Jordan Journal of Agricultural Sciences, Volume **10**, No.**1** 2014

Sustainable Breeding Program of Black Bedouin Goat for Conserving Genetic Diversity: Simulated Scenarios for In Situ Conservation

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ABSTRACT

A simulated conservation breeding program was designed for Black Bedouin goat to maintain genetic diversity rather than improving performance traits under subtropical conditions of Jordan. ZPLAN+ software was used considering a close breeding scheme of nucleus, multiplier and commercial unites. Four simulated scenarios utilized phenotypic and genetic parameters of various selection criteria and three breeding objectives; conservation, milk and meat production. The results showed that a drastic reduction of genetic gain for milk and meat production of ten-year breeding program and for meat production, milk production and conservation as independent breeding programs after fifth year. For integrated program of the three traits the genetic gain and kids' survivability were maintained with reasonable average genetic gain for production traits. Breeding in favor of meat and/or milk production probably lead to a reduction in census size of the goat resulting in loss of genetic diversity. Therefore, setting up a sustainable *in-situ* conservation breeding program for Black Bedouin goat to maintain genetic diversity is recommended.

Keywords: Black Bedouin Goat, Subtropics, Breeding Scenarios.

INTRODUCTION

FAO (2008) stated that most developing countries do not currently have animal genetic resources conservation strategies or policies in place. Without strategically planned interventions, using both *in situ* and *ex situ* conservation, the uniqueness of these resources will go into continuous genetic erosion. There are many examples of developing countries that have common animals facing threats of genetic erosion. Black Bedouin is a good example being found in many countries of Arabian Peninsula and Middle East countries. In fact, the Black Bedouin goat was known as Hejaz goat which is named after Hejaz region in Kingdom of Saudi Arabia (KSA) and historically assigned to Arabian deserts (Epstein, 1946). In present time, Hejaz goat is not well known as Hejaz goat in the countries of the area, and even in their founder country; KSA. It is known as Aardi goat in KSA (AlAmer, 2006), Dhaiwi goat (Zaitoun *et al.*, 2004; 2005) or Black Bedouin goat (Al-Tamimi, 2005) in Jordan, and Black Bedouin (Silanikove, 1986) in Palestine, and Egyptian Baladi or Bedouin goat (Agha *et al.*, 2008) in Egypt. In general, current geographical location of Black Bedouin or Hejaz goat is in areas of first domesticated goat (*Capra hircus*) in the Fertile Crescent of the Near East countries some 10,000–11,000 years ago (Mason, 1984) until present time (Pereira *et al.*, 2009).

On the other hand, Black Bedouin goats were, with no doubts, goats of the Bedouin who bred and raise them

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Received on 11/10/2012 and Accepted for Publication on 30/4/2013.

in Arabian Desert (Mason, 1984). Therefore, they are commonly known by Bedouin goat, Black Bedouin goat or desert goat. The recent interests of Black Bedouin goat are coming from their tolerability of prolonged heat stress, high diseases resistance and low water consumption under tropical and subtropical conditions (AlAmer, 2006; Al-Tamimi, 2007). The subtropical conditions of Arabian deserts challenge goats for better adaptation and survivability under environmental stresses of mainly prolonged heat and drought to local subtropical conditions (Iniguez, 2004). In general, evidences indicate that animal breeds of tropical areas have a range of unique genetic resources of adaptive traits (e.g. heat resistance, water and feed and, disease tolerance) which enable them to survive and produce in these conditions (Devendra and McLeroy, 1987)

