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Factors Affecting the Secondary Sex Ratio of the Iranian Raeini Goats

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COMMONLY, the secondary sex ratio - the animal proportion of the same gender in the population at birth- is equal. This study aimed to identify the environmental and genetic factors affecting the secondary sex ratio of the Iranian Raeini goats. The data from 13563 goats included 7752 males and 5811 females were used to evaluate the effect of genetic and environmental factors by fitting 10 different animal models. In these models, the effects of herd-year of birth, birth type, province, maternal age, permanent environmental (dam and sire) and genetic factors (such as additive, sire, maternal and maternal grandsire) were included. The results showed that the effect of the herd-year of birth and the birth month on the secondary sex ratio were significant ($P < 0.001$), while the effect of the province, birth type and maternal age were not significant ($P > 0.05$). By studying the animal models, it could be concluded that the contribution of the genetic factors contributing to the variations of the secondary sex ratio were negligible.

Keywords: Environmental factors, Genetic factors, Heritability, Raeini goat, Secondary sex ratio.

Introduction

Sex is an important factor that affects the development of animal economic traits. Adjusting the proportion of males and females in the flock is an important management tool. This important management tool allows breeders to maximize economic profit from sex traits and sex-limited traits by producing a desirable number of males and females [1]. The sex ratio is the animal proportion of the same sex in the population, which includes the primary sex ratio (the embryo sex after fertilization), the secondary sex ratio (sex at birth), and the tertiary sex ratio (sex after puberty) [2]. In species that males mated several females would have a reproductive potential, good strength, and longer lifespan [3]. Mostly, female animals with good physical conditions could produce male offspring [4]. Many studies in different species confirmed this hypothesis, including red deer [5,6], adult ewes [7], north deer [8], African sheep [9] and domesticated pigs [10].

The sex ratio is expected to be the same, according to the probability rules for the two sexes. This ratio can be influenced by many factors. In some studies; the mother body age and size, the birth season, the herd size and density, the mother ration and the maternal dominance effects affected the offspring sex in wild and livestock populations [11-14]. Other factors such as sexual behavior, hormonal concentrations, natural disasters, environmental pollution, endocrine problems and genetic factors affected the sex ratio in domestic animals [15]. In some breeds, the Ayrshire cows produce low percentage of male calves compared to the Swedish red and white breeds [16]. However, the sex ratio in the lambs of the two breeds of Polwarth and Corriedale did not have a significant deviation with the equal ratio [17]. Theoretical mechanisms deviatied the sex ratio of the offspring included the differences in the viability of the sperm, general conditions of the genital system (such as cervical mucus status, nutritional status and vagina pH during fertilization), intrinsic physiological differences and embryo selection or abortion [18].

The purpose of this study was to identify some environmental and genetic factors affecting the secondary sex ratio of the Iranian Raeini goats.

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Material and Methods

Data

The data sets of this study were obtained from the center for Iranian animal breeding. The data sets were composed of the birth information of 13563 goats of Iranian Raeini breed from 1986 to 2006 in two southern provinces of Iran. The available information included the animal number, herd number, animal sex, number of father, number of mother, birth date, birth type and maternal age at delivery. After the initial data processing, the final data files were prepared. The pedigree file was prepared with the tracing of parents and ancestors of animals with a birth record in previous generations. In the data file, 7752 and 5811 births were male and female goats, respectively. The pedigree information used is presented in Table 1.

TABLE 1. Statistics for the pedigree file of goats

Character	Number
Number of goats in the pedigree file	6685
Number of goats with known father	1255
Number of goats with known dam	2755
Number of goats in the base population	3908
Number of goats with known father in the base population	740
Number of goats with known dam in the base population	1721

A statistical model for describing the fixed effects (herd-year of birth, birth month, province, birth type) and the covariate (maternal age) were fitted using a logistic procedure with the binomial distribution.

