

ENVIRONMENTAL BY GENOTYPE INTERACTIONS AND THEIR EFFECTS ON GROWTH RATE OF AWASSI SHEEP REARED IN SEMI-ARID REGION

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ABSTRACT

Due to its reputation for receiving little rainfall, Jordan's Al-Mafraq region (where the sheep is reared) is susceptible to droughts and water shortages and poor range. Estimating genetic and environmental factors for growth traits in purebred Awassi sheep in Al Mafraq (semi-arid region) was the goal of the study. The study's data came from 3481 lambs born at the National Centre for Agricultural Research's (NARC) Al-Khanasri livestock and rangeland research station in Jordan over a 15-year period (2009–2023). Birth weights (BWT), weaning weights (WWT), and average daily gain from birth to weaning (ADG) were the traits under study. While genetic parameters were estimated assuming the mixed model using the Restricted Maximum Likelihood (REML) method process using the ASReml program, the environmental effects were estimated using the SAS program's General Linear Model (GLM) technique. BWT, WWT, and ADG were significantly impacted by the year of birth, dam weight at lambing, parity, lamb sex, and method of birth; however, the examined growth traits were not significantly impacted by the dam's age ($P > 0.05$). BWT, WWT, and ADG had heritability estimates of 0.38 ± 0.05 , 0.21 ± 0.05 , and 0.16 ± 0.05 , respectively, and corresponding repeatabilities of 0.41 ± 0.05 , 0.39 ± 0.06 , and 0.32 ± 0.05 . Environmental correlations ranged from negative (-0.20) between BWT and ADG to high (0.98) between WWT and ADG, while phenotypic correlations ranged from negative (-0.011) between BWT and ADG to high (0.98) between WWT and ADG. The estimated genetic correlations among the traits under study were high and strongly positive, ranging from 0.54 between BWT and ADG to 0.99 between WWT and ADG. To sum up, the findings ought to be used to a genetic selection program that aims to enhance Awassi sheep's growth performance.

Key words: heritability, quantitative genetics, repeatability, sheep



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INTRODUCTION

Sheep farming is a major part of Jordan livestock sector and plays a significant role in agrarian economy and industrial, due to its part in providing important products such as meat, milk, and their derivatives and leather, in addition to wool (Jawasreh et al., 2023 and Talafha and Ababneh, 2011). The Awassi sheep is one of the major indigenous sheep breeds of Jordan, and their number is estimated at 3 million heads (FAO, 2018). The breed is raised primarily for lamb and mutton, and with milk and wool being of

secondary importance. They are distinguished well adapted to the under difficult environmental conditions, showing a strong adaptability to both limited food resources and elevated temperatures and as well as its resistance to diseases (Saeed et al., 2023). Growth traits such as weight at birth, weaning weight, weight at six months, and daily pre- and post-weaning gains are one of the most important economic traits determining economic viability in all sheep production systems (Liu et al., 2024). For this reason, the first valuable step for selecting the animals for

improving growth traits is gaining knowledge in the estimates of non-genetic and genetic parameters, that intern will be used as a guide for designing the breeding strategies for better production. Growth traits are quantitative traits governed by many genetic and non-genetic factors such as farm-year, dam's age and lamb's sex, as well as their interaction (Al-Amareen and. Jawasreh, 2022). Several studies have shown that many non-genetic and genetic factors are known to affect significantly growth traits of lambs (Baba et al., 2020 and Dalaf, 2024). Furthermore, some studies have reported that genetic parameters, including heritability estimates and genetic correlations among growth traits, can significantly influence selection decisions and breeding programs (Besufkad et al., 2024 and BenSouf et al., 2025). Therefore, the objective of this study was to assess the genetic and non-genetic factors affecting birth and weaning weight and Average daily gain on growth rate of purebred Awassi sheep in Jordan.

MATERIALS AND METHODS

Location: This study was conducted on a flock of purebred Awassi sheep maintained at Al-Khanasri livestock and rangeland research station that belongs to the National Center for Agricultural Research (NARC), Jordan located at 32°24'30.2"N 36°03'22.3"E.