In Jordan desert, Black Bedouin or Dhaiwi goat is found in Wadi Rum valley that is in southern part. They are well adapted to conditions of extensive production system of low water and poor feed quality (Al-Tamimi, 2005). As a consequence, they have low genetic potential for better production when compared to other indigenous and exotic goat breeds in the country (Tabbaa and Al-Atiyat, 2009). Although, The goat is not productive in terms of meat and milk in particular, it was characterised as meat type breed which are reared under the harsh desert conditions (Tabbaa and Al-Atiyat, 2009). Black Bedouin goat breeding program has been carried out in Agriculture station at Mutah University in Jordan in order to optimize different breeding programs for different breeding objectives; meat and milk production and survivability. Hence, the generated data of this breeding program were utilized in simulating different breeding scenarios for optimised genetic potential of Black Bedouin goat as meat type breed (Al-Atiyat et al., 2010) and as dual breed of meat and milk (Al-Atiyat *et al.*, 2012). In both simulated studies, optimizing breeding programs were simulated using ZPLAN® software (Täubert *et al.*, 2011) for meat and milk production as breeding objectives. The simulated results showed that low genetic gain of milk and meat production could be achieved of five-year close scheme breeding program (Al-Atiyat *et al.*, 2010; Al-Atiyat and Al-Jumaah, 2013). The last breeding objective, to be simulated, is breeding the goat for better survivability for the sake of conserving their genetic resources. The ZPLAN® software accommodates pre-defined genetic and phenotypic parameters and pre-set breeding objectives and selection criteria by the user along with selection groups. The software then generates results such as the annual genetic gain for the breeding objective using a pure deterministic approach (Nitter and Graser, 1994). The aim of this study is to simulate sustainable conservation breeding program for Black Bedouin goat to maintain genetic diversity rather than improving performance traits under subtropical conditions.

MATERIALS AND METHODS

Breeding Population Structure and Selection Groups

The breeding population structure of three tiers, nucleus, multiplier and commercial, close scheme was simulated. In the nucleus, bucks were bred to be sires of next bucks in it or sires for multiplier. This tier was closed to genetic material with replacements from within and selected on indices forming a population of 1000 does. The multipliers of 24,000 does bred selected does and bucks to be used by commercial units. The commercial unit was formed of 50,000 does making up the total population of 75,000 does. This total population size was the real size of Black Bedouin goat populations in Jordan in year 2010 (MOA, 2011).

On the other hand, selection criteria were assumed to be measured in the nucleus and the multiplier units. Then, the scenario assumed to be simulating a situation where selection was for surviving and conserving kids done by breeders in both nucleus and multiplier units, whereas done by farmers in the commercial units. The selection groups were constructed from records on each individual into ten selection groups (SG). First and third SGs were bucks from the nucleus to breed bucks and does for the nucleus, respectively. Second and fourth SGs were does from the nucleus to breed bucks and does for the nucleus, respectively. Fifth and seventh SGs were bucks from the nucleus to breed does for the multiplier units and bucks for the commercial units, respectively. Sixth and eighth SGs were does from the multiplier units to breed does for the multiplier units and bucks for the commercial units, respectively. Finally, ninth SG was bucks from the commercial units to breed does and slaughter stock for the commercial units; and tenth SG was does from the commercial units to breed does for the commercial units and slaughter stock.

ZPLAN$^+$ Modelling Software

The computer ZPLAN$^+$ software (Täubert *et al.*, 2010) was used to simulate the Black Bedouin goat program in this study. ZPLAN$^+$ utilized pre-entered physiological, technical, genetic and economic parameters into a deterministic approach to calculate the annual genetic gain for the survivability (number of survived kids) per year. In this scheme, four different simulated scenarios, four different breeding objectives, were performed; for breeding in favor of each of milk production, meat production and survivability and for breeding to all of them together as breeding objectives. The breeding objectives were matched with each related traits as selection criteria. These simulated scenarios assumed that the population parameters and selection strategies were unchanged during the breeding period of ten years. The scenario was considered only one round of selection with defined selecting individuals and selection groups and optional choices of pedigree matrix and gene flow. It is good to note that economic optimization for simulated scenario was not performed in the studied simulation. In addition, the simulated conservation breeding program will be a combination of in situ conservation measures keeping live animals on their own farms of subtropical conditions.

