DOI : 10.5958/2277-8934.2024.00040.1 Vol 31 No 2, p 205-210

WEIGHT, GROWTH AND GENETICS IN SHAMI CAMELS (*Camelus dromedarius*)

Khaled A Al-Najjar[1], Moammar Dayoub[2], Azzam N. Al-Yacoub[3] and Widya P.B. Putra[4]

[1]General Commission for Scientific Agricultural Research, GCSAR, 12573, Damascus, SYRIA
[2]Turku University, Faculty of Technology, Computing Department, 20014, Turku, FINLAND
[3]Umm Al-Qura University, Faculty of Applied Science, Biology Department, 24382, Makkah, SAUDI ARABIA
[4]Research Centre for Applied Zoology-National Research and Innovation Agency Bogor-Jakarta Rd. Km. 46 Cibinong, Bogor, West Java, 16911, INDONESIA

ABSTRACT

This study examines Shami camel calf rearing in semi-arid regions of Syria, focusing on weight and growth (birth to 1 year), heritability and breeding values of birth weight for breeding purposes. Birth weight, weight at 12 months and growth rate from birth to 12 months differed depending on the birth year. However, weight at 6 and 9 months and growth from birth to these ages did not show significant variation. The differences in weight at 6 and 12 months and growth from birth to 6 and 12 months, were highly significant according to calf sex, while differences at birth, at 9 months and in growth from birth to 9 months were not significant. Shami camel weights were correlated across growth stages, especially between weight at 6 months and growth rate from birth to 6 and 9 months. Male Shami camel calves and calves born to multiparous she-camels had slightly higher birth weights. Sire affected birth weight, with significant variation among them. The high heritability (0.80) of birth weight in Shami camels was found. Male camels were ranked according to the estimated breeding value of their birth weight, with the top sire (ID 126) expected to produce heavier calves. This study found that birth weight and growth rates varied by birth year and sex, emphasising the importance of Shami camel male selection in breeding programmes aimed at improving weights as early growth strongly influences later weight gain.

Key words: Breeding values, growth rates, heritability, live weights, Shami camel

The distinctive single hump of the Shami camel is adapted for fat storage, complemented by features like long legs, flat feet, bushy eyebrows, thin nostrils, thick lips and efficient water retention mechanisms (Osterloff, 2024).

Research estimates the Shami camel's growth and predicted weights from birth to 4 years of age. Genetic studies have identified unique variations that enhance water conservation, metabolism and overall body weight, improving their survival in desert conditions (Ali *et al,* 2019; Joana *et al,* 2021).

Comprehensive knowledge of the species' weights, growth rates and genetic characteristics is essential for developing effective breeding programmes and conservation strategies. This supports genetic enhancement and custom breeding, securing Shami camels' sustainable future (Fraser, 2008; Balasundaram *et al,* 2023).

Genetic factors influencing growth patterns include traits like lean meat and lower fat content, with younger Shami camels producing superior meat quality (Al-Owaimer *et al,* 2014; Al-Saiady *et al,* 2015; Faraz *et al,* 2020; Suliman *et al,* 2020).

Research into camel breeding and management provides insights into optimal practices for preserving the Shami camel breed. Key considerations include improving reproduction, boosting productivity, developing fodder resources and training producers, supporting the sustainability of this valuable animal resource (Padalino *et al,* 2015; Sofiane *et al,* 2023).

Shami camel breeders' high-quality early care see faster growth and higher economic returns. Strong weight-growth rate links highlight the importance of breeding programmes for improved birth weights, herd productivity and market value. Utilising camels with high EBVs further maximises economic gains. Selective breeding and high-quality early care can significantly enhance breeder profitability. Therefore, this research was aimed to study the weights, growth rates and genetic aspects of the Shami camels.

SEND REPRINT REQUEST TO KHALED A AL-NAJJAR email: khnajj2011@yahoo.com

Materials and Methods

The herd

This research was conducted at the Deir Al-Hajar station, east of Damascus, Syria, for Shami camels adapted to semi-arid environments (Fig 1). The area receives annual rainfall between 100 to 125 mm, with coordinates at latitude: 33.5533 and longitude: 36.6339.

