

BREEDING PRACTICES AND SELECTION CRITERIA OF BREEDING STOCKS OF AFRICAN GOAT FARMERS: A SYSTEMATIC REVIEW

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Abstract. The aim of this systematic review is to provide information on African indigenous goat farmers' production objectives, breeding practices and preferred traits. Google Scholar, ScienceDirect, PubMed, and ResearchGate were used to search for information. The review focused on scientific articles, theses, and books in English from 2012 to 2023. 30 eligible studies were used in the review. Cash income and meat were ranked as their first and second breeding objectives. Good conformation and coat color was ranked second and third, respectively. Body size, coat color and mothering ability were ranked first, second and third, respectively. Goat farmers practiced castration using traditional methods, while some farmers used both traditional and modern methods. Goat farmers practiced culling for different reasons in their goats farming and sourced breeding bucks from their own flock, neighbors, and relatives. The results of this systematic review indicated that most African indigenous goat farmers have similar breeding objectives, selection criteria for both male and female goats, and breeding practices. This information can be used to develop breeding program for African goat farmers.

Keywords: *breeding objectives, source of breeding bucks, PRISMA, culling, castration methods*

Introduction

The goat industry plays a crucial role in the agricultural sector in developing countries, and Africa contributes 35% of the world's goat population (Hankamo and Woldeyohannes, 2022). Goats can feed and flourish on sparse bushes and shrubs since they are browsers and selective feeders and can also give birth twice a year due to their short reproductive cycle (Yousuf et al., 2020). According to Gebre et al. (2019) production of indigenous goats is low cost and can easily be ventured by resource-limited farmers since goats can withstand harsh environmental conditions, they are resistant to diseases and parasites, and they have low cost of maintenance. Indigenous goats are very crucial to the livelihood of smallholder farmers and rural people since they act as the source of meat, milk, generate income, and serve cultural and religious purposes (Tyasi et al., 2021). Despite their contributions to the lives of communal farmers, their production (meat and milk) is found to be very low (Mtshali et al., 2020), and this might be due to a lack of sustainable breeding programs and the knowledge of the production systems and following the correct breeding practices (Yemane et al., 2022). Therefore, several studies have been conducted to document the indigenous goat farmers' production objective, selection criteria and breeding practices to a develop sustainable breeding programs in different African countries including Ethiopia (Tades et al., 2014; Gebre et al., 2019), Nigeria (Dossa et al., 2015), and South Africa (Mtshali et al., 2022; Tyasi et al., 2021). Hence, this study intended to document common indigenous goat farmers' production objectives, breeding practices and preferred traits in African countries. However,

according to our knowledge there is no systematic review published on the indigenous goat farmers' production objectives, breeding practices, and preferred traits in Africa. Therefore, the objective of this study is to provide information on the indigenous goat farmers' production objectives, breeding practices, and preferred traits in Africa. The information from this systematic review will help goat researchers in the implementation and designing of community-based goat breeding programs for communal farmers.

Materials and methods

Eligibility criteria

Identification of the Population, Exposure and Outcomes (PEO) components of the research were performed for this systematic review as described by Bettany-Sallickov (2010). The "African indigenous goats' farmers" was defined as the population of the study, with the "indigenous goats' improvement" as exposure and "Breeding objectives, breeding practices, production systems and traits preferences" as outcomes. Before deciding to conduct the study, a preliminary search of the PEO components on Google Scholar was conducted.

Identification of relevant literature

The methodology of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) by Mekonnen et al. (2022), was followed when preparing the literature search for the review. Search databases such as Google Scholar, ScienceDirect, PubMed and ResearchGate were identified and chosen to probe information to be used during write-up. The review focused on scientific articles, thesis, and books written in English in the years between 2012 to 2023. The years were chosen in order to ensure that the study uses new and relevant information on the subject of interest. After going through and arranging the papers, only scientific papers on goat farmers' breeding objectives, breeding practices, traits preferences and production systems in Africa with an implication of community-based breeding program were chosen.

Inclusion criteria

The current systematic review considered the studies written in English and published between the year 2012 and 2023. The researchers considered studies that were investigating the goat farmers' breeding objectives, breeding practices, traits preferences, and production systems. The studies that were reviewed were all conducted from African countries.

