Turkish Journal of Veterinary & Animal Sciences

Volume 45 | Number 3 Article 15

1-1-2021

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Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2021) 45: 492-500
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doi:10.3906/vet-2010-15

Power of body live weights in differentiation physiological growth of goat breeds

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Received: 04.10.2020 • **Accepted/Published Online:** 06.03.2021 • **Final Version:** 29.06.2021

Abstract: We assumed that live body weight (LBW) would be useful to be utilized as informative categorical variable in differentiation goat performance towards better assignment into breeds. One-day old goat kids of both sexes were separately allocated as 3 breeds: Baladi, crossbreds and Shami. The kid LBW was recorded weekly until the 12th week of age. Weekly LBW showed a significant increase ($p < 0.05$) for both males and females of the 3 breeds and highly significant ($p < 0.0001$) between breeds. The high phenotypic correlation between most of the studied measurements encouraged us to investigate their efficiency in breed differentiation at early life age. Results showed that only LBW of the week 1, 2, 5, 9, and 11, and week 1, 2, 3, 11, and 12 were efficient in discriminating male and female kids, respectively. These results were better presented by showing significant genetic distances ($p < 0.0001$) between the breeds using the Unweighted Pair Group Method with Arithmetic mean (UPGMA) dendrogram. It is inferred that the phylogenetic tree lengths of the three breeds were 29.02 and 222.13 for male and female kids, respectively. Baladi and crossbred kids of both sexes grouped into one cluster closer than Shami kids. The canonical discriminant analysis was proved its successfulness for identifying breed based on LBW measurement.

Key words: Growth physiology, multivariate discriminant analysis, crossbreeding, welfare

1. Introduction

Goat breeds in developing countries have a variable body conformation and morphology with more than one billinon goat in the world, mostly in developing countries [1]. In particular, crossbreds of different breeds might be assigned as purebreds because they possess distinctive traits of one breed. Thus, differentiating the breeds is still a problem the farmers are facing because their knowledge is still lacking scientific basis. The farmers are usually would be able to differentiate breeds based on distinctive body morphology. However, they are not able to differentiate breeds' morphometric of economic interest. In other words, some morphometric characteristics have economic value and mostly considered by farmers breeders, traders, and consumers into their business profit function. The most considered traits are physiological growth traits such as live body weight (LBW) and gain [2,3].

The LBW in early stage of animal's life is a main indicator of future body performance and conformation. The farmers give it most attention in order to evaluate their animals' growth. We assume that LBW would be useful to be utilized more as informative tools in differentiation animals' performance towards differentiating animal breed. The differentiation breeds were previously reported for livestock species [4]. There are reports stating how sheep and goat individuals are assigned to their breeds based on body live characteristics [5,6]. So far, scientific reports based on statistical procedures indicated capability of assign goats to their breeds based on different body growth traits. In general, there are many researchers stated that comparisons among breeds was successful considering body weights characteristics [7,2]. Those researchers used statistical methods that provide reliable racial discriminants. As instance, studies applied the simple statistical procedure such as correlations and advanced statistical procedure such as multivariate discriminant analysis [5]. On the other hand, in Jordan, five goat breeds [Mountain Black, Dhaiwi, Desert Black Bedouin (Baladi), and Damascus (Shami)] were reported [8]. The Black Bedouin and Damascus are common in Middle East countries. In Jordan, they are reared in close geographical areas where their farmers practice crossbreeding on them assuming rapid genetic improvement of crossbreds. In general, the farmers are interested in pure Damascus goat as milk producer with high market price. Therefore, we need to provide a successful tool used by farmers to differentiate the crossbreds from pure Shami so that farmers could escape the fraud trap of buying crossbred

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as pure Damasucs goat. Therefore, this study aimed to distinguish and differentiate the Damascus and Baladi goats and their crossbreds based on weekly body weight measurments using multivariate discriminant analysis.

