Influence of Flock Size and Biological Performance Changes on Economic Efficiency of Barki Sheep under Semi-Arid Conditions in Egypt

I. Mona Mohammady

Desert Research Center, Animal Production and Poultry Division, Matarya, Cairo, Egypt
monamohammady@hotmail.com

Abstract: The aim of current study was to compare the profitability of nine simulated Barki flocks varying in their biological performance and flock size under semi-arid conditions in Egypt to achieve the most profitable combination among flock performance levels and flock sizes. Data on biological traits of 6331 records represent 2039 breeding ewes obtained from Maryout Research Station were analyzed. Biological criteria considered were number of ewes lambed per ewe joined (EL/EJ), number of lambs born per ewe joined (LB/EJ), number of lambs weaned per ewe joined (LW/EJ) and kilograms weaned per ewe joined (KGW/EJ). Estimates derived from statistical analysis were used to create nine simulated flocks of three biological categories of KGW/EJ (high, medium and low) and flock size of 250, 500 and 750 breeding ewes. Financial criteria were gross margin/ewe, benefit/cost ratio, cost per one kg of weaned lambs produced, and marginal rate of return. The overall least squares means for EL/EJ, LB/EJ, LW/EJ and KGW/EJ were 0.77, 0.80, 0.62 and 12.15 kg, respectively. The current indicators of economic efficiency concluded that, the simulated flock of high biological performance with flock size of 500 head was the most profitable Barki flock, since achieved the highest GM/E (LE 138.9), highest benefit/cost ratio (1.26), lowest cost to produce one kg weaned lambs (LE 33.5) and the highest marginal rate of return (1.33) among the all nine simulated flocks.

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Key words: Barki sheep, flock size, biological parameters, economic indicators

1. Introduction

Increasing annual lamb production is the ultimate goal of sheep producers, since it affects the net return of sheep enterprise. Biological performance level of the flock may affect the overall economic performance. Poor biological performance reduces income and profitability through its effects on several areas of flock profile: low number of ewes lambed per ewe joined (EL/EJ) and number of lambs born per ewes joined (LB/EJ) lead to fewer lambs born, subsequently, fewer lambs available for sale and/or for use as flock replacements. This may increase the number of lambs purchase for replacements to maintain fixed flock size. It is important to identify and estimate the critical control points involved in the search of profitable sheep enterprise, so managers can focus their efforts and skills on those points (Ahmed 2008).

Total kilograms of weaned lambs per breeding ewe joined (KGW/EJ) is consider as a useful single index of meat productive ability of a flock, since it combines all the major production parameters relating to reproduction, viability, growth, etc., (Younis *et al.,* 1990). This index is dependent on both the number of weaned lambs and the weight of the individual weaned lamb. In consequence, change in one or combination of those parameters will go to change KGW/EJ. The success of sheep production is usually measure in economic terms. Therefore, in order to compare profitability among sheep farms, biological and financial analysis are essential.

Few studies are available dealing with the changes of biological performance in relation to economic of flock size scale of Barki sheep under semi-arid conditions in Egypt. Barnard and Nix (1993) stated that simulation technique is an invaluable tool to test different proposed scenarios on economic efficiency of the sheep flock before implementation. The current study was conducted to investigate the expected sheep enterprise profitability and economic efficiency of different simulated Barki flocks varying mainly in biological performance level and flock size to achieve the most profitable combination among flock performance levels and flock sizes. raised under semi-arid conditions.

