Iranian Journal of Applied Animal Science

Simulating Past Dynamics and Assessing Current Status of Markhoz Goat Population on Its Habitat

Research Article

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Received on: 27 Jun 2014
Revised on: 16 Aug 2014
Accepted on: 31 Aug 2014
Online Published on: Jun 2015

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Online version is available on: www.ijas.ir

ABSTRACT

This study was conducted to collect comprehensive identification about Markhoz goat population and to simulate past dynamics of the population under its living conditions. Census data of the population size and the required parameters for the simulation model were obtained from published data or were collected in its habitat in the last 3 years. In this study, past population dynamics and expected loss of genetic diversity in the population were simulated by population viability analysis (PVA) using *Vortex* modeling program version 10.0. Markhoz breeding goats and population size showed a downward trend on its own habitat. The last known number of breeding does, bucks and total population of the Markhoz goat breed on its habitat were 917, 55 and 1669 heads in 2012. Computed and simulated inbreeding rates (ΔF) were 2.4% and 3.9%, respectively. Simulated N_e for this population was 128 which are near to critical size of 100. Furthermore, the extinction probability (EP) of 0%, stochastic growth rate of -0.1624, losing genetic diversity of 5% and inbreeding of 0.0311 were simulated using the PVA for a past time horizon(from 1996 to 2012). Having considered different parameters and threats with the reliable values and probabilities, PVA model simulated correctly the past period of population dynamics. Based on our findings, 1) future viability and the expected loss of diversity should be estimated under obtained demographic and environmental parameters. 2) different management scenarios should be examined to provide a conservation program.

KEY WORDS conservation, genetic diversity, Markhoz goat, viability analysis.

INTRODUCTION

Genetic diversity has a vital role in copying with environmental variations and response to selection. Within breed genetic diversity is needed for the breed to genetically adapt to changes in the production and economic environment and to prevent inbreeding problems. Between breeds diversity is needed to provide alternatives if a breed encounters with genetic problems due to genetic drift or if, because of changes in the production system, traits are required for which the commercial breeds are poor (Meuwissen, 2009).

Many populations are facing extinction due to loss of genetic diversity. Based on FAO's Global Databank for animal genetic resources, only 35% of the breeds of the world are not at risk. The survey reports that 9% of the investigated breeds are now extinct (FAO, 2007). To avoid the extinction of livestock breeds, the populations that are at risk must be identified and conserved. Livestock have great socio-economic and cultural value in various societies around the world. So the conservation of their genetic diversity may be valuable to meet the future needs (Philipsson *et al.* 2011). Gandini *et al.* (2004) have referenced some studies presenting further reasons for this necessity, including the social and economic value of local livestock breeds for rural communities, their contribution to management of agro ecosystems and maintenance of rural cultural diversity.

Markhoz goat is the only single coat goat that is producing shiny fine fibers in Iran. Its fibers are seen in white, different spectra of brown, grey and black colors. Worthy textile and clothes are made from its fibers in traditional workshops. In comparison with sheep and haired goat breeds, its milk products and meat are more acceptable in Baneh city in the vicinity of Iran / Iraq borderline, Kurdistan province, Iran. Markhoz goats are mainly distributed in the county of Armardeh in Baneh. This region is mostly covered with Oak trees and pasture plants. Herders in their farm, called Kokh, breed mostly Markhoz flocks alone or along with some sheep and haired goats. In addition to animal husbandry, farming and gardening are performed in these farms. The main sources of feed in the region are pasture plants and the leaves of oak trees. Flocks are grazed on pastures throughout the growing season, and are mainly fed with the leaves of oak trees and stored pasture plants from the end of autumn to the beginning of spring. Oak leaves are harvested in 2-3 year periodic pruning and are mostly stored on Oak trees, called Taieh (Bahmani, 1999; Bahmani *et al.* 2011). The most important characteristics of Markhoz goats fiber are luster, high length (≥14 cm), high efficiency (79%), high true fibers (≥92%), low kemp and medullated fibers (≤8%) and low diameter (≤34 µ) (Bahmani, 1999; Rashidi, 2000). Under semi-intensive conditions at Markhoz Goat Performance Testing Station, birth weight (kg); weaning weight (kg); average daily gain from birth to weaning (g/day); pre-weaning mortality; litter size at birth and litter size at weaning were 2.5 ± 0.5, 15.9 ± 4.3, 113.1 ± 35.3, 0.1 ± 0.29, 1.3 ± 0.46, 1.2 ± 0.51 respectively (Rashidi *et al.* 2011).

