Trop Anim Health Prod (2017) 49:1265–1271
DOI 10.1007/s11250-017-1324-6

REGULAR ARTICLES

A survey analysis of indigenous goat production in communal farming systems of Botswana

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Received: 8 December 2016 / Accepted: 30 May 2017 / Published online: 17 June 2017

Abstract A total of 153 communal farmers in four agro-ecological regions of Botswana were interviewed using a structured questionnaire. The aims of the survey were to characterise existing communal goat production systems, evaluate the importance of goats to farmers and identify breeding practices and constraints encountered in goat production in Botswana. Data was collected on socio-economic parameters, general and breeding management practices and major constraints limiting goat production in Botswana. All respondents were small-scale communal farmers with 63% respondents practising mixed crop-livestock farming and 37% keeping livestock as their primary activity. The majority (33%) of respondents were older than 60 years. Over 80% of the farmers kept goats for cash required for tuition, school uniforms and household commodities as well as re-stocking of animals. Most farmers (62%) kept indigenous crossed genotypes. Generally, uncontrolled mating was practised with the majority of farmers (41%) using on-farm reared bucks for more than two years of breeding and communal bucks (36%) as an alternative. The major constraints limiting goat productivity in communal areas included uncontrolled breeding, predators, theft and diseases. Issues raised by farmers should be considered in designing and implementing effective breeding programs for goats to improve their overall productivity and contribution to poverty alleviation in these communities.

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Keywords Botswana · Communal · Production system · Small holders

Introduction

Indigenous goats are important to resource-poor rural farmers as they contribute to food security and poverty alleviation. They are known for their ability to adapt to a variety of climatic conditions and reproduce under low input systems (Lebbie 2004). Indigenous goats represent over 95% of small ruminant populations in Africa of which approximately 90% are owned by rural households (Chiejina and Behnke 2011). Despite this, indigenous goats have often received less attention from researchers, funding institutions, veterinarians and other stakeholders when compared to other livestock species (De Vries 2008), resulting in limited genetic improvement and overall productivity. Some genetic improvement programmes for indigenous goats in tropical countries have collapsed due to the incompatibility of breeding objectives, failure to capture cultural (intangible) values and the prevailing management method of low input production system (Tibbo et al. 2006), such as the dairy development project in Ethiopia where local breeds were crossed with exotic Anglo-Nubian goats to improve milk yield. The crossbreds, however, failed to outperform the indigenous goats under similar management systems (Ayalew et al. 2003).

Botswana has approximately 1.6 million goats (Botswana 2015) that contribute significantly to the livelihoods of rural famers under communal production systems. Communal production systems in Botswana, as in other developing countries, are characterised by low input and productivity levels, lack of infrastructure and no properly defined breeding strategies (Kosgey 2004). The majority of goats in Botswana belong to the indigenous Tswana breed, characterised as multi-

coloured, medium sized goats with long lopping ears, short coarse hair and are often bearded and horned (Nsoso et al. 2004b). Although limited research has been conducted on the breed and production systems, it has been reported to have valuable traits such as tolerance towards diseases, drought and heat (Nsoso et al. 2004b). Evaluation of goat production systems through identification and prioritization of constraints is a prerequisite for planning and improving production. This study aimed to characterise existing goat production systems with regard to breeding practices and constraints encountered in communal goat production in four agro-ecological regions of Botswana.

Materials and methods

A structured questionnaire was used to investigate the production and breeding systems of indigenous goats in Botswana. The questionnaire was a slightly modified version of those designed for the livestock breed survey in Southern Africa (Rowlands et al. 2003).The questionnaire included socio-economic parameters (e.g. sex, age, education level, economic value of goats and production constraints), breeding management and goat production systems of each participant. Participants were asked to rank their major sources of income, reasons for keeping goats, buck selection criteria and major constraints (ranging from1 to 3, where 1 = most important and 3 = least important).Information was obtained through an oral interview for which individual consent was given by the farmers.