2. Materials and Methods

Source of Data

Data utilized in the current study were obtained from the accumulated 6331 records of Barki sheep flock. These data collected over 33 successive breeding seasons, representing 2039 breeding ewes raised at Maryout Research Station, belonging to Desert Research Center in Cairo. This station is located in the North West of Nile Delta, 180 km from Cairo, and represents costal semi-arid conditions. A regular recording system for flock biological performance was performed in each breeding season included reproductive and productive data. `

Flock Management Practices

A. Breeding plan

Flock was kept in open shed wire-fenced pens. Breeding ewes were naturally mated once a year in Autumn season starting from 15th September and lasted for 34 days (two estrous cycles). Breeding rams and ewes were selected according to Barki breed phenotypic characteristics, productive and reproductive criteria. Breeding ewes were homogeneity distributed in mating groups in breeding pens (20 – 25 heads each) according to their ages and assigned with fertile breeding ram. Rams' briskets were colored with different colored grease fortnightly and breeding pens were checked daily for marked ewes. At lambing, new born lambs were identified with metal ear tags, sex, type of birth and pedigree recorded. Weight was recorded within 24 hours of birth and bi-weekly until weaning age (90 days).

B. Feeding scheme

The studied flock kept under similar regular feeding scheme according to management program and physiological status of the breeding ewes. Feed was composed of concentrate feed mixture plus berseem (*Trifolium alexandrinum*) as a green fodder during the period from October to May, while the rest of the year berseem was replaced by berseem hay. Two weeks prior breeding season, extra supplementary concentrate feed mixture of about 0.5 kg/head/day offered for flushing the breeding ewes and also, during late pregnancy and early lactation. Breeding rams were offered the above-mentioned ration, in addition to extra daily 0.5 kg of barely per head during breeding season. The mixture offered once a day and water was available twice daily. Whenever available, the flock allowed grazing in neighboring areas from sunrise until sunset.

Design of the Study

A. Data processing

To achieve the established goals of the present study, data processing included two stages. The first stage considered as a base run utilized the 6331 collected cumulative records of the studied flock to extract the least squares estimates of KGW/EJ during the studied 33 different breeding seasons as a biological index and flock biological features. Figure (1) displays the result of base run and illustrates seasonal evolution of KGW/EJ throughout the studied breeding seasons.

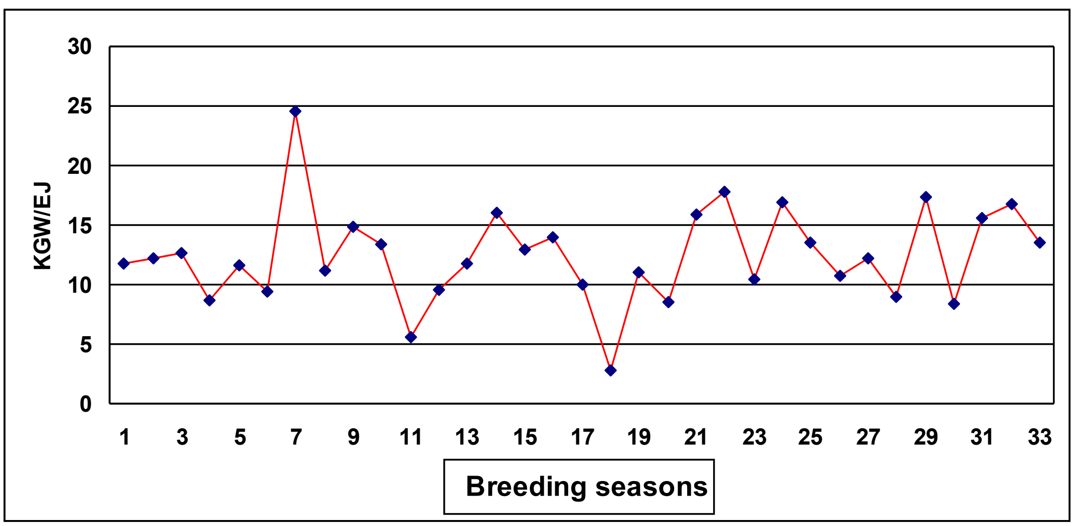


Figure (1): Evolution of kilograms weaned per ewe joined (KGW/EJ) during the studied breeding seasons.

