



Original article

Goat production system in peri-urban areas of Khartoum state, Sudan

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ABSTRACT

Data was collected from one hundred goats' owners from peri-urban areas in Khartoum state and were used to study the characteristics of dairy goat production. Reproduction traits, diseases prevalence, breeding objectives, feeding, housing and constraints were investigated. Crossbred flocks had the highest flock size, followed by flocks made up of Nubian goats and pure Saanen flocks recorded the lowest herd size. The main reasons for males to exit the flock were sales, slaughter and gifts. The main reasons for females' disposal were sales, death and gifts. 33.0% of owners constructed goat pens using untreated wood, 32.0% of owners used plastic sheets and scrap iron, 19.0% used iron sheets, and 11.0% used mud and a few used bricks and concrete for construction. A Few owners had clear ideas about the long-term aims of their goat enterprise. Most owners suggested improvement of their goats by crossing, while a few suggested improvement by selection and management. The Saanen breed seems to be a suitable dairy breed for crossing purposes in the Sudan.

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1. Introduction

Goat production is a promising business in the Sudan, which has wide ecosystem diversity and different social-economical zones. Dubeuf (2007) revealed that dairy goat systems have an important social impact and they can optionally utilize marginal areas. Tsegaye (2009) stated that the broad genetic variability of African small

ruminant breeds enables them to survive under stressful environmental conditions, including high disease incidence, poor nutrition, and high temperature. He also mentioned that environmental pressure maintains a wide range of genotypes, each adapted to a specific set of circumstances. Goats live as scavengers in the streets of towns and cities requiring minimum care and attention despite the fact that they provide many poor urban and rural families with milk and meat (Balall et al 2008).

Sudan has approximately 30.649.000 head of goats (Ministry of Animal Resource and Fisheries 2011). Behnke and Osman (2012) stated that the North Sudan goats produced 51.1 litres of milk per head and total production about 1,549,979 tons for human consumption. Despite the large size of the country's goat population, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low. This may be due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeds and breeding strategies and poor understanding of the production system as a whole. The present study is designed to identify and describe goat production systems and to determine their production potential in Khartoum state. This will be useful in identifying opportunities and challenges of goat's production in the Sudan.

2. Materials and methods

2.1. Questionnaire methodology

Personal interviews and a questionnaire were conducted to gain insight into the farming systems of goats in peri-urban areas in Khartoum State, namely Khartoum North and Omdurman. The goat owners were selected randomly within the two locations and were asked to complete the questionnaire. A detailed structured questionnaire was prepared and used to collect information from a total of one hundred goat owners in one-visit-interviews. Some of the information collected during interviews was supported by observations. The questionnaires were designed to obtain personal information such as age of respondents, gender and educational background and other data directly related to the research objectives such as general household characteristics, flock structure, flock management and dynamics, breeding practices, disease prevalence, production and reproduction performance, production objectives, and production constraints. Most of goat owners (89.0%) interviewed was male. The majority of interviewees (54.0%) bred crossbred goats, followed by those who bred local Nubian goats (38.0%), and only a few owners raised pure Saneen goats (8.0%). About (85.0% of respondents were formally educated (completed secondary schools or university graduates).

2.2. Statistical analysis

Data were statistically analyzed by using SPSS computer software (Statistical Package for Social Science, version 11.5). Chi-square tests (χ^2 for contingency tables) were performed for comparison between owners of different goat breeds. Analysis of variance and Duncan multiple range tests were carried out as appropriate to assess the statistical significance of various factors affecting milk production and reproduction traits.

3. Results and discussion

3.1. Flock structure and dynamics

Flock structure and number of breeding animals of the different goat breeds is presented in Table 1. The highest flock size was found for crossbred goats, followed by Nubian goats and Saanen goat recorded the lowest herd size. The mature females contributed about 50% of the total number of flock. The results showed insignificant differences in composition among flocks except in the number of males. The overall means for active males and mature females were 0.95 ± 0.11 and 13.39 ± 2.35 respectively. Crossbred goats herds recorded the highest numbers of breeding females and active males (17.33 and 1.26 heads), followed by Nubian goats (9.61 and 0.61 heads), while the Saanen breed had the lowest numbers (4.75 and 0.50 heads) but the differences were not significant ($P > 0.05$).