Camels were housed in concrete barns at night and during harsh weather for protection. They were vaccinated to prevent infectious diseases and spent 8-10 hours a day grazing on Atriplex Salty or Solsola rigid plants. Additionally, they received supplemental barley and bran (when available) and had free access to water. Breeding season occurs from November to March, with males allocated to females based on their reproductive efficiency. Both sexes can mate naturally when they reach 4-5 years old, depending on their weight. Calving happens from February to May and calves are weighed immediately after birth. Weaning occurs around 6 months of age, based on the calves' weight.

Data Analyses

The data set was covered a period from 2002 to 2007, which included 217 records of Shami camel weights that were analysed by SAS (2012).

The General Linear Model was used to analysis data weights and growth rates as following model,

$$Y_{ijk} = \mu + R_i + X_j + e_{ijk} \qquad (1)$$

Where, Y_{ijk}= Birth weight (BW), Weight at 6 months old (W6), Weight at 9 months old (W9), Weight at 12 months old (W12), Growth rate from BW until W6 (BW6), Growth rates from BW until W9 (BW6), Growth rates from BW until W12 (BW12) of ijkth observations. μ= overall mean. R_i= Birth year (1= 2002, 2= 2003 … and 6= 2007). X_J= Sex of calf (1= male and 2= female). e_{ijk}= Random error of ijkth observations with mean = 0 and variance= $I\sigma_e^2$.

Partial correlation coefficients were estimated from the SSCP errors matrix with their corresponding probability values denoted by (Prob.>|r|) according to equation (1).

$$Y_{ijk} = \mu + P_i + X_j + e_{ijk} \qquad (2)$$

Where, Y_{ijk}= Birth weight of ijkth observations. P_i= Parity (i = 1, 2… 6). The remaining symbols are shown in the previous models.

Heritability (h^2) value was computed by paternal half-sib (Method=TYPE1) with this model:

$$Y_{ij} = \mu + S_i + e_{ij} \qquad (3)$$

Where, Y_{ij}= Birth weight of ijth observations. S_i= Sire (i = 1, 2… 9). The prior models display the remaining symbols. e_{ij}= Effect of environmental and genetic deviation related to individual in a group of sire. Therefore, the h^2 value was computed in accordance to the Becker (1992).

$$h^2 = 4\,t,\ t = \frac{V_S}{V_s + V_w},\ k = \frac{1}{s-1}\left\{N - \frac{\sum N_I^2}{N}\right\},$$
$$SE\,(h^2) = 4\sqrt{\frac{2(1-t)^2(1+(k-1)t)^2}{k(k-1)(s-1)}} \qquad (3)$$

Where, h^2= heritability value, V_S= Variance component of sire, V_W= Variance component of an individual, t and k are the constant, $SE(h^2)$= Standard

Fig 1. Female and male camles at Deir Al-Hajar station, Damascus countryside (Syria).

error of heritability, N= Total number of progeny, N_i= Number of progeny per sire. S= Number of sires.

$$EBV = \frac{N_i h^2}{4 + (N_i - 1)h^2} \; (P_{prog.} - P_{pop.}) \qquad (4)$$

Estimated breeding values (EBV) were computed in accordance to the Hardjosubroto (1994).

Where, EBV= Estimated breeding value, N_i= Number of progeny per sire, h= Root of heritability value, $P_{prog.}$= Average trait of progeny, $P_{pop.}$= Average birth weight of the population. The previous models showed the remaining symbols.

Results

Table 1 displays notable disparities in birth weight (BW), weight at 12 months old (W12) and growth rates from birth to 12 months (BW12) across different birth years. Conversely, weight at 6 months old (W6), 9 months old (W9), growth rates from birth to 6 months (BW6) and growth rates from birth to 9 months (BW9) demonstrated no significant differences. When considering calf sex, (W6), (W12), (BW6) and (BW12) exhibited significant distinctions, while (BW), (W9) and (BW9) did not show significant variations.

Table 2 shows partial correlation coefficients for weights and growth rates to evaluate the relationships between response variables after controlling for the effects of other variables. It illustrates strong positive correlations between weights at different stages of development in Shami camels, particularly between early growth (6 months) and later weight gain (9 and 12 months).