In the second stage, the obtained estimates of KGW/EJ ranked in descending order. The ranked estimates were classified into three categories according to KGW/EJ value (high, medium and low), the top eleven breeding seasons represents the high category, while the middle eleven breeding seasons represents the medium category and the bottom eleven breeding seasons represents the low category. Figure (2) shows the distribution and the behavior of KGW/EJ of the three categories during the related eleven breeding seasons. The top curve represents the high biological performance breeding seasons, while the middle curve represents the medium level and the bottom curve represents the low biological level.

B. Statistical analysis

The data was subjected to one-way analysis of variance using fixed effect linear model described by SAS (1998) to derive least squares estimates of the studied biological criteria for the above-mentioned three categories. Biological criteria considered were EL/EJ, LB/EJ, LW/EJ and KGW/EJ. The model undertaken to develop technical coefficients was as follows;

$$Y_{ij} = \mu + a_i + e_{ij}$$

Where:

Y_{ij} = the observation,

μ = the overall mean,

a_i = the effect due to i^{th} category, i = 1, 2 and 3,

e_{ij} = the random effect associated with the individual observation. This element represents all the unidentified factors that may affect the traits under investigation and are not included in the model. Significant differences among biological categories were tested according to Duncan's new multiple ranges test (Duncan, 1955).

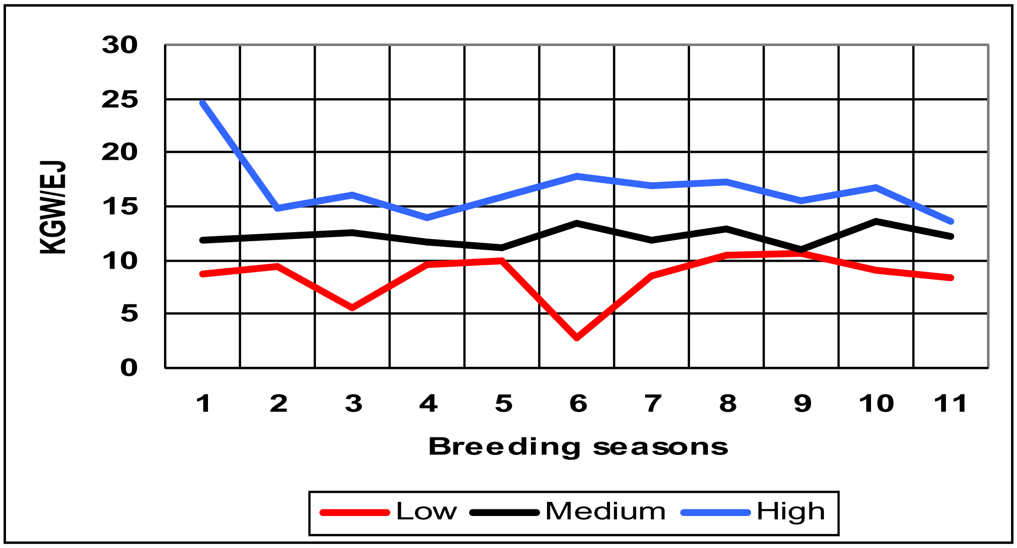


Figure (2): Distribution of breeding seasons according to the three biological performance categories.

C. Simulated flocks

Using deterministic simulation technique, an empirical economic study proposed to investigate the impact of different biological performance level under different flock size scales on flock profitability. Deterministic estimates set derived from the least squares analyses of the three biological categories were used to create simulated flocks. Two variables were considered factorially to generate nine simulated flocks. The first variable was biological performance of the three levels, high (H), medium (M) and low (L), while the second variable was flock size with three flock size scales (250, 500 and 750 head of breeding ewes). The simulated flock was designed by a hyphenated number, the character to the left indicating the biological level and the digit to the right indicating the flock size, e.g. H/250 indicates a simulated flock of high biological performance and flock size of 250 head of breeding ewes. A reasonably accurate estimate can be made using some assumptions based on previous management practices of the studied Barki flock. The following general assumptions were involved:

