

AFRICAN SHEEP KEEPER'S BREEDING PRACTICES, BREEDING OBJECTIVES AND SELECTION CRITERIA: A SYSTEMATIC REVIEW

PHALADI, A. M. – TYASI, T. L.* – TADA, O.

School of Agricultural and Environmental Sciences, Department of Agricultural Economics and Animal Production, University of Limpopo, Private Bag X1106, Sovenga, Limpopo 0727, South Africa

**Corresponding author
e-mail: louis.tyasi@ul.ac.za*

(Received 30th Oct 2023; accepted 9th Feb 2024)

Abstract. The objective of the current study was to systematically review published literature on breeding practices, breeding objectives, and selection criteria of African sheep keepers. Databases such as Google Scholar, PubMed, ScienceDirect, and Web of Science were evaluated systematically. A total of 26 eligible studies were found published between 2001 and 2023 in Ethiopia, Kenya, Gambia, Nigeria, Burkina Faso, Mali, Somaliland and Botswana. The results showed that from the 26 eligible articles, 6 articles revealed that mating was predominantly uncontrolled and no to few reports of controlled breeding in African sheep keepers were found. Whilst, 8 articles, revealed that a higher proportion of African sheep keepers got their breeding ram from their own flock. The results also revealed that from 13 articles, the main reasons for keeping sheep were mainly for meat, income, and savings. And consequently, 8 articles from the results on selection criteria revealed that appearance/size, coat color, and lambing interval were important criteria for breeding ewe while appearance/size, coat color, and tail size were important selection criteria for breeding ram. This systematic review concluded that uncontrolled mating and selection of breeding ram from own flock was a common breeding practice among African sheep keepers with limited focus on castration.

Keywords: *community-based breeding program, mating, meat, body size, sheep*

Introduction

In developing countries, sheep play a vital role by providing valuable contributions through income generation, direct food sources, non-food utilities, and various social privileges (Getachew et al., 2010; Mekuriaw et al., 2012; Dagnew et al., 2017; Hamadou et al., 2019). Particularly when crop farming is less reliable, due to drought or other factors, sheep are then commonly used to mitigate these adverse effects (Abebe et al., 2020). According to a study conducted in Ethiopia by Kenfo et al. (2018), in 2009 the official estimate of the livestock contribution to agricultural GDP was slightly more than 32 billion Ethiopia birr or \$3.2 billion US dollars, with sheep having had a contribution. In comparison to large ruminants such as cattle, sheep are highly prolific, have shorter generation intervals, and generally require low capital investment (Gizaw et al., 2008). African countries are endowed with a wide variety of sheep breeds that have evolved to adapt to the prevailing harsh environmental conditions (Kosgey, 2008). However, in this study, 25 sheep breeds were used. Despite the presence of a large number of these sheep breeds, populations and their diverse functions, the average productivity across the African sheep breeds is generally low (Abebe et al., 2020; Yakubu et al., 2020). The cause for low productivity is mainly multilaterally, but largely related to the lack of knowledge in terms of breeding practices, breeding objectives, and selection criteria (Abebe et al., 2020).

Several studies (Kosgey, 2004; Dossa et al., 2015; Kefale et al., 2017) showed that the productivity of indigenous sheep could also be enhanced by genetic improvement through selection. According to Kosgey (2004) when selecting the most desirable breed or breed combination, one needs to start by defining the breeding objectives of the farmers. Even though there are studies that have discussed breeding practices, breeding objectives, and selection criteria, based on our knowledge, there is no systematic review of breeding practices, breeding objectives, and selection criteria in African sheep keepers. Hence, the objective of the study was to systematically review the literature published on breeding practices, breeding objectives, and selection criteria of African sheep keepers. Therefore, systematically reviewing the research outcome will allow the provision of useful information that will assist farmers in increasing their sheep productivity through providing a documented study that will be used as a point of reference for the design and implementation of a community-based breeding programme.

Materials and methods

Eligibility criteria

Before deciding to conduct the study, a preliminary search of the PEO components on Google Scholar was conducted. Identification of the Population, Exposure, and Outcomes (PEO) components of the research questions was performed for this systematic review as described by Bettany-Saltikov (2010). The “African sheep farmers” was defined as the population of the study, with the “Community-Based Breeding Programme” as exposure and “Breeding objectives, Breeding practices, and Selection criteria” as outcomes. The study discussed breeding objectives such as meat, saving and insurance, breeding, wealth/personal fulfilment, ceremony, dowry payment, cultural rites, income, milk, hides/skins, manure, and wool/hair. Breeding practices such as mating system, age of castration (months), average years of using a breeding ram and source of breeding ram were discussed. Selection criteria in breeding rams such as appearance/size, coat color, mating ability, tail shape, ear size, sexual maturity, body size, competitive performance, true to breed, and genotype furthermore, selection criteria in breeding ewes, such as appearance/size, coat color, age at first lambing, twinning rate/ability, body size, tail type, sexual maturity, pedigree information, litter size, genotype, and lamb growth were also discussed. Kenfo et al. (2018), recommend that the introduction of a carefully planned and pertinent genetic improvement strategy through the involvement of the community is likely to have good chance of success as thus discussing the selection criteria of breeding sheep and the breeding practices of the African sheep keepers can help to improve the performance and production of the animals and the farm. Another study by FAO (2013) indicated that identifying the sheep keeper's objective may not only allow small breeds to survive but they may also thrive.

Search strategy

Two investigators (Abigail Mmapaseka Phaladi and Thobela Louis Tyasi) independently performed a scientific publication search on databases such as Google Scholar, PubMed, Science Direct and Web of Science up to the 20th of February 2023, using the combination of the following key terms: “African sheep farmers”, “Breeding objectives”, “Breeding practices” and “Selection criteria”. The keywords were combined in various combinations. Results were limited to English language papers only.