Exclusion criteria

The criteria for exclusion involved the following: studies that were not conducted in African countries, duplicate articles, and articles that did not fall between year 2012 and 2023. The study excluded papers published before 2012, to ensure the information to be used in the review is relevant. It further excluded the studies that did not use goats but other small ruminants and review articles.

Data extraction

The content from included articles was extracted by Madumetja Cyril Mathapo, Thinawanga Joseph Mugwabana and Thobela Louis Tyasi. The content included the

first author's name, year of publication, country where study was conducted, goat breed and sample size of respondents.

Ethical consideration

All authors of this systematic review considered ethical issues including plagiarism, misconduct, informed consent, data falsification, and fabrication.

Results

Eligible studies

Two researchers (Madumetja Cyril Mathapo and Thobela Louis Tyasi) at first managed to search for literature and collected a total of ninety-two ($n = 92$) references. The researchers made a thorough check on the 92 identified articles and found seven ($n = 7$) duplicates. The duplicates were then removed and remained with eight-three ($n = 85$) articles. After the removal of duplicates, the remaining articles were screened for topics and found that forty-four ($n = 44$) articles had titles that were not relevant to the review scale. Those articles were then excluded and remained with forty-one ($n = 41$) which all passed the screening of abstract. A total of 41 articles were further processed to full-text articles assessed for eligibility, and it was found that 8 articles were excluded since ($n = 3$) didn't meet the year between 2012 and 2023, two ($n = 2$) were review articles, two ($n = 2$) were from Brazil and one ($n = 1$) was focusing on sheep. Therefore, the studies included in the systematic review were thirty-three ($n = 33$). *Figure 1* indicates the PRISMA diagram of the identified and selected studies for the current systematic review.

Characterization of included studies

Table 1 below displays the characterization of included studies in the current systematic review where thirty-three ($n = 33$) studies were included in the study published between the year 2012 to 2023. Majority of the studies were from Ethiopia (89%) followed by South Africa (2%) (Tyasi et al., 2021; Mtshali et al., 2022), Liberia (1%) (Karnuah et al., 2018), Sudan (1%) (Hag et al., 2020), Malawi (1%) (Nandolo et al., 2016), Somalia (1%) (Marshall et al., 2016), (1) Tanzania (Nguluma et al., 2020), and West Africa: Burkina Faso, Nigeria, and Mali had (1%) (Dossa et al., 2015), respectively. The reviewed studies were much on interviewing the goats' owners and different sample sizes were observed from different studies. However, the minimum and maximum number of respondents with values of 25 and 500, were observed respectively. All the papers focused on the goats' farmers' farming with indigenous goat breeds of the countries/areas where they were conducted, since their aim was to document the information that will assist in developing a sustainable community-based breeding program for genetic improvement of the local goats. The search findings showed that one author published two articles in different years (Lorato et al., 2015; Lorato, 2017).

Socio-economic status of the goats' farmers

Table 2 indicates the socio-economic status of goat farmers in Africa. Out of 33 articles, only 6 articles discussed the socio-economic statuses of the goats' farmers and

focused on different genders, ages, and educational levels. The results indicated that the majority of the goat farmers were males with 69.62% while females were 30.26%. The age results indicated that the majority of the farmers were between 46-60 years (28.22%), followed by those who were between 46-60 years (21.07%), and those farmers at <30 and >60 years had an equal number (7.25%). The educational level results indicated that the majority of the farmers were illiterate (52.25%), followed by secondary (40.35%), primary (27.55%), informal (13.43%), and college (1.35%).

