Pedigree analysis of Cashmere goat breed of South Khorasan

Sahereh Joezy-Shekalgorni, Ali Maghsoudi, Amir Taheri-Yeganeh and Behzad Rajabi-Marandi

Young Researchers and Elites Club, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran; Department of Animal Science, Zabol University, Zabol, Iran; Animal Breeding and Milk Improvement Centre, Ministry of Jihad Agriculture, Karaj, Iran; Department of Animal Science, University of Tehran, Karaj, Iran

ABSTRACT

The genealogical data of Cashmere goat breed of South Khorasan province of Iran was analysed in this study. Records from a total of 10,635 animals collected during 1988–2014 from 20 registered flocks were analysed for evaluating pedigree parameters. The reference population was defined as the living reproductive animals born from 2010 till 2014. The average inbreeding coefficient in the studied breed was about 0.07% (ranging from 0 to 25%). In addition, the average inbreeding coefficient for the reference population was about 0.85%. The main reason for the low inbreeding level obtained in Cashmere goat population was related to the extensive production system and lack of sire registration in a large number of animals (about 78% missing sire information). A total of 200 animals were inbred. The inbred animals were all related to the breeding station flock which was acting as a closed nucleus flock and was under the control of Animal Breeding and Milk Improvement Centre of Iran. The result of analysis for gene origin parameters indicated the lack of pedigree depth, which could lead to management problems for conservation of the studied breed.

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Introduction

For the development of an appropriate programme for conservation of animal genetic resources, careful evaluation of the current genetic diversity is considered as an initial step. Pedigree analysis is an appropriate tool for the evaluation of genetic diversity of a population. This method has been commonly used for the study of the genetic variability in pig (Szabó et al. 2016), sheep (Mokhtari et al. 2014), cattle (Pienaar et al. 2015), buffalo (Marcondes et al. 2014), horse (Hasler et al. 2011), donkey (Cecchi et al. 2006) and in pet animals (Cecchi et al. 2013). A limited number of studies have also evaluated genetic diversity of goat breeds through this method (Portolano et al. 2004; Baldursdottir et al. 2012; Oravcová 2013; Rashidi et al. 2015).

Iran is considered as the third main Cashmere producing country. Cashmere goat of South Khorasan is an indigenous Iranian breed in South Khorasan province of Iran. The official breed registry on this breed was established in 1988. A few flocks of this breed are included in performance recording. The objective of the current study was to demonstrate demographic characteristics of South Khorasan Cashmere goat breed of Iran and to study genetic diversity of this breed by analysing the collected genealogical data.

Materials and methods

Genealogical information of 10,635 Cashmere goat of South Khorasan province (including 3493 bucks and 7142 does), collected by Animal Breeding and Milk Improvement Centre of Iran during 1988 to mid-2014, was investigated in this study. The pedigree was checked for inconsistencies in dam and sire registration, birth date and sex registration. The programmes CFC 1.0 (Sargolzaei et al. 2006) and ENDOG 4.8 (Gutiérrez & Goyache 2005) were utilised for performing pedigree analysis.

Founders were defined as individuals with one or both unknown parents. The reference population was defined as the population of interest, including living reproductive animals born from 2010 till 2014. Various parameters, including the effective number of founders, the absolute number of founders, the effective number of ancestors, number of inbred animals and...
inbreeding coefficient, the number of full traced generation, the equivalent complete generation, the maximum number of generation traced, etc., were obtained in order to provide insights into the genetic history of the breed.

Results and discussion
Demographic parameters derived from genealogical data of 20 flocks of Cashmere goat breed of south Khorasan indicated that among the studied population, 2.1% and 31.8% were presented as sires and dams, respectively. Of the total 10,635 animals, about 40% were considered to be founders (with both unknown dam and sire), and about 66.11% of animals did not have any progeny. The number of individuals with known sire, known dam and both known parents, were 2354, 6384 and 2354, respectively. Timeline trend of founders and animals with no progeny in various years is presented in Figure 1. Results indicated that from 1988 till 1993, more than 99% of the animals were founder. There did not exist a regular trend for the rate of founders in population, from 1994 to 2007. However, the rate of founders reached to zero in 2008 and continued to be less than 10%, afterward.

The structure of population across flocks is presented in Figure 2. Among the studied flocks, flock 19 and 8 had the most and the least registered population, respectively. In addition about 22 and 79% of the registered population, in flocks 19 and 13, were considered as founder. The number of registered animals showed a descending trend over the last decade of evaluation. No inbred animal was found till 2002. Inbred animals increased by 21% in 2011 and reached to 50% of the registered animals by 2013.