Inclusion criteria

All retrieved articles were screened for eligible studies according to several standards and were considered eligible if they met the following criteria: breeding practices, breeding objectives and selection criteria in the context of African sheep farmers.

Exclusion criteria

The exclusion criteria of the current study contained: (1) duplicate records (2) records irrelevant to African sheep farmers and breeding practices (3) investigators with no available original data such as sample size of the respondents in the publications with authors failing to be contacted, and (4) studies which were in the form of an abstract without the full text of the article.

Data extraction

Two sets of data were extracted independently by Abigail Mmapaseka Phaladi and Thobela Louis Tyasi for the current study, and a consensus was reached concerning all items. The information obtained from each article consisted of the first author, year of publication, number of sheep farmers used, country and sheep breed of interest for a community-based breeding program.

Ethical considerations

Plagiarism, misconduct, informed consent, data falsification, and fabrication were considered ethical issues by all authors when performing this systematic review.

Results

Searched results

A total of hundred and forty-four ($n = 144$) articles were retrieved through a publication search. About eleven ($n = 11$) of these articles were duplicates that were removed. As a result, a total of hundred and thirty-three ($n = 133$) articles were considered appropriate for the selection of title and abstract. Fifty-five ($n = 55$) articles were removed after a review of the title and abstract, and another fifty-two ($n = 52$) articles were eliminated after a review of the full text. Finally, a total of twenty-four ($n = 26$) full-text articles qualified for inclusion in the study as they met the requirements via screening for eligibility criteria, inclusion criteria and exclusion criteria to be included in the study. *Figure 1* represents the flowchart of the identification and selection of studies for systematic review.

Characterization of included studies

The twenty-four ($n = 26$) articles identified as meeting the criteria were appraised and considered suitable for inclusion as shown in *Table 1*. The included studies were conducted by different authors; however, two ($n = 2$) articles were done by the same authors in different years (Duguma et al., 2010, 2011; Getachew et al., 2010, 2011) and upon examination of the data it was found to be two different analyses done in the same country with the study methodology, but different sheep breeds in different study areas of one country (Ethiopia). The general number of respondents in the form of herders,

households, and farmers, mainly range from as low as 19 to as high as 608. The papers predominantly assessed indigenous sheep breed in the context of African sheep keepers, with majority ($n = 5$) of the studies focusing on the Menz, Bonga, Horro and Wollo sheep breed which are indigenous sheep that are mainly found in Ethiopia. Followed by the Djallonke sheep ($n = 4$) mainly found in west, south and central Africa. From the included studies, three ($n = 3$) articles had undefined sheep breed where it was said “local sheep or indigenous sheep or sheep” and not fully named down to the breed type.

