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Comparative Study Among Boer, Damascus and Their Crossbred Goats: Performance, Digestion, Nutritive Values and Blood Parameters

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Crossbreed different types of goats specialized in meat or milk production can produce crossbred kids with high meat and milk production, to address the meat and milk production shortage in human consumption. This study focused on the comparison between Boer, Damascus, and its crossbred goats, from where nutrients digestibility, rumen fermentation, and some blood parameters. Eight from each growing Boer and crossbred goats were fed a total mixed ration (TMR) for a180 day feeding trial. Then, eight adult goats from each Boer, Damascus, and their crossbred fed the TMR, according to their requirement for 21day digestibility trial. There were insignificant differences in average daily gain between Boer and crossbred goats. The feed conversion of Boer goats was better than crossbred goats being 9.11 and 9.43 feed/gain, respectively. The differences between Boer and Damascus goats for all nutrients and cell wall constituents' digestion were insignificant except for dry matter and ether extract. Contrarily, the differences between Boer and crossbred were significant except nitrogen-free extract digestibility (P>0.05). There were no significant differences in nutrient digestibility between crossbred and Damascus goats. Rumen pH and ammonia-nitrogen concentration were not significant among the experimental group. Boer and crossbred goats recorded the highest total volatile fatty acids than Damascus goats. Damascus goats had high blood LDL, ALT and ALP values; the lowest were in Boer goats, crossbred goats had intermediate of TP, HDL, LDL, ALP, and ALT values. In conclusion, the productive performance of crossbred goats in this study was high as that of Damascus goats.

Keywords: crossbred goats, daily gain, digestibility, rumen parameters, blood constituents.

Introduction

The continued availability of food resources is one of the most important problems facing humans in the twenty-first century as meat consumption will be increased by up to 58% by the year 2050 [1]. Since it provides an appropriate number of essential amino acids and fatty acids, the meat of small ruminants is considered one of the most significant animal protein sources. Goats present an important role in the animal production sector in the Egypt's livestock industry, as their number were reaching about 4 million heads [2]. Keeping small ruminants is considered necessary in rural areas because it plays an important role in the social and economic dimension, as it provides part of income and employment and reduces environmental pollution because it consumes the by-crop residues. Since the high adaptability to different climatic conditions in tropical and subtropical regions is the most important characteristic of goats to survive under the most extreme condition, [3] in addition to their efficient utilization of low quantity and quality feeds [4]. The local goat's production of meat and milk is low, therefore, crossing Boer goats specialized

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in meat production with Damascus goats, which have a high production of milk, will give new crossbred goats of high milk and meat production compared to pure Boer [5] and to Baladi goats [6]. Regarding the meat breeds, the crossbreds of Boer x Spanish, Boer x Angora, and Boer x Nobina goats are the most commonly used in genetically improvement programs [7]. In different production systems of goats, the growth traits are an important as an economic trait for production and useful in selection decisions of the kind of animals [8]. crossbreds produced from Boer goat are more resilient to diseases compared to native breeds [9], whereas the aim of crossbreeding are better growth, early maturity, adaptability, disease resistant, hardiness, less kid mortality, improved milk production and increasing twinning percentage [10 and 11]. This study aims to characterize the production performance of first generation of Boer x Damascus [crossbred goats] in comparison to their parents' using metrics of nutrient digestibility, rumen fermentation, and some biochemical blood parameters.

Material and Methods

Experimental animals

Fifteen Damascus females and two Boer males were mated to produce a crossbred of Boer X Damascus goats from 2021 to 2022 on the farm belonging to the National Research Centre, Egypt] were used for this study.

Estrus synchronization

The estrus cycle of all Damascus goats was synchronized by twin intramuscular injections of prostaglandin PGF2α [Estromate; Essex Animal Health, Friesoythe, Germany]. An initial dose [0.5 ml/head] was given, which was followed by a second dose 11 days later. Female goats received a single intramuscular injection of 0.5 Ml of Buserelin 48 hours before the second PGF2 injection [Receptal Hoechst-UK Ltd; UK]. According to the breeding group, females in estrus were naturally mating with Boer bucks. After two months of mating, sonar [3.5 MHz-transducer] was used to monitor the pregnant female, as reported in detail by Haibel [12] and Hesselink and Taverne [13]. The females were isolated in the delivery room at the final stages of their pregnancy. After birth, the kids were left with their mothers until weaning [4 months].