Data : In this study, biological and pedigree information on Awassi sheep were collected from Al-Khanasri research station, over a period of 15 years (2009- 2023). They included 3,481 lamb's records born from 123 sires and 1113 dams for birth weight and 2,706 lamb's records born from 116 sires and 971 dams for weaning weight and the same were for the pre-weaning daily gain. Recorded information consisted of pedigree information (Lamb ID, sire, and dam), date of birth, birth type, birth weight, sex, dam age, number of parities, dam's body weight at lambing and year of lambing. Because the lambs varied in age at every weighing day, their weaning weights were corrected to 60 days of age. The growth traits used for the analysis were birth weight (BWT), weaning weight adjusted to 60 days of age (WWT) and average daily gain in grams from birth to weaning (ADG) .

Management: The mating season of Awassi ewes is started from April and lasts through September. In the station, a mating strategy was applied through groups mating to avoid inbreeding and for identifying the sire of each new lamb; ewes were mated according to a group structure of 20–25 ewes to one male ratio. Ewes are either inseminated naturally or artificial inseminated with freshly collected semen from identified rams. All animals were raised under a semi-intensive management system, where they were allowed to graze for 4 h at morning and 3 h afternoon per day except during harsh weather conditions, where animals were kept stayed inside enclosures and hand-fed. Grazing consisted of natural herbage and green fodder. During availability of abundant grasses in the pasture, each animal was fed with 300 g/day of concentrate mixture. Additionally, when rang feed was scarce grazing resources during dry seasons, ewes were provided amount of concentrate mixture. The nutrition plan during the last two months of gestation was as follows, each ewe fed 1.2 kg/day concentrate and 0.5 kg/day alfalfa hay until lambing. The concentrate diet (composed of 67.5% barley, 12% soybean, 18% wheat bran, 1.4% limestone, 1% salt and 0.1% trace minerals) was increased up to 1.5 kg/ewe/day after lambing, while providing blocks of mineral, salts and water continuously. After lambing, the newborn lambs were identified by ear-tagged at birth or within 24 h of lambing and date of birth, weight at birth, and pedigree information (sire number and dam number), type of birth, sex, year of lambing, post-partum dam weight were also recorded. Lambs were allowed to suckle dams until weaning. Creep feeding starts at 15 days of age, continues until weaning on a concentrate mixture (it was composed of 55% crumbed barley, 18% soybean meal, 12% corn, 12% wheat bran, 1.5% limestone 1% salt, and 0.5% trace minerals and vitamins). Weaning strategy in the station is based on the lamb weight and age. Lambs were weaned at an average body weight of 14 kg. The measurement of the body weight was started after 15 days of birth up to weaning till weaning at the targeted weight. Health

procedures were done at station by vaccination schedule and treatments against parasites.

Statistical analyses: The obtained data were statistically analyzed using General Linear Model (GLM) method within the ready-available statistical program SAS/STAT® (version 9.1, SAS Institute Inc., Cary, NC, USA) to study the effect of sex of lamb, type of birth, parity, age of dam, year of lambing and dam weight at lambing on the traits of BWT, WWT and ADG according to the following equation:

$$Y_{ijklm} = \mu + S_i + T_j + P_k + A_l + Y_m + DW_n + e_{ijklm}$$

Where: Y_{ijklm} = the studied growth traits (BWT, WWT and ADG);

μ = overall mean for the trait;

S_i = fixed effect of the i th sex of lambing ($i = 1$ and 2 , of the males and females, respectively);

T_j = fixed effect of the j th type of birth ($j = 1$ and 2 , of the single and twin, respectively);

P_k = fixed effect of the k th parity of dam ($k = 1, 2, 3, 4, 5$ and $6 \geq$);

A_l = fixed effect of the l th age of dam ($A = 1, 2, 3, 4, 5, 6$ and $7 \geq$);

Y_m = fixed effect of the m th year of lambing ($m = 2009$ to 2023);

DW_n = fixed effect of the n th dam weight at lambing ($n = \leq 50, 51-65$ and $66 \geq$ Kg);

e_{ijklm} = random errors with the assumption of $N(0, \sigma^2)$.

The variance components used for the estimation of genetic parameters of each trait were obtained by variance components Procedure of ASReml 4.2 (Gilmour et al., 2021) program using Restricted Maximum Likelihood (REML) method that included fixed and random effects. The formulas used for estimating the heritability (h^2) and repeatability (R) are: $h^2 = \frac{\sigma^2_a}{\sigma^2_a + \sigma e}$

$$R = \frac{\sigma^2_a + \sigma^2_{pe}}{\sigma^2_a + \sigma^2_{pe} + \sigma e}$$

Where: σ^2_a : is the additive genetic variance

σ^2_e : is the environmental variance

σ^2_{pe} : is the permanent environmental effect variance.