Table 1. *Characterization of the included studies*

First author and year	Country	Goat breed	Respondents sample size
Marshall et al. (2020)	Somalia	Local goats of Somali	500
Urgessa et al. (2013)	Ethiopia	Indigenous goats of Ethiopia	270
Gebreyesus et al. (2013)	Ethiopia	Indigenous goats of Ethiopia	Not shown
Kidane et al. (2014)	Ethiopia	Local goats of Ethiopia	71
Tesfalem et al. (2021)	Ethiopia	Local goats of Ethiopia	144
Alebel et al. (2020)	Ethiopia	Indigenous goats of Ethiopia	180
Zergaw et al. (2016)	Ethiopia	Local goats of Ethiopia	240
Hankamo and Woldeyohanne (2022)	Ethiopia	Local goats of Ethiopia	240
Muluneh and Awoke (2021)	Ethiopia	Local goats of Ethiopia	180
Gebre et al. (2019)	Ethiopia	Indigenous goats of Ethiopia	90
Asefa et al. (2015)	Ethiopia	Indigenous goats of Ethiopia	360
Hag et al. (2020)	Sudan	Indigenous goats of Sudan	164
Guangul (2014)	Ethiopia	Indigenous goats of Ethiopia	120
Abegaz et al. (2014)	Ethiopia	Local goats of Ethiopia	None
Lorato et al. (2015)	Ethiopia	Indigenous goats of Ethiopia	230
Karnuah et al. (2018)	Liberia	Local goats of Liberia	107
Yemane et al. (2022)	Ethiopia	Indigenous goats of Ethiopia	210
Getachew et al. (2020)	Ethiopia	Indigenous goats of Ethiopia	70
Lorato (2017)	Ethiopia	Indigenous goats of Ethiopia	230
Yousuf et al. (2020)	Ethiopia	Indigenous goats of Ethiopia	240
Dossa et al. (2015)	Nigeria, Burkina Faso, and Mali	Indigenous goats of Nigeria, Burkina Faso and Mali	306
Tadesse et al. (2014)	Ethiopia	Local goats of Ethiopia	155
Fantahun et al. (2016)	Ethiopia	Local goats of Ethiopia	180
Debele et al. (2013)	Ethiopia	Local goats of Ethiopia	60
Abraham et al. (2018)	Ethiopia	Local goats (Begait) of Ethiopia	45
Getaneh et al. (2022)	Ethiopia	Indigenous goats of Ethiopia	202
Nandolo et al. (2016)	Malawi	Malawi indigenous goats	25
Tyasi et al. (2021)	South Africa	Non-descript indigenous goats	183
Mtshali et al. (2022)	South Africa	Indigenous goats of South Africa	35
Kebede and Usman (2023)	Ethiopia	Indigenous goats of Ethiopia	120

Table 2. Socio-economic status of goat farmers

Gender		AGE				EDU					Sources
M	F	< 30	30-45	46-60	> 60	PR	SE	CO	IN	IL	
%	%	%	%	%	%	%	%	%	%	%	
67.5	32.5	13.8	41.3	31.3	13.8	65.0	26.3	1.3	7.5	-	Nguluma et al. (2020)
58	41.25	-	29	-	-	0	94.75	-	5.25	-	Tyasi et al. (2021)
97	3	3	25.7	20.8	-	7.9	-	-	22.3	67.8	Getaneh et al. (2022)
88.2	11.8	11.8	20.1	11.1	0.7	25.2	2.1	1.4	-	40.6	Tesfalem et al. (2021)
92.8	7.2	-	-	-	-	57.2	-	-	8.3	34.4	Alebel et al. (2020)
14.2	85.8	0.4	25	-	-	10	-	-	23.8	66.2	Hankamo and Woldeyohannes (2022)
69.62	30.26	7.25	28.22	21.07	7.25	27.55	40.35	1.35	13.43	52.25	Overall (%)

M: Male; F: Female; < 30: Less than thirty years; 46-60: Between forty-six and sixty; > 60 greater than sixty; EDU: Education; PR: Primary; SE: Secondary; CO: College; IN: Informal education; IL: Illiterate

