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Review

A review on differentiation of goat populations in Ethiopia based on husbandry practices, breeding and morphological traits: The primary step for conservation

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The purpose of this review is to provide an overview of the differentiation of goat population in Ethiopia based on husbandry, breeding practices, and morphological traits of goats. Ethiopian goats have long been known for their extensive production methods, which have been reared in all agro-ecological zones. Rather than competing for fodder with cattle and sheep, goats complement them. The major feed resources for goats were natural communal/private pasture, crop residue, local fodder trees, shrubs and browsing, road and riverside and crop aftermath. Good housing is required to protect goat from extreme temperature, disease, theft, to make management easier and controlled breeding. Selection is an important parameter in replacing parents by best performing stocks, which is one of the tools for improvement of genetics. The selection criteria for breeding buck were appearance, coat color, growth rate prolificacy and libido. However; the selection criteria of does were appearance, age at first maturity, twinning ability, milk yield, kid survival, short kidding interval and growth rate, coat color and litter size. High rate of reproductive efficiency of goat is essential for survival, as well as the production of meat, milk, and skin, and the replacement of breeding stock. The major constraints of goat were disease occurrences, feed shortage and drought. Phenotypic characterization is the first step in breeding program design and conservation strategy. This phenotypic characterization includes husbandry practice, way of breeding, reproduction traits and morphological traits. For molecular characterization and genome selection, phenotypic characterization is also used as a source of information. In conclusion goat management practiced in Ethiopia was traditional, kept primarily for income source.

Key words: Conservation; goat breeding; husbandry practices, phenotypic characterization.

INTRODUCTION

Ethiopia is endowed with abundant livestock genetic resources, including a diverse range of genetic pools with specialized adaptations to a variety of agro-ecologies. Goat production is an important aspect of the country's livestock farming and activity. Ethiopia has a diversified indigenous goat population with a population of 52.5 million heads (CSA, 2020/2021). Because of their resilience to difficult environmental circumstances, cheap

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maintenance costs, suitability for small-scale production, and short reproductive cycle, goat production requires fewer resources and more efficient farming methods than large ruminant production (Seifemichael et al., 2014; Seid, 2017).

In Ethiopia, the traditional goat farming system is characterized by poor nutrition, management, and extensive production systems (Lemecha et al., 2013; Abegaz, 2014). Goats are browsers and selective feeders, thus bush enhancement in free-grazing areas must be controlled (Tilahun et al., 2019). In all agro-climatic situations, goats have always been an important part of farming systems (Seid, 2017).The poor performance of local goats might be attributed to different factors such as poor quality and quantity of feed, the occurrence of diseases, lack of suitable breed and breeding strategies, and poor understanding of their genetic potential especially adapted harsh environments and the production situation in which they have been raised for centuries (Tsegaye, 2009). There is also inadequate information on the real genetic potentials of local goat populations that are distributed in several regions of the country, which are characterized by contrasting agro-climatic environments.

Characterization is the first step in any breed improvement and conservation strategy (Misbah and Belay, 2016). Any form of development or improvement activity requires the identification of breeding objectives, characterization of husbandry procedures, and recording of goat breeds (Takele, 2014). The most important tool for identifying qualitative and quantitative features in the indigenous goat is phenotypic characterization. The examination of the phenotypic characteristics of populations raised in diverse production conditions should be used to build genetic improvement strategies for the sustainable protection and usage of local animal genetic resources (Tade et al., 2021).

In Ethiopia, phenotypically 13 breeds of goat have been identified (Farm Africa, 1996; DAGRIS, 2006), while 8 breeds of goat have been identified by genetic characterization (Alemu, 2004), and recently goat populations classified into seven genetic groups (Mekuriaw, 2016). Both phenotypic and genotypic information are utilized for genomic selection which improves the accuracy and genetic gain, by reducing the generation interval (Yadav et al., 2018). Genomic selection is the future of livestock breeding companies; it improves the genetic gain (Ibtisham et al., 2017). The previous studies have identified husbandry practices, breeding objects and phenotypic characterization goats in different production systems of Ethiopia and reported the existence of phenotypic variations among Ethiopian goat populations between and within these goat ecotypes Takele, 2014; Goats are kept in house during night to protect from temperature (rain, cold, excessive heat Seid et al., 2015; Getew et al., 2015; Zergaw et al., 2016; Yemane et al; 2020a; Tade et al; 2021; Tade et al., 2021); however, organized information is no more available. Therefore, the objective of this review is to overview and synthesizes the fragmented information on phenotypic characterization, breeding and husbandry practices of goats in Ethiopia.