Animal models and estimations

(Co) variance components and genetic parameters for the secondary sex ratio were estimated using restricted maximum likelihood (REML) by ASREML software [19]. In the logistic threshold model, it was assumed that the residual variance is 1 and the variance of other random effects was estimated relative to the residual variance. The animal models used (in matrix notation) are as follows:

$y = Xb + Z_a a + e$ Model (1)

$y = Xb + Z_a a + Z_m m + e \quad Cov(a,m) = 0$ Model (2)

$y = Xb + Z_a a + Z_m m + Z_{am} am + e \quad Cov(a,m) = A\sigma_{am}$ Model (3)

$y = Xb + Z_a a + Z_s s + e \quad Cov(a,s) = 0$ Model (4)

$y = Xb + Z_a a + Z_s s + Z_{as} as + e \quad Cov(a,s) = A\sigma_{as}$ Model (5)

$y = Xb + Z_a a + Z_{mgs} mgs + e \quad Cov(a,mgs) = 0$ Model (6)

$y = Xb + Z_a a + Z_{mpe} mpe + e$ Model (7)

$y = Xb + Z_a a + Z_m m + Z_{mpe} mpe + e \quad Cov(a,m) = A\sigma_{am}$ Model (8)

$y = Xb + Z_a a + Z_{spe} spe + e$ Model (9)

$y = Xb + Z_a a + Z_s s + Z_{spe} spe + e \quad Cov(a,s) = A\sigma_{as}$ Model (10)

Where y is a vector of observations for the trait; X, Z_a, Z_s, Z_m, Z_{mgs}, Z_{mpe} and Z_{spe} are corresponding design matrices associating the fixed, genetic effects (additive, sire, dam and maternal grandsire) and permanent environmental effects (dam and sire) to the vector of y, respectively; b, a, s, m, mpe, spe, mgs and e are vectors of fixed, genetic effects (additive, sire, dam and maternal grandsire), permanent environmental effects (dam and sire) and the residual effects, respectively; A is a relation matrix; σ_{am} and σ_{as} are additive genetic-maternal covariance and additive genetic- sire covariance, respectively.

(Co)Variance components of each animal

TABLE 2. (Co)Variance components of animal models.

Model	(Co)Variance components
1	σ^2_a, σ^2_e
2	σ^2_a, σ^2_m, σ^2_e
3	σ^2_a, σ^2_m, σ_{am}, σ^2_e
4	σ^2_a, σ^2_s, σ^2_e
5	σ^2_a, σ^2_s, σ_{as}, σ^2_e
6	σ^2_a, σ^2_{mgs}, σ^2_e
7	σ^2_a, σ^2_{mpe}, σ^2_e
8	σ^2_a, σ^2_m, σ_{am}, σ^2_{mpe}, σ^2_e
9	σ^2_a, σ^2_{spe}, σ^2_e
10	σ^2_a, σ^2_s, σ_{as}, σ^2_{spe}, σ^2_e

σ^2_a, additive genetic variance; σ^2_s, sire genetic variance; σ^2_m, maternal genetic variance; σ^2_{mgs}, maternal grand-sire variance; $\sigma^2_{mpe,}$ permanent environmental variance of the dam; σ^2_{spe}, permanent environmental variance of the sire; σ_{am}, additive genetic- maternal covariance; σ_{as}, additive genetic- sire covariance; σ^2_e, residual variance.

model is presented in the Table 2.

The Akaike's information criterion (AIC) was used to choose the most suitable animal model as follows [20]:

$$AIC_i = -2\log L_i + 2p_i \quad (1)$$

Where log Li is the maximized log likelihood of the model i at convergence and pi is the number of independently estimated parameters of model i. The model with the smallest AIC was considered as the most appropriate model.

A simplex algorithm is used to search for variance components to minimize the function, –2log likelihood (L). Convergence was assumed when the variance of the function values (–2logL) of the simplex was less than 10^{-8}. For all models, a restart was performed after a first convergence to verify that convergence was not at a local minimum. Heritability and repeatability were estimated as follows [21-23]:

$$h^2_a = \sigma^2_a / \sigma^2_p \quad (2)$$
$$h^2_m = \sigma^2_m / \sigma^2_p \quad (3)$$
$$r_s = (\sigma^2_a + \sigma^2_{spe}) / \sigma^2_p \quad (4)$$
$$r_m = (\sigma^2_a + \sigma^2_{mpe}) / \sigma^2_p \quad (5)$$

Where h_a^2, h_m^2, r_s and r_m are direct heritability, maternal heritability, sire repeatability and maternal repeatability, respectively.

Results and Discussion

Environmental effects

The results of the study of the environmental effects on the secondary sex ratio of the Iranian Raeini goats are presented in the Table 3.

TABLE 3. The study of the environmental factors on the secondary sex ratio of the Iranian Raeini goats.