- Flock raised under semi-arid conditions.
- Management practices of the nine simulated flocks were supposed to be similar to the standard practices used in the original flock.
- Feed requirements of the simulated flocks were calculated according to their physiological status, and availability of feedstuff.
- Annual replacement rate of breeding ewes = 15%
- Actual farm-gate prices in Egyptian Pound (LE) prevailing in 2013 were used; Concentrate feed mix = 2200/ton, barely = 4000/ton, berseem = 200/ton, berseem hay = 1600/ton, weaned lambs = 45/kg, culled rams = 1200/head, culled ewes = 1200/head, greasy wool = 4000/ton and manure = $65/m^3$

- Annual veterinary care = 50 LE /head.

D. Economical assessment

In order to asses the nine simulated flocks, partial budget was applied and financial calculations done on how costs and revenues change when biological performance level and flock size changes. Financial calculation included the variable costs of all inputs; feed (concentrate feed mix, barely, berseem and berseem hay), and non-feed (veterinary care, wages of permanent and hired labor for shearing season in addition to metal ear tags). While, total revenues represent the monetary value of weaned lambs, culled rams and ewes, wool and manure. Economic indicators used for comparison among the nine simulated flocks were gross margin per ewe (GM/E), benefit/cost ratio (B/C), and cost per one kg of weaned lambs produced. Another criterion, which considers the cost factor into account, is the marginal rate of return (MRR). MRR measures the increase or decrease in profit of a flock which is occurred by each additional unit of variable costs due to improve biological performance and/or flock size increase, compared to the basic flock (CIMMYT, 1988). The general equation for estimating the gross margin per ewe is:

$$GM/E = (R - VC)/\text{flock size},$$

Where; GM/E = gross margin per ewe, R = total revenues and VC = variable costs.

3.Results and Discussion

Biological Characteristics

Results of least squares analysis of the three biological performance categories of simulated flocks are shown in Table (1). In general, estimates obtained of the current work lies within the range of estimates published on Barki sheep and comparable to the most of these estimates.

Table (1) Least squares means (X) and standard errors (SE) of the three biological categories used in generating the simulated flocks.

Category	No.	EL/EJ	LB/EJ	LW/EJ	KGW/EJ
		X ± SE	X ± SE	X ± SE	X ± SE
Overall mean	6331	0.77 ± 0.005	0.80 ± 0.006	0.62 ± 0.007	12.15 ± 0.139
High	2199	$0.85^{a} \pm 0.014$	$0.89^{a} \pm 0.017$	$0.75^{a} \pm 0.022$	$16.19^{a} \pm 0.509$
Medium	1917	$0.73^{b} \pm 0.017$	$0.75^{b} \pm 0.018$	$0.60^{b} \pm 0.020$	$12.07^{b} \pm 0.418$
Low	2215	$0.73^{b} \pm 0.019$	$0.75^{b} \pm 0.021$	$0.51^{c} \pm 0.019$	$8.20^{c} \pm 0.374$

EL/EJ, Number of ewes lambing per ewe joined: LB/EJ, Number of lambs born per ewe joined; LW/EJ, Number of lambs weaned per ewe joined; KGW/EJ, Kilograms weaned per ewe joined. ^{A,b,c} Means in the same column with different superscripts are significantly different ($P < 0.01$).

The overall least squares means for EL/EJ, LB/EJ, LW/EJ and KGW/EJ were 0.77, 0.80, 0.62 and 12.15 kg, respectively. The overall least squares estimate for EL/EJ obtained is close to that reported by Mabrouk (1970) of 79.2% and Mohammady (2005) of 79 % for the same breed, but lower than those found by Salem (1990) of 87% and Mohammady (1999) of 82.4%.