Table 3 presents mean birth weights (BW) and standard errors for Shami camels based on sex, parity and sire ID. Key findings included that male calves had a slightly higher mean BW than females, while multiparous mothers had higher BWs than primiparous mothers did. Sire ID had a notable influence, with sire 126 producing the heaviest calves and sire 243 producing the lightest. These findings highlight the importance of considering maternal parity and sire genetics to improve birth weight of calves in Shami camels.

Table 4 shows a high heritability rate (0.8) for birth weight in Shami camels suggesting a genetic influence. Sire selection in breeding programmes can improve birth weight, potentially leading to better weight outcomes for offspring.

Table 5 shows the top six sire ranked by their estimated breeding values for birth weight. The first-ranked sire (ID 126) has an estimated breeding value of +2.07 kg, indicating that his offspring tend to be heavier than average. The second-ranked sire (ID 111) has an estimated breeding value of +1.79 kg and so on. The lower-ranked sires have negative estimated breeding values, indicating that their offspring tend to be lighter than average.

Table 1. Least square means ± Standard Errors and variance of analysis of weights and growth rates of Shami camels under Semi-intensive rearing (Equation 1).

Source of variance	BW	W6	W9	W12	BW6	BW9	BW12
μ	33.6±1.07	172.2±7.60	198.1±6.85	238.0±6.35	23.1±1.28	18.2±0.75	17.0±0.53
Birth year	**	Ns	Ns	**	Ns	Ns	**
Sex	Ns	*	Ns	*	*	Ns	*
Residuals	16.388	830.352	674.448	579.630	23.750	8.162	4.052

μ= Grand mean. **BW**= Birth weight; **W6**= Weight at 6 months old; **W9**= Weight at 9 months old; **W12**= Weight at 12 months old. **BW6**= Growth rates from BW until W6; **BW9**= Growth rates from BW until W9; **BW12**= Growth rates from BW until W12. **Coefficient of Variations** for BW, W6, W9, W12, BW6, BW9 and BW12 = 11.74, 17.56, 13.21, 10.31, 22.56, 15.86, 12.1, respectively.

Table 2. Partial Correlation Coefficients for weights and growth rates of Shami camels under Semi-intensive breeding from the Error SSCP Matrix/Prob.>|r|, (Equation 1).

Variables	W6	W9	W12	BW6	BW9	BW12
BW	-0.04^{ns}	0.14^{ns}	0.06^{ns}	-0.17^{ns}	-0.01^{ns}	-0.10^{ns}
W6		0.50**	0.17^{ns}	0.99**	0.51**	0.17^{ns}
W9			0.45**	0.47**	0.90**	0.44**
W12				0.16^{ns}	0.46**	0.99**
BW6					0.51**	0.18^{ns}
BW9						0.46**

BW= Birth weight; **W6**= Weight at 6 months old; **W9**= Weight at 9 months old; **W12**= Weight at 12 months old. **BW6**= Growth rates from BW until W6; **BW9**= Growth rates from BW until W9; **BW12**= Growth rates from BW until W12.

Discussion

Table 1 reveals significant variations in birth weight (BW), weight at 12 months (W12) and growth rates from birth to 12 months (BW12) across different birth years of Shami camels reared under semi-intensive conditions. In contrast, weight at 6 months (W6), 9 months (W9), growth rates from birth to 6 months (BW6) and growth rates from birth to 9 months (BW9) did not show significant differences across birth years, suggesting stable early growth rates. In addition, significant differences in W6, W12, BW6 and BW12 were observed based on calf sex, suggesting that sex-specific management practices are necessary. These have implications for breeding strategies, nutritional and management practices and sex-specific management to improve the growth of Shami camels. Camels at birth weigh about 35 kilograms, but this can vary significantly between breeds and within breeds depending on regions (Kadim *et al,* 2008). No significant difference exists between the birth weights of male and female camels (Al-Momani and Al-Najjar, 2020). However, although the birth weight differences between sexes were minimal, male camels tended to be heavier than female camels as they grew older (Njanja and Oba, 2011). Significant weight differences emerge at 6, 12 and 18 months, with males typically being heavier (Bakheit *et al,* 2017). Camel weights increased steadily from birth until age 4 under semi-intensive care conditions (Faris *et al,* 2022) and living weights continue to increase significantly as camels age (Seid *et al,* 2016). The year of birth also affects camel weight (Al-Momani and Al-Najjar, 2020). Camel growth rates are influenced by sex, nutrition, stress and health. These rates vary between strains and are affected by growth rates before and after weaning, which in turn affect body weights (Faraz, 2022). Birth weight differences between male and female camels are minimal; various factors such as sex, nutrition, health and environmental conditions significantly influence their growth rates and weights as they age. Understanding these factors can help optimise camel breeding and care practices to promote healthier and more robust growth.