Sampling strategy

The country was divided into four regions: Southern region which is mainly hard-veldt, the Central region that is hard-veldt with C*olosphospermun mophane* trees being dominant, the Northwest region which is sandvelt with thick forest, lush green plains and semi-arid shrub savanna trees and the Ghanzi region which is sandveldt with low trees and shrub savanna trees. Random sampling was used to select districts, villages and households that kept goats in each region. In the Northwest and Ghanzi regions only two districts were surveyed per region because of inaccessibility due to poor terrain.The survey was conducted from December 2015 to March 2016.

Statistical analysis

Statistical analyses were performed using Statistical Package for Social Sciences (SPSS 2007). Chi-square tests (χ^2) were used to assess the statistical differences, with $P < 0.05$ as significance level. An index described by Kosgey (2004) was used to calculate rankings and indicated the criterion's relative importance to the household.

Results

A total of 153 households were interviewed in four agro-ecological regions of Botswana namely: Southern (n = 43), Central (n = 54), Northwest (n = 36) and Ghanzi (n = 20). There was no significant ($P > 0.05$) difference in sex of head of households across the regions. The Central and Ghanzi regions had a significantly ($P < 0.05$) higher number of respondents older than 60 and between 46 to 60 years of age, respectively. The most common level of education was primary education in almost all the regions except in the Northwest region where most (42%) respondents had a secondary level of education. The Southern region had significantly more (14%) respondents with tertiary education than the other regions. The majority of respondents in all regions were small-scale communal farmers practising mixed crop-livestock farming (Table 1). The major crops grown included maize, sorghum, millet and cowpea. Cattle, goats, sheep, donkeys and poultry were the major livestock species kept in the study areas. On average, 24.3 ± 1.4 goats were kept per household with bigger average herd sizes of cattle and goats observed in the Ghanzi region (Table 2).

Farmers reported and ranked varying major sources of income amongst the regions, ranging from piece jobs (0.37) in the Southern region to the sale of crops (0.37) in the central region and sale of livestock in the Northwest (0.39) and Ghanzi (0.43) regions. The main reason for keeping goats was as a source of income (mainly used for school fees and school uniforms, household commodities and re-stocking of animals). Goats were also kept as a source of meat for home consumption (highly ranked after cash), especially in the Southern region. Keeping goats for breeding was ranked least by respondents across all regions (Table 3).

Most of the respondents across regions kept crossbred genotypes. Farmers in almost all the regions preferred Boer goat bucks, except in the Central region where indigenous Tswana bucks were preferred, and a significant number of indigenous Tswana goats were kept due to less susceptibility to diseases. In the Ghanzi region, a significant ($P < 0.05$) number of respondents prefer exotic breeds, such as Boer goat and Kalahari Red due to less prevalence of tick infestation in the area. The majority (73%) of households across regions practised uncontrolled mating, with the highest ($P < 0.05$) incidence in the Northwest region. Farmers generally reared their own breeding bucks for 2 to 4 years and alternatively, communal bucks were used (Table 4). Selection criteria for breeding bucks was mostly based on body conformation (0.5) and

Table 1 Socio-economic characteristics of households (%) keeping goats in the four regions of Botswana included in this study

Descriptors	Southern region	Central region	Northwest region	Ghanzi region	Overall total	X^2P value
Gender						
Male	65	50	47	45	53	
Female	34	50	52	55	47	0.29
Age (years)						
≤ 30	12[a]	17[a]	14[a]	0.0[b]	12	
31–45	21[a]	26[a]	31[a]	45[a]	28	
46–60	33[a]	13[c]	33[a]	40[b]	27	0.03
over 60	35[a]	44[b]	22[a]	15[a]	33	
Education						
None	16[a]	28[a]	22[a]	35[a]	24	
Primary	49[a]	43[a]	36[a]	40[a]	42	
Secondary	21[a]	28[a]	42[b]	25[a]	29	0.04
Tertiary	14[b]	2[a]	0[a]	0[a]	5	
Production system						
Livestock only	42[b]	15[a]	3[c]	20[a]	20	
Crop-Livestock	58[b]	85[a]	97[c]	80[a]	80	0.00

[abc] Frequencies of households within a row with different superscript are significant different ($P < 0.05$)

body size (0.3) other than performance history (0.1), availability (0.0) and colour (0.1) (Table 5).