Some events, including a decrease in population size, breeding herds and locations; use of animals of other breeds for reproduction; low effective population size and presence of threats to survival have been mentioned as indicators of imminent danger of breed extinction (Scherf, 1995; Simon, 1999). In recent years, Markhoz goat distribution on its main native area in the vicinity of Iran / Iraq borderline, Iran, has significantly been limited. In comparison with 1996 (Rasooli and Mahmoodi, 1999), there are no Markhoz goats left in Kermanshah province, they exist only in a few villages in western Azerbaijan and its native area has been extremely limited in Kurdistan province. Downward trend of breeding goats, herd size and population size are clearly observed. Two main factors are affecting this downward trend: decrease in economic and social incentives (Bahmani *et al.* 2011). Several reports (Henson, 1992; Scherf, 2000; FAO, 2007) show that decline in social and economic incentives are the main reasons for decrease in population size and put breeds in danger of extinction all over the world. Breeding location, government policies and projects, haired goat breed competition and history of natural disasters throughout previous years are reasons for this trend.

Population viability analysis originally describes methods of quantitative analysis to determine the probability of extinction over defined time periods for a designated population exposed to a specific scenario of environmental conditions, threats to persistence and future management actions and other foreseeable events. Two defining characteristics of a PVA are an explicit model of the extinction process and the quantification of threats to extinction (Lacy *et al.* 2014). Generally, the model of extinction underlying a PVA considers two categories of factors: deterministic and stochastic. The stochastic processes impacting on populations have been usefully categorized into demographic, stochasticity, environmental variation, catastrophic events, and genetic drift (Shaffer, 1981). *Vortex* is individual based simulation models for population viability analysis that can help the user understand the effects of deterministic forces as well as demographic, environmental and genetic random events on the dynamics of populations. *Vortex* models population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occur according to defined probabilities (Lacy and Pollak, 2014). *Vortex* has been used to compile the past population dynamics and future risk of population decline or extinction under current management scenarios. Al-Atiyat (2009) concluded that PVA model was good at predicting the future dynamics of the populations by simulating past time that mimicked the real past time dynamics.

It was recommended that the conservation program should be based on comprehensive identification of endangered populations considering population viability analysis (Lacy, 1994; Simianer *et al.* 2003).

The objectives of this study were comprehensive identification of endangered Markhoz goat breed and also simulation of past dynamics of the population under its living conditions in order to quantify the threats of extinction and to achieve measures of population viability.

MATERIALS AND METHODS

Data collection

Two kinds of data, including census data and parameters needed for simulation model were collected. Older census data of population size were available for the Markhoz goat population in its home region in 1996 and 2005 (Rasooli and Mahmoodi, 1999; Agricultural Jihad Organization of Kurdistan, 2005). From 2010 to 2012, more census data were collected by researchers through monitoring of all extant flocks in the mating season (Table 1).

Table 1 The number of breeding does, bucks and total population of Markhoz goat breed on its habitat in different years

Year	Does[1]	Bucks[1]	Total number (N)
1996	11398	675	21107
2005	2897	172	5359
2010	1195	68	2241
2011	1002	62	1851
2012	917	55	1669

[1] Does and Bucks in 1996 and 2005 are estimated based on the flock composition in last 3 years.

Biological parameters and data for events that might strike the population were collected through monitoring of all extant flocks, interviewing the owners and completing provided questionnaire about production system, mating status, mating ratio, reproduction performance, survival and mortality in different age-sex groups, limitations and problems of the owners during three stages of each year (the beginning of mating, the end of kidding period and the end of producing year) for 3 years. The data collected over 3 years were averaged and each parameter was determined to use in the simulation model. In order to get precise information about the production system, 7 flocks were investigated during the last producing year.