Growth trial of crossbred goats

A total of eight each female growing Boer and crossbred goats of Boer X Damascus were used, with an average initial body weight [BW] of 10.47±1.28 Kg. [6 months old] over a period of 180 days. The feeding ration [R1] was calculated according to the requirement of the NRC [14] to be offered as group twice daily at 8.0 a.m. and 4 p.m. (Table 1). Goats were weighed at biweekly intervals and kept under similar environmental conditions in a semi-open system during the experimental period. Feed intake, average daily gain and feed conversion (feed/ gain) were calculated.

Digestibility trial

The digestibility trial was conducted after the growth trial, using the eight adult crossbred goats [aged 12 months] compared to the adult Boer and Damascus goats [aged 1.5–2.0 years, 8 animals each]. The goats were fed a complete feed mixture as a group [R2, Table 1] calculated according to NRC [14]. They were raised in a semi-closed system for 21 days as a primary period in the digestibility trial. Feces Samples were taken from the rectum of three groups for 7 days. The feces samples were mixed and dried for 24 hours at 60°C until chemical analysis. The nutrients digestibility was determined according to Van Keulen and Young [15], in which acid-insoluble ash [AIA] was used as an internal marker. The nutritive value of the experimental ration, given as TDN, was calculated.

Rumen liquor samples were taken by stomach tube at 4 hours post-feeding and filtered through two layers of cheesecloth, and pH values were recorded. Some rumen liquor was used to determine ammonia nitrogen (NH_3-N]. The rest of samples were volatile fatty acids VFA·s concentration. Blood samples were collected using heparinized tubes and were immediately centrifuged at 4000 rpm for 20 minutes. Samples of blood plasma were frozen at -20 °C until analysis.

Analytical methods

The dry matter (DM), organic matter (OM), crude protein CP, crude fiber (CF), and ether extract (EE) were analyzed according to AOAC [16]. The fiber fraction was performed according to Van Soest et al. (17]. A digital pH meter measured the pH value was measured immediately after rumen liquor collection using a digital pH meter. The concentration of ammonia nitrogen (NH_3-N) was determined according to Preston [18] and total volatile fatty acids (VFA·s) were determined according Warner [19]. The blood biochemical parameters of total protein [TP], albumin [Alb], triglycerides (TG), cholesterol

(Chol), high-density lipoprotein (HDL), low-density lipoprotein (LDL), alkaline phosphatase (ALP), Aspartate transaminase (AST) and alanine transaminase (ALT), were determined using commercial kits (Bio diagnostic, Egypt). While, globulin (Glob) was estimated by subtraction (TP- Alb).

Statistical analysis

Collected data of feeding trial were subjected to T-test as two independent samples to compare means of the two animal species at α = 0.05 according to Snedecor and Cochran [20] applying the following mathematical model:

$$t = \frac{M1 - M2}{\sqrt{\frac{S1^2}{N1} + \frac{S2^2}{N2}}}$$

M1= Mean of group 1, M2= Mean of group 2, S1= Standard deviation of group1, S2= Standard deviation of group2, N1= Number of animals in group 1, N2= Number of animals in group 2, T$_{test}$ values were tested for significance on df = 10. All data of digestibility trial was statistically analysis as one-way analysis of variance using SPSS's general linear model technique [21], applying the following model:

$$Yij = \mu + Tj + Eij$$

where μ = general mean, Tj = effect of animal species, Eij = experimental error. Duncan's Multiple Range Test [22] was used to differentiate means at 5% level of probability.

Results

Data of the growing performance of Boer and crossbred kids are presented in Table 2. There were significant differences (P<0.05) between Boer and crossbred goats in initial weight, wherever there were insignificant differences between them in body weight gain and average daily gain. The feed conversion ratio (feed/ gain) value in the Boer goat was better than calculated in crossbred which were 9.11 and 9.43, respectively.

TABLE 1. Chemical composition of rations offered during the growth trail (R1] and digestible (R2] feeding.

Chemical composition, % as DM basis	Experimental rations	
	R1*	R2**
Dry matter	91.38	91.38
Organic matter	93.78	93.48
Crude protein	15.47	13.87
Crude fiber	15.60	15.89
Ether extract	2.90	2.85
Ash	6.22	6.52
Nitrogen free extract	59.81	60.87

*R1; Complete feed mixture consisted of: 45% yellow corn, 17% soybean meal, 15% wheat bran, 20% alfalfa hay, 2% limestone and 1% salt, **R2; Complete feed mixture consisted of: 50% yellow corn, 9% soybean meal, wheat bran 18%, 2% limestone, 1% salt and 20% alfalfa hay.

TABLE 2. Growth Performance of Boer and Crossbred goats (Mean ± SE).