RESULTS AND DISCUSSION

Data description of growth traits: Table 1 sets out the descriptive statistics for growth traits of Awassi lambs, including number of records, means, standard errors (SE) and coefficient of variation. The mean \pm SE of BWT, WWT, and ADG were 4.64 ± 0.02 , 17.74 ± 0.07 , and 0.216 ± 0.001 kg, respectively.

Table 1. Statistical description of data size used for the analysis of Awassi sheep

Traits	No.	Mean \pm SE	CV%
BWT (Kg)	3481	4.64 \pm 0.02	20
WWT (Kg)	2706	17.74 \pm 0.07	21
ADG (g/day)	2706	0.216 \pm 0.001	26

BWT: birth weight; WWT: weaning weight; ADG: Average daily gain

Effect of non-genetic factors on growth

traits: Table 2 show the least squares means \pm SE and test of significance for non-genetic factors affecting the growth traits in Awassi lambs. Sex of lambs had a highly significant affect ($P \leq 0.0001$) on growth traits being males having higher values or weights in all growth traits compared to females (Table 2), these findings were in agreement with those obtained by (Ali, 2021 and Haddad et al., 2025) who investigated Awassi lambs. The heavier body weights of males than females might be due to differences in action of sex hormones, which play a major role on body muscle building and fat makeup in the male (Raof and Khidhir, 2023 and Balasundaram et al., 2023). Furthermore, the results also indicated a highly significant effect ($P \leq 0.0001$) of type of birth on all growth traits, single born lambs were heavier in all growth traits than twin born lambs, they were 4.90 ± 0.02 and 3.83 ± 0.03 , 18.4 ± 0.10 and 15.0 ± 0.14 , 0.224 ± 0.002 and 0.186 ± 0.002 Kg, for single and twin, BWT, WWT, and ADG, respectively. The same conclusion was also claimed by (Jawasreh et al., 2018 and Al-Najjar et al., 2021) who investigated Awassi lambs. The superiority of single lambs over their counterparts twin lambs in body weight might be attributed to the minor competition for consuming milk among the single than twin-born lambs and less space availability occupied by a twin lamb of the dam's womb compared to the large space occupied by single lambs (Baba et al., 2020 and Sharif et al., 2022). Table 2 shows that the parity had a significant ($p < 0.01$) effect on all growth traits studied. As observed in the current study, the significant effects of parity of dam on body weight of lambs were reported by (Haile et al., 2027) in Awassi sheep and (Rather et al., 2020) in Kashmir Merino sheep. The lower body weight of lambs obtained from dams of 1st parity in this study might be attributed to reason that dams in 1st parity have less body

weight and small uterine space than dams in advanced parities (Besufkad et al., 2024). The competition for nutrients between the still growing dams and developing fetus during pregnancy period of dams has negative feedback on prenatal lamb growth (Rather et al., 2020). The year of birth had a highly significant ($p < 0.0001$) effect on BWT, WWT and ADG1. The same effect of year of birth were reported by (Al-Najjar et al., 2021 and Haile et al., 2017), in Awassi sheep. The significant effect of year of birth on growth and weight of lambs can be ascribed to the differences in environmental and management factors such as climate, morbidity and availability of feed (Nimase and Kandalkar, 2023). The age of dams had no significant effect on all body weights of lambs of Awassi sheep (Table 2), which is in line with the results published by (Alwan and Aljubouri,

2023). Ali, (2021) also reported no significant effect of age of dam on WWT and ADG in Awassi lambs. In contrast to these results, several other studies on Awassi ewes aged 2-5 years (Dalaf, 2024 and Haddad et al., 2025) found difference in lamb body weight. Moreover, the dam's weight at lambing had a highly significant ($P < 0.0001$) effect on all growth traits and it was observed that higher body weights of lambs were observed for heavier dam's at lambing. Similar results for dam's weight at lambing in different sheep breed have been reported by many researchers in the literature (Balasundaram et al., 2023 and Nimase and Kandalkar, 2023). However, the reason for these differences could be attributed to mothering ability, milk yield, nutrition and more uterine space provided by them for developing fetus (Nimase and Kandalkar, 2023).