Breeding Objectives and Selection Criteria

The breeding objectives considered in this simulating breeding scheme were milk production and meat production and survivability (Table 1). Selection criteria traits considered in the breeding objective are indicated in Table (1). The inclusion of each trait into breeding objectives was because of its direct or indirect relationship. On the other hand, calculated economic values of the breeding objectives based on inputs, such as feed, husbandry and marketing costs, as well as for outputs, such as income from sale of milk and meat output. Table (1) shows traits considered in estimating economic value of the breeding objective based on a reintegrated bioeconomic model developed by Rewe *et al.* (2006). The economic data were collected from the country Consumer Price Index (DJS, 2012) and the records of Agriculture research station.

Table 1. Description of breeding objectives and their selection criteria.

Breeding objectives	Economic Value*	Description
Total meat yield	1.45	Amount of meat produced from 180 days kid(s) per doe
Total milk yield	1.0	Amount of milk produced per doe
Kid conservation	10.4	Number of kids survived per doe
Selection Criteria		
Birth weight		Kids birth weight
Weaning weight		Weaning weight of kids
Daily gain weight		Daily gain of kids
Total milk production		Milk produced per lactation of five month
Partial milk production		Partial milk produced in a lactation of twice a week
Prolificacy		Number of kids per kidding
Dam weight		Does weight at kidding
Market weight		Body weight of kids at marketing time (180 days)
Kid survival (kid)		Number of kids survived per doe at market time
Neonatal mortality (%)		Mortality rate in the herd at kidding

Phenotypic and Genetic Parameters

Phenotypic parameters and pedigree data were taken and estimated from the records of the goat farm in Agriculture station at Mutah University (Table 2). On the other hand, the genetic parameters used in the simulated program were based on parameters of the Black Bedouin goat used earlier by Al-Atiyat et al. (2010) and from literature for tropical and dwarf goat breeds; goats of tropics - Devendra and McLeroy, 1987; Black Bengal goats - Husain et al. 1990; Blended goats - Das *et al.*, 1994; Dwarf goats - Draa goats - Odubote, 1996 and Boujenanea and ElHazzab, 2008 Emirati goats - Al-Shorepy *et al.*, 2002; West African goats - Bosso *et al.*, 2007, Arsi-Bale goats - Kebede *et al.*, 2011; Markhoz goats - Rashidi *et al.*, 2011. These parameters are phenotypic standard deviations, heritability and repeatability values and genetic and phenotypic correlations of each trait (Table 3 and 4). In cases where requested parameters were not available from published data of tropical goat breeds, information of breeds such as Damascus and Mountain goats were used (Zaitoun *et al.*, 2005; Tabbaa and Al-Atiyat, 2009).

Table 2. Physiological and economical input parameters for traits cost used in estimation economic values of the breeding objectives.

	Value	**Cost (JOD)**
Productive lifetime bucks in breeding unit	3 years	
Productive lifetime for does in breeding unit	3.5 years	
Productive lifetime for sires in commercial unit	3 years	
Productive lifetime for does in commercial unit	4 years	
Buck survival rate in both	85%	
Doe survival rate in both	85%	
Age at first kidding for sires in breeding unit	2.5 years	
Age at first calving for dams in breeding unit	2.0 years	
Age at first calving for sires in commercial unit	2.5 years	
Age at first calving for dams in commercial unit	2 years	
Kidding interval	365,00	
Kidding rate at birth	1.1 kids	
Pre-weaning survival rate	93%	
Post weaning survival rate	90%	
Doe survival rate	90%	
Doe weight (Kg)	60	
Milk yield of five month lactation period (Liter)	170	
Dressing percentage	48%	
Consumed meat percentage	70%	
Replacement rate per doe per year	20%	
Weaning age in days	90	
Sale age in days	180	
Age at first kidding in days	730	
Constant for energy requirement for maintenance	0.35	
Constant for energy for production	0.35	
Birth weight (kg)	3.50	
Weaning weight (kg)	16.00	
Daily gain till marketing (g)	0.15	
Sale weight for males (kg)	40.40	
Sale weight for females (kg)	35.35	
Price of feed		0.40
Energy content in feed mix (Kcal/kg)	2000	
Energy content in pasture of mixed grasses and legumes (Kcal/Kg)	2000	
Energy content in half-Kg feed block concentrates (Kcal/half Kg)	1000	
Amount of milk fat in total milk (Kg)	5	