Items	Experimental animals		
	Boer	Crossbred	Sig.
Initial body weight (Kg)	11.75±0.60	9.18±0.55	0.01
Final body weight (Kg)	24.00±0.34	20.75±1.51	NS
Total gain (Kg)	12.25±0.54	11.58±1.38	NS
Average daily gain (g/h/d)	68.06±3.02	64.31±7.68	NS
Daily feed intake (g/h/day)	620.00	606.20	-
Feed conversion ratio	9.11	9.43	-

[a, b] Means in the same row having different superscripts differ significantly at level (P<0.05). NS: non-significant.

No significant difference among groups in NFE digestibility (Table 3). However, the digestibility of all nutrients, cell wall and nutritive value as TDN were not significant between Damascus and Boer goats, except DM and EE (P<0.05), and between Damascus goats and crossbred kids (P>0.05) for all parameters, while they were significantly higher (P<0.05) in Boer goats compared to crossbred goats except (P>0.05) for NFE digestibility.

The values of pH, NH_3-N, and total VFA·s concentrations in the experimental groups are displayed in Table 4. After 4 hrs. post-feeding, rumen pH and NH_3-N concentrations did not differ significantly among the experimental groups. Meanwhile total VFA·s concentration was increased significantly in Boer and crossbred compared to Damascus goats. Table 5. shows the biochemical parameters of the Boer, Damascus goats serum blood and their crossbred, there were no significant differences among experimental goats in TP, Glob, Chol, and HDL blood levels. Blood Alb recorded significantly higher concentrations in Boer and crossbred goats than in Damascus. On the other side, Damascus goats had significantly greater blood concentrations of LDL, ALP, AST, and ALT than those in Boer goats. Meanwhile, there were significant differences between Damascus and crossbred in Alb was lower in Damascus and ALP was higher in Damascus. Meanwhile compared to Boer goats, the blood levels of ALP, and AST were significantly (P< 0.05) higher in crossbred goats. Additionally, there were no significant differences in blood concentration of Alb and LDL between Boer and crossbred goats.

TABLE 3. Nutrients digestibility, cell wall constituents and nutritive values of different experimental goats.

Item	Experimental animals			
	Boer	Damascus	Crossbred	SEM
Nutrients digestibility (%)				
DM	88.02^{a}	84.58^{b}	83.20^{b}	0.618
CP	73.60^{a}	70.32^{ab}	66.31^{b}	1.150
CF	37.19^{a}	34.92^{ab}	33.31^{b}	0.622
EE	65.62^{a}	53.29^{b}	56.00^{b}	1.663
NFE	79.02	77.40	76.20	0.820
Cell wall constituent's digestibility (%)				
NDF	51.89^{a}	48.73^{ab}	46.47^{b}	0.869
ADF	41.07^{a}	39.07^{ab}	37.45^{b}	0.646
Hemicellulose	63.21^{a}	59.36^{ab}	56.41^{b}	1.803
Cellulose	47.26^{a}	44.76^{ab}	43.26^{b}	0.713
Nutritive values (%)				
TDN	68.43^{a}	65.83^{ab}	64.46^{b}	0.756

$^{a, b}$ Means in the same row having different superscripts differ significantly at level (P<0.05). SEM: standard error of mean.

TABLE 4. Rumen pH, ammonia nitrogen (NH_3-N) and total volatile fatty acids (TVFA·s) of the ration (4hr. post feeding) (Mean ±SE).

Item	Experimental animals		
	Boer	Damascus	Crossbred
pH values	6.27±0.12	6.53±0.20	6.4±0.15
NH_3-N (mg/100 ml)	33.20±0.54	30.56±1.13	30.58 ±1.22
TVFA·s (mg/100 ml.)	50.61^{a}±1.23	36.75^{b}±1.51	50.50^{a}±1.50

^{a,b} Means in the same row having different superscripts differ significantly at level (P<0.05).

TABLE 5. Blood biochemical analysis of Boer, Damascus and its crossbred goats (Mean ±SE)