2. Materials and methods

2.1. Experimental design and measurements

A total of 36 females and 39 male kids (one-day old) was allocated into three groups: Baladi, Shami, and Hybrid (12 females and 13 males of each breed) in a separate completely randomized design. The three breeds are common breeds in practice by Jordanian farmers for milk production into sedentary production system. All procedures performed in the present trial involving animals were in accordance with the ethical standards of the Animal Care and Use Committee at Mutah University, Jordan (No. AGR-82006). All animals from the three breeds were ear-tagged at one-day old. The three different breeds were described earlier by our publications [3,9] Baladi (Black Bedouin), Shami (Damascus), and Hybrid (F1 of both Baladi and Shami). The sample size assumes to be 12 at least following previous similar studies that dealt with goat's performance and ended in determining significant differences considering coefficient of variation (CV) for LBW around 6%. The following simple formula was used: $N = [8(CV\%)^2]/(d\%)^2$, where CV is coefficient of variation for weekly body weight and d% is level of significance (5%). The animals were reared under an intensive farming system in the Animal Farm of Agricultural Research Station at Mutah University in Karak city, Jordan. Their mothers (does) were born in the same year (September-November of year 2014) and reared under similar conditions in the Agricultural Research Station. The animals were chosen as homogeneous as possible considering, for example, their age, initial LBW, and birth type. The kids were allowed to suckle their mothers twice a day: morning at 8:00 and afternoon at 15:00. Their LBW (kg/kid) of the newborn kids in each treatment group was weighed following the complete drying of the body within 6 h as maximum after birth, and then at weekly intervals by using a digital balance for 12 consecutive weeks of the trial period. All procedures performed in the present trial involving animals were in accordance with the ethical standards of the Animal Care and Use Committee at Mutah University, Jordan.

2.2. The statistical multivariate discriminant analysis

The collected data of LBW were subjected to different discriminant and clustering analyses using SAS-program version 9.2 [10]. The SAS statistical analyses were calculated means (PROC MEANS), general linear model (GLM), and the LSMEAN as mean separation procedure was performed and the simple discriminant analysis procedure (SAS DISCRIM) to calculate the probabilities of including an animal in predefined breed. The GLM was $Yijk = \mu + Bi + Sj + Eijk$, where Yij is the observed k measurement of LBW in the ith breed, jth is sex, μ is the overall mean εijk, Bi is fixed effect of ith breed (i = 1, 2, and 3; Black Bedouin, Damascus and Hybrid); A j is the fixed effect of jth sex (j = 1 and 2; Male and female); Eij is the random residual error.

In addition, stepwise discriminant procedure (STEPDISC) was applied to determine which body measured traits will be used in the final clustering analysis. Another type of procedure, canonical discriminant analysis (CANDISC procedure) was used to perform uni- and multivariate analyses to derive canonical variables (CAN) for best match breed/strain [11,10]. Furthermore, genetic square distances (Mahalanobis distances) were also generated. These distances were used to construct a dendrogram using MEGA software [12].

3. Results

The statistical descriptions of LBW (kg) for kids in each breed were presented in Table 1. The LBW was highly significant among different breeds ($p < 0.0001$). Their mean and standards error values were presented in Table 1 showing higher values for Shami kids over those of crossbreds and Baladi breeds.

We found it better to provide further insights on the association between each other in terms of LBW every week (Table 2). The significant correlation coefficients were reported in most cases within each breed (Table 2). All LBWs of male kids from week 1 until week 12 were significantly correlated with each other with exceptions. The exceptions were noticed for some LBW of week 1 in Baladi male kids and crossbred male and female kids. Furthermore, LBW of week 3 was not correlated with those of week 11 and 12. The latter was not correlated with week 6. Similar results were noted for week 3 in crossbred male kids. The most noted results were highly significant correlations for all LBW measurements in Shami male and female kids.

Table 3 shows univariate procedure within multivariate discriminant analysis for providing the significant discriminate power ($p < 0.05$) of the characteristics. All 12 measurements of LBW were shown to be effective in discriminating kids of goat breeds considering the values of R-Square, F-test, and significant level ($p < 0.05$). The efficient measurements in discriminating kids were LBW of week 1, 9, 2, 11 and 5 for males and week 2, 11, 12, 1 and 3 for females. In fact, the most efficient variable, which has the highest R-Square is LBW-week 1. Its R-Square value is 70%; whereas, the R-Square values of the other variables are much quite low. In general, they were ranked in the previous order as a result of high average squared Canonical correlation ($p < 0.0001$), higher R-Square, Wilks lambda, and F-values than the other studied traits (Table 3).