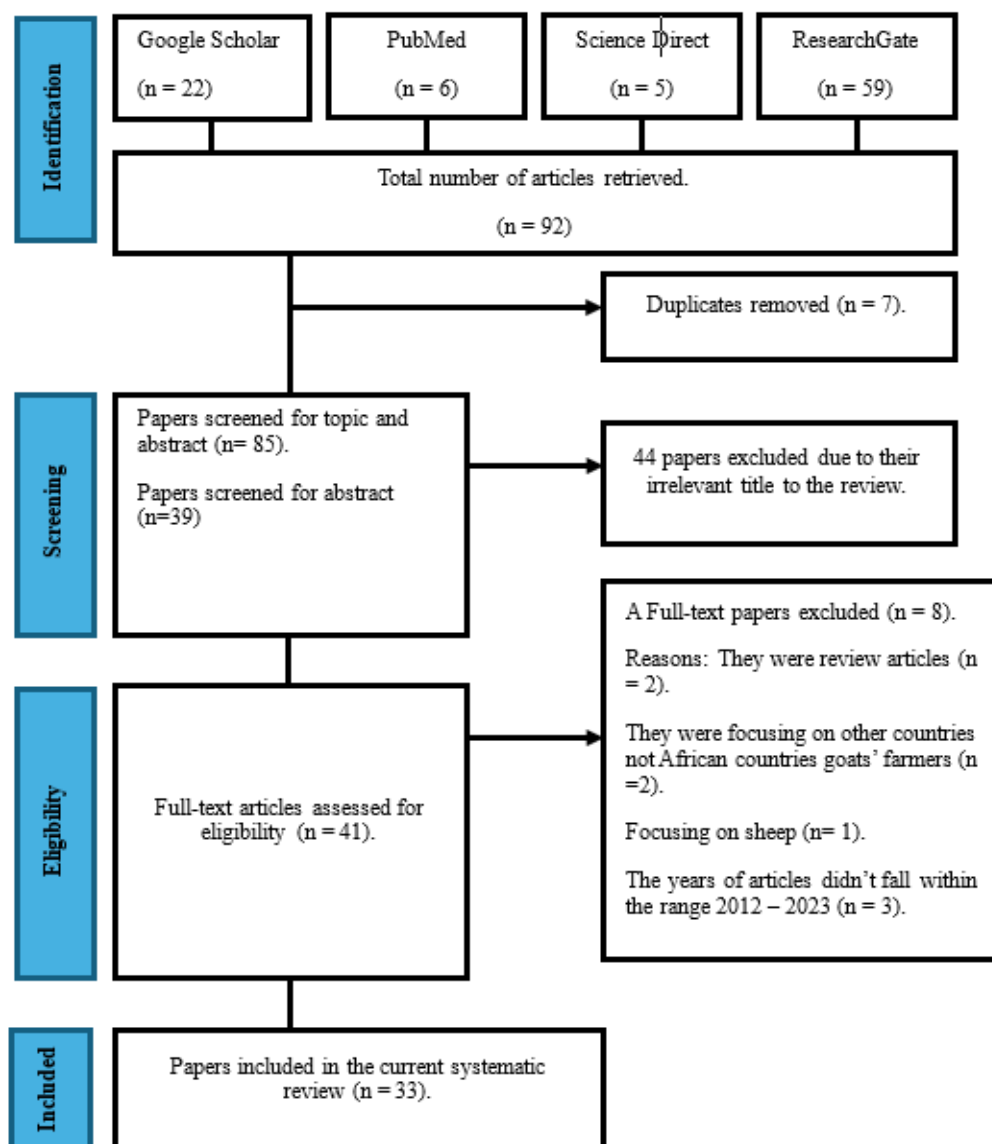


Figure 1. Flowchart of identification and selection of studies used in the systematic review

Breeding objectives

Figure 2 indicates the breeding objectives of goat farmers in Africa. Out of 33 collected articles, it was found that 29 articles discussed the breeding objectives of the goats' farmers. Breeding objectives such as milk, cash income, meat mothering ability, home consumption, twinning ability, appearance of the goats, prestige, breeding, social status, socio-economic status, savings, manure, and increased fertility were documented. From a total of 29 articles, cash income, milk and meat were ranked first by a number of articles 16 (53.33%), 6 (19.35%), and 5 (16.13%), respectively. Meat, milk, and savings were ranked second by the number of articles 9 (29.03%), 5 (16.13%) and 2 (6.45%), respectively. It was further noticed that meat, cash, and savings were ranked third by the number of articles 8 (25.81%), 3 (9.77%) and 4 (12.90%), respectively.