FEED RESOURCES AND FEEDING SYSTEM OF GOATS IN ETHIOPIA

Most of the small ruminant populations (70%) found in the developing countries used the grazing system and were primarily found in the more marginal areas which are unfit for cropping because of topography, low temperature, or low rainfall (Steinfeld et al., 2006). The major feed resources for goats were natural communal/private pasture, crop residue, local fodder trees, shrubs and browsing, road and riverside and crop aftermath. The quantity and quality of fodder available from natural pasture show seasonal fluctuation, and the critical problem of feed shortage during the dry season and drought periods occurred (Lemecha et al., 2013; Berihu et al., 2015). After harvesting crops, goats are allowed to graze stubble of different crops (maize, teff, finger millet, etc.) mainly, from November to December depending on the type of crop and time of harvest and the contribution of improved forage as animal feed sources was very low (Belay and Negesse, 2019).

Mixed herds usually freely graze on common grazing land (FARM-Africa, 1996). In moist midland and moist highland, herders tethered their goats near their farmstead using long or short rope based on the size of the land. When goats tethering around homestead provided with crop residues is also common and family members who stay at home are usually engaged in looking after the goats while feeding (Assefa, 2007). According to Zewdie and Welday (2015), the feed resources are frequently used household wastes, market area wastes, industrial by-products and roadside grazing, particularly in the peri-urban system.

As explained by Zeleke and Melese (2018) goat grazing was practiced without sex and age separation except kids, which separated until they grow strong enough to browse in free rage system. Traditionally, goats are reared under an extensive system of management on open grassland (77.33%), tree cover grassland (9.33%), bush/shrub grasslands (8.45%), stone covered grazing land (4%) and swampy grazing area (0.89%) under continuous grazing system in Gamo Gofa area.

HOUSING OF GOAT IN ETHIOPIA

Good are kept in house during night to protect from

extreme temperature (rain, cold, excessive heat and wind), disease, predator, theft, to make management easier and to provide opportunities for intensive feeding and controlled breeding while in day time in free grazing area (Asefa et al., 2015). Goats are vulnerable because of their small size. As a result, giving a good house can reduce environmental stress while also increasing productivity. Keeping animals of various sizes together could result in a loss of productivity (Zeleke and Melese, 2018). Housing system for goats depends on the size of flocks. The moist low land area herders used a separate house for their goats at night. Suckling kids are separated from their does and used the same house with family house shares roof externally in highland and midland area (Assefa, 2007).

According to Abraham et al. (2017) in western Tigray the house of goat were temporary and constructed of locally available materials due to animals move in access of feed and water. However, farmers around in urban areas used permanent houses separated from their homesteads. Those permanent house might be need more cost especially when using iron sheet for roof in addition to cost of local material.

CASTRATION AND FATTENING OF GOAT IN ETHIOPIA

Castration is the blocking of male animals' sperm from testicles to avoid sperm in their ejaculation, to prevent unwanted pregnancy in the flock, to practice controlled mating, to fattening goats, to get better price and to control temperament of bucks (Alemu, 2015; Hagos et al., 2016; Needham et al., 2017; Oumer et al., 2019). When castration of bucks is applied, they become older or aggressive to minimize the risk of fighting among bucks (Hagos et al., 2016). However, when castration is performed at too early age will cause stunning of growth. Farmers used closed castrations methods by using traditional ways indifferent parts of Ethiopia (Kidane et al., 2014; Fantahun et al., 2016; Fantahun and G/Michael, 2017). In the traditional method, goats were castrated by experienced farmers using materials like river stones while modern type of castration procedure at a veterinary clinic by using Burdizo (Yemane et al., 2020b). The traditional castration method mostly causes damage on the testicle of goat resulting in bleeding around the vas deference and the castration area. Such incidences were the major causes of illness due to development of infections around the testicle.

The main age of goat castration was from one year to two years in Bale zone (Asefa et al., 2015). However, castration commonly practices in buckling were more than six months old in Bench Majie zone (Fantahun et al., 2016). Castration was practiced to improve fattening potential to get a higher selling price (Samuel et al., 2016). Categories of goats used for fattening activity were young male and castrates male because of these animals are to be culled (Wendimu et al., 2018). The main feed for fattening were hay, natural pasture, crop residues and concentrates additionally local brewery by-products (Asefa et al., 2015; Muluneh et al., 2016). The common periods of fattening were February up to May, June up to August and October up to January to marketing in holiday (Yemane et al., 2020).