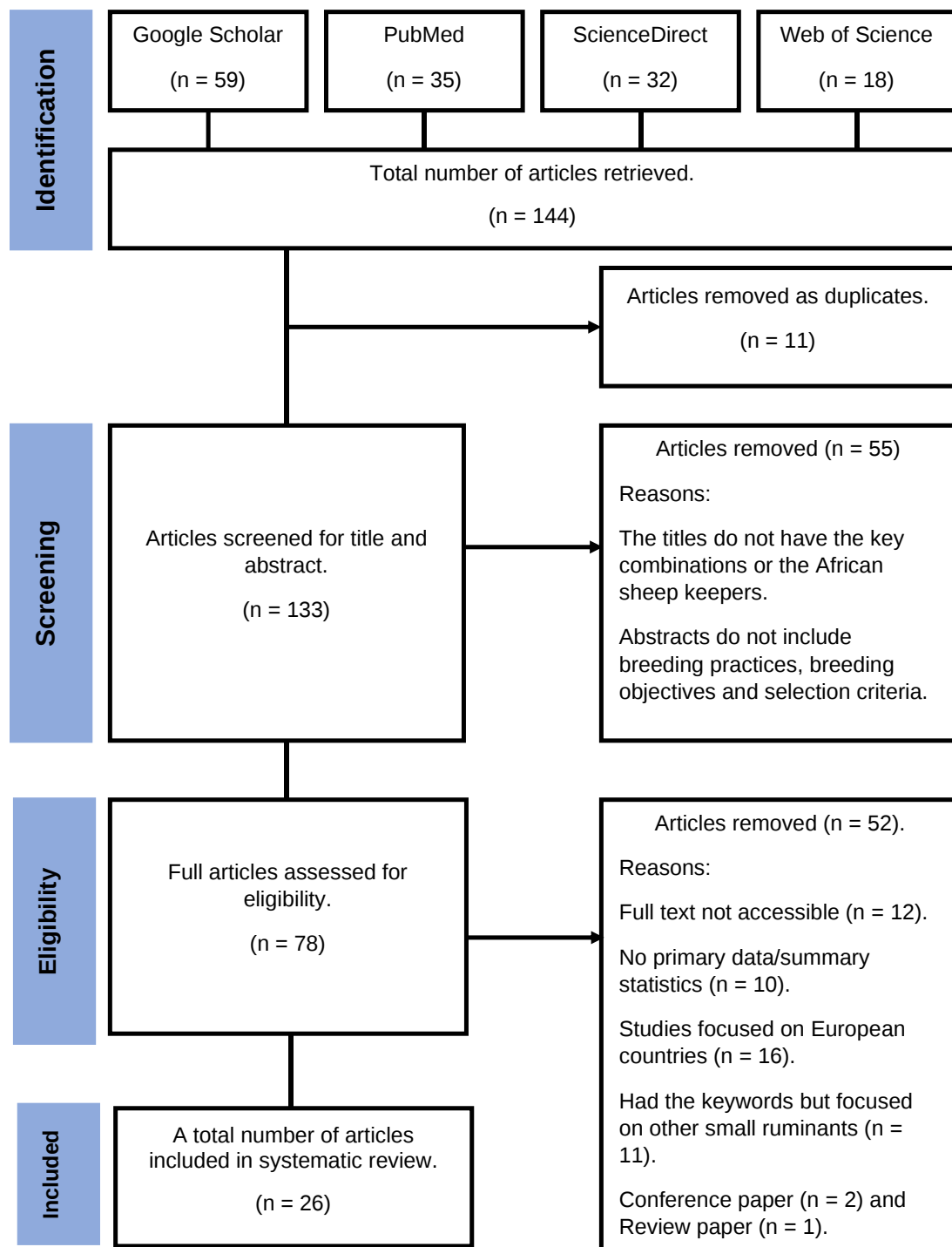


Figure 1. Flowchart of identification and selection of studies for systematic review

Table 1. *Characterization of included studies*

Authors	Year	Country	Number of sheep used	Sheep breed
Jainter et al.	2001	Gambia	608	Djallonke sheep
Kosgey et al.	2004	Kenya	562	Red Maasai sheep
Getachew et al.	2010	Ethiopia	228	Ethiopian menz and afar sheep
Gizaw et al.	2010	Ethiopia	161	Menz and Wollo sheep
Mbuku et al.	2010	Kenya	30	East African black-headed Persian sheep and blackhead Somali (Blackhead Persian) sheep
Duguma et al.	2010	Ethiopia	480	Afar, Bonga, horro and menz sheep
Duguma et al.	2011	Ethiopia	60	Afar, bonga, horro and menz sheep
Getachew et al.	2011	Ethiopia	60	Washera sheep
Haile et al.	2011	Ethiopia	500	Horro sheep
Hamadou et al.	2011	Nigeria	168	Koundoum sheep
Ejlertsen et al.	2012	Gambia	198	Djallonke sheep
Garcia	2013	Gambia Senegal	412	Djallonke sheep
Abera et al.	2014	Ethiopia	300	Indigenous sheep
Dossa et al.	2015	Nigeria Burkina Faso Mali	301	Yankasa sheep Djallonke sheep
Zonabed et al.	2016	Ethiopia	19	Red Maasai sheep
Marshall et al.	2016	Somali	506	Blackhead Somali sheep
Tindano et al.	2017	Burkina Faso	137	Fulani sheep breed Moosi sheep breed
Kefale et al.	2017	Ethiopia	180	Holla sheep
Amare et al.	2018	Ethiopia	135	Wollo highlands sheep
Kenfo et al.	2018	Ethiopia	128	Sheep
Abebe et al.	2020	Ethiopia	370	Farta sheep breed
Yakubu et al.	2020	Nigeria	120	Yankasa sheep Uda Balami and West African Dwarf sheep
Bolowe et al.	2022	Botswana	105	Indigenous Tswana sheep
Tezera and Engidashet	2022	Ethiopia	180	Indigenous sheep
Hemacha et al.	2022	Ethiopia	180	Local sheep

Publication by year

A line graph of the number of articles published and the number of years is presented in *Figure 2*. Out of 26 collected articles following the PRISMA guidelines, it was discovered that the highest number of articles ($n = 5$) were published in 2010, followed by ($n = 4$) in 2011, and followed by ($n = 3$) in 2020 and 2022. Furthermore, only two ($n = 2$) articles were published in 2016, 2017 and 2018. Only one ($n = 1$) article was published in the following years: 2001, 2004, 2012, 2013, 2014, 2015.

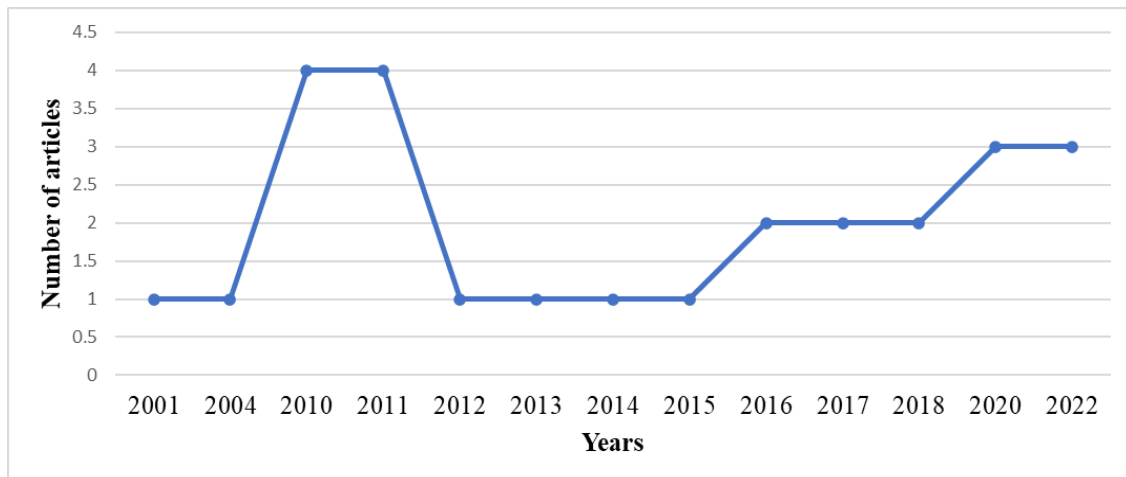


Figure 2. Distribution of articles by year

Publication by country

The map showing the number of articles and the countries in which the studies were conducted is presented in *Figure 3*. It was found that 8 African countries were used to compile the 26 articles used in this systematic review. Out of eight ($n = 8$) countries, four ($n = 4$) are the countries from the Eastern part of Africa namely: Ethiopia, Mali, Somaliland and Kenya. Four ($n = 4$) are from the western part of Africa, namely Burkina Faso, Nigeria, Gambia and Senegal. From the 26 collected studies, Botswana was the only country from the southern part of Africa. However, the countries from western part of Africa had majority of the articles ($n = 18$), while countries from eastern part of Africa had ($n = 7$) and seemingly, there was only one ($n = 1$) from the southern part of Africa.