Source of Variation	DF	P.Value
Herd- Year of birth	207	<0.000
Birth month	9	<0.000
Province	1	0.367
Birth type	3	0.607
Mother age	1	0.574

The herd-year effect on the secondary sex ratio was significant (P < 0.000). In a study, a weak positive correlation reported between this trait and population density [24]. In the mentioned study which was performed on Soay sheep, the herd size had a very high correlation with the sex ratio (P < 0.001). This correlation has been reported poorly in red deer. [6]. The herd-year effect on the secondary sex ratio can be due to differences in the management conditions, environmental conditions and different conditions in different herds. Changing the weather conditions in different years, in addition to being able to affect the amount of nutrition and grazing in the rangelands, affects the quality and quantity of pastures and changes the animal's access to food. Changes in management factors such as health, herd vaccination and herd grazing management in different years, can affect sex ratio [6,24,25]. It seems that the fertilization time in domestic animals has affected the offspring sex ratio [26]. In cows, artificial insemination at the beginning of the estrus period increased the probability of the female offspring's [27].

The birth month had a significant effect on the secondary sex ratio of the Iranian Raeini goats (P < 0.000). The most of the male offspring's were born in the spring months, especially in march. Similarly, the month and season significantly affected the sex ratio [7,28]. It is reported that difference in climatic conditions (such as humidity, ambient temperature, rainfall, etc.) especially in pregnant and pre-natal months affect the maternal power and the sex ratio [7,28]. The winter rainfall and environmental factors are associated with nutritional stress during pregnancy and reduce the number of the male offspring born in red deer each year [6]. The ration of experimental rats played a leading role in controlling the offspring. Moreover, the use of ration rich in saturated fats but with low content of carbohydrates increased male offspring [29].

The effect of the province on the secondary sex ratio of the Iranian Raeini goats was not significant (P = 0.367). The effect of geographical area's refers mainly due to differences in environmental and climatic conditions. In Soay sheep, the climate effect on the sex ratio was due to differences in management and environmental conditions as well as the different conditions of herds [24]. In addition, environmental conditions can affect the amount of nutrition and grazing in the rangelands. Also affect the quality and quantity of pastures, change the animal's access to food and supply the necessary nutritional requirements [24]. The insignificant effect of the province may refer to the similarity of the environmental and climatic conditions of the studied provinces.

As presented in the Table 3, the effect of birth type on the secondary sex ratio was not significant (P = 0.607). In mountain goats, the effect of birth type was not also significant [30]. In the two breeds of Merino and Corriedale sheep, the proportion of males in the single births was high compared to the twin births [31]. The significance of the birth type effect on the sex ratio can return to the uterus capacity and condition (for the embryo growth) and competition between the embryos for use of the limited uterine resources [32]. It seems that in the present study, the maternal environment at pre-puberty did not have a significant effect on the sex determination.

As presented in the Table 3, the effect of maternal age on the secondary sex ratio was not significant (P = 0.574). As well as, this effect was not significant in Bighorn sheep [33], Merino and Corriedale sheep [31]. The offspring sex ratio is independent of maternal mass (before pregnancy), but it is a function of maternal age at previous reproduction, environmental conditions and their interactions [34]. In contrast, the increasing maternal age affected the fertility and the sex ratio of lambs [35], by either decreasing the proportion of female offspring's of the mountain goats [30], or increasing the proportion of male offspring in other breeds [13,26].

Genetic effects

In the present study, the direct and maternal heritability estimation in all of the animal models was not significant. The estimated heritabilities are not significantly different from zero. The estimation of the (co)variance components and the genetic parameters are presented in the Table 4.

By studying the animal models, it could be observed that the contribution of the genetic factors contributing to the variations of the secondary sex ratio were negligible (Table 4). The AIC index of the various models was close together. The lowest value of the AIC index is for the animal model 1. This model only included the additive genetic effect. The direct heritability Estimation of the model was 0.004 ± 0.000, which is low. In the animal breeding programs, traits that have a high heritability will respond better to the selection programs. In other words, genetic progress will be greater in these traits. Because model 1 has a low direct heritability, it responds slowly to the selection programs. So, the genetic improvement of this trait will require more time by using the selection program.

Genetic diversity is an effective factor in the animal breeding programs. A significant variation in the offspring sex ratio among breeds of sheep has been reported [36]. A part of this variation was related to the additive genetic effects. So, the direct selection can change the sex ratio of the population in the desired direction.