Numbers of entire males and females were shown in Table 2. The results revealed that the animals bought were the most important factor affecting flock size, followed by exchange and gift of animals. All studied factors had no significant ($P > 0.05$) effect on herd size in the different breeds.

Numbers of animals removed from the flock are presented in Table 3. The main reasons for males to exit the flock were sales, slaughter and gift. The main reasons for females were sales, death and theft. There were no significant ($P>0.05$) differences between breeds in any of the culling reasons.

Table 1
Flock structure of different goat breeds (Mean \pm standard error).

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Flock structure				
Mature female	13.13 ^a \pm 2.13	9.37 ^a \pm 2.06	4.63 ^a \pm 0.93	11.02 \pm 1.41
Doling	3.87 ^a \pm 0.77	2.03 ^a \pm 0.58	1.88 ^a \pm 0.77	3.01 \pm 0.48
Suckling kids	7.22 ^a \pm 1.30	5.53 ^a \pm 1.29	1.88 ^a \pm 0.79	6.15 \pm 0.87
Males	1.50 ^b \pm 0.20	0.76 ^{ab} \pm 0.18	0.50 ^a \pm 0.19	1.14 \pm 0.13
Total	25.67 ^a \pm 3.81	17.68 ^a \pm 3.70	8.88 ^a \pm 2.27	21.29 \pm 2.54
Breeding animals				
Active males	1.26 ^b \pm 0.18	0.61 ^{ab} \pm 0.11	0.50 ^a \pm 0.19	0.95 \pm 0.11
Breeding females	17.33 ^a \pm 4.03	9.61 ^a \pm 2.08	4.75 ^a \pm 0.82	13.39 \pm 2.35

^{a,b} means in the same row with same letters were not significantly ($P<0.05$) different

Table 2
Means and standard errors of the numbers of animals entering the flocks.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Males bought	2.81 \pm 2.22	0.18 \pm 0.18	1.50 \pm 1.23	1.71 \pm 1.21
Males exchange	0.17 \pm 0.09	0.03 \pm 0.05	0.00	0.10 \pm 0.05
Males gift	0.33 \pm 0.19	0.00	0.25 \pm 0.25	0.20 \pm 0.11
Females bought	14.06 \pm 11.21	1.58 \pm 0.90	1.63 \pm 0.87	8.32 \pm 6.071
Females exchange	0.41 \pm 0.32	0.13 \pm 0.13	0.25 \pm 0.25	0.29 \pm 0.18
Females gift	0.07 \pm 0.05	0.00	0.13 \pm 0.13	0.05 \pm 0.03

Table 3
Means and standard errors of numbers of animals removed from the flocks.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Males sold	3.98 \pm 2.24	2.11 \pm 1.34	1.88 \pm 1.23	3.10 \pm 1.31
Males slaughtered	1.33 \pm 0.35	1.45 \pm 0.33	0.63 \pm 0.38	1.32 \pm 0.23
Males exchanged	0.11 \pm 0.06	0.00	0.00	0.06 \pm 0.03
Males dead	0.89 \pm 0.30	0.24 \pm 0.15	0.13 \pm 0.13	0.58 \pm 0.17
Males stolen	0.04 \pm 0.03	0.13 \pm 0.07	0.00	0.07 \pm 0.03
Males gifts	0.70 \pm 0.31	0.39 \pm 0.18	1.00 \pm 0.63	0.61 \pm 0.19
females sold	16.59 \pm 10.86	1.16 \pm 0.68	0.88 \pm 0.64	9.47 \pm 5.89
females slaughtered	0.30 \pm 0.21	0.39 \pm 0.29	0.00	0.31 \pm 0.16
females exchanged	0.37 \pm 0.24	0.05 \pm 0.05	0.00	0.22 \pm 0.13
females dead	1.69 \pm 0.44	1.03 \pm 0.43	0.25 \pm 0.16	1.32 \pm 0.29
females stolen	0.75 \pm 0.40	0.39 \pm 0.19	0.00	0.56 \pm 0.23
female gifts	0.72 \pm 0.28	0.29 \pm 0.17	0.13 \pm 0.13	0.51 \pm 0.16