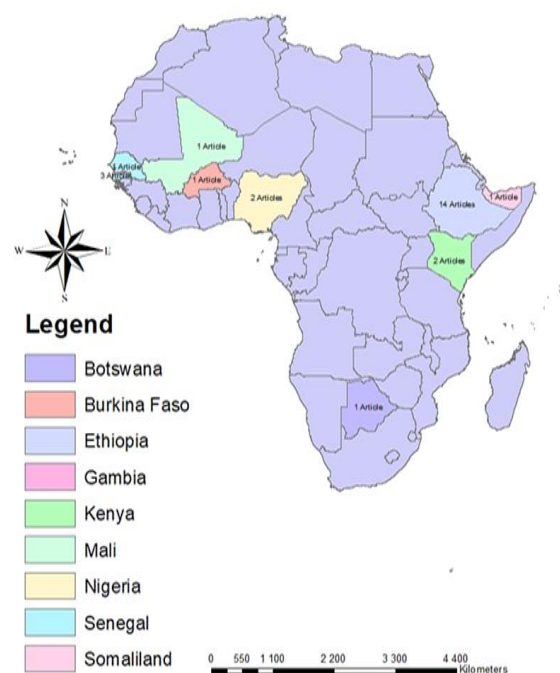


Figure 3. Distribution of articles by country

Socioeconomic characteristics of sheep keepers

The socioeconomic characteristics of sheep keepers are presented in *Table 2*. Out of 26 collected articles, it was found that 7 articles discussed the socioeconomic characteristics of the African sheep keepers. All the seven (n = 7) reviewed articles on socioeconomic characteristics of sheep keepers used frequencies and means for data analysis. Socioeconomic characteristics such as sex, educational level, age, and average flock size were documented. Most of the interviewed individuals were male headed, while one article, had no female respondents. From a total of 7 articles, 5 (85.71%) articles showed that majority of the interviewed sheep farmers had primary school education as their highest education level. While 1 (14.29%) study had the inclusion of koranic school as an educational level. 3 out of 7 (42.86%) studies, showed the ages of the African sheep keepers, with the least number of African sheep keepers at the age of < 25 and > 70.3 years old. Lastly, 3 out of 7 (42.86%) articles had the average flock size, with a minimum range of 10.21 to a maximum range of 45.89 sheep.

Table 2. Socioeconomic characteristics of sheep keepers

Citation	Sex	Education level	Age	Average flock size
Abera et al., 2014	Male = 220 Female = 80	Primary school = 143 Secondary school = 56 Illiterate = 101	< 30 = 31 31-50 = 113 51-70 = 129 > 70 = 27	-
Abebe et al., 2020	Male = 353 Female = 17	Primary school = 108 Read and write = 121 Secondary school = 43 Illiterate = 98	-	10.21
Aguiar et al., 2020	Male = 76 Female = 46	Read and write = 115 Illiterate = 7	-	45.89
Kefale et al., 2017	Male = 128 Female = 52	Primary school = 32 Read and write = 75 Illiterate = 73	< 25 = 1 26-35 = 26 36-45 = 85 46-56 = 46 > 56 = 22	11.52
Kenfo et al., 2018	Male = 64	Primary = 43 Read and write = 29 Secondary school = 23 Illiterate = 33	< 31 = 18 31-40 = 55 41-50 = 35 51-60 = 16 61-70 = 3 > 70 = 1	-
Yakubu et al., 2020	Male = 89 Female = 31	Primary school = 14 Secondary school = 32 Illiterate = 23 Tertiary = 52	-	-
Tindano et al., 2017	Male = 92 Female = 8	Koranic school = 31 Primary school = 26 Secondary school = 12 No instruction = 18 Tertiary = 12	-	-

Purpose of keeping sheep

The reasons of keeping sheep are presented in *Figure 4*. Out of 26 collected articles, it was found that 13 articles discussed the purpose of keeping sheep. All the thirteen (n = 13) reviewed articles on purpose of keeping sheep used frequency and means for data analysis. Purpose such as meat, saving and insurance, breeding, wealth/personal fulfilment, ceremony, dowry payment, cultural rites, income, milk, hides/skins, manure, and wool/hair

were documented as purpose of keeping sheep. From the number of articles, the three leading reasons for keeping sheep among African sheep farmers were income (13, 100%), meat (12, 92.31%), and savings/insurance (11, 84.62%). It was further noticed that the least reasons for keeping sheep supported by several articles found were breeding with 2 (15.39%) articles and transport with 2 (15.39%) articles, respectively.