Parameters	Experimental animals		
	Boer	Damascus	Crossbred
Total protein (g/dL)	7.57±0.23	7.01±0.18	7.28± 0.30
Albumin, g/dL)	2.89[a] ±0.09	2.39[b] ± 0.07	3.05 [a] ± 0.05
Globulin (g/dL)	4.68 ± 0.06	4.62 ± 0.06	4.23 ± 0.06
Triglyceride (mg/dL)	44.17[a] ± 0.91	41.99 [ab] ± 0.27	40.54 [b] ± 1.14
Cholesterol (mg/dL)	89.08 ± 2.12	88.06 ± 2.82	89.92 ± 4.01
HDL (mg/dL)	67.55 ± 1.95	61.36 ± 3.15	65.37 ± 5.21
LDL (mg/dL)	12.37[b]± 0.41	14.85 [a] ± 0.89	14.27 [ab] ±0.88
ALP (IU/L)	33.53[c]±0.71	41.92 [a] ± 0.21	35.54 [b] ±0.59
AST (IU/L)	38.65 [b]± 0.21	42.00 [a] ± 0.49	43.54 [a] ± 1.33
ALT (IU/L)	25.61[b] ±1.10	28.08 [a] ± 0.34	26.31 [ab] ± 0.50

[a b and c] Mean in the same row having different superscripts differ significantly at level (P<0.05).

Discussion

As known for meat production, the average daily gain [ADG] of body weight is an important factor for the economic income of farms [23]. The results that were reached in crossbred goats represented in total weight gain, ADG, total feed intake, and FC were very close to Boer goat and these are agree with the values found by Abd-Allah et al. [6] in crossing goats of Boer x Baladi goats [67 g, 652.2 g and 9.73, respectively], in contrast ADG and FC were higher than found in Egyptian Baladi goats which recorded 57 g and 10.06, respectively [24] and this confirms the importance of crossing in goats and its effect on increasing growth and improving feed conversion [25]. The nutrients digestibility of Boer goats found in this study compared to those by Mbatha et al., [26] were in OM digestibility was very close [70.5% vs 70.7) and higher for CP digestibility [73.6 vs. 64.9 %), while were lower in ADF and NDF digestibility (41.07 vs. 65.5 and 51.98 vs 73.2%, respectively). The cell wall can decrease protein digestibility by limiting or preventing the digestive enzymes to access into plant cells [27]. The same results of digestion of NDF and ADL decreasing and CP increasing in this study compared to those reported by Kholif et al. [24] [59.9, 55.9 and 56.7, respectively], this superiority in CP digestibility of Boer goats in this study is may be due to the lower percentage of NDF content (37.50%) in this experimental ration as compared to the 42.6% found by Kholif et al. [28]. Hamchara et al. [29] found that CP in crossbred goats (Thai Native x Anglo Nabian) was 64.95%, which is very close to the results in the current study. In the present study, the digestibility of CP, EE and NDF of crossbred goats were slightly lower than those reported by Maxiselly et al. [30], which were (70.95%, 71.35%, 70.10% and 57.93%, respectively), In comparison, ADF (34.65%) was lower than our values [37.45%]. The value of TDN of experimental rations is a reflection of rates of nutrients digestibility [31]. The variation in digestibility results in the literature may be due to the different components of the rations, the roughage to concentrate ratio, the type of goat, age and environmental conditions. Ruminal pH levels under 6.00 may prohibit cellulolytic bacteria from functioning, and for fiber digestion, bacterial activity prefers a higher pH value [29]. The value of ruminal pH in the present study is more than 6 which is in agreement with Lopes et al. [32], Helmy et al. [33], and Maxiselly et al. [26]. It is known that NH_3- N is one of the main sources for bacteria growth and bacterial protein synthesis [34]. In the present results, the values of NH_3-N ranged from 33.20 to 30.58, which were higher than those obtained by Hamchara et al. [29], Maxiselly et al. [30], and Kholif et al. [28]. Therefore, the results of nutrient digestibility in the present study were higher. In crossbred goats, the current values of total VFA were lower than those found by Hamchara et al. [29], Maxiselly et al. [30] and Helmy et al. [33], which may be due to the different ingredients of the ration and different of roughage to concentrate ratio. There are many factors that affect blood parameters, some of it is genetic and others are non-genetic, age, breed, sex, nutrition, disease, stress, muscle activity, gestation and management systems [35].