3.2. Feeding and flock management

Table 4 shows type of feed ingredients used in different flocks of goats. The results indicated that 37.4% of owners fed their animals alfalfa, 24.2% of owners fed their animals Alfalfa and Abu70 (*Sorghum bicolor*) together, and 21.2% fed abu70 only. However, a few of the owners fed their goats Alfalfa and hay together or hay only. The

chi-square test for independence was significant ($\chi^2 = 27.99$; $P < 0.01$) indicating the presence of a correlation between the type of breed and the type of ration fed.

Table 5 shows the fate of male and female kids after weaning. The results revealed that 27.8% of owners disposed of their male kids by sale, while 25.8% disposed of them by slaughtering. Most of Saanen goat owners (62.5%) sold redundant male kids while the highest percentage of Nubian (29.7%) and crossbred goats (28.8%) owners slaughtered and sold their excess male kids. The chi square test for independence was not significant ($\chi^2 = 16.96$; $P > 0.05$). On the other hand; most owners (81.6%) kept their female kids after weaning for breeding. The chi square test for independence was again not significant ($\chi^2 = 5.27$; $P > 0.05$).

Table 6 shows adoption of culling policies and the major reasons for culling. 70.1% of owners had a consistent culling policy, while 29.9% of them did not adopting culling policy. The association between adoption of a culling policy and type of breed raised was not significant ($\chi^2 = 5.23$; $P > 0.05$). According to the majority of owners (36.8%) the most important reason for culling was age while 13.2% of them said that low production was another reason for culling. 27.9% of owners revealed that culling may be due to more than one reason. Also association between reason of culling and type of breed raised was insignificant ($\chi^2 = 15.49$; $P > 0.05$).

Table 4

Type of feed ingredients used in rations in different flocks in Khartoum state.

Feed type	Breed			Total
	Crossbred	Nubian	Saanen	
Abu70*	18.5	27.0	12.5	21.2
Alfalfa	37.0	40.5	25.0	37.4
Alfalfa and abu70	25.9	25.0	0.0	24.2
Hay	0.0	0.0	12.5	1.0
Alfalfa and hay	3.7	12.1	25.0	4.0
Other	14.8	5.4	25.0	12.1

*Sorghum bicolor

Table 5

The fate of male and female kids after weaning.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Males				
Sale	28.8	18.9	62.5	27.8
Slaughter	26.9	29.7	0.0	25.8
Breeding	11.5	21.6	0.0	14.4
Slaughter & breeding	5.8	2.7	0.0	4.1
Sale & breeding	13.5	2.7	0.0	8.2
Sale & slaughter	13.5	24.3	37.5	19.6
Females				
Sale	3.8	5.3	0	4.1
Breeding	75.5	89.5	85.7	81.6
Other	5.7	2.6	0	4.1
Sale & breeding	15.1	2.6	14.3	10.2

3.3. Housing of goats

The materials used in housing construction are presented in Table 7. The results showed that 33.0% of owners constructed goat pens using untreated wood, 19.0% of them used iron sheets and 11.0% used mud. A few goat owners used bricks and concrete for construction. On the other hand, 32% of owners used other materials such as plastic sheet and scrap iron in pens construction. The association between materials used in pen construction and goat breed was insignificant ($\chi^2 = 17.458$; $P > 0.05$).

Table 6

Adoption of culling policy and main culling reasons.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Adoption of culling policy				
Yes	72.2	60.0	100.0	70.1
No	27.8	40.0	0.0	29.9
Culling reasons				
Temperament	2.6	0.0	0.0	1.5
Health	2.6	0.0	0.0	1.5
Body condition	2.6	0.0	0.0	1.5
Production	15.4	4.8	25.0	13.2
Age	25.6	61.9	25.0	36.8
Fertility	7.7	4.8	0.0	5.9
More than one reason	35.9	9.5	37.5	27.9
Other	7.7	19.0	12.5	11.8

Table 7

Materials used in the construction of pens.

