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Evaluation of Some Management and Biological Factors Affecting Growth Performance of Sohagi Sheep

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Abstract

The present study was conducted in Upper Egypt to evaluate the factors affecting productivity and growth of Sohagi sheep, which is a unique local breed. This study was conducted at the Experimental Sheep Farm of Sohag University over a one-year period. Involving a total of 28 male lambs12 individually raised and 16 raised in a group feeding system. Key factors evaluated include growth rate, feeding systems, birth type (single vs. twin), parity, and the age of the dam. The results indicate significant differences in final body weight, average daily gain (ADG), and total body gain between the fast-growing and slow-growing groups, with the fast-growing lambs exhibiting superior performance ($P < 0.0001$). Lambs born as singles also demonstrated significantly higher initial and final body weights compared to twins ($P = 0.0003$ and $P = 0.0194$, respectively). While the parity and the age of the dam did not significantly affect growth performance. However, the feeding system had a significant impact, where individually fed lambs achieved higher final body weights and ADG than those in group feeding ($P < 0.0001$). These findings highlight the importance of optimizing management practices, including feeding strategies and understanding the influences of non-genetic factors on growth performance, to enhance the productivity of the Sohagi breed. The study emphasizes the need for targeted breeding programs and effective feeding systems to support the sustainability and profitability of sheep farming in Upper Egypt.

Key words: non-genetic, feeding system , slow-growing , fast-growing , Sohagi sheep

INTRODUCTION

Sheep play a critical role in the agricultural economy of Egypt, serving as a primary source of animal protein and contributing significantly to the livelihoods of many farmers, particularly in rural areas. The total sheep population in Egypt is approximately 5.6 million, with the Sohagi breed being one of the most notable native breeds found in Upper Egypt. Sohagi sheep are primarily raised for their meat and wool, and they represent an essential component of local agricultural practices (Sallam et al., 2012; FAOSTAT, 2018). Despite their significance, the Sohagi breed has received limited attention in research compared to other sheep breeds, and no comprehensive breeding programs have been established to improve their genetic potential (Elnahas et al., 2017). Growth performance of sheep is a crucial indicator of production efficiency and profitability, as it directly affects reproductive health and overall productivity. Fast growth rates in sheep enable earlier reproduction and increased lamb production over their lifetime, making it an important aspect of genetic improvement programs (Bela and Haile, 2009; Ghafouri-Kesbi and Eskandarinasab, 2008). Moreover, the economic viability of sheep farming heavily relies on the ability to reach market weight efficiently, emphasizing the need for understanding factors that influence growth performance. The growth performance of farm animals is regulated by a combination of genetic and non-genetic factors, including environmental conditions, feeding management, and breeding practices (Alemneh and Getabalew, 2019). Non-genetic factors such as the type of birth (single or twin), sex of the lamb, breed characteristics, and the age and parity of the dam can significantly impact growth rates and overall productivity (Yilmaz et al., 2007). For instance, lambs born as singles generally exhibit better growth performance compared to those born as twins due to enhanced access to maternal resources. This study aims to evaluate the impact of various factors on the growth performance of Sohagi sheep, focusing on growth rate, feeding systems, birth type, number of parities, and the age of the dam. The investigation of these factors is essential for establishing effective management practices and breeding programs aimed at enhancing the productivity of the Sohagi breed. The lack of research on the specific growth patterns of Sohagi lambs from birth to marketing age highlights a critical gap in knowledge that this study seeks to address. By understanding the relationships between these non-genetic factors and growth performance, this research will contribute to optimizing production practices for Sohagi sheep, which is vital for improving local sheep farming in Upper Egypt. Ultimately, the findings of this study may be useful for farmers besides support broader efforts to enhance the sustainability of sheep production systems in the region.

MATERIALS AND METHODS

Materials and Methods

Ethical Approval

Ethical approval for animal welfare regarding the protocol for enhancing meat production of sheep was granted by the Institutional Animal Care and Use Committee (CU-IACUC) at Cairo University (Giza, Egypt), with approval number CU II F 28 22, dated October 2022.