The major constraints limiting goat production are shown in Fig. 1. Predation (0.28) was highly ranked by participants as one of the main constraint affecting goat production in Botswana. Stock theft (0.24), diseases (0.23) and drought (0.13) were other major constraints reported by farmers across the regions.

Discussion

The design of sustainable genetic improvement programmes requires an understanding of the production systems and constraints affecting them. Demographic characteristics of the current study have shown reasonably good participation of women in goat production, which indicates an increase in female economic autonomy and bargaining power within the households (Dossa et al. 2008). Most of the households attained relatively low levels of education which could have an impact on production methods, management ability, record keeping and accessing of market information (Kosgey et al. 2006). Training of farmers will therefore empower them and enhance the potential success of breeding programs which depend profoundly on record keeping (Kosgey and Okeyo 2007).

The low participation of youth observed in this study was also reported by Nsoso et al. (2004a) in a survey on goat production in the Kweneng district of Botswana. The youth generally perceive agriculture as a non-viable sector of employment (FAO 2012) and are discouraged by constraints such as limited capital, land, water, access to markets and inadequate involvement in policy dialogue (FAO 2014).This is unfortunate as they are the future generation of farmers that should ensure the future of the industry. As a way of encouraging youth participation in farming, the Botswana government grants loans of 5% interest with 24 months grace period as start-up capital to youth (18 to 40 years) for any agricultural

Table 2 Average number of livestock kept per household in the four surveyed regions of Botswana

Species	Southern Mean ± SE	Central Mean ± SE	Northwest Mean ± SE	Ghanzi Mean ± SE	Overall Mean ± SE
Goats	22.5 ± 2.4	22.3 ± 1.9	25.5 ± 3.7	31.0 ± 4.6	24.3 ± 1.4
Cattle	5.2 ± 1.6[a]	4.0 ± 1.1[a]	11.5 ± 3.3[ab]	18.8 ± 6.1[b]	8.0 ± 1.3
Sheep	4.2 ± 1.3	2.9 ± 1.3	0.2 ± 0.2	3.3 ± 3.3	2.7 ± 0.7
Chicken	7.6 ± 1.6	6.5 ± 1.0	4.2 ± 1.1	6.0 ± 1.1	6.2 ± 0.7
Donkeys	0.2 ± 0.1[a]	2.0 ± 0.5[b]	0.7 ± 0.3[a]	1.3 ± 0.4[ab]	1.1 ± 0.2

SE standard error

[a, b] Means on the same row with different superscripts are significantly different ($P < 0.05$)

Table 3 Frequency (%) of source of income, reasons for keeping goats and the ranking of these descriptors as described by respondents in four surveyed regions of Botswana

Descriptors	Southern region	Rank index	Central region	Rank index	Northwest region	Rank index	Ghanzi region	Rank index
Source of Income								
Livestock Product	30	0.22	41	0.19	86	0.39	75	0.43
Crops	16	0.13	66	0.37	61	0.34	40	0.20
Piece Jobs	49	0.37	46	0.27	39	0.17	45	0.23
Salary/wages	33	0.28	32	0.18	20	0.10	20	0.14
Purpose								
Cash	77	0.33	81	0.30	89	0.34	90	0.40
Meat	81	0.34	57	0.20	39	0.20	55	0.23
Milk	61	0.23	53	0.18	25	0.08	30	0.08
Insurance	12	0.04	51	0.17	69	0.26	40	0.16
Investment	5	0.01	11	0.06	17	0.05	25	0.10
Culture	7	0.02	9	0.03	11	0.04	5	0.02
Ceremony	7	0.02	6	0.02	8	0.03	5	0.02
Breeding	2	0.00	8	0.03	6	0.01	0	0.00