Table 2. Least square means \pm standard error of factors affecting growth traits in Awassi lambs

	No.	BWT	No.	WWT	ADG
Sex		***		***	***
M	1707	4.50 \pm 0.02 ^a	1355	17.3 \pm 0.11 ^a	0.212 \pm 0.002 ^a
F	1774	4.25 \pm 0.02 ^b	1351	16.1 \pm 0.11 ^b	0.197 \pm 0.002 ^b
Type of Birth		***		***	***
1	2585	4.90 \pm 0.02 ^a	2107	18.4 \pm 0.10 ^a	0.224 \pm 0.001 ^a
2	896	3.83 \pm 0.03 ^b	599	15.0 \pm 0.14 ^b	0.186 \pm 0.002 ^b
Parity		**		**	**
1	700	4.12 \pm 0.06 ^d	499	15.9 \pm 0.31 ^d	0.193 \pm 0.005 ^d
2	621	4.28 \pm 0.05 ^c	501	16.8 \pm 0.22 ^a	0.208 \pm 0.004 ^a
3	666	4.37 \pm 0.04 ^b	526	16.8 \pm 0.21 ^a	0.206 \pm 0.003 ^a
4	570	4.44 \pm 0.05 ^{ab}	447	17.0 \pm 0.23 ^a	0.209 \pm 0.004 ^a
5	385	4.51 \pm 0.06 ^a	322	16.6 \pm 0.30 ^a	0.201 \pm 0.005 ^a
6	539	4.47 \pm 0.07 ^{ab}	411	17.1 \pm 0.33 ^a	0.210 \pm 0.005 ^a
Age of Dam		NS		NS	NS
2	559	4.34 \pm 0.07	405	17.4 \pm 0.36	0.219 \pm 0.006
3	571	4.45 \pm 0.05	453	16.8 \pm 0.26	0.205 \pm 0.004
4	672	4.40 \pm 0.05	523	16.8 \pm 0.23	0.205 \pm 0.004
5	575	4.37 \pm 0.05	448	16.5 \pm 0.22	0.201 \pm 0.004
6	408	4.41 \pm 0.05	342	16.5 \pm 0.26	0.201 \pm 0.004
7	696	4.24 \pm 0.06	535	16.2 \pm 0.28	0.197 \pm 0.004
Years		***		***	***
2009	181	4.31 \pm 0.06 ^d	112	14.4 \pm 0.31 ^f	0.166 \pm 0.005 ^c
2010	122	4.03 \pm 0.07 ^e	100	16.7 \pm 0.32 ^{cd}	0.212 \pm 0.005 ^c
2011	140	4.08 \pm 0.07 ^e	107	17.2 \pm 0.31 ^c	0.218 \pm 0.005 ^{bc}
2012	182	4.30 \pm 0.06 ^d	149	18.0 \pm 0.27 ^b	0.226 \pm 0.004 ^b
2013	168	4.38 \pm 0.06 ^{cd}	104	17.1 \pm 0.31 ^c	0.207 \pm 0.005 ^{cd}
2014	116	4.40 \pm 0.07 ^{cd}	97	17.0 \pm 0.33 ^{cd}	0.209 \pm 0.005 ^c
2015	114	4.47 \pm 0.07 ^c	104	16.5 \pm 0.32 ^{de}	0.198 \pm 0.005 ^d
2016	163	4.61 \pm 0.06 ^b	91	19.5 \pm 0.34 ^a	0.249 \pm 0.005 ^a
2017	247	4.40 \pm 0.05 ^{cd}	191	14.2 \pm 0.23 ^f	0.165 \pm 0.004 ^c
2018	225	4.45 \pm 0.05 ^c	188	16.0 \pm 0.29 ^e	0.191 \pm 0.004 ^d
2019	268	4.90 \pm 0.05 ^a	240	17.3 \pm 0.21 ^c	0.206 \pm 0.003 ^{cd}
2020	274	4.43 \pm 0.05 ^c	247	17.2 \pm 0.21 ^c	0.212 \pm 0.003 ^c
2021	425	4.11 \pm 0.04 ^e	315	16.5 \pm 0.21 ^d	0.206 \pm 0.004 ^{cd}
2022	435	4.40 \pm 0.04 ^{cd}	303	16.0 \pm 0.21 ^e	0.199 \pm 0.003 ^d
2023	421	4.22 \pm 0.04 ^d	358	17.0 \pm 0.18 ^c	0.212 \pm 0.003 ^c
Dam weight at lambing		***		***	***
< 50	667	4.12 \pm 0.03 ^c	465	15.4 \pm 0.17 ^c	0.186 \pm 0.003 ^c
51-65	1933	4.44 \pm 0.02 ^b	1529	17.0 \pm 0.11 ^b	0.208 \pm 0.002 ^b
> 66	831	4.54 \pm 0.03 ^a	712	17.7 \pm 0.13 ^a	0.220 \pm 0.002 ^a