Table 2 shows strong positive correlations between weights at different stages of Shami camel development, especially between early growth (6 months) and later weight gain (6 and 12 months). This indicated that early growth significantly influenced later weight gain. Conversely, the partial correlation coefficients between birth weight and later weights and growth rates were low and not statistically significant, suggesting birth weight had little impact on later development. These findings implied that

Table 3. Means ± standard error for birth weight base on sex and parity and sire of Shami camels (Equation 2).

Trait	Parity						Sex		Sire ID					
	1st	2nd	3th	4th	5th	6th	M	F	111	118	126	230	238	243
BW (kg)	29.87±6.21	32.35±4.74	32.66±4.63	33.41±4.85	34.00±5.08	33.00±4.70	32.25±5.54	31.78±5.14	34.10±5.66	32.04±4.48	34.26±4.12	30.31±4.84	27.95±5.88	23.71±5.62

BW= Birth weight, M= Male, F= Female.

Table 4. Variance component and heritability ± standard error for birth weight of Shami camels (Equation 3).

Component	N_S	$N_{Prog.}$	V_s	V_w	k	t	h^2
Values	6	217	7.38	29.58	33	0.20	0.80 ± 0.12

Ns= Number of sire, N_{Prog}= Number of progeny, Vs= Variance component of sire, Vw= Variance component of individual within sire, k and t= Constant, h^2= Heritability.

Table 5. Estimated breeding values for body weight of Shami camel males (Equation 4).

Sire rank	Sire ID	$N_{prog.}$	BWp (kg)	EBV (kg)
1st	126	65	34.10	+2.07
2nd	111	29	32.04	+1.79
3rd	118	56	34.26	-0.02
4th	230	35	30.31	-1.57
5th	238	20	27.95	-3.43
6th	243	12	23.71	-5.31

$N_{prog.}$= Number of progeny, BWp= Average birth weight of progeny, EBV= Breeding value.

optimising early growth was crucial for effective breeding, nutrition and management practices in Shami camels. According to these results, we should evaluate birth weight from an environmental and genetic perspective. Fatih *et al* (2021) showed a strong relationship between birth weight and mature weight. Furthermore, Njanja and Oba (2011) emphasised the important relationship between dam weights and calf birth weights. These underscore the importance of understanding the interaction between birth weight and subsequent growth and highlight potential implications for management practices in animal husbandry and husbandry programmes.

Shami camel birth weight (Table 3) shows trends, i.e. males were heavier than females and multiparous mothers exceeded primiparous ones. Sire genetics matter with sire 126 excelling. This highlights the importance of maternal experience and sire selection for improving birth weight. According to Almutairi *et al* (2010), parity significantly affects the birth weight of camels, indicating the importance of understanding maternal factors in camel breeding programs. Fatih *et al* (2021), who emphasised the importance of birth weight as a critical measurement in camels, suggesting its significance in monitoring camel weight, further supported this finding. Additionally, Bene *et al* (2020) confirmed that directing attention to the she-camel and optimising the environment could enhance the calf weight at birth, providing insights into practical strategies for improving calf weights in camel farming.

The heritability value of 0.80 ± 0.12 indicates that approximately 80% of the variation in birth weight can be attributed to genetic factors. Sire selection would have an impact on improving birth weight compared to other traits (Table 4). Camel growth studies show varying genetic influences on weight. Some researchers found birth weight heritability high (Almutairi *et al,* 2010) or low (Bene *et al,* 2020). Later weight and gain showed moderate heritability (Al-Sobayil *et al,* 2006; Kaleri *et al,* 2017).