Table 1. Significance level, means, and standard deviation of live body weight (kg) for goat breeds.

	R-Square		Baladi		Shami		Crossbreds	
Variable		Pr > F	Mean	SE	Mean	SE	Mean	SE
Male								
LBW – week 1	0.703	<.0001	4.96	0.25	8.15	0.27	5.78	0.29
LBW –week 2	0.686	<.0001	5.51	0.33	9.28	0.35	6.15	0.34
LBW –week 3	0.643	<.0001	5.91	0.37	10.04	0.38	7.49	0.39
LBW –week 4	0.583	<.0001	6.45	0.47	10.94	0.47	8.18	0.48
LBW –week 5	0.652	<.0001	6.91	0.58	13.56	0.59	9.43	0.61
LBW –week 6	0.608	<.0001	7.43	0.6	14.01	0.63	10.56	0.66
LBW –week 7	0.566	<.0001	8.03	0.68	14.58	0.69	11.05	0.71
LBW –week 8	0.603	<.0001	9.47	0.8	17.79	0.81	13.53	0.84
LBW –week 9	0.592	<.0001	9.96	0.87	18.83	0.88	14.38	0.91
LBW –week 10	0.583	<.0001	10.53	0.92	19.68	0.94	15	0.96
LBW –week 11	0.634	<.0001	11.52	0.9	21.55	0.91	15.51	0.95
LBW –week 12	0.6	<.0001	12.32	0.96	22.12	1.0	15.96	1.1
Female								
LBW –week 1	0.704	<.0001	4.57	0.22	4.69	0.23	7.12	0.29
LBW –week 2	0.717	<.0001	5.08	0.25	5.00	0.26	7.95	0.29
LBW –week 3	0.697	<.0001	5.47	0.3	5.83	0.31	8.89	0.34
LBW –week 4	0.677	<.0001	5.92	0.4	6.33	0.42	10.22	0.45
LBW –week 5	0.638	<.0001	6.33	0.51	6.73	0.52	11.33	0.55
LBW –week 6	0.658	<.0001	6.73	0.55	7.13	0.55	12.25	0.60
LBW –week 7	0.643	<.0001	7.28	0.61	7.68	0.62	13.28	0.65
LBW –week 8	0.634	<.0001	7.87	0.65	9.03	0.68	14.73	0.7
LBW –week 9	0.632	<.0001	8.32	0.7	9.63	0.73	15.62	0.79
LBW –week 10	0.624	<.0001	8.68	0.71	10.41	0.77	16.44	0.97
LBW –week 11	0.640	<.0001	9.03	0.80	10.95	0.83	17.6	0.98
LBW –week 12	0.676	<.0001	9.54	0.81	11.29	0.88	18.49	0.91

LBW: Live body weight, SD: Standard deviation.

On the other hand, eigen values showed high value for male (5.43) and for females (4.13) in Canonical function 1 (CAN 1) that exhibited 77% and 79% for males and females, respectively, of the total variation of all traits (Table 4).

For kids of both sexes, the canonical functions CAN 1 and 2 assigned the measurements to its function as the percentage of correct assignment (Table 5). The most discriminating traits in CAN 1 were LBW of the first three weeks. The result indicates that those traits had the highest power in assigning the lambs into their possible breed, and, thus, they differentiate them along X-axis (Figure 1). While the most discriminating traits in CAN 2 were LBW of advanced weeks (Table 5), their discriminant power was presented along Y-axis of principal component analysis of Figure 1. Particularly, the results revealed that those traits had the highest loading between CAN 1 to CAN 4 as a matrix of the correlation of each variable with each discriminant function (Table 5). The highest loading of the traits suggested that the correlation between them was the function that discriminating the kids.

On the other hand, the genetic relationship of all studied kids breeds was better presented in the multiple correspondence analyses (Figure 1) with data obtained from canonical discriminant analysis. It is clear from the figure that the kids were separated from each other and gathered into three distinct clusters. The clusters were matching the predefined breeds of Baladi, crossbred and Shami. It is

Table 2. The correlation coefficients and p values (significant value at $p < 0.05$) for all live body weight measurements in male (above diagonal) and female (below diagonal) goat kids of the three breeds.