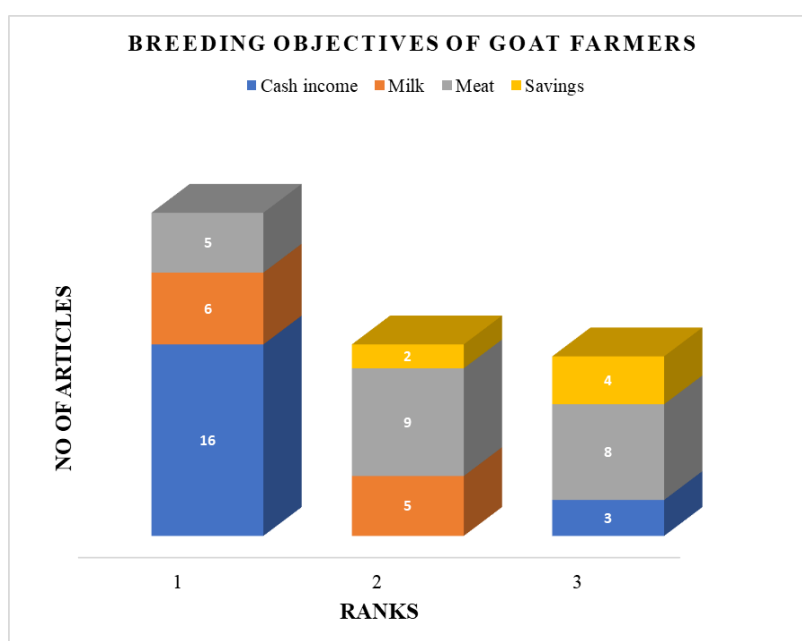


Figure 2. Breeding objectives of African goat farmers

Selection criteria for breeding bucks

Figure 3 indicates the selection criteria of goats' farmers for breeding bucks. Out of 33 articles searched, it was found that 16 articles showed different preferred traits such as conformation, body size, growth rate, coat color, testicular shape, high libido, adaptability, horn presence, temperature, height, pedigree, and mating ability by goats' farmers in Africa. From a total of 16 articles, conformation, body size, coat color, growth rate and height were ranked first by a number of articles 8 (50%), 4 (25%), 2 (12.5%), 1 (6.25%) and 1 (6.25%), respectively. Coat color, growth rate, conformation, pedigree, body size, high libido, adaptability, and mating ability were ranked second by the number of articles 5 (31.25%), 3 (18.75%), 2 (12.5%), 2 (12.5%), 1 (6.25%), 1 (6.25%), 1 (6.25%) and 1 (6.25%), respectively. Coat color, growth rate, conformation, pedigree, and horn presence were further ranked third by the number of articles 6 (37.5%), 4 (25%), 2 (12.5%), 2 (12.5%) and 2 (12.5%) (Fig. 3).

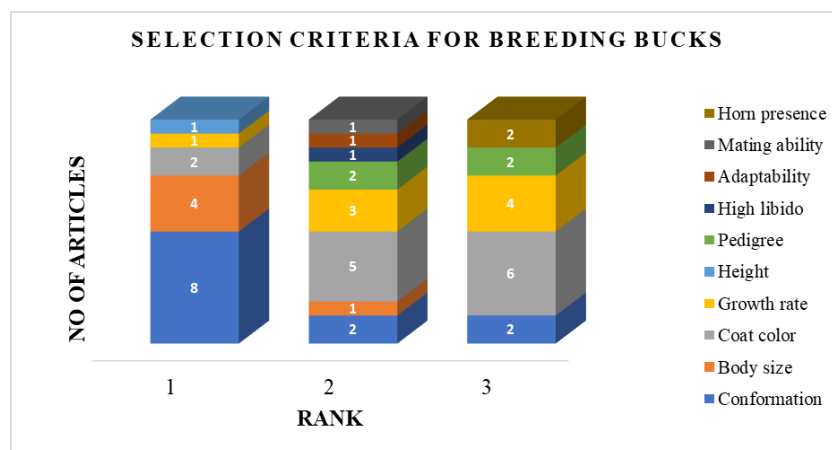


Figure 3. Selection criteria for breeding bucks

Selection criteria for breeding does

Figure 4 indicates the goat farmers' selection criteria for breeding does. Out of 33 articles searched, 19 articles showed different traits preferred such as conformation, body size, growth rate, coat color, mothering ability, kid growth, adaptability, milk yield, twinning ability, height, pedigree, and kidding ability. Body size, conformation, twinning ability, milk yield, mothering ability and kid growth were ranked first by number of articles 6 (31.58%), 5 (26.32%), 3 (15.79%), 3 (15.79%), 2 (10.53%), 1 (5.26%) and 1 (5.26%), respectively. Coat color, twinning ability, body size, milk yield, conformation, growth rate, mothering ability, kid growth, adaptability and height were ranked second by the number of articles 4 (21.05%), 3 (15.79%), 2 (10.53%), 2 (10.53%), 1 (5.26%), 1 (5.26%), 1 (5.26%), 1 (5.26%), 1 (5.26%) and 1 (5.26%). It was further shown that mothering ability, milk yield, twinning ability, conformation, body size, coat color, adaptability and kidding ability were ranked third by the number of articles 5 (26.32%), 4 (21.05%), 2 (10.53%), 1 (5.26%), 1 (5.26%), 1 (5.26%), 1 (5.26%) and 1 (5.26%) (Fig. 4).