Table 5 shows sire's genetic merit for Shami camel birth weight using EBVs. Sires with positive EBVs (like 126 and 111) were predicted to have heavier offspring, while those with negative EBVs were predicted to have lighter offspring. This information helps breeders improve birth weight in future Shami camel generations. Estimating breeding values is crucial for evaluating performance and guiding breeding operations to achieve sustainable trait development using genetic models, as emphasised by Al-Mutairi *et al* (2010), who noted a gradual improvement in weights and growth rates in camel breeding. Significant differences in breeding values for birth weight were found among male camels (Bene *et al,* 2020). Al-Sobayil *et al* (2006) assessed breeding values ranging from 25.3 to 115.1 for body weight and 0.270 to 0.638 kg for daily gains. The purposes are to enhance the selection process for superior camels, leading to improved weight and growth rates, achieving better economic returns and contributing to the sustainability and efficiency of camel breeding programs.

Conclusion

This study highlights significant disparities in birth weight and growth rates across different birth years and sex-related differences were found. Strong positive correlations were found between weights at different stages, particularly between early growth and later weight gain. Maternal parity, sire genetics and breeding values play a crucial role in improving birth weight. Male calves and multiparous mothers had higher birth weights. A heritability value of 0.80 indicates that genetic factors contribute significantly to birth weight variation and breeding values of sire can improve birth weight.

Recommendations

The study recommends the importance of taking into account maternal parity and the genetic breeding values of sires to improve birth weight and growth rates in Shami camels.

Acknowledgements

The authors thank the universities and research institutions that provided essential administrative support for this collaborative research.

Conflict of Interest

The authors declare no conflicts of interest to disclose.

References

Ali A, Baby B and Vijayan R. From desert to medicine. A Review of camel genomics and therapeutic products. Frontiers in Genetics. 2019; 10:17. DOI: 10.3389/fgene.2019.00017

Al-Momani Ahmad and Al-Najjar Khaled. Some productive characteristics of Shami camels (*Camelus dromedarius*). Journal of Camel Practice and Research. 2020; 27(3):345-349. DOI:10.5958/2277-8934.2020.00050

Almutairi SE, Boujenane I, Musaad A et al. Genetic and nongenetic effects for milk yield and growth traits in Saudi camels. Tropical Animal Health and Production. 2010; 42:1845-1853. DOI: 10.1007/s11250-010-9647-6

Al-Owaimer AN, Suliman GM, Sami AS, Picard B and

Hocquette JF. Chemical composition and structural characteristics of Arabian camel (*Camelus dromedarius*) m. longissimus thoracis. Meat Science. 2014; 96(3):1233-1241. DOI: 10.1016/j.meatsci.2013.10.025

Al-Saiady MY, Mogawer HH, Al-Mutairi SE, Bengoumi M, Musaad A, Gar-Elnaby A and Faye B. Factors affecting feed intake, body weight, testicular size and testosterone, follicle-stimulating hormone (FSH) and luteinising hormone (LH) serum concentrations in peri-pubertal male camels. African Journal of Agricultural Research. 2015; 10(14):1709-1713. DOI:10.5897/AJAR2014.9319

Al-Sobayil KA, Khalil MH, Al-Jobeile HS, Mohamed KM and Salal SA. Quantitative genetic analysis and evaluation for early growth performance in Saudi camels. In: International Scientific Conference on Camels 2006; pp 9-11.

Bakheit Sallam Abdelfadeil, Faye Bernard, Ibrahim IE and Idris AO. The effect of management system on camel calves growth rate and daily gain. Journal of Scientific and Engineering Research. 2017; 4(2):41-47. https://jsaer.com/archive/volume-4-issue-2-2017/

Balasundaram B, Thiruvenkadan AK, Murali N, Muralidharan J, Cauveri D and Peters SO. Genetic parameters of growth traits and quantitative genetic metrics for selection and conservation of mecheri sheep of Tamil Nadu. Animals (Basel). 2023; 13(3):454. DOI: 10.3390/ani13030454

Becker WA. A Fortran Program for testing and analysing multiple comparisons. Journal of Educational Statistics. 1992; 17(4):344-353.