Study Location

The current study was conducted at the experimental sheep arm, Department of Animal Production, Faculty of Agriculture, Sohag University, El-Kawthar City, Sohag Governorate, Egypt. Sohag is located in Upper Egypt's center area, between latitudes 26° 08′ and 27° 18′ N and longitudes 31° 18′ and 32° 48′ E, according to the Information and Decision Support Center (2021). The environment is arid and semi-tropical, which creates special problems for sheep farming. A research team from the Department of Animal Production at Sohag University's Faculty of Agriculture has expressed an early interest in stabilizing phenotypic traits and improving the performance of the Sohagi sheep breed, which is popular in Upper Egypt, particularly in the Sohag and Qena governorates.

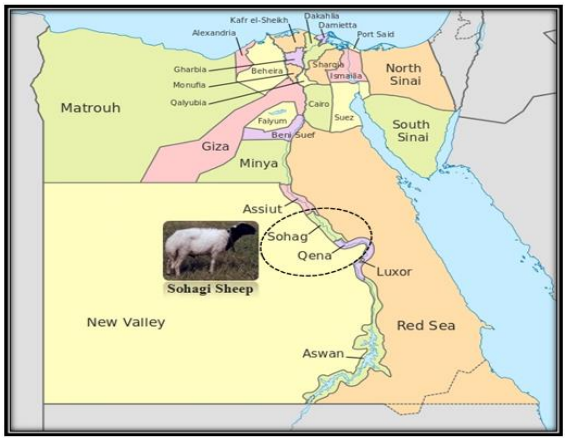

Fig (**1**) Sohag and Qena governorates which raised Sohagi sheep breed https://commons.wikimedia.org/w/index.php?curid=32089528

Experimental Animals

The experiment was conducted from July 1, 2022, to July 1, 2023. The study used 28 male Sohagi lambs, 12 lambs were raised individually and 16 raised in a group feeding approach. All lambs were the same approximately age and were tracked for one year. Individually grown lambs were fed after weaning at 2 months (beginning body weight) until 12 months (final body weight). These lambs were housed in cubic cement enclosures of 120 cm wide, 150 cm long and 135 cm high, which gave ample area for movement and comfort. They were given fresh water and a balanced diet. The 16 lambs in the group feeding method were weaned at 2 months old and raising in a wider area than individually one that allowed for social interactions while assuring sufficient diet. All lambs in both groups were fed a meal designed to meet normal nutritional needs, ensuring that they were well-nourished for optimal growth. The lambs were fed according to a standard schedule provided by the National Research Council (NRC, 1985), which met their nutritional requirements. They were given specific amounts of a commercial concentrate mixture comprising 14% crude protein, as well as alfalfa hay (*Medicago sativa L*). To achieve optimal growth, the quantities of concentrate feed mixture (CFM) fed to the lambs were adjusted biweekly based on their live body weight. Additionally, water was made available ad libitum for the experimental animals throughout the study period.

Body Weight Measurement

The lamb's body weight was measured every 15 days using a precision scale with an accuracy of 0.1 kg. Weighing was done in the morning to guarantee uniform measurements. This constant monitoring enabled an accurate assessment of growth performance throughout the trial period.

Statistical analysis

Data were analyzed by SAS software (SAS, 2004). Duncan's Multiple Range Test (Duncan, 1955) were used for tested for significance for difference among treatment means the model used was

$$Y_{ijklmn} = \mu + G_i + T_j + P_k + A_l + F_m + e_{ijklmn}$$

Where Y_{ijklm} is the dependent variable, μ is the overall mean, G_i the fixed effect of growth rate groups, T_j the fixed effect of type of birth, P_k the fixed effect of parity number of the ewe, A_l the fixed effect of age of the dam, F_m the fixed effect of feeding system and ε_{ijklmn} is the random residual error.

RESULTS

Growth Rate Groups

The results of this study revealed clear differences in growth performance between the slow-growing and fast-growing lamb groups, especially in terms of final body weight, average daily gain, and total body gain. While no significant differences were observed between the groups in terms of birth weight ($P = 0.4157$) or initial body weight ($P = 0.1999$), the growth trajectory quickly diverged as the lambs matured. The fast-growing group reached a significantly higher final body weight of 41.99 kg compared to the slow-growing group 38.77 kg ($P < 0.0001$). This difference in final weight was also reflected of their daily growth rates. Lambs in the fast-growing group gained weight at a much higher rate (92.53g per day) compered with those in the slow-growing (76.51 g per

day) ($P < 0.0001$)Additionally, when we looked at total body gain, the fast-growing group showed a higher total gain of 30.49 kg compared to 25.24 kg in the slow-growing group ($P < 0.0001$). These results suggest that the fast-growing group exhibited superior growth performance over time compared to the slow-growing lambs.