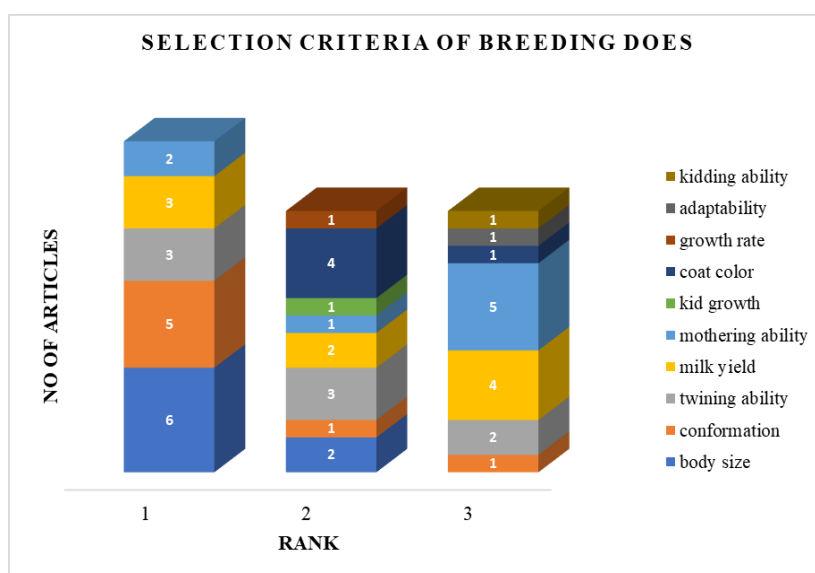


Figure 4. Selection criteria of breeding does

Breeding practices

Table 3 indicates some of the breeding practices that African goat farmers' practices. The researcher wanted to check if the African goat farmers practiced castration, and which methods were they using and if they cull their goats. Out of 33 articles, only 16 (51.61%) articles indicated that African goat farmers' practices castration, 7 (22.58%) indicated that goat farmers used traditional method for castration, 3 (9.68%) indicated that modern castration method (burdizzo and rubber ring) was used and 2 (6.45%) used both the methods (traditional and modern). 15 (48.39%) articles indicated that goats' farmers were culling their animals for different reasons (Fig. 5).

Table 3. Breeding practices

Castration		Culling		Source
Yes	No	Yes	No	
✓		✓		Nguluma et al. (2020)
✓		✓		Getachew et al. (2020)
✓		✓		Lorato (2017)
✓		-	-	Yousuf et al. (2020)
✓		-	-	Dossa et al. (2015)
✓		-	-	Fantahun et al. (2016)
-	-	✓		Debele et al. (2013)
✓		✓		Tyasi et al. (2021)
✓		✓		Getaneh et al. (2022)
-		✓		Marshall et al. (2016)
✓		✓		Gebreyesus et al. (2013)
✓		✓		Kidane et al. (2014)
✓		✓		Tesfalem et al. (2021)
✓		✓		Alebel et al. (2020)
✓		✓		Zergaw et al. (2016)
✓		-		Hankamo and Woldeyohannes (2022)
✓		-		Muluneh and Awoke (2021)
✓		✓		Gebre et al. (2019)
✓		✓		Guangula (2014)
-	-	✓		Lorato et al. (2015)