Estimation of effective population size and inbreeding rates

N_e is an important parameter determining the genetic structure of small populations. To declare whether the breed of goats is endangered or not, effective population size (N_e) was estimated on the basis of the number of breeding livestock animals. In brief details, for a typical livestock population where the number of breeding males (N_m) is different from the number of breeding females (N_f) as was the case of the present study, the N_e was estimated using the equation of N_e= 4 (N_m×N_f) / N_m + N_f (Falconer, 1989). On the other hand, the rate of inbreeding (ΔF) was estimated according to the equation ΔF= 1 / (2N_e) (Falconer, 1989). Effective population size was evaluated by using the European Associations of Animal Production (EAAP) assessing system (Simon, 1999; Gandini *et al.* 2004) and several other approaches (Meuwissen, 2009; Toro *et al.* 2011).

Simulation scenario

Past dynamics of population within the studied time frame (16 years) was simulated using the population viability analysis model of *Vortex*. *Vortex* simulated the population dynamics by stepping through a series of events that describe the typical life cycle of sexually reproducing, diploid organisms. It modeled population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occurred according to defined probabilities. The sequence of events in the annual cycle specified as environmental variation setting; breeding; mortality; aging; catastrophes and harvest. The probabilities of events were modeled as constants or as random variables that followed specified distributions. Since the growth or decline of a simulated population is strongly influenced by these random events, separate model "runs" using the exact same input parameters produced different results. Consequently, the model was repeated many times to reveal the distribution of fates that the population experienced under a given set of input conditions (Lacy *et al.* 2014). In this study, 1000 "runs" were used. *Vortex* was provided with events and biological parameters that were necessary to PVA model to mimic real fate of the Markhoz goat population throughout each year of its lifetime in the population dynamics. The details of each event were described as model assumptions for each animal in each year of the simulation.

The model description and assumptions

The modeling exercise required a set of parameters to describe the biological characteristics and stochastic events of the goat population. The parameters were derived using unpublished data by monitoring and investigating Markhoz goat flocks from 2010 to 2012. Data and parameters are summarized in Table 2. Due to unavailability of some data about the population, for sex ratio at birth and initial inbreeding at the beginning of simulation, equal amounts for both sexes and zero (default settings of the program) were respectively used out of necessity.

RESULTS AND DISCUSSION

Normal and effective population sizes and inbreeding rate

The census data reporting the number of total population size, number of breeding females and breeding males are presented in Table 1. The data shows a downward trend of breeding goats and population size. Markhoz population size in its native area has decreased about 92% in comparison with 1996. A decreasing trend in population size is an undesirable indicator of increased vulnerability to extinction. Small populations are more vulnerable to genetic drift and are facing loss of genetic diversity over time. Based on the FAO and the EU assessing systems considering demographic risk (European Commission, 2002; FAO, 2007), Markhoz goat is at risk. The owners emphasize on two main factors which affecting this downward trend: decrease in social and more importantly economic importance that have been mentioned (Henson, 1992; Scherf, 2000; FAO, 2007) as the most important reasons that put breeds in danger of extinction overall the world.

Table 2 The input parameters used in basic *Vortex* model for simulation of Markhoz goat population dynamics