No significant differences observed for EL/EJ and LB/EJ between M and L biological categories, however H category was significantly higher than both. The obtained overall mean of LB/EJ is higher than those reported by Bedier (1987) of 63.0% and Younis *et al.* (1984) of 68.0 % for the same breed. The overall least squares mean of LW/EJ is higher than those stated by Bedier (1987) of 59% and Ahmed *et al.* (1992) of 54% for the same breed. The estimated overall mean of KGW/EJ is close to that reported by Bedier (1987) of 11.08 kg. However, Younis *et al.* (1990) and Ahmed *et al.* (1992), reported lower estimates. Significant differences ($P < 0.01$) were found among the three categories in LW/EJ and KGW/EJ.

For the purpose of financial calculation, the expected revenues from the studied simulated flocks; it is assumed that all surplus lambs are sold at weaning. Therefore, the economical efficiency evaluated based on the monetary value of weaned lamb's crop. In this context, the obtained least squares estimates of the biological categories of the simulated flocks were transformed to the equivalent number of ewes and weaned lambs under the three studied flock sizes of each biological level as shown in Table (2).

Table (2). Distribution of ewes and weaned lambs of the nine simulated flocks.

Criteria	High			Medium			Low		
Flock size (head)	**250**	**500**	**750**	**250**	**500**	**750**	**250**	**500**	**750**
Ewe lambed	213	426	638	183	367	547	183	367	550
Lambs born	223	447	670	188	376	564	188	377	565
Lambs weaned	188	377	564	151	302	453	128	256	383
Replacement:									
Ewe lambs	47	93	140	47	93	140	47	93	140
Ram lambs	8	15	21	8	15	21	8	15	21
Surplus for sale:									
Ewe lambs	47	96	142	29	58	87	17	35	52
Ram lambs	86	174	261	68	136	206	56	113	171

Economical Evaluation

The current study facilitates comparison among the studied nine simulated flocks through two ways. The first among the simulated flocks of the same biological performance level of different flock size, while the second among flocks of the same size of different biological performance. Results of partial budget analysis of the nine simulated flocks are displayed in Figure (3). Generally, it is clear that the variation of the attained revenues and variable costs among the simulated flock reflected the significant interaction among the biological performance levels and flock size scales. It could be notice that, as the biological criteria of the simulated flocks improve, the revenues increase. At the same time, the variable costs had the same trend, which account for some of the increased associated with improved reproduction such as feed costs for extra pregnant ewes and more labor for extra lambs born.

Concerning simulated flocks of the same size under different biological performance (low, medium and high), results revealed that the simulated flocks of high level (H) achieved the highest revenues per flock among all the studied flocks. High level exceeded L and M flocks by 47% and 24%, respectively, while the simulated flocks of low level earned the lowest revenues. In this context, variable costs of high level accounted for some increase that would be associated with extra number of ewes lambed (16%) more than the other two levels as shown in Table 2. On the other hand, simulated flocks of the same level of biological performance revealed that revenues increased by 100% and 200%, while variable costs increased by 90% and 180%, when flock size enlarged to 500 and 750 head, respectively (Figure 3).