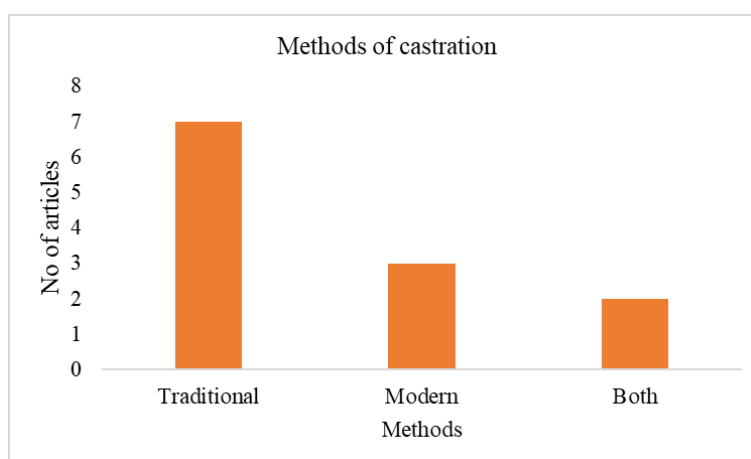


Figure 5. Methods of castration

Source of breeding bucks

Figure 6 indicates the different ways that African goat farmers used to source their breeding bucks. The farmers used bucks born from their flock, purchased from the market, neighbors, relatives, renting, from grazing, and inherited from their parents. Out of 33 articles, 13 articles indicated how farmers sourced their breeding bucks. Bucks born in the flock and neighbors were ranked first by a number of articles 12 (92.31%) and 1 (7.69%), respectively. Bucks from neighbors, purchased from the market, born from the flock, relatives, from grazing, and inherited from parents were ranked second by a number of articles 5 (38.46%), 4 (30.77%), 1 (7.69%), 1 (7.69%), 1 (7.69%) and 1 (7.69%) respectively. Bucks from relatives, purchased from the market, renting and from grazing were ranked third by several articles 4 (30.77%), 3 (23.08%), and 1 (7.69%), respectively (Fig. 6).

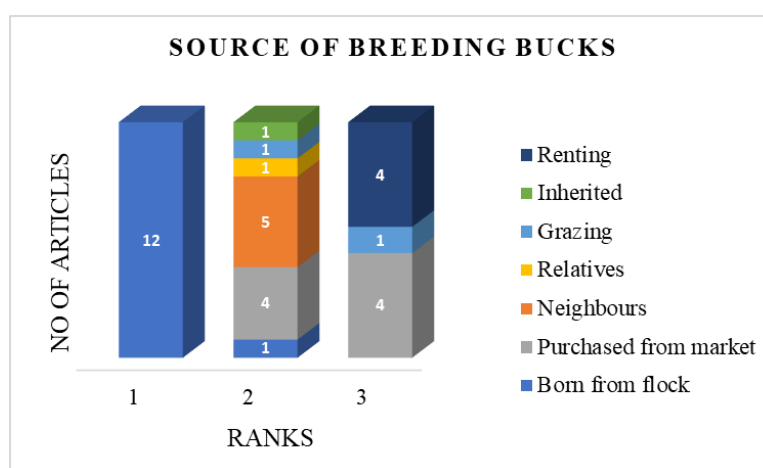


Figure 6. Source of breeding bucks

Discussion

Knowing the rural indigenous goat farmers breeding practices, breeding objectives and traits preferred can assist in designing and developing of community-based breeding program (Tyasi et al., 2021). This study focused on gathering information on breeding objectives, breeding practices and traits preferred by African goat farmers. Firstly, the current systematic review focused on the breeding objectives of the goat farmers. From thirty articles search, twenty-seven articles were reviewed on breeding objectives. Sixteen articles out of twenty-seven indicated that goat farmers of Africa ranked cash income first, then followed by meat, by nine and seven articles, respectively. However, two articles from thirty articles reviewed (Gebre et al., 2019; Hankamo and Woldeyhannes, 2022), indicated that the milk was the first trait to be ranked by goat farmers. According to Muluneh and Awoke (2021), goat milk is very important to the lives of new-born since it is used against internal parasites that normally grow in their stomach and is not allergic as compared to other animal milk. Majority of farmers keep goats for cash income, since they need it to run some household errands, for taking kids to school and for emergency purposes (Dossa et al., 2015). The findings of this systematic review suggest that goats are very important to the livelihoods of the goats' farmers since they provide them with money. For a certain breeding objective to be feasible, relevant selection criteria need to be followed when

selecting breeding stocks. Therefore, the current systematic review study focused on the goat farmers' selection criteria for breeding bucks and does. Sixteen articles out of thirty reviewed articles indicated that majority of African goat farmers when selecting their breeding bucks looked at the body conformation first and followed by the coat color. About three articles (Fantahun et al., 2016; Yemane et al., 2022; Getaneh et al., 2022) from thirty reviewed articles, indicated that goat farmers were focusing more on the body size when selecting their bucks for breeding. Based on our findings, the preferred traits of the goat farmers on selecting males, correlated with their objective of cash income, since goat appearance, shape, structure, and body condition score, and coat color determine goat price. These findings suggest that these traits can be used to determine the parents of the future generation.