BWT: Birth weight; WWT: Weaning weight; ADG: Average daily gain. NS: Non-significant ($p > 0.05$); **, *** Significant at $P \leq 0.01$ and $P \leq 0.001$. Within column, within each fixed effect, least square means with different superscripts (a – f) are different at $P \leq 0.05$

Genetic parameters Estimate

Heritability Estimates: The estimates of heritability \pm SE for growth traits recorded at BWT, WWT and ADG are showed in Table 3. The heritability (h^2) estimates for BWT was high (0.38) while WWT was moderately heritable (0.21), and ADG was lowly heritable (0.16). The estimated heritability of BWT in the current study were similar to the estimates reported by (Jawasreh et al., 2018) in Awassi sheep (0.30), and (Ehsaninia, 2021) Sangsari sheep (0.30). Contrary to the result found here, lower heritability estimate for body weight at birth was reported by (Raof and Khidhir, 2023) for Kurdi sheep (0.17), (Haile et al., 2019) for Awassi sheep (0.03), (Ren et al., 2024) for Luzhong sheep (0.15), (Sharif et al., 2022) for Lohi Sheep (0.15) and (Ali et al., 2020) for Kajli sheep (0.05). However, moderate heritability for WWT was in agreement with the findings of many researchers: (Raof and Khidhir, 2023) in Kurdi sheep (0.27) and (Balasundaram et al., 2023) in Mecheri Sheep (0.20). In contrast, some studies reported higher weaning weight heritability estimates in different sheep breeds, such as Lohi Sheep (0.45) (Sharif et al., 2022), and Luzhong sheep (0.54) (Ren et al., 2024). Other authors have also reported lower estimate of heritability for weaning weight compared to those estimated in the present study (Ali et al., 2020; Boujenane and Diallo, 2017; Raof, 2021). Lower heritability estimates for ADG traits in Awassi sheep are consistent with the findings in the Kurdi sheep (0.13) (Raof and Khidhir, 2023), dorper sheep (0.11) (Besufkad et al., 2024), Awassi sheep (0.09) (Haile et al., 2019) and Sangsari sheep (0.15) (Ehsaninia, 2021). Opposing to the present finding, the higher estimated heritability for ADG was reported by (Ren et al., 2024), in Luzhong mutton sheep (0.53) and Harnali sheep (0.40) (Malik et al., 2026). However, These variations between the results of the current study and those of previous studies could be attributed to differences in sheep breed genetic structure, management systems, environment conditions, the number of records used for analysis, data structure used for analysis and the model used for analysis, which it important determinants in

the estimates genetic parameter effects on body weights (Ali et al., 2020; Ren et al., 2024; Tesema et al., 2023; Boujenane and Diallo, 2017).

Repeatability estimates

The estimates of repeatability \pm SE for growth traits recorded at BWT, WWT and ADG are shown in Table 3. The repeatability estimates for BWT was high at 0.41 ± 0.05 whereas the estimates for WWT and ADG are moderate at 0.39 ± 0.06 and 0.32 ± 0.05 respectively. This is in accordance with Mudawamah et al. (Mudawamah, et, al, 2022) that the repeatability value standard is between 0% to 1% which can be grouped into three categories, namely low (0.00-0.20); medium (0.20-0.40) and high if the value is more than 0.40. In this study, the repeatability estimate for BWT was higher compared with most literature estimates. In their review, Juma and Alkass (2006) indicated a range of 0.13–0.37 for BWT in Awassi sheep. Other studies reported also lower values of 0.15 for BWT (Vergara et al., 2018) in Colombian Hair sheep. However, higher repeatability for BWT was obtained by (Juma and Alkass, 2006) in adult body weight of Awassi ewes (0.43). The estimates of repeatability of WWT in this study were higher than those reported by (Juma and Alkass, 2006), in Awassi sheep (0.08-0.29) and (Vergara et al., 2018), in Colombian Hair sheep (0.16). Lower estimates of repeatability (0.16) were estimated for ADG for Awassi sheep (Juma and Alkass 2006) which are not consistent with the estimate obtained in this study. Other studies reported lower values of 0.13 for ADG (Vergara et al., 2018) in Colombian Hair sheep. However, repeatability estimates for ADG obtained in this study was in close agreement with those found by (Mudawamah et al., 2022) in Sapudi Sheep (0.37). The difference in repeatability values estimated in various literatures might be due to differences in breed sheep, methodology of genetic evaluation, management systems, environment factors, fixed effects fitted, the number of records used for analysis, data structure for analysis and the model used for analysis. Generally, repeatability estimates for the considered traits were higher than the heritability estimates