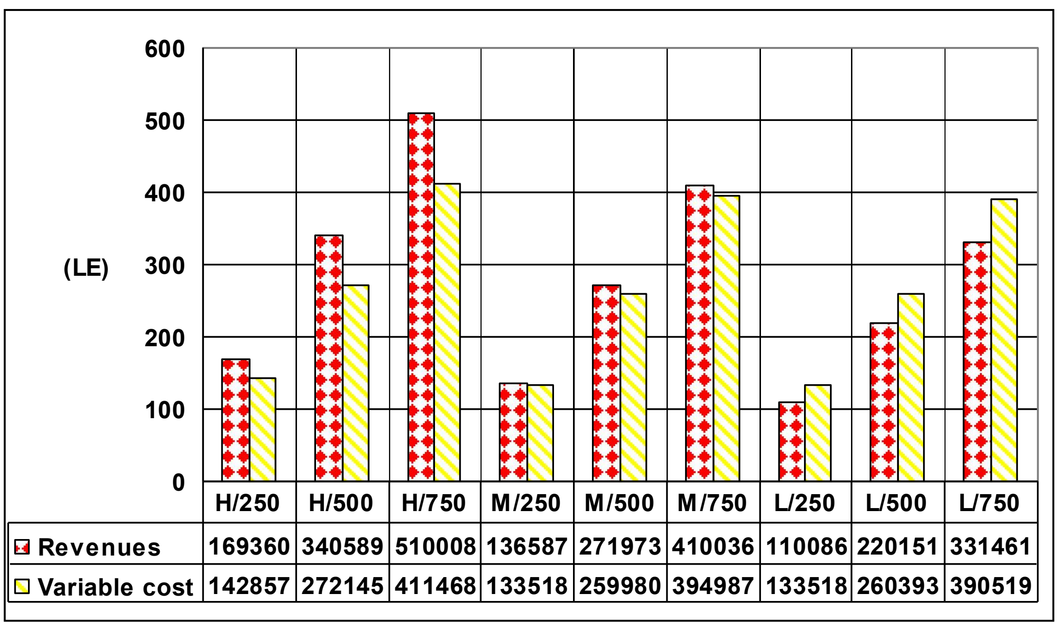


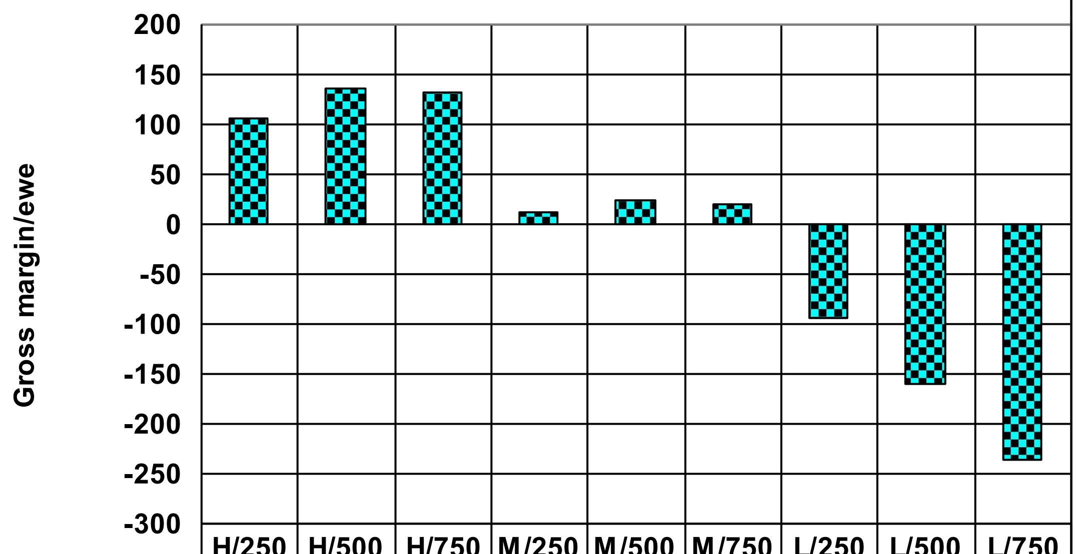
Figure (3): Partial budget results of the studied nine simulated flock.

From economic point of view, under current simulated flocks, the obtained results showed that the H/750 flock achieved the highest gross margin per flock (LE 98537). The current results are in accordance with that stated by Suresh *et al*. (2008) they concluded that the largest flock earned the highest gross margin among the studied flocks (small, medium and large flocks). It is interest to observe that, in spite of flock of low biological performance earned revenues under the three flock sizes (250, 500 and 750) but it could not reached the break-even point between revenues and variable costs and scored negative gross margin values per flock for the three studied flock sizes (LE -23432, -40242 and -59058, respectively). These results are in agreement with that reported by Nunez and Moyano (2006) they cited that the top biological performance flock can be considered profitable, while the bottom one have a negative economic balance.