On the does, out of thirty articles searched, only eighteen articles reviewed the selection criteria for selection of breeding does. The current systematic review indicated that African goat farmers ranked body size first in does, followed by coat color and mothering ability which were ranked second and third. Only one article Dossa et al. (2015), indicated that goat farmers looked at the fertility of the does when selecting for breeding. The selection criteria of African indigenous goats' farmers on female goats' link with their breeding objective which is cash income. These findings suggest that these traits (body size, coat color and mothering ability) can be used to determine the parents of the future generation.

The current systematic review then looked on the breeding practices of African goat farmers, where the focus was on the castration and the methods used to castrate their goats. From out of thirty articles searched, twenty-eight articles reviewed African goat farmers breeding practices their method. The current systematic review findings indicated that majority of African goat farmers practiced castration using traditional method. It further revealed that farmers were practicing culling. Only one article Hankamo and Woldeyohannes (2022), found that the majority of farmers did not practice castration since it was against their culture. According to our knowledge, this is the first systematic review reporting on the breeding practices of African goat farmers. The finding of this systematic review suggest that African goat farmers were controlling breeding, since they castrated and culled the animals, they were old, not showing desirable traits and not performing well. It is important for researchers to know farmers' source of breeding bucks in order to assist on developing a breeding program for farmers. Therefore, the current study review focused on how the African goat farmers sourced their breeding bucks. Out of thirty articles searched, twenty-eight reviewed articles showed how African goat farmers sourced their breeding bucks. The systematic review indicated that majority of farmers selected breeding bucks from their own flock, followed by those who relied from neighbors and relatives breeding bucks. However, Dossa et al. (2015) was the only one article indicated that farmers normally got their breeding bucks from the rural market. According to our knowledge, this is the first systematic review reporting on the African goat indigenous farmers breeding objectives, breeding practices and traits preferred. Therefore, there is no systematic review findings that can be used for comparison with the results of the current systematic review. The finding of this current review on source of breeding bucks suggest that African indigenous goat farmers does not have a background knowledge about the inbreeding and its effect on the animals. The current systematic review adds the body of knowledge that will assist in developing and implementing community breeding program that will assist in genetic improvement of indigenous goats of Africa. The limitations of the

current systematic review study are that majority of the reviewed articles used to write this systematic review were from Ethiopia as compared to other African countries, and the researchers considered only articles from 2012 up to date, which might limit researcher in terms of getting enough information. The strength of this systematic review was that no similar systematic review has been conducted in this field on African goat farmers' breeding objectives, breeding practices and trait preferences.

Conclusion

The systematic review conclude that the African goat farmers kept their goats for cash income. When selecting breeding bucks, farmers focused on the conformation and coat color. For breeding does, they focused on body size, twining ability and mothering ability. Goat farmers selection criteria clearly indicated that their preferred traits link with their breeding objectives. The goat body conformation, body size and coat color will then make farmers get better money during sales, since the animal will satisfy the buyer. The systematic review showed that the farmers were controlling breeding since they were castrating and culling their goats. It further indicated that for breeding bucks, farmers where using those bred from their own flock. This showed that the farmers did not know about the effect of using their own bucks for breeding. This means that to enhance the production of the indigenous goats, researchers need to provide farmers with information on the breeding management of their animal. The information from this systematic review can assist researchers to design and develop the community-based breeding program for African indigenous goat farmers. This can be achieved by drawing a program that aligns with their breeding objective. The program will include the traits from both breeding does and bucks that link with the farmers breeding objective, to prevent inbreeding and ensure healthy growth. The authors recommend that the effect of agro-ecological zones should be considered when conducting studies on goat farmers' breeding objectives, trait preferences and their production systems. Furthermore, the researchers can focus on the effect of age on the productivity of breeding stocks.

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