Bene S, Szabó F, Polgár JP, Juhász J and Nagy P. Genetic parameters of birth weight trait in dromedary camels (*Camelus dromedarius*). Tropical Animal Health and Production. 2020. 52(5):2333-2340. Doi: 10.1007/s11250-020-02256-z

Faraz A, Younas M, Waheed A, Tauqir NzA, Nabeel MS, Mirza RH, Ishaq HM and Khan NU. Growth management of marecha camel (*Camelus dromedarius*) in feedlot under desert conditions. Advances in Animal and Veterinary Sciences. 2020; 8(11):1114-1119. DOI: 10.17582/ journal.aavs/2020/8.11.1114.1119

Faraz A. Growth assessment in camel (*Camelus dromedarius*): A meta-analysis study. Journal of Zoological Research. 2022; 4(1):15-20. DOI: 10.30564/jzr.v4i1.2273

Faris, Shadi; Al-Najjar, Khaled; Dib, Ali and Nouh Abdulla. Estimation of growth curve prediction equation parameters for weights of shami camel before mature/ Syria. Arab Journal of Arid Environments. 2022; 13(1). https://digitalcommons. aaru. edu.jo/aae/vol13/iss1/9

Fatih A, Celik S, Eyduran E, Tirink C, Tariq MM, Sheikh IS, Faraz A and Waheed A. Use of MARS algorithm for predicting mature weight of different camel (*Camelus dromedarius*) breeds reared in Pakistan and morphological characterisation via cluster analysis. Tropical Animal Health and Production. 2021; 53:191. DOI: 10.1007/s11250-021-02633-2

Fraser DJ. How well can captive breeding programmes conserve biodiversity? A review of salmonids. Evolutionary Applications. 2008; 1(4):535-86. DOI: 10.1111/j.1752-4571.2008.00036.x

Hardjosubroto P. Breeding value of sires based on offspring weaning weight as a recommendation for selecting kebumen ongole grade cattle. Journal of Animal Science. 1994; 72(12):3456-3463.

Joana L. Rocha, Raquel Godinho, José C Brito and Rasmus Nielsen, Life in deserts. The genetic basis of mammalian desert adaptation. Trends in Ecology & Evolution. 2021; 36(7):637-650. DOI: 10.1016/j.tree.2021.03.007.

Kadim I, Mahgoub O and Purchas R. A review of the growth and of the carcass and meat quality characteristics of the one-humped camel (*Camelus dromedarius*). Meat Science. 2008; 80(3):555-569. DOI: 10.1016/j.meatsci.2008.02.010

Kaleri RR, Kaleri HA, Baloch SK, Kaleri A, Mangi RA, Bhatti AL, Mari GM, Qureshi FN, Pahnwar MS and Marri A. Heritability estimates for some growth traits of dhatti camel breed in Tharparkar. Journal of Basic & Applied Sciences. 2017; 13:556-558.

Njanja JC and Oba G. The turkana camel breed in North-Western Kenya: Part 2: Productivity characteristics. Outlook on Agriculture. 2011; 40(3):273-279. DOI: 10.5367/oa.2011.0053

Osterloff Emily. How do camels survive in deserts? Natural History Museum. 2024; https://www.nhm.ac.uk/discover/how-do-camels-survive-in-deserts.html

Padalino B, Monaco D and Lacalandra GM. Male camel behavior and breeding management strategies: how to handle a camel bull during the breeding season? Emirates Journal of Food and Agriculture. 2015; 27: 338-349.

SAS. The SAS System for Windows. Release 9.1.3. SAS Institute, Cary, North Carolina, USA. 2012.

Seid A, Kurtu MY and Urge M. Effect of age and body condition on slaughter characteristics of dromedary camels (*Camelus dromedarius*) in Eastern Ethiopia. Journal of Camelid Science. 2016; 9:35-53. http://www.isocard.net/en/journal

Sofiane Boudalia, Yassine Gueroui, Rabah Zebsa, Tarek Arbia, Ammar Elhassen Chiheb, M'hamed Benada, Zouheyr Hadri, Abdeldjalil Youcefi and Aissam Bousbia. Camel livestock in the Algerian Sahara under the context of climate change: Milk properties and livestock production practices. Journal of Agriculture and Food Research. 2023; 11: DOI: 10.1016/j.jafr.2023.100528.

Suliman GM, Al-Owaimer AN, Hussein EOS, Abuelfatah K and Othman MB. Meat quality characteristics of the Arabian camel (*Camelus dromedarius*) at different ages and post-mortem ageing periods. Asian-Australasian Journal of Animal Sciences. 2020; 33(8):1332-1338. DOI: 10.5713/ajas.19.0589