Input parameter	Value
Reproductive system	Polygynous
Age of the first offspring is born for (female/male) (year)	2
Maximum lifespan	6
Maximum breeding age of female (year)	6
Maximum breeding age of male (year)	4
Maximum little size (kid)	2
Sex ratio at birth	(50% male, 50% female)
Adult breeding females (%)	85
Females produce 1 progeny in a year (%)	85
Females produce 2 progeny in a year (%)	15
Mortality of females between ages 0 and 1 (%)	12
Mortality of females between ages 1 and 2 (%)	3
Mortality of females after age 2 (%)	3
Mortality of males between ages 0 and 1 (%)	12
Mortality of males between ages 1 and 2 (%)	3
Mortality of males after age 2 (%)	3
Catastrophe type 1: feed limitation	
Frequency of occurrence (%)	50
Severity on reproduction (proportion of normal values)	0.85
Severity on survival (proportion of normal values)	0.90
Catastrophe type 2: haired breed competition	
Frequency of occurrence (%)	100
Severity on reproduction (proportion of normal values)	0.9
Severity on survival (proportion of normal values)	1
Mate monopolization Males in the breeding pool (%)	5
Initial population size	21107
Harvest	Every year
Number of females harvested before age 2 (%)	20
Number of females harvested after age 2 (%)	28
Number of males harvested before age 2 (%)	45
Number of males harvested after age 2 (%)	90

Breeding location, government policies and projects, haired goat breed competition and history of natural disasters through previous years describe this trend. Owing to localization of the Markhoz goat native area in the vicinity of Iran / Iraq borderline, animal husbandry has prominently affected by government's foreign policy and border exchanges. Lack of governmental support for animal fiber production and governmental conservation of natural resources (forest and pasture) without considering goats by conducting the projects of decreasing small domestic animals and preventing herders from pruning Oak trees have affected Markhoz goat population. Natural disasters such as droughts have likely reduced the population every few years. In addition, haired goat breed with more meat production has been used to replace Markhoz goats by the owners in order to increase incomes. In many cases, due to weak financial capacity of herders, replacement of sold or removed goats has not presumably been possible.

It would be better to predict whether the breed needs conservation on the basis of actual N_e rather than N. So, the effective population sizes and inbreeding rate estimations are presented in Table 3. A decreasing trend of N_e and increasing trend of ΔF are observed within the time frame.

These changes were mainly due to the small number of goats in the breeding pool. Increasing trend of ΔF is related to the decreasing trend in N_e. This is in agreement with population genetic theory as N_e is an indicator of the increase of the inbreeding rate per generation (Falconer, 1989).

Table 3 The normal (N) and effective (N_e) population sizes as well as calculated and simulated inbreeding rates of Markhoz goat breed in different years on its habitat

Year	N	Calculated N_e	Calculated ΔF	Simulated ΔF
1996	21107	2549	0.0002	-
2005	5359	649	0.0008	0.0015
2010	2241	257	0.0019	0.0030
2011	1851	233	0.0021	0.0034
2012	1669	207	0.0024	0.0039

Within the EAAP assessing system, species' specific minimum values of N_e for five classes of endangerment, depending on the maximum values of acceptable inbreeding, F-50, after 50 years of conservation have been determined. Resulting N_e for goats being considered at risk is 95 (Simon, 1999). From several other approaches, the consensus recommended effective population size is 100, i.e. ΔF= 0.5% per generation (Meuwissen, 2009; Toro *et al.* 2011). Computed N_e and ΔF (207, 2.4%) and simulated ones (128, 3.9%) show that Markhoz goat was not at risk in the last year. On average, methods based on the number of breeding males and females and variance of progeny size produced larger values of N_e for livestock, than those based on identity by descent probabilities (Leroy *et al.* 2013). The Wright equation assumes random selection and a poisson distributed progeny sizes, which are unlikely assumptions for most livestock populations. Consequently, in selected populations the rate of inbreeding is likely to be higher than in unselected populations (Gandini *et al.* 2004). Therefore, it seems that simulated N_e and ΔF are better to assess the real situation. A persistent decrease in N_e can have severe consequences in the near future. The amount of genetic variation begins to decrease at an accelerated rate, once the N_e falls below 100. Henson (1992) recommended that minimum N_e of 250 animals should establish the basis of a conservation program. Of course, estimation probabilities of extinction (PE) for future time horizon provide valuable information to assess the population viability.