suggesting that traits are affected more by non-additive genetic effects and permanent maternal environmental effects. Therefore, repeatability measures the correlation among performance records in different lambings; thus, the selection accuracy should be medium in the first lambing.

Table 3. Heritability (h^2) and Repeatability (R) estimates for growth traits for Awassi lambs

Trait	$H^2 \pm S.E$	$R \pm S.E$
BWT	0.38±0.05	0.41±0.05
WWT	0.21±0.05	0.39±0.06
ADG	0.16±0.05	0.32±0.05

BWT: birth weight; WWT: weaning weight; ADG: Average daily gain

Correlation Estimates

The genetic, phenotypic and environmental correlations among BWT, WWT and ADG are presented in Table 4. In general, the estimated genetic correlations among all growth traits were high and strongly positive, ranging from (0.54) for BWT-ADG to (0.99) for WWT-ADG. As shown in Table 4, the strong, positive genetic correlation between BWT-ADG (0.63), and between BWT- WWT (0.54) and between WWT-ADG (0.99) obtained in our study are in agreement with the previously reported estimates in Awassi (Jawasreh et al., 2018), Sangsari (Ehsaninia, 2021) and Luzhong sheep (Ren et al., 2024). However, low genetic correlations were reported by Juma and Alkass, (2006) for the traits in their study in Awassi sheep. The high and strongly positive genetic correlation between any pair of traits implies pleiotropy effect, a condition in which two traits are under the control of same gene. Thus selection for any one of these traits would lead to positive changes in the other. The phenotypic correlation value of the study results is between -0.011-0.98, categorized as medium and negative to high and positive (Table 4). The estimated of phenotypic correlations between BWT-WWT in the current study were positive and medium, and similar to those reported by (Ren et al., 2024) in Luzhong sheep (0.32), (Besufkad et al., 2024) in Dorper sheep (0.28) and (Balasundaram, et, al, 2023) in Mecheri Sheep (0.34). However, high and strongly positive estimates reported by others (Jawasreh et al., 2018; Ali, 2021; Sharif et al., 2022) for

different sheep breed. The phenotypic correlations between BWT-ADG (-0.01) were weak negative and similar to that reported in Awassi (Juma and Alkass, 2006), and in Sardi (Boujenane and Diallo, 2017) sheep, being -0.05, -0.42, and -0.01, respectively. Estimates of phenotypic correlations for BW-WWT in the present study were not in agreement with estimates of (Jawasreh et al., 2018) in Awassi sheep (0.48). A high and strongly positive phenotypic correlation estimate was obtained for WWT-ADG (0.97) which was in agreement with those obtained by (Ali, 2021) in Awassi sheep (0.99), (Ren et al., 2024) Luzhong sheep (0.91) and (Tesema et al., 2023) in Dorper X indigenous sheep (0.98). The phenotypic correlation between traits may be attributed to share common environmental effects (Jawasreh et al., 2018; Ren et al., 2024). The estimated of environmental correlations among growth traits were positive and low to high, ranging from (-0.20) for BWT-ADG to (0.98) for WWT-ADG. (Ehsaninia, 2021) found that the estimates of environmental correlations among growth traits were positive and medium to high, ranging from (0.16) for BWT-ADG to (0.98) for WWT-ADG, while (Rashidi et al., 2008) found that the environmental correlations among growth traits were weak low and high positive, ranging from (0.02) for BWT-ADG to (0.95) for WWT-ADG. However, lower values of environmental correlation were obtained by (El-Arian et al., 2008) in Romanov sheep. The environmental correlation between traits may be attributed to greater similarity of environmental and management factors (Ehsaninia, 2021 and 2023).