Type of Birth

Interestingly, when we compared single-born lambs to twins, birth weight differences weren't statistically significant. Single-born lambs had a birth weight of 2.62 kg, which was similar to the 2.71 kg of twin-born lambs ($P = 0.7275$). However, the initial body weight of single-born lambs (13.01 kg) was significantly higher than that of their twin-born counterparts (9.01 kg) ($P = 0.0003$). By the end of the study, single-born lambs also outpaced twin-born lambs in final body weight, reaching 40.70 kg compared to 37.06 kg ($P = 0.0194$). Despite these differences in initial and final weights, there was no significant difference in average daily gain or total body gain between the two groups. Both single-born and twin-born lambs grew at nearly the same rate, with single-born lambs gaining 83.93 g per day and twin-born lambs 85.12 g per day ($P = 0.6954$). Similarly, total body gain remained comparable between the two groups (27.68 kg for single-born vs. 28.05 kg for twins, $P = 0.7147$).

Parity

When the analysis shifted to parity (≤ 5 versus > 5), we saw no major differences in birth weight, initial weight, or final weight. The average birth weights for lambs from mothers with five or fewer parities (2.72 kg) and those from mothers with more than five parities (2.61 kg) were nearly identical ($P = 0.6839$). Initial body weight also showed no statistical difference between the two groups ($P = 0.5444$). Despite slight variations, lambs from both parity groups ended with a similar final body weight, and no significant differences in growth rate or total body gain were observed.

Age of the Dam

The age of the dam did not seem to influence the growth of the lambs in any significant way. Whether the lambs were born to younger dams (aged ≤ 5 years) or older dams (> 5 years), birth weight, initial body weight, final body weight, and daily growth rate were all comparable. Lambs born to younger dams had a birth weight of 2.65 kg, which was almost identical to the 2.68 kg of lambs born to older dams ($P = 0.9145$). Final body weight, daily gain, and total body gain were all consistent across the two age groups, showing no meaningful differences.

Feeding System

One of the most noticeable findings came from the comparison between individual and group feeding systems. Lambs raised in an individual feeding system significantly outperformed those raised in group settings across several key metrics. While birth weight (2.66 kg vs. 2.67 kg, $P = 0.9403$) and initial body weight (10.92 kg vs. 11.10 kg, $P = 0.8240$) did not differ significantly between the feeding systems, the difference in final body weight was striking. Lambs on the individual feeding system reached an average final weight of 47.06 kg, whereas those on the group system weighed only 30.70 kg ($P < 0.0001$). This difference was reflected in their average daily gain as well, with lambs on the individual system gaining 109.62 g/day compared to 59.42 g/day for lambs on the group system ($P < 0.0001$). Total body gain was also significantly higher for lambs on the individual system, with 36.14 kg compared to 19.59 kg for group-fed lambs ($P < 0.0001$). These results indicate that individual feeding provides a more efficient and effective environment for lamb growth. In summary, the lamb population studied had a consistent birth weight, averaging around 2.66 kg, with moderate variation. Initial body weight averaged 11.75 kg, and the final body weight of the lambs reached an average of 38.53 kg, with relatively low variability in the population. The study's high R-squared values for final body weight ($R^2 = 0.9212$), average daily gain ($R^2 = 0.9548$), and total body gain ($R^2 = 0.9545$) indicate that the

growth outcomes were strongly influenced by the factors analyzed.

Table (1). Means and standard error (SE) for body weights at birth, Initial body weight (kg), Final body weight (kg), Average daily gain (g), and Total body gain (kg) according to growth rate groups, Type of birth, parity, Age of the dam and Feeding system.