Simulated past population dynamics

In this part, the simulation results of the study that mimic the past time horizon of reduction in population size till current time of this study, 2012, is presented and discussed. Population sizes (N), probabilities of extinction (PE), stochastic mean growth rates (r), genetic diversities (GD), inbreeding coefficients (IC) and the mean number of alleles of simulated Markhoz goat population dynamics in the past 16 years from 1996 to 2012 are shown in Table 4.

Table 4 Population sizes (N), probabilities of extinction (PE), stochastic mean growth rates (r), genetic diversities (GD), inbreeding coefficients (IC) and the mean number of alleles (A) of simulated Markhoz goat population dynamics in the past 16 years (from 1996 to 2012)

	years								
	0	1	2	3	4	5	6	7	8
N	21107	17925.4	15221.4	12847.5	10959.8	9413.1	8053.2	6837.4	5861.3
PE	0	0	0	0	0	0	0	0	0
r	0	-0.165	-0.166	-0.172	-0.163	-0.156	-0.160	-0.167	-0.159
GD	1	0.9994	0.9988	0.9979	0.997	0.9958	0.9942	0.9924	0.9902
IC	0	0	0	0.0004	0.0009	0.0016	0.0025	0.0036	0.0051
A	42214	23330	15696	10718	7449	5255	3634	2601	1895
	9	10	11	12	13	14	15	16	
N	4990.8	4268.5	3672	3130	2674.3	2281.8	1944.8	1662.8	
PE	0	0	0	0	0	0	0	0	
r	-0.163	-0.160	-0.155	-0.164	-0.161	-0.161	-0.166	-0.160	
GD	0.9875	0.9845	0.981	0.977	0.9713	0.9653	0.9585	0.9506	
IC	0.0067	0.0086	0.011	0.014	0.0173	0.0213	0.0258	0.0311	
A	1393	1036	784	601	466	366	291	233	

After 1000 "runs" to reveal the distribution of fates that the population experienced under the given set of input parameters, Figure 1 shows past simulated population dynamics started with a population size of 21 107 till current size with the mean growth rate, *r*, of -0.1624 ± 0.106 as a harvested population after 16 years. If stochastic variation was minimal, this population would increase with the deterministic mean growth rate of 0.0778 to reach its carrying capacity, for example to 25000 heads (Figure 2).

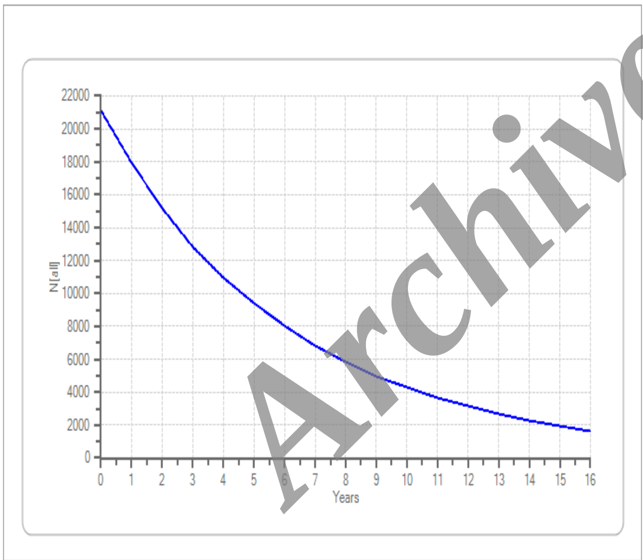

Figure 1 Plot of N *vs.* year relating to simulated Markhoz goat population dynamics in the past 16 years (from 1996 to 2012)

Before the actual stochastic simulation begins, *Vortex* performs a standard life table analysis (Krebs, 1994) to calculate the deterministic mean population growth rate. This calculation will provide accurate long-term average, if stochastic variation (due to demographic stochasticity, environmental variation, catastrophes and inbreeding effects) is minimal. Life table analyses implicitly assume that age-specific birth and death rates are constant through time and there is no limitation of mates; they yield over-estimates of long-term population growth if there is any variation in demographic rates.