PURPOSE OF KEEPING GOAT IN ETHIOPIA

Breeding goals are the first step in designing genetic improvement strategies and identifying the traits farmers want to improve (Seid, 2017). Most of the farmers primarily purposes of breeding goats were to generating income for emergency cases, educational fees and for other household expenses in different part of Ethiopia (Alemu, 2015, Assefa et al., 2015; Tade et al., 2022). However, goat milk is not among the different purposes for which goats are raised in Western Ethiopia (Seid et al., 2015). As stated by Zeleke and Melese (2018) in Gamo Gofa Zone goats were primarily kept for asset and security purposes, whenever there is a need of cash they sell their goat and serve as an immediate source of income. Similarly, they used as an indication of wealth statuses; owning large number of livestock brought respect and high social value within the society.

According to Gizaw (2010), farmers' breeding management decisions are determined by the quality of livestock breeds, farmers' breeding goals and production environment. Uncontrolled breeding is the common practice due to bucks and does run together throughout the year in different part of Ethiopia (Seid et al., 2015; Hagos et al., 2016; Zeleke and Melese, 2018). However, controlled or hand mating is usually practiced in systems where tethering is practiced in Shabelle Zone (Takele, 2014). Mating and kidding seasons are concentrated in seasons when feed is most available. The practice of selection and maintenance of own breeding males varies with production systems. The primary purpose of keeping buck was mainly for mating specially for intentionally selected breeding bucks in Abergelle and Central highland goat (Alemu, 2015).

GOAT SELECTION CRITERIA IN ETHIOPIA

Selection is an important parameter in replacing parents by best performing stocks, which is one of the tools for improvement. Selection of both replacements (does and bucks) brings a quick improvement on the performance of the flock rather than selection of only breeding bucks or does (Tesfahun, 2013). Selection by farmers suggests that they try to maintain good performing animals and cull the inferior ones, but the selected does are not

necessarily mated with selected bucks, as they are freely travelling and grazing together with other flocks, which make mating uncontrolled. Farmers believe that large, white-colored goats produce high milk yields, while black or red goats have no choice because they don't think they produce as much milk Arsi-Bale zone (Asefa et al., 2015).

According to Galal (2005), selection criteria principally used to cull less desirable male and female animals to exclude them from passing genes to the next generation. In developing countries, farmers and/or breeders who select primarily on the basis of milk yield and morphological characteristics have selected within each goat breed. High preference of twining capability shows the genetic potential of Arab and Oromo goats for multiple births and the farmers' general objective to increase flock size and overall flock productivity Arabian and Oromo goat breeders tend to sell beautiful and fast-growing goats, mostly bucks that are probably best bred early for better market prices. This implies that bucks with unwanted traits are replicating which resulted in negative selection (Oumer et al., 2019).

Traits like kidding frequency, age at first maturity, kid survival and mothering ability were selection criteria of does in Arab and Oromo goats, while adaptability, ability to walk long distance, horns, and age at first maturity, character, and pedigree were selection criteria of bucks to reform in the flock (Oumer et al., 2019). As indicated by different scholar, appearance, coat color, growth rate prolificacy and libido were some of the selection criteria for breeding buck to reform (Asefa, 2013; Zergaw, 2014; Seid et al., 2015; Gatew et al., 2015; Tade et al., 2022). Similarly, selection criteria of does were appearance, age at first maturity, twinning ability, milk yield, kid survival, short kidding interval and growth rate coat color and litter size. However, according to Alemu (2015), Seid et al. (2015) and Tade et al. (2022) milk yield were not the selection criteria of breeding does in Abergelle, western Ethiopia and south Gonder, respectively.

REPRODUCTIVE PERFORMANCES OF GOATS IN ETHIOPIA

Reproductive performance is a requirement for every successful livestock production program, and failure is the first symptom of decreasing output (Mukasa-Mugerwa et al., 2002). Reproductive performance is influenced heavily by management decisions, but it is also of critical economic relevance (Notter, 2000). Adequate knowledge on reproductive performances of the indigenous breeds is crucial for planning a feasible breeding scheme. However, little information is available on the reproductive characteristics of native goat breeds (Mekasha, 2007). However, various aspects of goat production are determined by reproduction, and a high rate of reproductive efficiency is essential for the species' survival, as well as the production of meat, milk, and skin, and the replacement of breeding stock (Abebe, 2008).

The acceptance of the first service depends upon the sexual maturity and body condition (Tsegaye, 2009).