Items	Birth weight (kg)	Initial body weight (kg)	Final body weight (kg)	Average daily gain (g)	Total body gain (kg)
	LSM ± SE	LSM ± SE	LSM ± SE	LSM ± SE	LSM ± SE
Overall mean	2.660714	11.75000	38.52857	81.21652	26.77857
Growth rate groups					
Slow growing	2.59 ± 0.14	10.52 ± 0.57	35.77 ± 0.89^{b}	76.51 ± 1.84^{b}	25.24 ± 0.61^{b}
Fast growing	2.74 ± 0.13	11.51 ± 0.54	41.99 ± 0.83^{a}	92.53 ± 1.73^{a}	30.49 ± 0.57^{a}
P-value	0.4157	0.1999	<.0001	<.0001	<.0001
Type of birth					
Single	2.62 ± 0.12	13.01 ± 0.48^{a}	40.70 ± 0.75^{a}	83.93 ± 1.55^{a}	27.68 ± 0.52^{a}
Twin	2.71 ± 0.18	9.01 ± 0.73^{b}	37.06 ± 1.14^{b}	85.12 ± 2.36^{b}	28.05 ± 0.78^{b}
P-value	0.7275	0.0003	0.0194	0.6954	0.7147
parity					
≤ 5st	2.72 ± 0.17	10.66 ± 0.68	37.88 ± 1.06	82.81 ± 2.21^{b}	27.22 ± 0.73^{b}
> 5nd	2.61 ± 0.18	11.37 ± 0.73	39.88 ± 1.14	86.23 ± 2.36^{a}	28.51 ± 0.78^{a}
P-value	0.6839	0.5444	0.2780	0.3690	0.3100
Age of the dam					
≤ 5st	2.65 ± 0.20	11 ± 0.79	39.13 ± 1.23^{a}	85.1 ± 2.55^{a}	28.13 ± 0.85^{a}
> 5nd	2.68 ± 0.18	11.03 ± 0.73	38.63 ± 1.23^{b}	83.95 ± 2.33^{b}	27.6 ± 0.77^{b}
P-value	0.9145	0.9842	0.8002	0.7828	0.6997
Feeding system					
Individual	2.66 ± 0.16	10.92 ± 0.63	47.06 ± 0.99^{a}	109.62 ± 2.05^{a}	36.14 ± 0.68^{a}
Group	2.67 ± 0.13	11.10 ± 0.52	30.7 ± 0.81^{b}	59.42 ± 1.68^{b}	19.59 ± 0.56^{b}
P-value	0.9403	0.8240	<.0001	<.0001	<.0001
CV %	18.34360	16.69477	7.902919	7.783124	7.829911
R^2	0.051765	0.539285	0.921236	0.954766	0.954463

Letters with the different superscripts in the same row were considered statistically significant at P ≤ 0.05. Data are expressed as mean ± standard error. R2 determination coefficient and C.V. coefficient of variation.