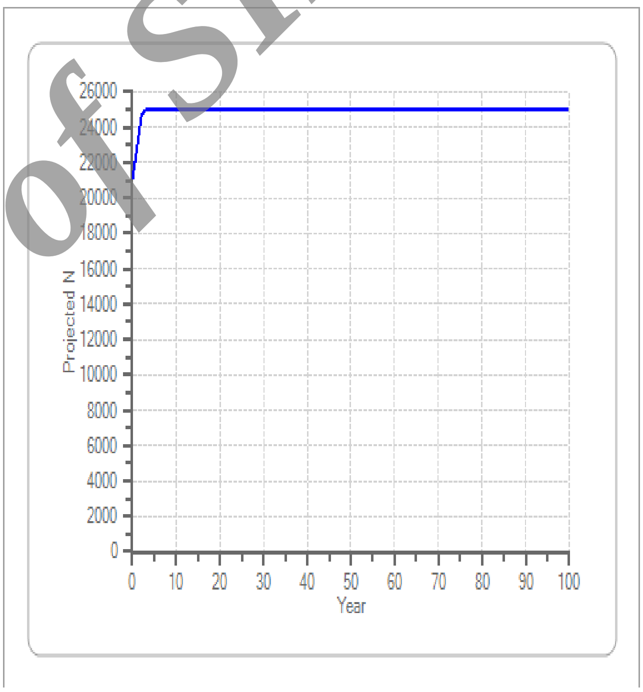

Figure 2 Plot of N *vs.* year relating to simulated Markhoz goat population dynamics achieved by the deterministic calculations

The difference between the deterministic population growth rate and the growth rate resulting from the simulation can give an indication of the importance of stochastic factors as threats to population persistence (Lacy *et al.* 2014).

When the simulated population dynamics were compared with real population dynamics (Figure 3), there was no variation. It can be seen from Figure 3 that simulated population dynamics mimicked nature dynamics results. Where there was data, the population size was nearly close to those simulated ones. If there were more census data, the conclusion would have been better. This similarity shows that PVA model under defined assumption and parameters has correctly simulated the past horizon of the population dynamics. In contrast to wildlife species (Lindenmayer *et al.* 1995; Brook *et al.* 2000), few researchers have used PVA model to investigate endangered livestock breeds (Bennewitz and Meuwissen, 2005; Al-Atiyat, 2009; Thirstrup *et al.* 2009).

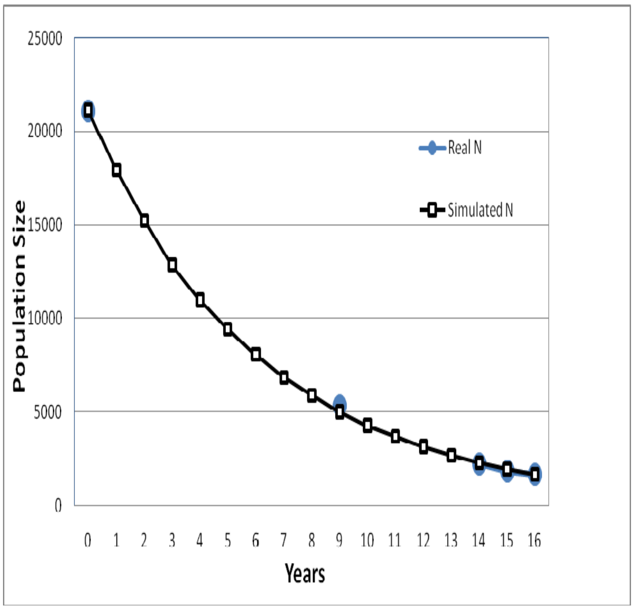

Figure 3 Real and simulated Markhoz goat population dynamics in the past 16 years (from 1996 to 2012)

The time span of 16 years might be considered very short for getting accurate knowledge about any population dynamic because in this case the 16 years period forms almost 8 generations with at least one generation every 2 years. However, reliability of population growth rate estimates is more accurate for a short time (Goodman, 1993).