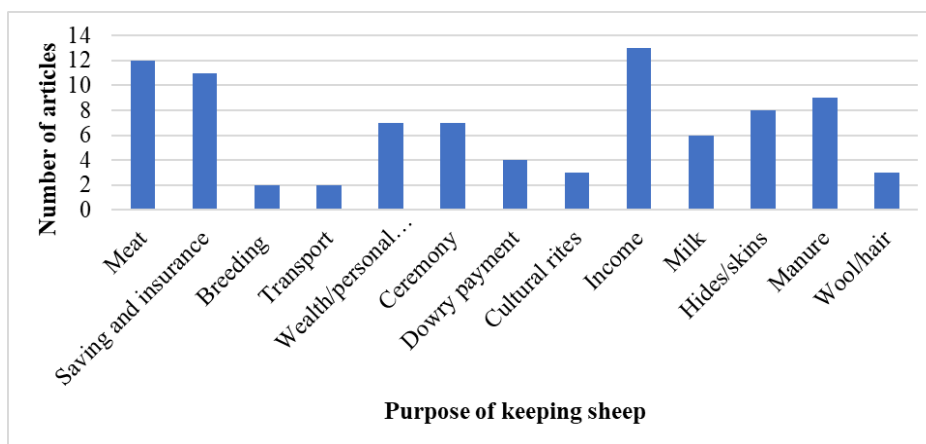


Figure 4. Purpose of keeping sheep

Breeding practices of African sheep keepers

The breeding practices of African sheep keepers are presented in *Table 3*. Out of 26 collected articles, it was discovered that 8 articles discussed the breeding practices of African sheep keepers. All the eight ($n = 8$) reviewed articles on breeding practices of African sheep keepers used frequencies and means for data analysis. The breeding practices such as mating system, age of castration (months) and average years of using a breeding ram were documented. In this systematic review, uncontrolled mating was a predominant common practice. From the 8 articles, 5 articles (62.5%) found that castration was done at a minimum month of 3.6 and a maximum of 30.72. 3 out of 8 (37.5%) articles found out that the average years of using a breeding ram was at a minimum of 1.5 to a maximum of 3.5 years.

Table 3. Breeding practices of African sheep keepers

Citation	Mating system		Age of castration (months)	Average years of using a breeding ram
	Uncontrolled	Controlled		
Abera et al., 2014	Yes	No	-	1.5 to 3.5
Abebe et al., 2020	Yes	No	-	2.2
Bolowe et al.,2022	Yes	No	3.6 to 12	-
Getachew et al., 2010	Yes	No	18 and 20.4	1.9 and 3.5
Getachew et al., 2011	-	-	9.2	-
Hemacha et al., 2023	Yes	No	Below 12 and above 12	-
Amare et al., 2018	No	Yes	-	-
Tezera and Engidashet, 2022	Yes	No	9.2 17.8 30.72	-

Source of breeding ram

The source of breeding ram is presented in *Table 4*. Out of 26 collected articles, it was found that 9 articles discussed the source of breeding ram. All the nine (n = 9) reviewed articles on the source of breeding ram used frequencies and means for data analysis. Methods to source breeding rams such as unidentified ram, own flock, purchased from the market, borrowed from neighboring flock and donated ram were documented. The descriptors were ranked with the standard score of 1: being the most widely used method, 2: second most used method, 3: third most used method and 4: being the least used method. From a total of 9 articles, own flock was ranked 1, as the most widely used method to source a breeding ram. While from the number of articles 2 (22.22%), donated ram was scored as the method that was never use used by several articles, respectively.

Table 4. Source of breeding ram

Citation	Unidentified ram	Own flock	Purchased from the market	Borrowed from neighboring flock	Donated ram
Abera et al., 2020	1	2	3	-	-
Abebe., et al. 2020	2	1	3	-	-
Bolowe et al., 2022	2	1	4	-	3
Dossa et al., 2022	-	1	-	-	-
Getachew et al., 2010	-	1	2	-	-
Getachew et al., 2011	-	1	2	2	-
Hemacha et al., 2023	-	2	3	1	-
Jaitner et al., 2001	-	1	2	-	-
Amare et al., 2018	-	1	2	3	4

1: Most widely used method, 2: second most used method, 3: third most used method and 4: least used method

Selection criteria for breeding rams

Out of 26 collected articles, it was found that 9 articles discussed the selection criteria for breeding ram of African sheep keepers (*Table 5*). All the nine (n = 9) reviewed articles on selection criteria for breeding rams used mean ranking indexes for data analysis. The criteria such as appearance/size, coat color, mating ability, tail shape, ear size, sexual maturity, body size, competitive performance, true to breed, and genotype were documented, with (1,2,3,4) as the ranking indexes. From a total of 9 articles, appearance/size, growth rate, tail shape, and competitive performance were ranked first by the number of articles 8 (88.89%), 1 (11.11%), and 1 (11.11%). Coat color, growth rate and competitive performance were ranked second by the number of articles 4 (44.44%), 1 (11.11%), and 1 (11.11%). The results also discovered that growth rate was ranked fourth by two articles (Abera et al., 2014; Abebe et al., 2020).

Selection criteria for breeding ewes

The selection criteria for breeding ewes are presented in *Table 6*. Out of 26 collected articles, the results found that 8 articles discussed the selection criteria for breeding ewes of African sheep keepers. All the eight (n = 8) reviewed articles on selection

criteria for breeding ewes used mean ranking indexes for data analysis. The criteria such as appearance/size, coat color, age at first lambing, twinning rate/ability, body size, tail type, sexual maturity, pedigree information, litter size, genotype, and lamb growth were documented, with (1, 2, 3, 4) as the ranking indexes. From a total of 6 articles, appearance/size, age at first lambing, and twinning rate/ability were ranked first by the number of articles 4 (50%), 1 (12.5%), and 1 (12.5%). Coat color and lambing interval were ranked second by the number of articles 2 (25.00%), and 1 (12.5%). Lambing interval, age at first lambing and coat color were ranked third by the number of articles 2 (25.00%), 1 (12.5%), and 1 (12.5%). Lastly, tail type and litter size were ranked fourth by two articles (Abebe et al., 2020; Hemacha et al., 2023).

