding objectives for Australian Cashmere Goats. J Anim Breed Gen. 107:351–370.
Rischkowsky B, Momen SS. 2012. Cashmere quality of Raeini goats kept by nomads in Iran. Small Ruminant Res. 104: 10–16.
Salehi M, Lavaf A, Farahvash T. 2013. Fleece traits and important physical properties of hair fibers in lori goats. Iranian J Appl Anim Sci. 3:797–801.
SAS Institute (2009). SAS/STAT User’s guide: Version 9.1, SAS institute.
Shamsaddini-Bafti M, Salehi M, Maghsoudi A, Tehrani A, Mirzaei F, Momen SM. 2012. Effect of sex and rearing system on the quality and mineral content of fiber from raeni cashmere goats. J Anim Sci Biotechnol. 3:20.
Z. WANG ET AL.

Singer JD. 1998. Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. J Edu Behav Stat. 23:323–355.

Terrill CE. 1953. The relation between sale price and merit in Columbia, Targhee and Rambouillet rams. J. Anim. Sci. 12(3):419–430.

Visser C, Marle-Köster EV. 2014. Strategies for the genetic improvement of South African Angora goats. Small Rum Ruminant Res. 121:89–95.

Wang Z, Wang R, Li J, Zhang W, Wuriliga, Su R, Liu Z, Zhou J, Wei Y, Meng R, et al. 2014. Modeling genetic covariance structure across ages of fleece traits in an Inner Mongolia cashmere goat population using repeatability and multivariate analysis. Livestock Sci. 161:1–5.

Wang Z, Wang R, Zhang W, Wang Z, Wang P, Liu H, Gao L, Bai K, Meng R, Zhou J, et al. 2013. Estimation of genetic parameters for fleece traits in yearling Inner Mongolia Cashmere goats. Small Ruminant Res. 109:15–21.

Wani SA, Shaheen FA, Wani MH. 2018. Cashmere producing smallholder nomads of Himalaya: Survival challenges of a system. Small Ruminant Res. 163:45–50.

Wu S. 2018. Estimation of fiber diameter using age of animal and fiber natural length in Liaoning cashmere goats. Modern J Anim Husbandry Veter Med.

Wudubala, Bin L, Cun-fa Z, Yu-rong L, Yun-mei H, Yun-deng Z, Pei-rong T, Fu T. 2015. Correlation and regression analysis of body size, cashmere traits and economic traits in Erlangshan cashmere goat. Chin Anim Husbandry Veter Med. 42:1245–1252.

Xuewu LI, Ruijun W, Zhiying W, Qing NA, Hongwei, LI, Zhenyu W, et al. (2017). Study on the estimation of genetic parameters and genetic progress for fleece traits of Inner mongolian cashmere goats. Heilongjiang Animal Science & Veterinary Medicine. 124(1):117–120.

Yan Ji, Long Li. 2009. Discussion on the status of Cashmere spinning. Chemical Fiber & Textile Technology. 6(2):34–37.

Yue-Jun MA, Bin L, Yu-Rong LI, Bao-Hua, L. 2009. Analysis of influencing of non-genetic factors on the main production traits in Inner mongolia arbas cashmere goats. Animal Husbandry and Feed Science. 30(10):3–7.

Zhang Y, Wang Z, Lei H, Wang Z, Su R, Zhang W, Zhou J, Wei Y, Meng R, Wang R, et al. 2014. Estimates of genetic parameters and genetic changes for fleece traits in Inner Mongolia cashmere goats. Small Ruminant Res. 117:41–46.

Zhou HM, Allain D, Li JQ, Zhang WG, Yu XC. 2002. Genetic parameters of production traits of Inner Mongolia cashmere goats in China. J Anim Breed Gen. 119:385–390.

Zhou HM, Allain D, Li JQ, Zhang WG, Yu XC. 2003. Effects of non-genetic factors on production traits of Inner Mongolia cashmere goats in China. Small Ruminant Research. 47:85–89.