The distribution of the inbreeding coefficient among Cashmere goat of South Khorasan breed is presented in Table 1. The inbreeding coefficient ranged from 0.1% to 25%. The average inbreeding value and the mean average relatedness in the whole studied population were 0.07 and 0.08%, respectively. The average inbreeding in the inbred individuals was 3.88%. Evolution of the inbreeding coefficient per year of birth showed that the occurrence of inbreeding was mainly due to the recent generation indicating that the historical knowledge of the pedigree is lacking (Gutiérrez et al. 2003). The extensive production system used in Cashmere goat of South Khorasan contributed toward loss of much of fatherhood information data from past generation. Another reason for low inbreeding observed in Cashmere goat of South Khorasan was related to the type of pedigree data for this breed. Investigation of the pedigree across herds indicated that the presence of registered flocks had been changed across years. Some flocks were excluded from or included into the registration programme. Flock 19 was the only flock with continuous pedigree registration and all inbred individuals were found in this flock. No relatedness was found between animals in various flocks except for flock 19 and 9

Figure 1. Number of founders and number of individuals across herds.
(relatedness $=0.041\%$) indicating flock 19 was acting as a closed nucleus herd.

The average inbreeding and coancestry in the reference population were 0.85 and 1.18%, respectively. The average relatedness of individuals within the reference population was about 2.36%. Table 2 gives an overview on the probabilities of gene origin parameters in the studied breed. Of the total 692 animals in the reference population, there did exist a number of 366 males and 326 females which were related to 225 and 217 founders, respectively. The ratio of the effective number of founders (fe) to the total number of founders (f) in the studied population was 0.23 indicating unbalanced contribution of founders as parents in the population. Similar fe/f ratio was reported for the Slovak White Shorthaired goat breed and Italian Girgentana goat breed (Portolano et al. 2004; Oravcová 2013). On the other hand, this ratio was about 0.46 for Iranian Markhoz goat (Rashidi et al. 2015) indicating more equivalent contribution of founders to the reference population in this breed. The number of ancestors contributing to the reference population of Cashmere goat of South Khorasan was about 81% of founders, which is a sign of lack of pedigree depth and short time distance among founder and young living population (Gutiérrez et al. 2003; Oravcová 2013). Effective number of ancestor was about 60, which could be a result of occurring genetic bottleneck and loss of genetic diversity in the studied breed (Álvarez et al. 2010). The ratio of the effective number of founders to the effective number of ancestors (fe/fa) was about 1.5. Our result on the ratio of fe/fa was similar to the result reported for the White

Table 1. Distribution of the inbreeding coefficient in South Khorasan goat breed.

| Level of inbreeding, % | Number of animals |
|-----------------------|-------------------|
| 0 < F ≤ 5            | 149               |
| 5 < F ≤ 10           | 13                |
| 10 < F ≤ 15          | 33                |
| 15 < F ≤ 20          | 3                 |
| 20 < F ≤ 25          | 2                 |

Table 2. Parameters of probability of gene origin for the reference population in the Cashmere goat breed of South Khorasan.

| Item                                      | Value         |
|-------------------------------------------|---------------|
| Number of animals in the reference population | 692           |
| Number of ancestors contributing to the reference population | 289           |
| Total number of founder animals in the reference population | 358           |
| Effective number of founders              | 88            |
| Effective number of ancestors             | 60            |
| Number of founder herds in the reference population | 3             |
| Effective number of founder herds         | 1.3           |
| Founder equivalent                        | 315           |
| Founder genome equivalent                 | 42.37         |
| Effective number of non-founders          | 68.66         |
| Genetic contribution of main ancestor, %  | 5.02          |
| Number of ancestors explaining 50% of gene pool | 34            |
| Number of ancestors explaining 75% of gene pool | 84            |
| Number of ancestors explaining 100% of gene pool | 289           |

Figure 2. The number of animals and the number of founders in various herds of Cashmere goat of South Khorasan.
Shorthaired (1.6) and Markhoz (1.32) goats. Smaller value of effective number of founder herds compared with the actual number of herds obtained in this study refers unbalanced contribution of various flocks in gene pool of the population and emphasises that some flocks behave as nucleus herds providing genetic material for other flocks (Gutiérrez et al. 2003).

Mean maximum generation, mean complete generation and mean equivalent generation was 2.06, 1.28 and 1.61 years, respectively. Effective population size regarding the estimated maximum, complete and equivalent generations were 362.79, 128.46 and 183.83, respectively. Low value obtained for the equivalent generation in this study indicates pedigree incompleteness and low pedigree depth. Loss of genetic diversity is expected in population with small effective population size. According to the FAO (1998) guideline on preserving animal genetic resources, effective population size less than 50 affects the fitness of the breed under consideration. Estimate of effective population size for Cashmere goat of South Khorasan was above the critical level which ensures low inbreeding rate and consequently, stable development of population without concerning about high relatedness of animals. However, missing pedigree information could be the main reason for obtaining low inbreeding value and it does not have to be ignored when interpreting the results for the Cashmere goat breed of South Khorasan.

Conclusions

Population structure across the years and flocks in Cashmere goat of South Khorasan was documented in this study. Large number of unknown sires was the reason for the low inbreeding coefficient obtained in the studied breed. Results indicated to unbalance contribution of founders in the population. Generally, animals with unknown parents are assumed to have no inbreeding. However, in reality, they quite often are related to each other leading an underestimation of the inbreeding coefficient. For including the studied breed in the conservation programme, solving the problem of pedigree completeness is necessary. Nomadic breeding system applied in tropics, including South Khorasan, could be the main reason for loss of pedigree information in the registered flocks of Cashmere goat of South Khorasan.

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Disclosure statement

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