Multiple answers were possible, thus frequency (%) will add to more than 100

Table 4 Frequency (%) of breed kept, mating system, source of buck and duration of buck for breeding in the four surveyed regions of Botswana

Descriptors	Southern region	Central region	Northwest region	Ghanzi region	Overall Total	X^2 *P* value
Breed kept						0.00
Indigenous	16^a	39^b	31^a	10^a	27	
Pure exotic	2^a	4^a	17^b	40^c	11	
Indigenous*exotic crosses	81^b	57^a	53^a	50^a	62	
Mating						0.01
Uncontrolled	56^b	76^a	89^c	70^a	73	
Group mating	5^a	0^a	0^a	10^b	3	
Controlled	40^c	24^a	11^b	20^a	25	
Source of buck						0.78
Borrowed	7	4	3	10	5	
Hired	7	4	3	0	4	
Bought	16	11	8	20	13	
Own flock	40	41	41	45	41	
Communal area buck	30	41	41	25	36	
Other	0	0	3	0	1	
Breeding buck						0.18
Boer	48	36	43	57	44	
Tswana	16	45	29	7	27	
Boer x Tswana	36	16	24	29	25	
Kalahari x Tswana	0	3	0	7	2	
Saanen	0	0	5	0	1	
Years of buck for breeding						0.28
1–2 years	32	18	10	21	21	
2–4 years	36	39	62	29	42	
≥ 5 years	32	42	29	50	33	

[abc] Frequencies of mating system within a row with different superscript are significant different ($P < 0.05$)

Table 5 Ranking of selection criteria of buck as reported by households (%) in the four surveyed regions of Botswana

Reasons for choice of Buck	Southern region	Rank Index	Central region	Rank Index	Northwest region	Rank Index	Ghanzi region	Rank Index
Body conformation	58	0.5	56	0.5	47	0.5	70	0.4
Body size	56	0.3	50	0.3	42	0.3	70	0.3
Colour	19	0.1	19	0.2	25	0.2	10	0.1
Performance	19	0.1	4	0.0	11	0.0	15	0.1
Availability	9	0.0	4	0.0	8	0.0	10	0.1

Multiple answers were possible, thus frequency (%) will add to more than 100

project (FANRPAN 2007). However, most of these projects collapse as soon as government support is withdrawn probably due to lack of marketing opportunities and inappropriate breeding objectives.

Most respondents in all regions were not formally employed and depended on a mixed crop and livestock production system for financial income and household food security. This dependency of rural livelihoods on crop and livestock production is a common phenomenon in developing countries and is also seen as an opportunity for efficient use of resources (Kosgey and Okeyo 2007). The overall flock sizes were similar to those reported by Dube (2015) in the Eastern Cape (South Africa) but inconsistent with Homann et al. (2007) who reported lower flock size of 8 per household in Zimbabwe. The large flock sizes and record keeping are important for development of breeding programs especially for selection intensity and genetic gain (Shumbusho et al. 2013). However, lack of sustainable performance recording in livestock has been a problem in most developing countries (Kosgey et al. 2006).

Variation of source of income across the regions was influenced by several factors such as climate, soil conditions and proximity to the urban areas. For instance, in the Ghanzi and Northwest regions, major source of income was influenced by poor crop production due to restricted climatic conditions. In these regions, livestock production may present a viable alternative. The good soil and moderate climatic conditions in the Central region (Mogotsi et al. 2013) supports the high frequency of crop production as a source of income. The respondents in the Southern region preferred piece jobs in urban or peri-urban areas for day-to-day cash flow. In all regions, goats were kept and used as an additional source of food and potential income. The results indicate the multiple needs of the family, dependant on crops and livestock, especially goats, for maintaining their livelihoods. The importance of goats to the households clearly requires a strategy for genetic improvement and sustainable utilization.