An unsuccessful attempt was done to change the sex ratio by direct selection in mice and Drosophila Melanogaster [37]. In mice, despite the heterogeneity among the families, the sex ratio of progeny was not statistically significant and the heritability was reported to be about 0.05. The existence of genes with major effects that could alter the sex ratio has been confirmed [27]. When genetic and environmental interactions existed or environmental fluctuations plaied a key role in shaping the phenotype, it may be difficult to heritability this estimation [38].

Conclusion

The sex ratio is a vital and important parameter in the population that is affected by the processes of sex determination and differentiation. The results of this study showed that some environmental factors such as the herd-year of birth and the birth month affect the sex ratio of goats. The effect of the genetic factors on the secondary sex ratio is negligible.

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TABLE 4. Estimation of (co)variance components and genetic parameters for the secondary sex ratio of the Iranian Raeini goats

Model	σ^2_a	σ^2_s	σ^2_m	σ^2_{mgs}	σ_{as}	σ_{am}	σ^2_{mpe}	σ^2_{spe}	σ^2_e	σ^2_p	h^2_a	h^2_m	r_s	r_m	AIC
1	0.004±0.000	------	------	------	------	------	------	------	1	1.004±0.012	0.004±0.000	------	------	------	554
2	0.004±0.000	------	0.000±0.000	------	------	------	------	------	1	1.004±0.006	0.004±0.000	0.000±0.000	------	------	563
3	0.004±0.000	------	0.000±0.000	------	------	0.000±0.000	------	------	1	1.004±0.003	0.004±0.000	0.000±0.000	------	------	568
4	0.004±0.000	0.001±0.000	------	------	------	------	------	------	1	1.005±0.002	0.004±0.000	------	------	------	564
5	0.004±0.000	0.001±0.000	------	------	0.000±0.000	------	------	------	1	1.005±0.019	0.004±0.000	------	------	------	563
6	0.004±0.000	------	------	0.000±0.000	------	------	------	------	1	1.004±0.031	0.004±0.000	------	------	------	565
7	0.004±0.000	------	------	------	------	------	0.008±0.000	------	1	1.012±0.025	0.004±0.000	------	------	0.012±0.008	569
8	0.004±0.000	------	0.000±0.000	------	------	0.000±0.000	0.008±0.000	------	1	1.012±0.036	0.004±0.000	0.000±0.000	------	0.012±0.008	570
9	0.004±0.000	------	------	------	------	------	------	0.006±0.000	1	1.010±0.059	0.004±0.000	------	0.010±0.003	------	575
10	0.004±0.000	0.001±0.008	------	------	0.000±0.000	------	------	0.005±0.000	1	1.010±0.068	0.004±0.000	------	0.010±0.002	------	578

σ^2_a, direct additive genetic variance; σ^2_s, sire genetic variance; σ^2_m, maternal genetic variance; σ^2_{mgs}, maternal grandsire variance; σ_{am}, additive genetic- maternal covariance; σ^2_{mpe}, maternal permanent environmental variance; σ^2_{spe}, paternal permanent environmental variance; σ_{as}, additive genetic- sire covariance; σ^2_e, residual variance; h^2_a, direct heritability; h^2_m, maternal heritability; r_s, sire repeatability; r_m, maternal repeatability; AIC, Akaike's information criterion.

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العوامل المؤثرة على نسبة نوعى الجنس عند الولادة فى الماعز الراينى الايرانيه

شاهابودين غارافيزى - بيمانى حميدى- روح الله عبد الله هابور وعباس عباس
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بصفة عامة فان نسبة نوعى الجنس فى الحيوانت تكون متساويه عند الولادة وتهدف هذه الدراسة الى دراسة عدد من العوامل البيئية والوراثية التى تؤثر على نوع الجنس عند الولادة فى الماعز الراينى الايرانية وقد اجريت الدراسة على عدد (135636) من الماعز منها عدد (7754) من الذكور وعدد (5811) من الاناث وقد شملت العوامل البيئية شهر وسنة الولادة - مكان الولادة - نوع الولادة -عمر الامهات واما العوامل الوراثية فشملت علاقة الامهات مع الجدود المختلفة واوضح التقييم الاحصائى ان العوامل البيئية كانت غير مؤثرة معنويا على نوع الجنس عند الولادة .

الكلمات الدالة: الماعز- العوامل البيئية - جنس المولود.