	Value	Cost (JOD)
Doe recording milk total		0.2
Doe recording milk partial		0.2
Recording birth weight		0.15
Recording weaning weight		0.2
Recording dam weight		0.25
Recording prolificacy		0.50
Recording daily gain		0.50
Fixed costs		3.80
Labour cost per animal		2.00
Veterinary costs per animal		0.30
Reproduction costs per doe		0.50
Marketing costs total per year		80
Price of meat per kilogramme		11.0

Table 3. Phenotypic standard deviations (σ_P)*, heritability and repeatability+ values of selection criteria and breeding objective applied to the simulation scenario.

Name	(σ_P)	Heritability	Repeatability
Birth weight (kg)	0.6	0.38	0.7
Daily gain till marketing (kg)	0.16	0.36	0.63
Dam weight at kidding (kg)	4.5	0.41	0.68
Kid survival (kid)	0.05	0.35	0.58
Marketing weight (kg)	4.0	0.16	0.53
Partial milk (kg)	0.05	0.37	0.65
Weaning weight (kg)	0.5	0.23	0.41
Milk yield(kg)	6.5	0.21	0.41
Neonatal mortality (%)	0.01	0.38	0.70
Prolificacy at kidding (kg)	0.06	0.12	0.25

* Estimated from data records of the station

+ Adopted from previously mentioned references in materials and methods section.

Table 4. Phenotypic (above the diagonal) and genotypic (lower the diagonal) correlations among selection criteria applied to the simulations scenarios.

Traits	Birth Wt	Daily gain	Dam Wt	Kid Survival	Market Wt	Neonatal Mortality	Partial milk	Weaning Wt	Milk yield	Prolificacy
Birth Wt	1	0.25	0.26	0.45	0.2	0.12	0.3	0.55	0.13	0.3
Daily gain	0.3	1	0.4	0.54	0.42	0.05	0.4	0.09	0.4	0.25
Dam Wt	0.05	0.0	1	0.67	0.54	0.2	0.33	0.25	0.3	0.25
Kid Survival	0.63	0.43		1	0.75	0.4	0.30	0.7	0.85	0.63
Market Wt	0.45	0.35	0.54	0.72	1	0.0	0.1	0.35	0.41	0.55
Neonatal Mortality	0.9	0.03		-0.15		1	0.31	0.0	0.4	0.3
Partial milk	0.1	0.0	0.15	0.3	0.1	0.3	1	0.0	0.52	0.3
Weaning Wt	0.45	0.4	0.2	0.45	0.37	0.0	-0.13	1	0.0	0.25
Milk yield	0.2	015	0.45	0.75	0.0	0.30	0.65	0.1	1	0.35
Prolificacy	0.3	-0.25	0.0	-0.34	0.25	0.23	0.25	0.42	0.26	1