LBW Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
	Baladi											
Week 1	Coefficient	0.90	0.84	0.71	0.60	0.66	0.58	0.52	0.49	0.41	0.29	0.18
	P values	<.0001	0.00	0.01	0.03	0.01	0.05	0.07	0.09	0.16	0.33	0.55
Week 2	0.96		0.93	0.88	0.80	0.79	0.79	0.78	0.75	0.68	0.54	0.42
	<.0001		<.0001	<.0001	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.15
Week 3	0.91	0.97		0.91	0.83	0.79	0.77	0.71	0.69	0.61	0.44	0.32
	<.0001	<.0001		<.0001	0.00	0.00	0.00	0.01	0.01	0.03	0.13	0.28
Week 4	0.88	0.93	0.98		0.95	0.90	0.89	0.87	0.84	0.80	0.68	0.57
	0.00	<.0001	<.0001		<.0001	<.0001	<.0001	0.00	0.00	0.00	0.01	0.04
Week 5	0.83	0.89	0.95	0.99		0.95	0.94	0.91	0.89	0.83	0.67	0.57
	0.00	0.00	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	0.00	0.01	0.04
Week 6	0.82	0.89	0.94	0.97	0.98		0.93	0.83	0.79	0.71	0.57	0.48
	0.00	0.00	<.0001	<.0001	<.0001		<.0001	0.00	0.00	0.01	0.04	0.09
Week 7	0.80	0.86	0.92	0.96	0.98	0.99		0.93	0.90	0.83	0.69	0.63
	0.00	0.00	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	0.00	0.01	0.02
Week 8	0.75	0.82	0.88	0.94	0.96	0.97	0.99		0.99	0.96	0.85	0.78
	0.01	0.00	0.00	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	0.00	0.00
Week 9	0.73	0.80	0.86	0.92	0.95	0.97	0.99	0.99		0.99	0.87	0.81
	0.01	0.00	0.00	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	0.00
Week 10	0.70	0.77	0.85	0.92	0.95	0.97	0.98	0.99	0.99		0.92	0.87
	0.01	0.00	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	0.00
Week 11	0.71	0.78	0.85	0.91	0.94	0.96	0.98	0.99	0.99	0.99		0.98
	0.01	0.00	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
Week 12	0.72	0.78	0.83	0.90	0.93	0.95	0.98	0.99	0.99	0.98	0.99	
	0.01	0.00	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
Crossbreds												
Week 1	Coefficient	0.91	0.86	0.78	0.65	0.55	0.53	0.51	0.49	0.50	0.37	0.41
	P values	<.0001	0.00	0.00	0.02	0.05	0.06	0.07	0.09	0.08	0.21	0.17
Week 2	0.95		0.96	0.92	0.87	0.77	0.74	0.71	0.69	0.71	0.56	0.59
	<.0001		<.0001	<.0001	<.0001	0.00	0.00	0.01	0.01	0.01	0.05	0.03
Week 3	0.44	0.66		0.93	0.82	0.72	0.69	0.69	0.66	0.68	0.49	0.53
	0.15	0.02		<.0001	0.00	0.01	0.01	0.01	0.01	0.01	0.09	0.06
Week 4	0.46	0.70	0.95		0.85	0.79	0.78	0.79	0.78	0.78	0.63	0.67
	0.13	0.01	<.0001		0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
Week 5	0.33	0.58	0.87	0.93		0.97	0.95	0.91	0.91	0.92	0.82	0.83
	0.30	0.04	0.00	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	0.00	0.00
Week 6	0.38	0.63	0.86	0.91	0.94		0.99	0.93	0.93	0.92	0.84	0.83
	0.22	0.03	0.00	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	0.00	0.00
Week 7	0.51	0.73	0.82	0.92	0.88	0.95		0.94	0.94	0.93	0.85	0.85
	0.09	0.01	0.00	<.0001	0.00	<.0001		<.0001	<.0001	<.0001	0.00	0.00

Table 2. (Continued).