Economic indicators

Economic analysis was undertaken to compare the expected economic efficiency generating from the nine simulated flocks. In general, all the simulated flocks achieved varied profits per ewe except low biological performance flocks under the three studied flock sizes (250, 500 and 750). Results of the gross margin per ewe are displayed in Figure. (4). The results showed that H/500 earned the highest gross margin/ewe (LE 138.9) among the studied flocks. While GM of L/750, scored remarkable negative value of LE -230.4. This could be attributed to low biological performance, which characterizes by fewer numbers of weaned lambs for replacement and/or surplus for sale (Table 2) and low weaning weight of lambs. Meanwhile, if the sheep producers plan to enlarge flock size of more than 500 breeding ewes, the GM/ewe will be decline due to more variable costs incurred during the studied production period.

Benefit/cost ratio clearly indicates the relationship between the revenues earned from the flock and variable costs needed to translate the biological criteria into lamb's crop. The current B/C ratios as shown in Table (3) revealed that, simulated flock H/500 scored the highest ratio of LE 1.26, while Ahmed (2008) reported higher value of B/C ratio of 1.58 for Barki sheep. In contrary, the three simulated flocks (L/250, L/500 and L/750), which characterized by low biological performance, each unit of money spent, earned only LE 0.83, LE 0.85 and 0.85, respectively. The observed results declared that at low biological level of the proposed flock sizes, the revenues obtained could not compensate the variable costs spent due to less number of weaned lambs of low live body weight.



	H/250	H/500	H/750	M/250	M/500	M/750	L/250	L/500	L/750
Gross margin	106	137	131	12	24	20	-94	-161	-236

Figure (4): The expected gross margin per ewe of the nine simulated flocks.

Table 3. Economic indicators for the nine simulated flocks.

Indicators	Simulated flocks								
	High			Medium			Low		
Flock size (head)	250	500	750	250	500	750	250	500	750
Revenues/ewe	677	681	680	546	544	547	440	440	442
Variable cost/ewe	569	542	546	543	518	524	532	518	518
GM/E	108	138.9	133	2.3	25.8	21.9	-91.8	-157.1	-230.4
B/C ratio	1.19	1.26	1.24	1.0	1.05	1.04	0.83	0.85	0.85
Cost/one kg	35.2	33.5	33.8	45.1	42.9	43.5	32.9	64.1	96.1
MRR	----	1.33	1.27	----	1.1	1.05	----	0.87	0.86

The main objective of sheep producers is to maximize the difference between, what it costs to produce one kg of meat and what price received. Under the prevailing market price of inputs and outputs, the attained results indicated that variable costs per one kg of weaned lambs produced decreased as flock biological performance improves. The obtained estimates revealed that cost of one kg of weaned lambs of H/500 flock was the lowest (LE 33.5) among all the studied simulated flocks, while L/750 flock was the highest (LE 96.1).

Under the proposed biological performance levels (high, medium and low), when flock size of (H) level enlarged to 500, MRR was LE1.33, and when increased to 750, MRR declined to LE1.27 compared to H/250 flock as a basic one. Nunez and Moyano (2006) observed similar results, they concluded that as the size of the flock becomes larger, general management becomes poorer and profit decreases. While under low biological performance, sheep producer will expect to face high possible financial losses and lose more money when flock size will be larger.

Conclusion

The obtained results declared the significant relationship between biological performance and flock size. All evidence estimated in the current study concluded that maintaining high level of biological performance is required to improve flock profitability. Gross margin per ewe considered as main determinant and a key indicator in measuring the direct effect of sheep farm management and external effect of market for decision maker. It is of interest to conclude that, not every increasing of flock size lead to profit. In this context, under the two variables considered, the economic flock size of scale composed of 500 head of breeding ewes for high biological performance level under the semi-arid conditions.

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