Table 4. Estimates of the genetic, phenotypic and environmental correlations between growth traits of Awassi lambs

Trait-1	Trait-2	G_r	P_r	E_r
BWT	WWT	0.625724	0.301205	0.174639
BWT	ADG	0.543975	-0.01071	-0.20407
WWT	ADG	0.99129	0.97576	0.97504

BWT: birth weight; WWT: weaning weight; ADG: Average daily gain; G_r : genetic correlation; P_r : phenotypic correlation; E_r : environmental correlation

CONCLUSION

The result of our study showed a considerable effect of non-genetic factors on the growth

traits of Awassi lamb therefore should be taken into consideration while evaluating the performance of the animals. The high and moderate estimates of heritability for BWT and WWT have indicated the possibility of including them in genetic improvement programs for Awassi lamb. On the other hand, the low heritability estimates for the ADG trait indicated that to point a stronger environmental impact. The moderate and high estimates of repeatability obtained in the current study for growth traits indicate that future performance for the animals can be predicted on the basis of their present performance. Furthermore, positive and high genetic correlations between growth traits indicate that selection for any of these traits could result in genetic progress for the other traits as a correlated response. In conclusion, the results should be used for applying of genetic selection program aiming at improving the growth performance of Awassi sheep.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

AUTHOR/S DECLARATION

We confirm that all Figures and Tables in the manuscript are original to us. Additionally, any Figures and images that do not belong to us have been incorporated with the required permissions for re-publication, which are included with the manuscript.

Author/s signature on Ethical Approval Statement.

Ethical Clearance and Animal welfare

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K.I. J, and A.H.A design the project data collection, analysis and paper writing all other

authors review the article and participate in its design and analysis

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تأثير التداخل الوراثي والبيئي في صفات النمو لدى الأغنام العواسي في المناطق شبة جافة

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المستخلص

أجريت هذه الدراسة في محطة الخناصري لبحوث الثروة الحيوانية والمراعي التابعة للمركز الوطني للبحوث الزراعية، الأردن للمدة 2009-2023 حيث تم استخدام 3481 سجلا لأوزان الحملان عند الولادة ووزنها عند الفطام ولمعدل الزيادة الوزنية اليومية من الولادة الى الفطام وذلك بهدف دراسة تقدير العوامل الوراثية والبيئية لصفات النمو في أغنام العواسي في المفرق (منطقة شبة قاحلة). تم تقدير المعالم الوراثية باستخدام طريقة الاحتمالية القصوى المقيدة (REML) باستخدام برنامج ASReml، كما تم تقدير العوامل البيئية باستخدام النموذج الخطي العام (GLM) باستخدام برنامج SAS. تبين من النتائج بأن لكل من سنة الميلاد ووزن الأم عند الولادة والجنس المولود ونوع الولادة وعدد البطنات تأثيرا معنويا في الصفات النمو المدروسة، ولم يكن لعمر الأم تأثيرا معنويا في أي من صفات النمو. بلغت تقديرات المكافئ الوراثي 0.16، 0.21، 0.38 و 0.16 لكل من الوزن عند الولادة، وزن عند الفطام ومعدل الزيادة اليومية من الولادة الى الفطام، كما بلغ المعامل التكراري 0.32، 0.39، 0.41 و 0.32 للصفات أعلاه وبنفس الترتيب السابق. بلغت تقديرات الارتباطات الوراثية بين الصفات المدروسة موجبة والعالية، حيث تراوحت 0.54 بين الوزن عند الولادة ومعدل الزيادة الوزنية اليومية و0.99 بين وزن عند الفطام ومعدل الزيادة الوزنية اليومية، في حين بلغت تقديرات الارتباطات المظهرية سالبة -0.011 بين وزن عند الولادة ومعدل الزيادة الوزنية اليومية، وعالية 0.98 بين وزن عند الفطام ومعدل الزيادة الوزنية اليومية. أما الارتباطات البيئية فكانت سالبة -0.20 بين وزن عند الولادة ومعدل الزيادة الوزنية اليومية، وعالية 0.98 بين وزن عند الفطام ومعدل الزيادة الوزنية اليومية. باختصار، ينبغي استخدام هذه النتائج في برنامج انتقاء وراثي يهدف إلى تحسين أداء نمو أغنام العواسي.

الكلمات المفتاحية: المكافئ الوراثي، الوراثة الكمية، المعامل التكراري، الأغنام