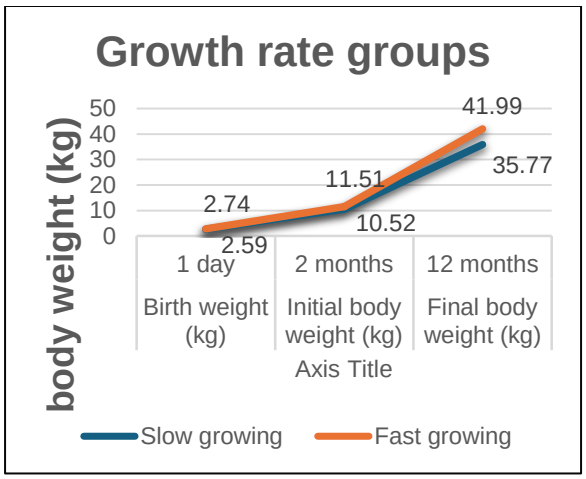

Fig 2: Effect of Growth Rate Groups on Growth Performance for Sohagi Lambs

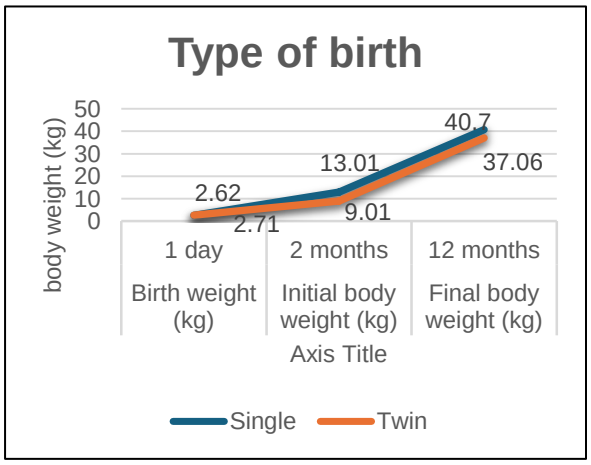

Fig 3: Effect of Type of Birth on Growth Performance for Sohagi Lambs

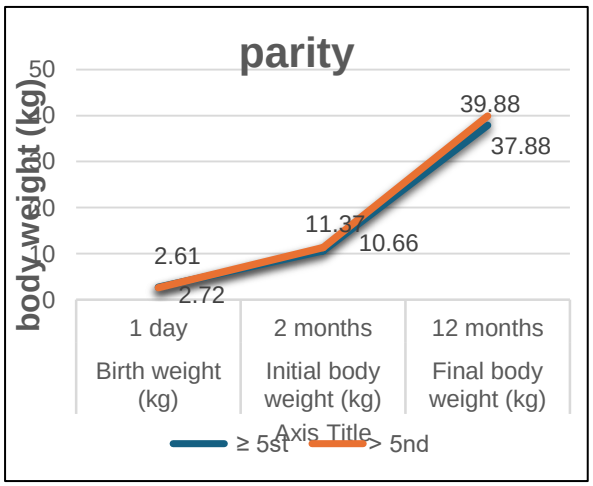

Fig 4: Effect of parity on Growth Performance for Sohagi Lambs

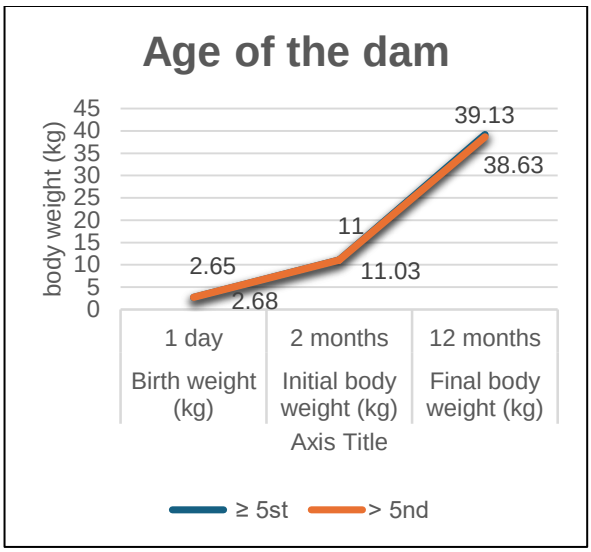

Fig 5: Effect of Age of the Dam on Growth Performance for Sohagi Lambs"

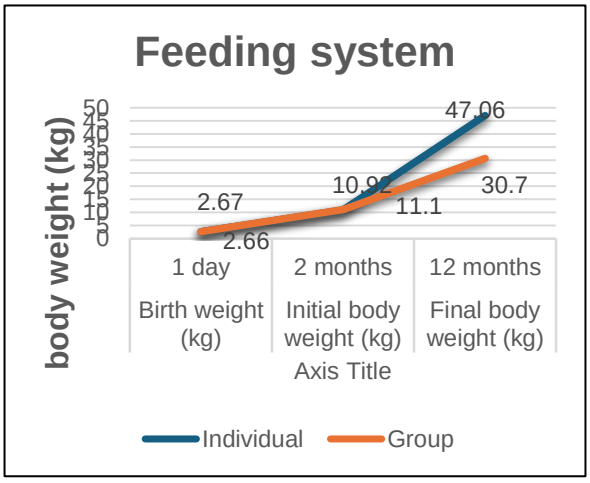

Fig 6: Effect of feeding management system on growth performance for Sohagi lamb.

DISCUSSION

Growth Rate Groups

Growth traits such as birth weight, initial body weight, final body weight, average daily gain (ADG), and total body gain are crucial economic parameters influencing sheep productivity, particularly in regions like Egypt, where there is an increasing demand for mutton (Sallam et al., 2012). Optimizing meat production in local breeds like Sohagi sheep necessitates selecting animals that demonstrate rapid growth and substantial body weights at slaughter (Parker et al., 1991; Richards and

Atkins, 2004; Wang et al., 2015; Zhang et al., 2013a, b). In this study, the lack of significant differences in birth weight between the slow-growing and fast-growing groups of Sohagi lambs (2.59 kg vs. 2.74 kg; P = 0.4157) indicates that birth weight alone may not be a decisive factor in determining growth potential in this population. This outcome aligns with findings by Moghaddam et al. (2021), who suggested that while genetic and environmental factors shape birth weight, they do not strongly influence early growth rates. The results here reinforce the idea that other factors, such as postnatal management, nutrition, and environmental conditions, likely play a larger role in determining growth trajectories beyond the initial weight at birth. However, significant differences were observed in final body weight, ADG, and total body gain between the groups, with fast-growing lambs showing a significantly higher final body weight (41.99 kg) compared to the slow-growing group (35.77 kg; P < 0.0001). Additionally, ADG was greater in the fast-growing group (92.53 g/day vs. 76.51 g/day), emphasizing the importance of growth rate for production performance. These findings are consistent with the conclusions of Richards and Atkins (2004) and Buzanskas et al. (2014), who also noted the critical role of optimizing growth rates in enhancing livestock productivity. The significant differences here indicate that production systems may be increasing growth rates.