Material	Breed			Total
	Crossbred	Nubian	Saanen	
Untreated wood	27.8	47.4	0.0	33.0
Iron sheet	27.8	5.3	25.0	19.0
Bricks	5.6	0.0	12.5	4.0
Mud	11.1	10.5	12.5	11.0
Concrete	1.9	0.0	0.0	1.0
Other	25.9	37.8	50.0	32.0

3.4. Reproduction performance

The means and standard errors of some reproductive traits were shown in Table 8. The overall means of male and female weaning age were found to be 2.61 ± 0.10 and 2.69 ± 0.10 months respectively. However; the male and female sexual maturity age were found to be 7.19 ± 0.21 and 7.32 ± 0.20 months respectively. The average age at first kidding was found to be 13.1 ± 0.20 months. Analysis of variance results revealed that the goat breed had no significant ($P > 0.05$) influence on above studied traits except female sexual maturity. The Saanen goat breed had lower sexual maturity and first kidding age averages in comparison with Nubian and crossbred goats.

Table 9 shows birth type among different goat breeds. About half of goat owners said their animals on average gave single and twin kids and 40.5% of them said their animals on average kidded twins, while a few of them said their animals usually gave single kids. Most of Saanen goat owners revealed that their goats on average gave twins. The chi square test for independence showed insignificant ($\chi^2 = 8.71$; $P > 0.05$) correlation between goat breed and birth type. The most of owners (60.4%) said their female goats kidded twice every year. There was no correlation between breed and number of parities per year ($\chi^2 = 0.49$; $P > 0.05$).

The source of breeding bucks used in flocks is shown in Table 10. About 36.0% of owners used breeding bucks from their flock, followed by those who borrowed bucks (25.0%) and those who bought bucks (23.0%). Some owners used bucks from the AI center or used donated bucks from neighbors. The majority of Saanen owners (62.5%) and 31.5% of crossbred owners bought breeding bucks, while 50.0% of Nubian goat owners used bucks from their flocks. The correlation between goat breed and source of buck used for breeding was not significant ($\chi^2 = 33.58$; $P < 0.01$).

Table 8

Means and standard errors of some reproductive traits of goats (in months).

Traits	Breed			Total
	Crossbred	Nubian	Saenen	
Male weaning age	2.79 ^a ±0.13	2.46 ^a ±0.15	2.19 ^a ±0.30	2.61±0.10
Female weaning age	2.91 ^a ±0.14	2.46 ^a ±0.15	2.38 ^a ±0.28	2.69±0.10
Male sexual maturity	7.32 ^a ±0.28	7.05 ^a ±0.35	6.88 ^a ±0.61	7.19±0.21
Female sexual maturity	7.30 ^a ±0.23	7.66 ^a ±0.37	6.00 ^b ±0.82	7.32±0.20
Age at first kidding	13.18 ^a ±0.29	13.12 ^a ±0.34	12.50 ^a ±0.27	13.1±0.20

^{a,b} means in the same row with same letter were not significantly (P<0.05) different**Table 9**

Birth types and number of parities per year among different goat breeds.

Item	Breed			Total
	Crossbred	Nubian	Saenen	
Birth type				
Singletons	9.3	13.5	0.0	10.1
Twins	35.2	37.8	87.5	40.4
Singles & twins	55.6	48.6	12.5	49.5
No. parities/ year				
Two parities	62.7	59.4	50.00	60.4
One parity	37.3	40.6	50.00	39.6

Table 10

The source of breeding bucks used in flocks.

Source	Breed			Total
	Crossbred	Nubian	Saenen	
From herd	29.6	50.0	12.5	36.0
Bought	31.5	2.6	62.5	23.0
Donation	3.7	0.0	0.0	2.0
Borrowed	14.8	42.1	12.5	25.0
Not specific	3.7	2.6	0.0	3.0
From herd & out herd	11.1	0.0	0.0	6.0
AI centre	5.6	2.6	12.5	5.0

3.5. Health and disease prevalence

Table 11 shows the reasons of kid mortality in different goat breed flocks. About 36.2% of owners said that diarrhoea was an important reason, 17.5% of them mentioned non pathogenic factors such as nutrition or accidents, 13.8% of them said that pneumonia was the major cause of death. A few owners said the main reason was P.P.R, while 12.6% of them said that the main mortality reasons were unknown to them. There was no correlation between breed and major cause of death ($\chi^2 = 6.28$; $P > 0.05$).