Reduction in socio-economic incentives was the main reason of the downward trend of the Markhoz goat population that resulted in selling more breeding goats. Consequently, instead of usual annually harvesting of breeding adult females, twice of this value, i.e. 28% was used in PVA model as harvested adult females (Table 2). Exotic breed competition and feed limitation were included as catastrophes in the model. Each was modeled as a separate type of catastrophe to simulate the reduction in population size. The frequency of each type of studied catastrophe (feed limitation=50% and exotic breed competition=100%) and the effects of the catastrophes on survival and reproduction were specified for the first one as 10% and 15%, and for the second one as 0% and 10%, respectively (Table 2). Conducting the projects of decreasing small domestic animals and preventing herders from pruning Oak trees were the main restricted factors affecting feeding of flocks.

Similarly, Al-Atiyat (2009) successfully considered economic exotic breed competition and feeding limitation as catastrophes with reliable probabilities for Jordan indigenous cattle breed. In this study, reproduction performance, survival and mortality in different age-sex groups (Table 2) were collected in Markhoz goat habitat for the first time.

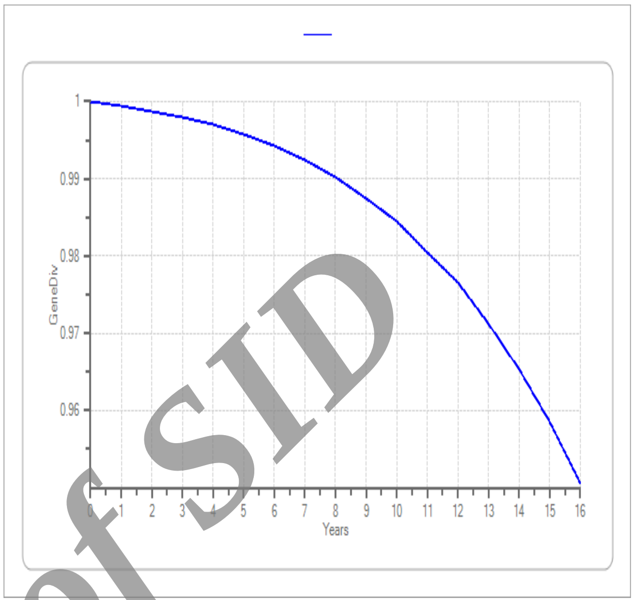

Figure 4 Plot of genetic diversity *vs.* year relating to simulated Markhoz goat population dynamics in the past 16 years (from 1996 to 2012)

The probability of extinction (PE) after 16 years was zero, determined by 1000 "runs" for the given population. The gene diversity or expected heterozygosity (H_e) of the population, expressed as a percent of the initial gene diversity of the population was 95%. Figure 4 shows 5% reduction of initial gene diversity. In simulated model, some of the adult females do not breed each year, and it is specified that only 5% of the adult males are breeders each year. Therefore, some animals will have many more descendants than others so the reduction of initial gene diversity is expected to be close to the real value.

Increasing of inbreeding and decreasing of the mean number of alleles, remaining within extant populations from an original number equal to twice the number of founder individuals, are observed in Table 4. When the population size is restricted or the number of individuals allowed to breed is fairly small, the allele frequencies change, which results in increased homozygosity and losses of alleles (Toro *et al.* 2011). In a genetically small population, there can be immediate consequences such as increased homozygosity, leading to undesirable consequences and the most noticeable being the emergence of Mendelian recessive defects or polygenic inbreeding depression.

In the long term, poor management results in reduced potential for genetic change and the danger of accumulation of deleterious mutations. Because the genetic diversity is of utmost relevance, one of the first steps in planning a development scheme in a breed, either for conservation or selection purpose, is to estimate the current state of diversity in the population and more importantly the predicted changes in the variation given the current size and use of parents. It is important at very early stages to understand and analyze to which direction the variation is moving, given that the current size and use of parents will prevail (Toro *et al.* 2011).