All blood parameters of the experimental goats were within the normal range reported by Latimer [36]. Values of TP, Alb, and Glob in the study were very similar to those obtained by Sabar et al. [37], Helmy [33], and Ghoneem and El-Tanany [37]. On the other hand, higher values of TP and lower albumin were found in Damascus goats compared to the data published by Mohammed et al. [39]. High blood TP may be due to a high intake of grains and high temperatures [40]. Also, Chovanova [41] found that total serum protein may be increased to 7.4 g/dl in goats that didn't have any treatment. Moreover, high-temperature results in reduced plasma volume and thus increased protein concentration [42]. ALP plays an important role in transporting phosphate and sugar, which are generated from various tissues such as the liver, intestines, bones and placenta [43]. The concentration of ALP in the three groups of the current study was lower than the normal range in comparison to different species of goats reported by Al-Bulushi et al. [44], Soul et al. [45] and Al-Rukibat et al. [46]. In the current study, ALT values were very near to the data obtained by Radfar [47], on the opposite, albumin was higher and AST was lower than the current study. The higher AST and cholesterol and lower triglyceride concentrations were detected comparable to data of Lashari et al. [48] in Jattal non-pregnant goats (36.57 U/L, 56.86 IU/L and 54.86 mg/dl, respectively), while ALT (26.43 U/L) was very close. The HDL concentration for all groups in this study was higher and LDL was lower than reported by Basmaeil et al. [49]. As known HDL is a lipoprotein that brings cholesterol from tissue to the liver and into bile. LDL is also a lipoprotein that carries cholesterol from the liver to the tissues, which responsible for reducing heart disease [50]. The Chol and HDL values in Boer goats are within the normal range, while LDL and triglyceride in the study are out of the range obtained by Adeyemi et al. [51].

Conclusion

We can be concluded that crossbred goats are close to the growth performance of Boer goats and approximately close to the nutrients digestibility and serum blood parameters of Damascus goat. Further studies are needed to characterize the subsequent crossbred generations of growth performance, digestibility and blood parameters at different stage of age to get an accurate conclusion about the improvement that happened using the crossing.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approve

The Medical Research Ethics Committee at the National Research Centre, Egypt approved the experimental research, in accordance with Egyptian laws, Helsinki Declaration, GCP and GLP guidelines, IACUC guidelines, and WHO rules, granting final ethical approval No. 1481022022.

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Authors contribution

SMA designed the work and assisted in performing the experiments and drafting the manuscript. WMES drafted the original manuscript. SE assisted in performing the experiments, chemical analysis and re-write and revised the manuscript. HAAO analyzed the data, and GA assisted in revising the final manuscript. All authors read and approved the final manuscript.

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دراسة مقارنة بين ماعز البور والدمشقي وهجينهما: الأداء، الهضم، القيم الغذائية وخصائص الدم

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تهجين أنواع مختلفة من الماعز المتخصصة في إنتاج اللحوم أو الحليب يمكن أن ينتج عنه هجين عالي في إنتاج اللحوم والحليب، وذلك لمعالجة النقص في إنتاج اللحوم والحليب للاستهلاك البشري. ركزت هذه الدراسة على المقارنة بين ماعز البور والدمشقي وهجينها من حيث النمو وهضم العناصر الغذائية وتخمر الكرش وبعض تحاليل الدم. تم تغذية ثمانية من كل من ماعز البور والماعز الهجين بعليقة متكاملة (TMR) لتجربة تغذية مدتها 180 يومًا. بعد ذلك، تم تغذية ثمانية ماعز بالغة من كل من البور والدمشقي وهجينهما بعليقة متكاملة، وفقًا لمتطلباتها لتجربة الهضم لمدة ٢١ يومًا. لم يكن هناك فروق ذات دلالة إحصائية في متوسط النمو اليومي بين ماعز البور والماعز الهجين. كان التحويل الغذائي لماعز البور أفضل من الماعز المهجن حيث بلغ ٩,١١ و٩,٤٣ علف/نمو يومي على التوالي. كانت الفروق بين ماعز البور والماعز الدمشقي في جميع العناصر الغذائية وهضم مكونات الجدار الخلوي ضئيلة باستثناء المادة الجافة ومستخلص الأثير. على النقيض من ذلك، كانت الاختلافات بين البور والهجين كبيرة باستثناء قابلية هضم المستخلص الخالي من النيتروجين ($P> 0.05$). لم تكن هناك فروق ذات دلالة إحصائية في هضم العناصر الغذائية بين الماعز الهجين والماعز الدمشقي. ولم تكن درجة الحموضة في الكرش وتركيز نيتروجين الأمونيا معنوية بين المجموعات التجريبية. سجلت ماعز البور والماعز الهجين أعلى نسبة من الأحماض الدهنية الكلية الطيارة مقارنة بماعز الدمشقي. كانت لدى الماعز الدمشقي مستويات عالية من LDL وALT وALP في الدم؛ أدنى المعدلات كانت في ماعز البور، أما الماعز الهجين فكان متوسط قيم TP، وHDL، وLDL، وALP، وALT. نستنتج من ذلك أن الأداء الإنتاجي للماعز الهجين في هذه الدراسة كان قريبا بالماعز الدمشقي.

الكلمات الدالة: الماعز الهجين، النمو اليومي، الهضم، مؤشرات الكرش، مكونات الدم.