Table 5. Selection criteria for breeding rams

Citation	A/S	CC	GR	MA	TS	ES	P	SM	CP	FD	PI	TB	G
Abebe et al., 2020	1	2			3	4							
Abera et al., 2014	1	2	4		3								
Getachew et al., 2011	1	2	1		1				1		3		
Hemacha et al., 2023	1	2			3								
Kefala et al., 2017	1		2								3		
Kosgey, 2004	1								2			3	
Tezera and Engidashet, 2022	1		3										2
Hamadou et al., 2019	2	1											
Mbuku et al., 2010	1									2			

A/S = Appearance/size, CC = Coat color, GR = Growth rate, MA = Mating ability, TS = Tail size, ES = Ear size, P = Pedigree, SM = Sexual maturity, CP = Competitive Performance, PI = Pedigree information, TB = True to breed, G = Genotype, FD = Fat deposition

Table 6. Selection criteria for breeding ewes

Citation	A/S	FD	GH	CC	MA	AFL	LI	TR/A	TT	SM	PI	LS	G	LG
Abebe et al., 2020	1			2			3		4	3				
Abera et al., 2014	1			2				3						
Getachew et al., 2011						1	3				2			
Hemacha et al., 2023	1			3	2							4		
Kefale et al., 2017						3	2	1						
Tezera and Engidashet, 2022	2							3					1	3
Dossa et al., 2015			1											
Mbuku et al., 2010	1	2										3		

A/S = Appearance/size, CC = Coat color, MA = Mothering ability, AFL = Age at first lambing, LI = Lambing interval, TR/A = Twinning rate/ability, TT = Tail type, SM = Sexual maturity, PI = Pedigree information, LS = Litter size, G = Genotype, LG = Lambing growth, FD = Fat deposition

Discussion

When designing a breeding programme, the first step is to decide on breeding objectives, in conjunction with the sheep keepers in participatory ways that are achievable and relevant to the future of the breeds and the farmers (Kosgey, 2004). The main objective of this study was to systematically review the breeding practices, breeding objectives and selection criteria of African sheep keepers. Understanding the influence that the decision on breeding practices, breeding objectives, and selection criteria have on productivity is necessary to improve the genetic capability of sheep at the communal level (Aguiar et al., 2020). The results of the current systematic review

indicated that 8 articles out of 26 reviewed articles revealed that mating was predominantly uncontrolled and no to little report of controlled breeding. According to Jaitner et al. (2001), the management system concerning the land used for grazing, free roaming of the sheep since they are farmed under extensive farming system and also sharing of herder, makes controlled mating very difficult. In addition, Kefale et al. (2017), suggested that the major reason for uncontrolled mating is possibly the lack of awareness on the importance of castration at an early age. Out of 26 reviewed articles, 9 of them revealed that a higher proportion of African sheep keepers get their breeding ram source from their own flock, while some replace ram either from neighboring flock or purchased from the market and lastly from unidentified ram. This is an attribute present in rural areas, due to lack of funds as such farmers tend to source from their own flock. Also sourcing of breeding rams from own flock increases the rate of inbreeding and this is consistent with the remarks of Jaitner et al. (2001) in Djallonke sheep in Gambia. This might pose as a contributing factor as to why the herd productivity is decreasing. Therefore, the sheep keepers should invest in sharing of a breeding ram that is deemed to be productive. From the findings of the systematic review, on average, a breeding ram was used for 2 years with ranges of 1.5 to 3.5 years. The results were consistent with the findings of a study done by Abera et al. (2014) on indigenous sheep in Ethiopia. Subsequently, Getachew et al. (2011), reported that a prolonged keeping period was common practice in Ethiopia (Afar area) and only practiced in Ethiopia (Menz area) when the breeding ram is perceived to have distinctive features (good appearance, preferred coat color, large body size, large broad tail and true to breed type). The results discovered that among African sheep keepers the age of castration can be as young as 3.6 month and higher as 30.72 months. The reasons for early castration were mainly to improve rate at which the sheep gain weight and used as a method to control breeding (Hemacha et al., 2023). An increase body weight suggests that the selling price will increase therefore more income to the farmer. In addition to the reasons highlighted by Hemacha et al. (2023); Kefale et al. (2017), reported that the reasons for castration was to control temperament. Subsequently, a study by Tezera and Engidashet. (2022) revealed that the two main reasons for late castration were 1: to enable the ram to mature before castration and 2: to use the ram for breeding purposes before castration.

According to Jaitner et al. (2001), the prerequisite to deriving an operational breeding goal is knowing the reasons for keeping animals. Therefore, the findings from 13 articles out of 26 collected revealed that the main reasons for keeping sheep were mainly for meat, income and saving as insurance. This implies that the sheep keepers kept their animals mainly to sustain their lives rather than for breeding or production of their byproducts (wool/hair). This is evident, as the finding of this systematic review showed a flock size of (10.21 to 45.09), as such making it difficult for the sheep keepers to head into commercialization of the farm. Subsequently, this was expected since majority are aged 51 up to 70 with low education level (primary) while others are illiterate. This is consistent with the findings of this systematic review, whereby the recorded number of respondents who were illiterate were 352 with primary education of 353 while secondary and tertiary educational level were 166 as such, they would find it difficult to read. Ejlersen et al. (2012), suggests that related interventions to improve productivity must be that African sheep keepers select breeding animals based on criteria that somewhat align with their breeding objectives. Hence, 8 out of 26 reviewed articles from the results on the selection criteria of breeding ewe revealed that