Mortality reasons of mature goats among flocks of different breeds were shown in Table 12. 25.0% of owners revealed that diarrhoea was an important reason, followed by those (17.9%) who said that non pathogenic reasons were important, nutritional causes (16.1%) and pneumonia (12.5%). However, 19.6% of owners indicated that the main reason of mortality of mature goats was unknown to them. On the other hand; 50.0% of owners who bred Saenen goats said P.P.R was the most important reason. The correlation between breed and mortality cause was significant ($\chi^2 = 30.71$; $P < 0.01$).

Table 13 shows the importance of mortality among different types of birth. Most of owners (68.8%) said mortality of twins was higher than among singles, while 25.0% of them said there was no difference in mortality rate between single births and twins. The correlation between view regarding mortality and breed was insignificant ($\chi^2 = 4.20$; $P > 0.05$).

Table 14 reflects the ability of owners to control epidemic diseases using vaccination and control of internal and external parasites. 47.4% of owners vaccinated their goats against epidemic diseases, while 52.6% of them did not vaccinate. 87.5% of Saanen goat owners vaccinated their animals while only 38.9% and 47.2 % of crossbreed and Nubian goat owners vaccinated their animals against infectious diseases. The correlation between breed raised and use of vaccination was significant ($\chi^2=6.20$; $P<0.05$). Most owners (76.0%) controlled internal and external parasites. The correlation between breed and control of parasites was not significant ($\chi^2 = 5.09$; $P>0.05$).

Table 11

Reasons of kid mortality among flocks of different goat breeds.

Reasons	Breed			Total
	Crossbred	Nubian	Saanen	
Diarrohea	26.5	52.9	42.9	36.2
Pneumonia	14.7	11.8	14.3	13.8
Dierrohea & pneumonia	11.8	5.9	14.3	10.3
Non pathogenic	17.6	17.6	14.3	17.2
Nutritional	8.8	5.9	14.3	8.6
Unknown	17.6	5.9	0.0	12.1
P.P.R	2.9	0.0	0.0	1.7

Table 12

Reasons of mortality of mature goats among different goat breeds.

Reasons	Breed			Total
	Crossbred	Nubian	Saanen	
Diarrohea	30.0	25.0	0.0	25.0
Pneumonia	13.3	10.0	16.7	12.5
Diarrohea & pneumonia	3.3	5.0	0.0	3.6
Not pathogenic	23.3	15.0	0.0	17.9
Nutritional	10.0	25.0	16.7	16.1
Unknown	20.0	20.0	16.7	19.6
P.P.R	0.0	0.0	50.0	5.4

Table 13

Type of birth with highest mortality.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Single	5.7	8.6	0.0	6.3
Twins	73.6	57.1	87.5	68.8
No difference	20.8	34.3	12.5	25.0

Table 14

Control epidemic disease using vaccination and control of internal and external parasites.

Item	Breed			Total
	Crossbred	Nubian	Saanen	
Vaccination against epidemic diseases				
Yes	47.2	38.9	87.5	47.4
No	52.8	61.1	12.5	52.6
Control of parasites				
Yes	79.6	65.8	100.0	76.0
No	20.4	34.2	0.0	24.0

3.6. Purpose of goat keeping and future plans

Table 15 presents the reasons of keeping different breeds of goats. 56.0% of owners bred goats for milk production, followed by those who raised goats because of low investment cost and ease of management. However; those who kept local Nubian goats for crossing represent only 2.4%. The majority of owners said they bred Saanen goats (85.7%) for milk production and a few of them (14.3%) said that the reason they raised Saanen goats was the low investment cost. The chi-square test for independence was significant ($\chi^2 = 11.74$; $P < 0.05$).