Type of Birth

The analysis of birth type further highlights its influence on growth outcomes, with single-born lambs exhibiting significantly higher initial body weights (13.01 kg) compared to twins (9.01 kg; P = 0.0003). This finding supports the notion that single-born lambs benefit from enhanced access to maternal resources, potentially improving their early growth performance, as suggested by Moghaddam et al. (2021) and El-Wakil and Elsayed (2013). Despite this, no significant differences in birth weight were observed between the fast- and slow-growing groups (P = 0.7275), indicating that while birth type plays a role, it is not the sole factor influencing growth. Other variables, such as nutrition and management practices, likely have a more substantial impact on early and overall growth.

Parity

While parity number did not significantly affect lamb performance, lambs born to dams with more than five parities demonstrated a slightly higher ADG (86.23 g/day) compared to those from dams with fewer parities (82.81 g/day), although this difference was not statistically significant (P = 0.3690). These results are in agreement with earlier research by Richards et al. (2001) and El-Wakil and Elsayed (2013), which suggested that increased maternal experience may provide some advantage to lamb performance, though the effect appears to be modest. This modest effect could be attributed to other environmental or management factors that might diminish the potential benefits of increased maternal experience in more complex production systems.

Age of the Dam

In terms of number of parities, Sohagi lambs from dams with more than five parities demonstrated a slightly higher average daily gain (86.23 g) compared to those from dams with fewer parities (82.81 g), although these differences were not statistically significant (P = 0.3690). This result is consistent with earlier research that suggests increased maternal experience may enhance lamb performance (Richards et al., 2001; El-Wakil and Elsayed, 2013).

Feeding System

Feeding systems had a notable impact on growth outcomes in Sohagi lambs. Lambs fed individually exhibited superior performance, achieving a final body weight of 47.06 kg and an average daily gain (ADG) of 109.62 g. In contrast, lambs in group feeding had a final body weight of 30.70 kg and an ADG of 59.42 g (P < 0.0001). This supports the hypothesis that individualized nutrition enhances growth rates, a finding echoed by previous studies (Richards and Atkins, 2004; Buzanskas et al., 2014). However, Khalifa et al. (2013) reported no significant differences in growth performance due to feeding systems, highlighting the role of

varying environmental conditions in influencing such outcomes.

Economic efficieny

Economically, the difference in final body weight between individual and group feeding systems was 16.36 kg, translating to an additional income of 3272 EGP based on a live weight price of 200 EGP/kg. Considering that the cost of an individual feeding box, amortized over an economic lifespan of 20 years, is 1500 EGP (equivalent to 75 EGP/year), the additional profit from the weight gain significantly outweighs the annual cost. Therefore, individual feeding systems not only improve growth efficiency but also offer a clear economic advantage, proving to be more efficient and profitable than group feeding systems

Variability and Model Fit

Statistical measures such as the coefficient of variation (CV) and R-squared (R^2) values offered insights into variability and model fit for growth traits. The R^2 value for final body weight was 0.9212, indicating a strong correlation between growth factors and outcomes, consistent with Zhang et al. (2013b), who stressed the importance of body weight in evaluating sheep performance.

CONCLUSION

This study revealed that the growth performance in Sohagi lambs is highly influenced by specific factors, notably the growth rate, feeding system, and birth type. Fast-growing lambs achieved, particularly under individual feeding conditions, which not only demonstrated enhanced nutrient utilization and metabolic efficiency but also provided significant economic benefits. The additional weight gain observed under individual feeding was translated to high income, effectively offsetting the cost of the feeding system and underscoring its profitability. Single-born lambs also demonstrated higher growth metrics, likely due to improved access to maternal resources compared to twin-born lambs. Conversely, factors under controlled feeding environments. These results emphasized the critical role of optimized feeding systems and strategic breeding in enhancing the productivity and profitability of the Sohagi breed. Tailored management practices focusing on individualized feeding and selective breeding could significantly improve the economic returns of sheep farming in Upper Egypt. Further studies involving are necessary to confirm and expand the this study.