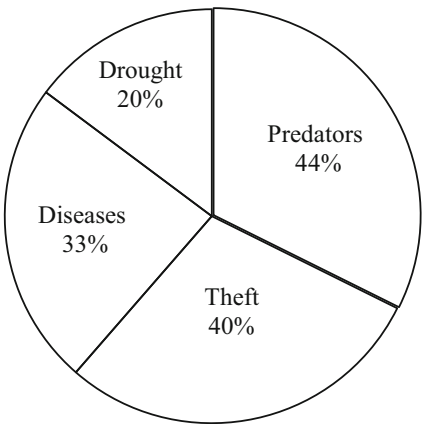

Fig. 1 The major constraints limiting goat production in the four surveyed regions of Botswana

The observed high frequency of households keeping crossbreds is in contrast with the findings of Kosgey et al. (2008) where famers in Kenya predominantly kept indigenous goats. The initial purpose of crossbreeding was to improve the growth of indigenous Tswana goats in order to obtain higher revenues. However, this was performed indiscriminately without the desired improvement in goat performance or farmers' livelihoods. Similarly, selection criteria for bucks were mostly based on growth traits that will ultimately increase income. The desire for larger animals has also been expressed in pastoralists' flocks in Kenya (Kosgey et al. 2008). The constitution of adaptive and growth traits will be important in designing breeding programs for goat production in communal areas of Botswana.

The observed uncontrolled random mating across the regions in this study was due to unfenced communal grazing lands, an insufficient number of breeding bucks and a lack of skills and understanding of the adverse effect of inbreeding. Similar practises have been reported by Gwaze et al. (2009) and Kosgey et al. (2008).Uncontrolled mating leads to an absence of fixed kidding seasons and inbreeding (Jimmy et al. 2010). Parturition throughout the year requires high levels of managerial skills, such as timing of dosing and weaning, which is generally lacking in communal production systems. Inbreeding is exacerbated by small flock sizes, a

lack of animal recording and the long periods that bucks stay in the flocks before they are culled. Subsequent inbreeding depression leads to decreased fitness (e.g. low reproduction rates and high mortality) as well as small body sizes and poor growth rates (Jimmy et al. 2010).

Communal fields were not fenced and goats were not herded which predisposed them to predators and theft, which is consistent with constraints reported elsewhere in Africa (Gwaze et al. 2009; Fikru and Gebeyew 2015). Infectious diseases and parasites were also a serious constraint to communal goat production in this study. This is an endemic situation in many regions of Southern Africa (Githiori et al. 2006; Gwaze et al. 2009), where livestock are usually reared extensively, and it is difficult to implement control measures. Low management levels such as drinking dirty water from rivers and poor housing also predisposes animals to diseases (Peacock 2005). Most animals in this study were kept in a kraal with piled up manure and little protection against extreme weather conditions. Although indigenous goat breeds exhibit higher tolerance to local diseases and gastrointestinal parasite infestation (Bishop and Morris 2007), veterinary management remains imperative to improve overall productivity and animal welfare.

The revealed challenges are essential in genetic improvement and development of sustainable breeding programs. There is neither a systematic goat breeding program nor a goat breeding policy in Botswana. An improvement program launched by the Botswana government aims to place goats with rural households to improve food security and general livelihoods (MoA 2006).The success of this program will depend on adequate knowledge transfer and proper breeding objectives at national and regional level with relevant stakeholders to improve goat productivity. The above mentioned constraints can be mitigated by designing a community breeding program suitable for traditional low input livestock production systems.

Goats contribute significantly to the livelihoods of smallholders and are kept in mixed crop-livestock systems in the communal areas of Botswana. Several constraints hinder goat productivity in Botswana and these should be considered when designing and implementing genetic improvement programmes. It is paramount to look at the production system holistically and involve all stakeholders in designing and implementing effective breeding programmes. This will assist in using scarce resources efficiently and designing appropriate technologies which are compatible with the production system.

Acknowledgements The authors wish to acknowledge the farmers in the four regions of Botswana for participating in the study. The Botswana University of Agriculture and Natural Resources (BUAN) and Organization for Women in Science for the Developing World (OSWD) supported the project financially.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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