appearance/size, coat color and lambing interval were important criteria of breeding ewe according to rankings. These traits are in line with herd production and the need for certain coat color for ceremony purposes. However, a study by Hamadou et al. (2009), disagrees that the preference for larger body sizes constitutes as an unfavorable factor, especially for certain sheep breeds, mainly the Koundoum sheep in Nigeria. Likewise, 9 out of 24 reviewed articles revealed that appearance/size, coat color and tail size were the first, second and third important selection criteria of breeding ram in this systematic review. The combined findings on selection criteria on appearance/size and coat color does emphasize the importance of body size as a companion to a higher income and the importance of coat color to cultural rites of African sheep keepers. Hamadou et al. (2019) highlighted that the less cited criteria might show significant importance with respect to furthering the development of a breeding or conservation programme, when explored more. An important criterion that has been absent from the focus group discussion is resistance or adaptation to the environment, which needs to be explored more since indigenous sheep breeds have more potential. As such Hemacha et al. (2023), highlighted that appreciating indigenous knowledge is vital to confirm the sustainability of a breeding program which is intended to be implemented at a community level since applying selection based on body size has shown to have a linear relation with growth. The results of this systematic review implied that productivity might be increased when the African sheep keepers use the information documented on the breeding practices, breeding objectives and selection criteria as guide and to help them improve their indigenous sheep productivity when designing and seeking to implement a community-based breeding program on their farm. The strength of this systematic review is that this systematic review is the first to be written and document the breeding practices, breeding objectives and selection criteria of African sheep keepers, systematically so, as to provide a reference point to guide them on the breeding practices that are viable, how to select their preferred traits and their objectives looking at the goal of their farm. Therefore, the current study will contribute to the body of knowledge on identified and documented common breeding practices, breeding objectives and selection criteria used by African sheep keeper. The limitation of this systematic review was that out of the 26 included articles for review, most of the articles were from one country (Ethiopia), little to no literature on South Africa and only one article by Bolowe et al. (2022) on a landlocked country in Southern part of Africa called Botswana.

Conclusion

In conclusion, uncontrolled mating, and selection of a breeding ram from own flock was a common breeding practice among African sheep keepers, with limited focus on castration. As such, it is recommended that African sheep keepers in rural areas should come together to select a superior ram that will be used to service their breeding ewes whereas the other rams have to be withdrawn either through castration, culling or selling them. African sheep keepers bred their sheep breeds principally as a source of income, meat for home consumption and for savings/insurance, in this order of importance. With common selection criteria for breeding ram and ewe as appearance/size. This emphasis the low productivity noticed, mainly because less focus is given to breed improvement. Therefore, to increase productivity, the African sheep keepers must come together with researchers, agricultural extension workers and other

stakeholders to design a community-based breeding program for their farm, taking into account the breeding practices, breeding objectives and selection criteria documented in this study as point of reference. Furthermore, more studies should be conducted to gather information on the influence that tail size of breeding ram and the number of years of using breeding ewe in a farm has on herd productivity.

Authors contributions. Conceptualization, T.L.T.; Study design, A.M.P. and T.L.T.; Electronic literature search, A.M.P. and T.L.T.; Data extraction, A.M.P. and T.L.T.; Data analysis and interpretation, A.M.P. and T.L.T.; Quality assessment, T.L.T. and O.T.; Supervision, T.L.T. and O.T.; Writing—original draft, A.M.P. and T.L.T.; Writing—review and editing, O.T. All authors have read and agreed to the published version of the manuscript.

Acknowledgements. This systematic review has been supported and approved by the University of Limpopo.

Funding statement. This systematic review was financially supported by the South African National Research Foundation (Postgraduate: Reference No. MND32875432).

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

Data availability statement. All data generated during this study are available through a request to the corresponding author.

REFERENCES

- [1] Abebe, A. S., Alemayehu, K., Johansson, A. M., Gizaw, S. (2020): Breeding practices and trait preferences of smallholder farmers for indigenous sheep in the northwest highlands of Ethiopia: inputs to design a breeding program. – *PloS ONE* 15(5): 23.
- [2] Abera, B., Kebede, K., Gizaw, S. (2014): Indigenous breeding practices and selection criteria of sheep breed in Selale area, Central Ethiopia. – *International Journal of livestock research* 4(7): 49-56.
- [3] Amare, T., Goshu, G., Tamir, B. (2018): Flock composition, breeding strategies and farmers' traits of interest evaluation of Wollo highland sheep and their F1 crosses. – *Journal of Animal Science and Technology* 60(1): 1-12.
- [4] Bettany-Saltikov, J. (2010): Learning how to undertake a systematic review: part 2. – *Nursing Standard* (through 2013) 24(51): 47.
- [5] Bolowe, M. A., Thutwa, K., Monau, P. I., Malejane, C., Kgwatalala, P. M. (2022): Production characteristics and management practices of indigenous Tswana sheep in southern districts of Botswana. – *Animals* 12(7): 830.
- [6] Dagneu, Y., Urge, M., Tadesse, Y., Gizaw, S. (2017): Sheep production and breeding systems in northwestern lowlands of Amhara region, Ethiopia: implication for conservation and improvement of Gumz sheep breed. – *Open Journal of Animal Sciences* 7(02): 179.
- [7] De Aguiar, A. L., da Silva, R. R., Alves, S. M., da Silva, L. P., de Moraes, O. R., Lobo, R. N. B. (2020): Breeding objectives and selection criteria of a participatory community-based breeding programme of goats and sheep. – *Tropical Animal Health and Production* 52: 1933-1943.
- [8] Dossa, L. H., Sangaré, M., Buerkert, A., Schlecht, E. (2015): Production objectives and breeding practices of urban goat and sheep keepers in West Africa: regional analysis and implications for the development of supportive breeding programs. – *SpringerPlus* 4(1): 1-12.
- [9] Duguma, G. (2010): Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia. – *Doctoral Dissertation, Austrian University of Natural Resources and Life Sciences.*