REFERENCES

Alemneh, T.; Getabalew, M. 2019. Factors Influencing the Growth and Development of Meat Animals. International Journal of Animal Science, 3, 1-5.

Bela, B., Haile, A. (2009). Factors affecting growth performance of sheep under village management conditions in the southwestern part of Ethiopia. Livest. Res. Rural Dev.21(11); 128 – 185.

Buzanskas, M. E., Grossi, D. A., Ventura, R. V., Schenkel, F. S., Sargolzaei, M., Meirelles, S. L., ... & Munari, D. P. (2014). Genome-wide association for growth traits in Canchim beef cattle. PloS one, 9(4), e94802.

Duncan, D.B. (1955). Multiple Range and Multiple F-test Biometrics, 11: 1- 42.

Elnahas, A., A.M. Manal Elsayed and M. Elshennawy, (2017) . Prediction of live body weight from body measurements using stepwise regression analysis in Sohagi sheep. J. Anim. Poult. Prod., Mansoura Univ. 8, 415 – 418

Elsayed, M. (2013). Genetic, phenotypic and environmental trends towards improving body weight in Barki sheep. *Egyptian Journal of Sheep and Goats Sciences*, *8*(2), 1-10.

Fao, F. A. O. S. T. A. T. (2018). Food and agriculture organization of the United Nations. *Rome, URL: http://faostat. fao. org*, 403-403.

Ghafouri-Kesbi, F., & Eskandarinasab, M. P. (2008). An evaluation of maternal influences on growth traits: the Zandi sheep breed of Iran as an example. *Journal of Animal and Feed Sciences*, *17*(2008), 519-529.

Khalifa, E. I., Ahmed, M. E., Hafez, Y. H., El-Zolaky, O. A., Bahera, K. M., & Abido, A. A. (2013). AgeThe age atof puberty and fertility

of Rahmani sheep fed on biological inoculated corn silage. *Annals of Agricultural Sciences*, *58*(2), 163-172.

Moghaddam, V. K., Elahi, M. Y., Nasri, M. H. F., Elghandour, M. M., Monroy, J. C., Salem, A. Z., ... & Mlambo, V. (2021). Growth performance and carcass characteristics of finishing male lambs fed barberry pomace-containing diets. *Animal Biotechnology*, *32*(2), 178-184.

Parker, W. J., McCutcheon, S. N., & Awickham, G. (1991). Effect of administration and ruminal presence of chromic oxide-controlled release capsules on herbage intake of sheep. *New Zealand journal of agricultural research*, *34*(2), 193-200.

Richards, J. S., & Atkins, K. D. (2004). Simultaneous assortment of animals for meat and wool production in Merino flocks. *Wool Technology and Sheep Breeding*, *52*(3).

Sallam, A., Galal, S., Rashed, M. A., & Alsheikh, S. M. (2012). Genetic diversity in Barki sheep breed in its native tract in Egypt. *Egyptian Journal of Animal Production*, *49*(1), 19-28.

SAS Institute Inc., (2004). SAS procedures Guide for personal Computers, Statistical Analysis System Institute, Inc., Cary, N.C.

Wang, H., Zhang, L., Cao, J., Wu, M., Ma, X., Liu, Z., ... & Du, L. (2015). Genome-wide specific selection in three domestic sheep breeds. *PloS one*, *10*(6), e0128688.

Yilmaz, O. S. M. A. N., Denk, H., & Bayram, D. A. V. U. T. (2007). Effects of lambing season, sex and birth type on growth performance in Norduz lambs. *Small Ruminant Research*, *68*(3), 336-339.

Zhang, C.; Wang, G.; Wang, J.; Ji, Z.; Liu, Z.; Pi, X.; Chen, C. 2013a. Characterization and comparative analyses of muscle transcrip tomes in Dorper and small-tailed Han sheep using RNA-Seq tech nique. PLoS One, 8, e72686.

Zhang, L.; Liu, J.; Zhao, F.; Ren, H.; Xu, L.; Lu, J.; Zhang, S.; Zhang, X.;,X.; Wei, C.; Lu, G.; Zheng, Y.; Du, L. 2013b. Genome-wide association studies for growth and meat production traits in sheep. PLoS One, 8, e66569