The owners' views regarding future flock plans are presented in Table 16. The results showed that the most owners (61.2%) desired to increase their flock size, followed by those who wanted stability of their flock size. A few owners (2.0% and 5.1 %) desired to withdraw and decrease their flock size gradually. The test for independence was insignificant ($\chi^2 = 10.55$; $P > 0.05$).

Table 17 shows owners plans for flock improvement. More than half of respondents suggested the method they adopted for improving their flock was by crossbreeding; while only 4.0% of them adopted improvement by selection. 18.0% of owners had no plan for flock improvement. On the other hand, 17.0% suggested flock improvement through management. 87.5% of owners who bred Saanen goats suggested genetic improvement by crossbreeding; while only 39.5% owners who bred Nubian goats had a similar view. There was insignificant ($\chi^2 = 16.13$; $P > 0.05$) correlation between the adopted plan for improvement and breed of goat.

Table 15

Reasons for keeping different breeds of goats.

Reasons of keeping goat	Breed			Total
	Crossbred	Nubian	Saanen	
Milk yield	60.8	38.5	85.7	56.0
Meat & Milk	9.8	7.7	0.0	8.3
Business	5.9	3.8	0.0	4.8
Research	5.9	11.5	0.0	7.1
Low investment cost	11.8	23.1	14.3	15.5
Crossing	0.0	7.7	0.0	2.4
Hobby	5.9	7.7	0.0	6.0

Table 16

Views of owners regarding future flock plans.

Plan	Breed			Total
	Crossbred	Nubian	Saanen	
Increase numbers	61.10	55.60	87.50	61.20
Stabilize numbers	13.00	22.20	12.50	16.30
Decrease numbers	9.30	0.00	0.00	5.10
No plans	13.00	22.20	0.00	15.30
Withdraw from business	3.70	0.00	0.00	2.00

Table 17

Owners plans for flock improvement.

Plan	Breed			Total
	Crossbred	Nubian	Saanen	
Crossbreeding	63.0	39.5	87.5	56.0
Selection	5.6	2.6	0.0	4.0
Management	14.8	21.1	12.5	17.0
Extension	5.6	2.6	0.0	4.0
No proposal	9.3	34.2	0.0	18.0
Management & crossbreeding	1.9	0.0	0.0	1.0

The findings suggested the presence of sub-optimal management factors such as lack of vaccination which could be addressed by extension. The strong points in the system were the desire of owners to improve productivity and their awareness of the importance of selection of good stock for breeding. It appears that

significantly increased productivity from goats can be achieved, and is justified primarily by the demand for more animal proteins, and the need for efficiency in the use of the available natural resources.

The following management areas deserve attention:

Housing management: The type of housing needed will vary with the number of goats owned and the convenience preferred. Goat houses in the study area were made of wire, scrap and corrugated iron, thorn bushes, skewer, and wooden poles. Bad roofing was common resulting in accumulation of water and muddy floors, 5% of the pens provided no shelter from the rain. It is necessary to raise the level of nutrition and management to take reasonable advantage of the breeds' genetic potential for milk production. Health care (vaccination and parasite control) is not very common among goat owners. In case of integration of other livestock with goats, care needs to be taken especially in relation to grazing management, prevention and control of internal and external parasites. Wherever the animals are dependent on grazing marginal lands trace elements in salt licks must be provided. Livestock extension services are important to improve management standards and convey research results to breeders. The high percentage of university graduate owners is a promising feature for future improvement. Through experience, many goats' owners have come to understand that the best results are obtained by crossing the best local goat with exotic breeds such as Saanen.

4. Conclusions

More research needs to be done to investigate other areas such as mortality levels, breed maintenance costs/requirements and local goat breed productivity (yield distribution throughout the year and genetic improvement etc).

Despite management constraints the Saanen breed manages to produce much higher milk than the indigenous breed under medium level management conditions and this implies that this breed can provide reasonably adequate milk to the small holder farmers. The Saanen breed seems to be a suitable dairy breed for crossing purposes in the Sudan.

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