Week 8	0.54	0.71	0.72	0.83	0.88	0.89	0.92		0.97	0.97	0.91	0.91
	0.07	0.01	0.01	0.00	0.00	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
Week 9	0.61	0.75	0.68	0.81	0.87	0.85	0.87	0.98		0.99	0.96	0.96
	0.04	0.00	0.01	0.00	0.00	0.00	0.00	<.0001		<.0001	<.0001	<.0001
Week 10	0.58	0.73	0.66	0.78	0.83	0.85	0.88	0.97	0.98		0.94	0.94
	0.05	0.01	0.02	0.00	0.00	0.00	0.00	<.0001	<.0001		<.0001	<.0001
Week 11	0.65	0.77	0.62	0.73	0.78	0.79	0.81	0.95	0.96	0.96		0.99
	0.02	0.00	0.03	0.01	0.00	0.00	0.00	<.0001	<.0001	<.0001		<.0001
Week 12	0.68	0.79	0.63	0.74	0.78	0.78	0.82	0.94	0.95	0.96	0.99	
	0.01	0.00	0.03	0.01	0.00	0.00	0.00	<.0001	<.0001	<.0001	<.0001	
Shami												
Week 1	Coefficient	0.98	0.73	0.62	0.74	0.78	0.78	0.86	0.89	0.92	0.94	0.93
	P values	<.0001	0.01	0.03	0.01	0.00	0.00	0.00	0.00	<.0001	<.0001	<.0001
Week 2	0.96		0.75	0.64	0.77	0.78	0.78	0.88	0.90	0.93	0.94	0.94
	<.0001		0.00	0.02	0.00	0.00	0.00	0.00	<.0001	<.0001	<.0001	<.0001
Week 3	0.86	0.93		0.97	0.94	0.88	0.89	0.91	0.87	0.82	0.80	0.78
	0.00	<.0001		<.0001	<.0001	0.00	<.0001	<.0001	0.00	0.00	0.00	0.00
Week 4	0.85	0.89	0.93		0.93	0.86	0.89	0.88	0.84	0.77	0.75	0.74
	0.00	0.00	<.0001		<.0001	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Week 5	0.77	0.86	0.90	0.97		0.92	0.93	0.95	0.91	0.86	0.83	0.80
	0.00	0.00	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	0.00	0.00	0.00
Week 6	0.73	0.84	0.89	0.95	0.99		0.99	0.95	0.92	0.88	0.89	0.88
	0.01	0.00	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	0.00	0.00	0.00
Week 7	0.73	0.84	0.89	0.94	0.99	0.99		0.96	0.93	0.90	0.90	0.88
	0.01	0.00	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	0.00
Week 8	0.72	0.81	0.92	0.93	0.95	0.96	0.95		0.98	0.96	0.95	0.94
	0.01	0.00	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001
Week 9	0.69	0.79	0.92	0.91	0.94	0.95	0.95	1.00		0.99	0.98	0.97
	0.01	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
Week 10	0.66	0.76	0.90	0.88	0.91	0.93	0.92	0.99	1.00		0.99	0.98
	0.02	0.00	<.0001	0.00	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
Week 11	0.73	0.83	0.92	0.91	0.93	0.94	0.95	0.99	0.98	0.98		0.99
	0.01	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
Week 12	0.73	0.84	0.92	0.91	0.95	0.96	0.96	0.99	0.99	0.98	1.00	
	0.007	0.00	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	

LBW: Live body weight, correlation is significant at $p < 0.05$ level.

worth mentioning that crossbred kids of both sexes were clustered close to both breeds. Furthermore, these results were better presented by showing the genetic distances (Mahalanobis distances) between the breeds (Figure 2). Figure 2 shows evolutionary genetic tree as significant genetic distance ($p < 0.0001$) between breeds with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree including both sexes of the three breeds. Branch lengths that inferred using the Unweighted Pair Group Method with Arithmetic mean (UPGMA) method and reflecting the evolutionary history were 29.02 and 222.13, respectively for male and female kids (Figure 2). The Baladi and the crossbred kids of both sexes grouped into one cluster (Figure 2), and the

Table 3. Stepwise selection summary of the most discriminant power live body weight weekly measurements of male and female goat kids.