RESULTS AND DISCUSSION

Genetic Gain for Each Breeding Objective

Genetic trends for the three studied traits through the independent simulated scenarios are shown in Figure (1). The assumption was that simulated breeding program for each trait in long term of ten years would illustrate the potential for sustainability in one hand, and to give better predication of the genetic gain after few generations for each trait separately, on the other hand. The genetic gain per year for milk and meat production linearly increased up to five-years then slight drop-down was observed (Figure 1). The reduction after such duration, of probably four generations, might be because of close nucleus scheme that assumed which reflect fixed heritability and repeatability estimates through the successive generation. The genetic trend that was obtained for milk production was sharply reduced after 5 years of selection but the figure was much butter for meat production and conservation (Figure 1). It would assume that open nucleus scheme more sustainable of long term breeding program but not reflecting the real case of breeding goats in Jordan. On the other hand, average increment for conserving 2.116 kids per doe of whole program, starting by 2.2 kids and ending the program by 2.09 kids. It is clear that number of conserved kids was maintained during the program while, genetic gain of milk yield per doe averaged to 0.189 kg and for meat yield 0.096 kg with wide range from starting value to end-up value of the breeding program (Figure 1). For those breeding objectives, it seems that they are not to be considered in long term breeding program because it would not be sustainable.

These results showed that the average genetic improvement was possible for each breeding trait an independent breeding program and it genetically worthwhile. The genetic improvement was resulted from the related selection criteria under assumption of increasing selection accuracy of selection groups. It was observed that, in nucleus and multiplier unites, the high proportion of selected (high selection intensity) bucks the great genetic gain was expected to obtain. Similar findings were reported for using that high selection intensity of bulls in cattle breeding and resulted in higher genetic gains (Archer et al 2004, Rewe *et al.*, 2010). For breeding goats, similar situation were stated where the sires have the greatest influence on the entire population genetic gain (Shrestha and Fahmy, 2007).

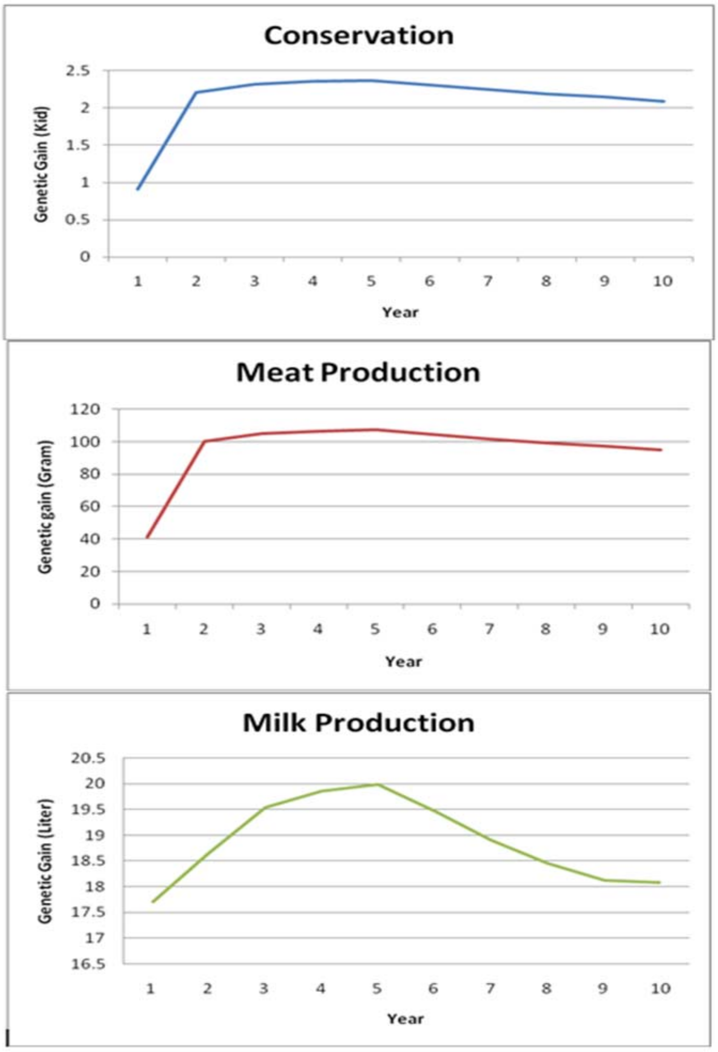

Figure 1. Genetic gain of each year in independent breeding program for genetic conservation and improving milk and meat production in Black Bedouin goat.