CONCLUSION

Markhoz breeding goats and overall population size showed a downward trend on its own habitat. Based on the FAO and the EU assessing systems considering demographic criteria, Markhoz population is at risk. On the other hand, considering the EAAP assessing system and several other approaches, computed and simulated N_e and ΔF showed that the population is not at risk. However, N_e decline and its consequences are possible in the near future owing to the fact that decreasing trend may persist. At this stage, estimation of probabilities extinction (PE) for future time horizon provides valuable information to us. Past dynamics simulation showed that 5% of initial genetic diversity has been reduced for Markhoz goat population in recent years which is an undesirable indicator. Simulation exercise provided more accurate N_e and ΔF for the population with no pedigree information. The simulation model was a fairly accurate simulation of the likely fate in studied past living conditions which shows that defined assumption and parameters were successfully considered in PVA model with reliable values and frequencies. Based on our findings, 1) future viability and the expected loss of diversity should be estimated under obtained demographic and environmental parameters. 2) different management scenarios should be examined to provide conservation program.

ACKNOWLEDGEMENT

The authors appreciate the valuable guidance of Dr. Robert Lacy for using *Vortex* in our study. We acknowledge the cooperation of Agricultural Research Center and Agricultural Jihad Organization of Kurdistan. This study was financially supported by Agricultural Jihad Organization of Kurdistan, Kurdistan province, Iran.

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IJAS Iranian Journal of Applied Animal Science

شبیه‌سازی دینامیک گذشته و ارزیابی وضعیت موجود جمعیت بز مرخز در زیستگاه اصلی آن

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چکیده

به منظور جمع آوری اطلاعات جامعی از جمعیت بز مرخز و شبیه‌سازی دینامیک گذشته جمعیت در زیستگاه اصلی آن، این تحقیق انجام شد. اطلاعات سرشماری جمعیت و فراسنجه‌های مورد نیاز برای مدل شبیه‌سازی از منابع منتشر شده یا در زیستگاه بز مرخز در طی سه سال از سال ۱۳۸۹ تا ۱۳۹۱ جمع آوری شدند. در این بررسی، دینامیک گذشته و کاهش مورد انتظار در تنوع ژنتیکی جمعیت از طریق تجزیه و تحلیل حیاتی جمعیت (PVA) و با استفاده از نسخه دهم نرم افزار Vortex شبیه‌سازی شدند. اندازه جمعیت و مولدین بز مرخز یک روند رو به کاهش را در زیستگاه جمعیت نشان دادند. تعداد مولدهای ماده، مولدهای نر و کل جمعیت در آخرین سال بررسی به ترتیب ۹۱۷، ۵۵ و ۱۶۶۹ رأس بودند. نرخ همخونی محاسبه شده و شبیه‌سازی شده به ترتیب ۲/۴ و ۳/۹ درصد بودند. اندازه مؤثر شبیه‌سازی شده جمعیت (۱۲۸) نیز نزدیک به اندازه بحرانی ۱۰۰ بود. بعلاوه، احتمال انقراض، نرخ رشد تصادفی، کاهش در تنوع ژنتیکی و ضریب همخونی از ۱۶ سال پیش تا سال ۱۳۹۱ با تجزیه و تحلیل حیاتی جمعیت به ترتیب، ۰ درصد، ۰/۱۶۲۴-، ۵ درصد و ۰/۰۳۱۱ شبیه‌سازی شدند. روش تجزیه و تحلیل حیاتی جمعیت با در نظر گرفتن مقادیر و احتمالات معتبری از فراسنجه‌های زیستی و تهدیدات موجود، به درستی دینامیک گذشته جمعیت را شبیه‌سازی کرد. بر اساس یافته‌های این تحقیق، توصیه می‌شود: ۱) با استفاده از فراسنجه‌های محیطی و جمعیتی بدست آمده، احتمال بقاء جمعیت در آینده و مقدار مورد انتظار کاهش در تنوع ژنتیکی برآورد گردند. ۲) سناریوهای مختلف مدیریتی به منظور تهیه برنامه حفاظتی برای این نژاد شبیه‌سازی شوند.

کلمات کلیدی حفاظت، تنوع ژنتیکی، بز مرخز، تجزیه و تحلیل حیاتی.