Entered variable	R-Square	F Value	Pr > F	Wilks' Lambda	Pr < Lambda	Canonical Correlation	Pr > ASCC
	Male						
LBW-week 1	0.70	41.49	<.0001	0.30	<.0001	0.35	<.0001
LBW-week 9	0.16	3.32	0.05	0.25	<.0001	0.43	<.0001
LBW-week 2	0.30	7.01	0.00	0.17	<.0001	0.56	<.0001
LBW-week 11	0.27	6.00	0.01	0.13	<.0001	0.62	<.0001
LBW-week 5	0.27	5.61	0.01	0.09	<.0001	0.65	<.0001
	Female						
LBW-week 2	0.72	41.99	<.0001	0.28	<.0001	0.36	<.0001
LBW-week 11	0.22	4.57	0.02	0.22	<.0001	0.47	<.0001
LBW-week 12	0.23	4.73	0.02	0.17	<.0001	0.50	<.0001
LBW-week 1	0.19	3.44	0.05	0.14	<.0001	0.58	<.0001
LBW-week 3	0.15	2.66	0.09	0.12	<.0001	0.62	<.0001

LBW: Live body weight, ASCC: Average squared canonical correlation.

Table 4. Function, Eigen-value, variance percentage, and canonical correlation of male and female goat kids.

CAN	Canonical correlation	Adjusted canonical correlation	Approximate standard error	Squared canonical correlation	Eigenvalues Eigenvalue difference Proportion cumulative			
	Male							
1	0.92	0.89	0.03	0.84	5.43	3.81	0.77	0.77
2	0.79	0.73	0.06	0.62	1.62		0.23	1.00
	Female							
1	0.90	0.86	0.03	0.80	4.13	3.01	0.79	0.79
2	0.73	0.65	0.08	0.53	1.12		0.21	1.00

CAN: Canonical function.

reflecting genetic distance between them was 29.02 and 222.13 for male and females, respectively. The crossbreds breed location, being in the intermediate position, would be expected to reflect that they are F1 crossing individuals.

4. Discussion

This study provides the opportunity to assess power of LBW in assigning the individuals into their own correctly defined goat breeds. Goat LBW is regarded as a critical benchmark for goat welfare, production, and profitability. Thus, sustainable breeding program of goat can be achieved considering misidentification of goat breed lead to misplace breeding in developing countries [13].

In the current study, breed had a significant effect on LBW as LBW of Shami goats was significantly higher than Baladi and Hybrid breeds; this is consistent with our previous finding obtaind using the same animals [3]. In general, higher growth rate and body weight for Shami kids over other breeds were frequently reported [14,15]. Subsequently, estimates of correlations between LBW weekly variables reflected the high correlation values in most cases within each breed. It was mostly noted for Shami male and female kids suggesting LBW as an indicator trait in this breed. In fact, knowledge of LBW relationships in early ages is totally essential for goat breeding, nutrition, and management as reported by Abd-Allah et al. [14]. In particular, the results of highest correlations with LBW of Shami kids were supported by Abdel-Mageed and Ghanem [16] and Abd-Allah et al. [14]. In general, previous researchers reported correlation

Table 5. Total canonical function for male and female kids of the three breeds.

Variable	CAN 1	CAN 2	CAN 3	CAN 4	CAN 1	CAN 2	CAN 3	CAN 4
	Male						Female	
LBW –week 1	0.89	0.21	0.09	0.08	0.93	-0.09	-0.22	0.01
LBW –week 2	0.90	0.12	0.05	0.14	0.93	-0.17	-0.24	0.03
LBW –week 3	0.82	0.34	0.12	0.13	0.93	-0.03	-0.24	0.05
LBW –week 4	0.78	0.32	0.18	0.19	0.92	-0.04	-0.23	0.01
LBW –week 5	0.83	0.33	0.05	0.11	0.89	-0.05	-0.21	0.09
LBW –week 6	0.77	0.42	0.10	0.23	0.90	-0.06	-0.20	0.07
LBW –week 7	0.75	0.39	0.11	0.25	0.89	-0.07	-0.24	0.09
LBW –week 8	0.76	0.43	0.03	0.27	0.89	0.04	-0.21	0.02
LBW –week 9	0.75	0.44	0.05	0.20	0.89	0.05	-0.17	0.03
LBW –week 10	0.75	0.43	0.08	0.19	0.88	0.10	-0.19	0.02
LBW –week 11	0.82	0.35	0.06	0.21	0.89	0.10	-0.21	0.03
LBW –week 12	0.80	0.31	0.07	0.25	0.91	0.07	-0.16	0.03

LBW: Live body weight, CAN: Canonical function.