Potential of Genetic Gain of the Three Objectives in integrated Breeding Program

The simulated genetic gain of integrated breeding program of the three breeding objectives was plotted in Figure (2B). In general, the results showed same values of genetic gain for conservation with lower values of genetic gain of the other traits (Figure 2 A and B). The integration of all breeding traits for predicting the genetic gain for conservation level required integration of the heritability, repeatability and genetic correlation values of studied criteria under investigation. Therefore, the genetic correlations of all studied traits in particular might be most contributing to genetic gain responses in each trait (Table 4). The simulated scenario was then performed assuming integration of phenotypic and genetic correlation of studied criteria under investigation, keeping heritability values, genetic variance and repeatability values constant. The simulated scenario showed that the genetic gains were constant for conservation as trait of interest, whereas genetic gains for milk and meat production sharply dropped (Figure 2B). It is clear that the values of genetic gain were decreased for milk and meat production as selection was weighted on conservation in the integrated breeding program in comparison with independent breeding program for each trait (Figure 2). Therefore, the genetic gain in milk and meat decreased when breeding objective conservation was integrated into the sustainable long term breeding program. However, non-sustainability of long term breeding program was reported due to incompatibility of the genotypes with the breeding objectives, management approaches and environmental conditions (Wilson, 1991; Wollny *et al.*, 2003). These might be changes for any proposed future breeding program for Black Bedouin goat. There are, on the other hand, proposed solutions such as considering within breed selection of the adapted indigenous genotypes that approved efficiency on-farm sustainable conservation breeding program (Simon, 999; Ruane, 2000). Finally, it is good to draw attention that due to crossbreeding and/or replacement with exotic breeds, large number of Black Bedouin goats might be at risk of extinction. Therefore, we recommend a real implementation of sustainable in-situ conservation breeding program for Black Bedouin goat to maintain genetic diversity.