- [10] Duguma, G., Mirkena, T., Haile, A., Okeyo, A. M., Tibbo, M., Rischkowsky, B., Sölkner, J., Wurzinger, M. (2011): Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: choice model approach. – *Animal* 5(12): 1984-1992.
- [11] Ejlersen, M., Poole, J., Marshall, K. (2012): Traditional breeding objectives and practices of goat, sheep and cattle smallholders in The Gambia and implications in relation to the design of breeding interventions. – *Tropical Animal Health and Production* 45: 219-229.
- [12] FAO (2013): In Vivo Conservation of Animal Genetic Resources. FAO Animal Production and Health Guidelines. – FAO, Rome.
- [13] Garcia, L. I. P. (2013): Production objectives and selection criterions of three endemic ruminant breeds in The Gambia and Senegal. – Master's Thesis, Swedish University of Agricultural Sciences, Uppsala.
- [14] Getachew, T., Haile, A., Tibbo, M., Sharma, A. K., Sölkner, J., Wurzinger, M. (2010): Herd management and breeding practices of sheep owners in a mixed crop-livestock and a pastoral system of Ethiopia. – *African Journal of Agricultural Research* 5(8): 685-691.
- [15] Getachew, T., Gizaw, S., Lemma, S., Taye, M. (2011): Breeding practices, growth, and carcass potential of fat tailed Washera sheep breed in Ethiopia. – *Tropical Animal Health and Production* 43(7): 1443-1448.
- [16] Gizaw, S., Komen, H., Hanotte, O., Van Arendonk, J. A. (2008): Indigenous sheep resources of Ethiopia: types, production systems and farmers preferences. – *Animal Genetic Resources/Recursos Genéticos Animales/Recursos Genéticos Animales* 43: 25-39.
- [17] Haile, A., Wurzinger, M., Mueller, J., Mirkena, T., Duguma, G., Okeyo Mwai, A., Sölkner, J., Rischkowsky, B. A. (2011): Guidelines for setting up community-based sheep breeding programs in Ethiopia: lessons and experiences for sheep breeding in low-input systems. – *ICARDA tools and guidelines*.
- [18] Hamadou, I., Moula, N., Siddo, S., Issa, M., Marichatou, H., Leroy, P., Antoine-Moussiaux, N. (2019): Valuing breeders' preferences in the conservation of the Koundoum sheep in Niger by multi-attribute analysis. – *Archives Animal Breeding* 62(2): 537-545.
- [19] Hemacha, S. A., Kebamo, M., Hailemeskel, D. (2022): Breeding practice, trait preferences and flock structure of local sheep in selected districts of Hadiya zone, Southern Ethiopia. – *Journal of Livestock Science* 13: 171-179.
- [20] Jaitner, J., Sowe, J., Secka-Njie, E., Dempfle, L. (2001): Ownership pattern and management practices of small ruminants in The Gambia—implications for a breeding programme. – *Small Ruminant Research* 40(2): 101-108.
- [21] Kefale, A., Awoke, T., Getu, A., Abegaz, S. (2017): Herd management and breeding practices of holla sheep owners in South Wollo Zone, Ethiopia. – *International Journal of Advanced Geosciences* 5(2): 41-47.
- [22] Kenfo, H., Mekasha, Y., Tadesse, Y. (2018): A study on sheep farming practices in relation to future production strategies in Bensa district of Southern Ethiopia. – *Tropical animal Health and Production* 50: 865-874.
- [23] Kosgey, I. S. (2004): Breeding Objectives and Breeding Strategies for Small Ruminants in the Tropics. – Wageningen University and Research, Wageningen.
- [24] Marshall, K., Mtimet, N., Wanyoike, F., Ndiwa, N., Ghebremariam, H., Mugunieri, L., Costagli, R. (2016): Traditional livestock breeding practices of men and women Somali pastoralists: trait preferences and selection of breeding animals. – *Journal of Animal Breeding and Genetics* 133(6): 534-5.
- [25] Mbuku, S. M., Kosgey, I. S., Kahi, A. K. (2010): Identification systems and selection criteria for small ruminants among pastoralist communities in northern Kenya: prospects for a breeding programme. – *Tropical Animal Health and Production* 42: 1487-1492.

- [26] Mekuriaw, S., Mekuriaw, Z., Taye, M., Yitayew, A., Assefa, H., Haile, A. (2012): Traditional management system and farmers' perception on local sheep breeds (Washera and Farta) and their crosses in Amhara Region, Ethiopia. – *Livestock Research for Rural Development* 24(1).
- [27] Tezera, B. T., Engidashet, D. H. (2022): Traditional sheep breeding practices under agroforestry system of Gedeo zone, Southern Ethiopia. – *PloS ONE* 17(6): e0269263.
- [28] Tindano, K., Moula, N., Traoré, A., Leroy, P., Antoine-Moussiaux, N. (2017): Assessing the diversity of preferences of suburban smallholder sheep keepers for breeding rams in Ouagadougou, Burkina Faso. – *Tropical Animal Health and Production* 49: 1187-1193.
- [29] Yakubu, A., Isa, S., Alabi, O., Shoyombo, A. J., Adeolu, A. I. (2020): Breeding practices and trait preferences of sheep farmers in a Sub-Humid tropical environment. – *Tropical Animal Science Journal* 43(4): 377-384.
- [30] Zonabend König, E., Mirkena, T., Strandberg, E., Audho, J., Ojango, J., Malmfors, B., Okeyo, A. M., Philipsson, J. (2016): Participatory definition of breeding objectives for sheep breeds under pastoral systems—the case of Red Maasai and Dorper sheep in Kenya. – *Tropical Animal Health and Production* 48: 9-20.