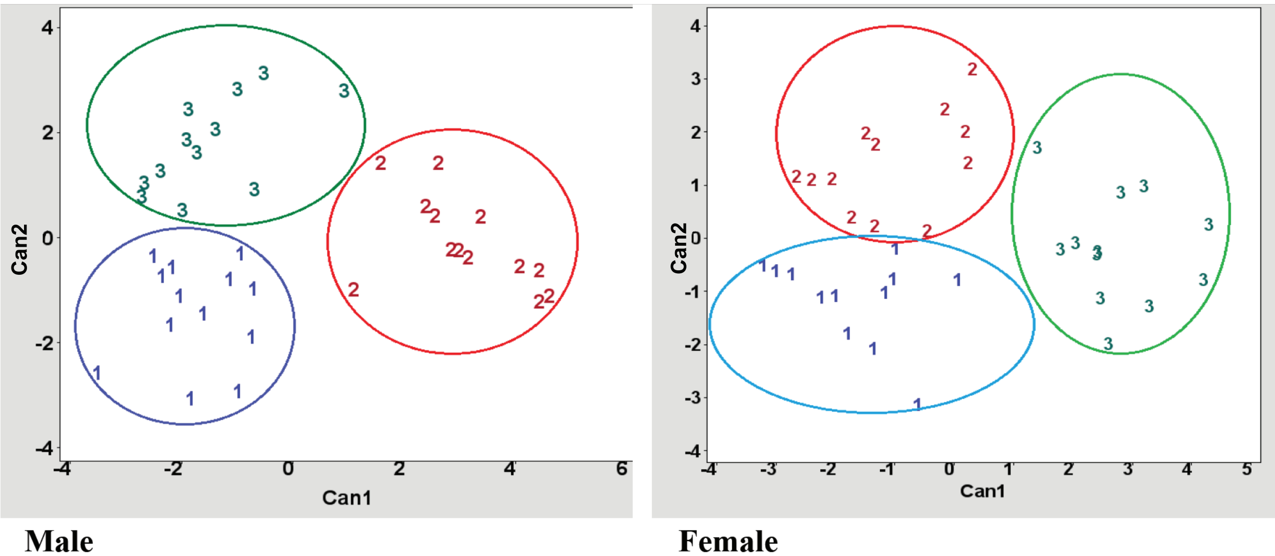

Figure 1. Cluster analyses for male and females goat kids. (1: Baladi (Black Bedouin), 2: crossbreds, 3: Shami).

of LBW with its frequent measures and other measures such as gain in local or crossbred goats [17,18,9]. The LBW was extensively utilized as a reliable predictors to assess live weight in different goat breed [19,20,21] who stated that since there are high correlation coefficients between LBW and body measurements, either of the same variables or combination could provide a good estimation regarding the live weight in goat breeds.

Overall, the canonical discriminant analysis was proved to be successful for identifying breed based on early live measurement of most economic and it is advisable for on field application when it's difficult for farmers to distinguish pure goat kids from crossbred kids, which is in line with the findings of of Sanni et al. [22]. The current study revealed a remarkable influence of LBW of all 12 measurements in discriminating kids of goat breeds. In addition, Stepwise procedure allowed the selection of the most discriminating power LBW weekly measurements that enable a clear separation between the males and females. The first and last two weeks measurements of LBW in this study were the most discriminant traits to be relayed on in differentiating goat breeds. The other LBW