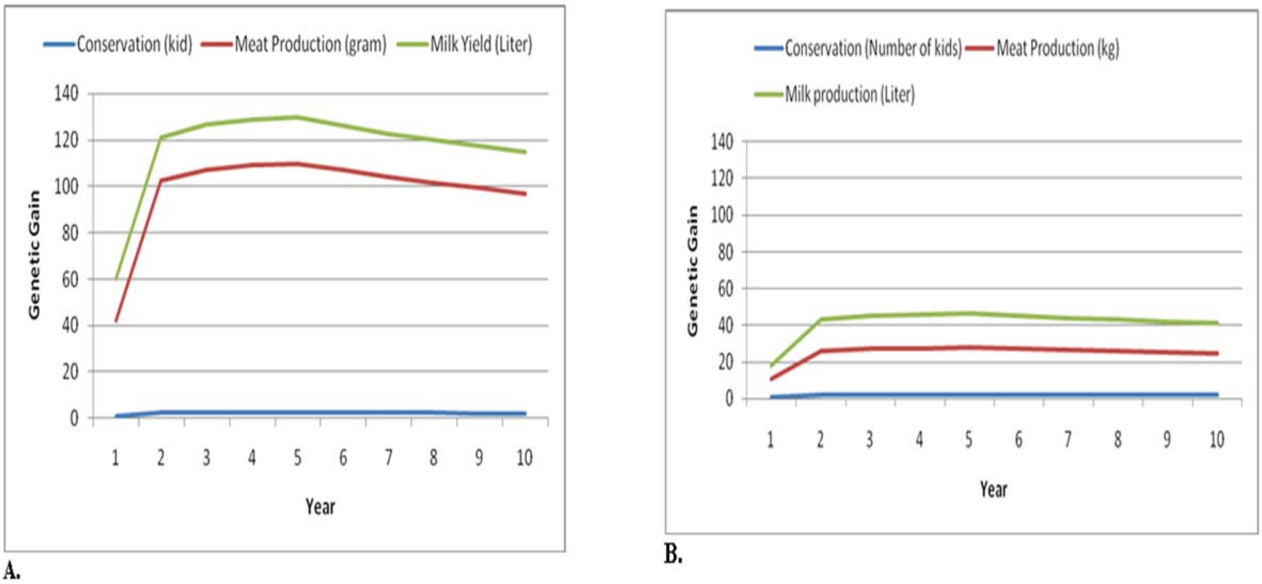

Figure 2. A. Genetic gain of each year in independent breeding program for genetic conservation and improving milk and meat production in Black Bedouin goat . B. Genetic gain of each year in integrated breeding program for genetic conservation and improving milk and meat production in Black Bedouin goat.

CONCLUSION

The present study meets the demands of sustainable breeding program of indigenous goat breed in Arabian countries not only regarding the production traits but also survivability. Four simulated scenarios showed that a positive genetic gain achieved for meat production, milk production and conservation as independent breeding programs and Integrated programs of the three traits together. Black Bedouin goat is currently considered as dual purpose breed with no worldwide performance records and known genetic parameters. A drastic reduction of genetic gain was noticed for milk and meat production programs of ten-year breeding program after fifth year. It was noticed that integration conservation genetics as breeding program maintain the genetic gain for kid survivability and provide reasonable genetic gain for production traits of meat and milk. The best sustainable breeding program might be of five-year duration and by then might be reconstructed under assumption of close scheme. Breeding in favor of meat and/or milk production alone probably lead to a reduction in census size of goat herd resulting in loss of genetic diversity. Loss of genetic diversity can further be expected if the common practice by farmers of crossing and/or replacing with exotic breeds. Therefore, it is recommended to set up a real implementation of sustainable in-situ conservation breeding program for Black Bedouin goat to maintain genetic diversity.

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تصميم برنامج تحسين الوراثي مستدام للماعز البدوي الأسود من أجل حفظ التنوع الوراثي: برامج محاكاة في بيئته الحقيقية

رائد العطيات[1]

ملخص

تمت محاكاة برنامج تحسين وراثي للماعز البدوي الأسود من اجل حفظ التنوع الوراثي عوضاً عن تحسين الأداء في ظل الظروف الأردنية شبه القاحلة. وتم استخدام برنامج *ZPLAN*+ مع الأخذ بعين الاعتبار نمط التربية المغلق المكوّن من قطيع النواة، والإكثار والتجاري، باستخدام المعايير المظهرية والوراثية للصفات المختارة وأهداف التربية الثلاثة من الحفظ الوراثي وإنتاج الحليب واللحوم. وقد أظهرت نتائج أربعة سيناريوهات للمحاكاة، وهي: انخفاض معدلات التحسين الوراثي للحليب وبرامج إنتاج اللحوم ضمن برامج مستقلة ولفترات طويلة لمدة عشر سنوات لإنتاج اللحوم، وإنتاج الحليب، والحفظ الوراثي. أما بالنسبة للبرنامج الشامل لثلاث صفات، فإن التحسين الوراثي والقدرة على البقاء للمواليد قد تمت المحافظة عليها مع متوسط تحسين وراثي معقول لصفات إنتاج اللحم والحليب. إن التربية لصالح إنتاج الحوم و/أو الحليب وحده يؤدي – على الأرجح– إلى انخفاض في حجم وعدد الماعز، مما يؤدي إلى فقدان التنوع الوراثي. لذلك يوصي الباحث بإنشاء برنامج تحسين مستدام للحفاظ على الوضع الطبيعي لبرنامج تربية الماعز البدوي الأسود وتنوعه الحيوي.

الكلمات الدالة: الماعز البدوي الأسود، شبه القاحلة، برنامج تحسين وراثي، المحافظة على التنوع الحيوي.

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تاريخ استلام البحث 2012/10/11 وتاريخ قبوله 2013/4/30.