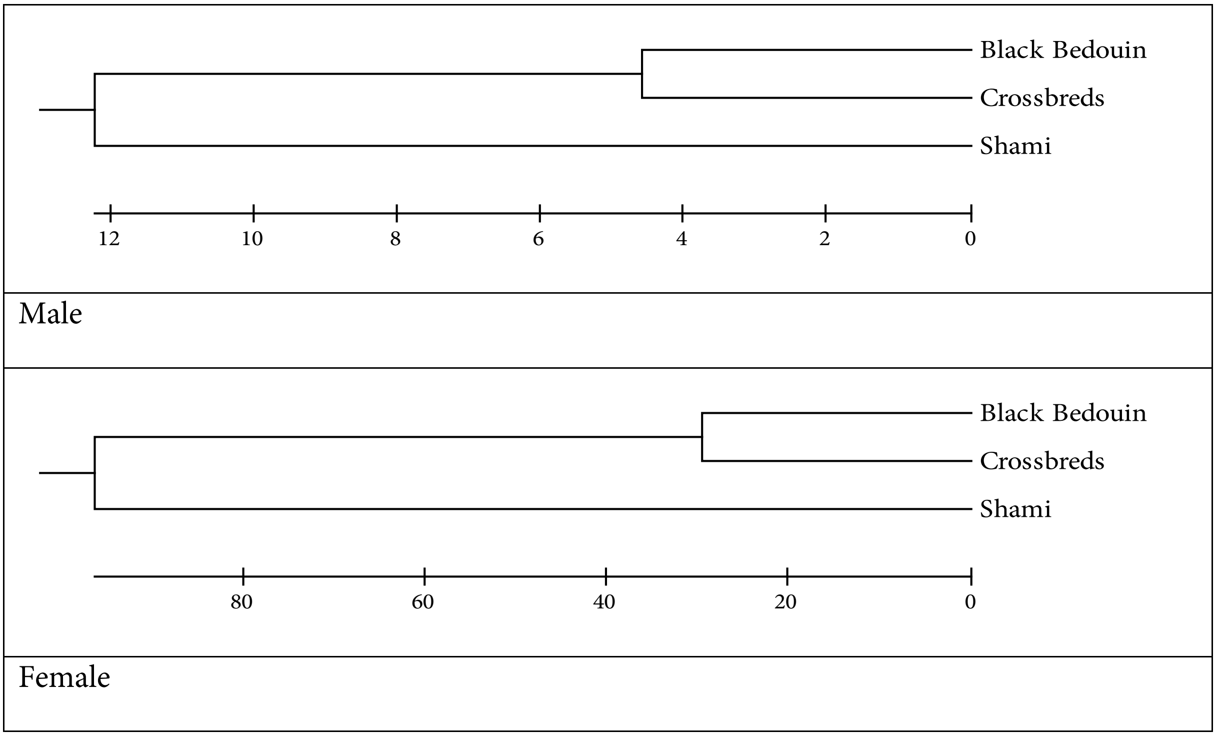

Figure 2. Male and female goat kids evolutionary relationships of breeds.

measurements were still to be considered for both sexes. However, in our previous study, the goat farmers in Jordan were mostly (84%) considering milk production [8]. Finally, it inferred that the phylogenetic tree lengths of the three breeds were 29.02 and 222.13 for male and female kids, respectively. As expected, Baladi and the crossbred kids of both sexes were grouped into one cluster closer than Shami kids as reported earlier by Zaitoun et al. [23].

In conclusion, discriminant canonical analysis based on data from LBW could differentiate individuals among the goats. Therefore, we may conclude that, in order to practice good goat management, the measurement of LBW is totally essential for breeding. The positive and significant correlations of weekly LBW would indicate that the measurements can be used as a marker to differentiate individual of each separated breed and for each sex. In the current study, LBW measurements of first weeks after birth and weeks at weaning were very effective in differentiation of goat kids based on their own correct breeds. To sum up, although molecular genetic identification helps DNA genotyping, the process is time consuming, relatively expensive and requires scientific basis; thus, identification of some descriptive and discriminant traits may be useful for farmers to identify and select goat breeds beforehand.

Funding
The authors would like to thank Agricultrure Research station and Animal production department at Mutah University for financial support (in kind) of this project.

Acknowledgments
The authors are thankful to Mutah University and its Animal Production Department for providing the staff, the facilities and logistic support and their help during the field work.

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