Kidding for the first time is defined as the age at which does birth for the first time (Tsegaye, 2009; Gataw et al., 2015). It is determined by puberty, age of first breeding, conception, and pregnancy completion. Age at first kidding varies both across breeds and across management within breed such as a genetic makeup of an individual, physical environment, nutrition, and time of birth (Abebe, 2008).

The number of days between successive parturitions is referred to as the kidding interval, which is one of the components of reproductive performance that determines productivity (Rume et al., 2011). It is a significant predictor of lifelong production, and a prolonged kidding interval causes a drop in goat productivity. The most significant indication for improving reproductive efficiency is reducing the number of days between kidding, which is influenced by age, season, parity, management type, diet, and mating type (Tade et al., 2021). As concluded by Legesse (2008) the opportunity of indigenous Ethiopian goats to possess three time kidding in two year. Nutrition, suckling, parity (number of times kidded), and breed have all been reported to influence the kidding interval, which is important for productive efficiency (Banerjee et al., 2000). Shorter KI, according to Gemiyu (2009), increases the amount of kid crops, which increases the lifetime production of does.

Litter size is a combination of ovulation rate and embryo survival, number of lambs or kids born per parturition. The number of kids born per doe per kidding is referred to as litter size (Akpa et al., 2011). Litter size and age, as well as litter size and parity, have a positive association (Legesse, 2008; Abebe, 2008). In tropical and subtropical areas, goats are the most prolific ruminant of all domesticated ruminants (Table 1).

CONSTRAINTS OF GOAT PRODUCTION

Planning effective goat treatments requires a thorough grasp of the existing production limits. Goats were hampered by a lack of pasture, periodic droughts, and a high frequency of sickness and parasites. Another stumbling block was the ineffectiveness of government-run veterinary services. Low restrictions to goat production include predators, input (mostly veterinary services), a lack of improved genotypes, labor and capital, theft, a lack of market, and a lack of extension service (Abegaz, 2014). According to several scholars, drought, feed shortage, disease, and a lack of nourishment all impacted goat productivity in different part of Ethiopia (Takele, 2014; Zergaw, 2014; Alemu, 2015; Gatew et al., 2015).

Table 1. Reproductive performance of some Ethiopian indigenous goat breeds.

Goat breed	AFS(month)		AFK (month)	KI (month)	LS	References
	M	F				
Maefur	11.1	12.7	21.2	7.2	NA	Gebreyowhens and Kumar (2018)
Short-eared Somali	13.43	14.8	20.15	8.81	NA	Gataw et al. (2015)
Hararghe highland	NA	NA	16.6	8.1	NA	Tsegaye et al. (2013)
Woyto-Guji	18.61	14.4	21.97	6.79	1.39	Tesfahun (2013)
Begait	6	7	NA	8-12	NA	Hagos et al. (2016)
Arsi-Bale	NA	NA	NA	8	1.3	Asefa (2013)

Note: AFS= Age at First Service; AFK= Age at first kidding; KI= Kidding interval; LS =Litter Size; NA= Not available.
Source: Authors 2022

PHENOTYPIC CHARACTERIZATION OF GOATS IN ETHIOPIA

Indigenous goat breeds/types are widely distributed and may be found in all Ethiopian agro-ecologies, suggesting that natural selection valued adaptation and survival over output (Galal, 2005). Farm Africa (FARM Africa, 1996) classified Ethiopian goats based on their geographic location and thus the ethnic groups who raise them, as well as a comprehensive phenotypic categorization. All operations connected to the identification, quantitative and qualitative description and documenting of breed populations, and thus the natural environments and production systems to which they are or are not adapted, are included in AnGR characterization. It is critical to have a thorough awareness of breed traits in order to make informed decisions in livestock development and breeding programs (FAO, 2007). Based on an evaluation of the phenotypic traits of a population raised in diverse production contexts, genetic improvement schemes should be developed for the sustainable conservation and usage of indigenous animal genetic resources (Tade et al., 2021).

According to FAO (2012), phenotypic characterization of AnGR is the process of defining distinct breeds or populations by describing their exterior and production features in a specific environment and under a given management, while taking social and economic aspects into mind. Characterization studies provide crucial information for planning AnGR management at the local, national, regional, and global levels. A comprehensive grasp of breed traits is vital for decision-making in livestock development and breeding programs, according to the FAO's Global Plan of Action for Animal Genetic Resources (FAO, 2007). Nowadays, there is a lot of interest in goat genetic resources protection and better application all over the world.

Phenotypic characterization is critical for creating a list of traits for a group of animals and ensuring the long-term viability of its animal genetic resources. Lack of information on genetic resource characterization may result in underutilization, replacement, and dilution through cross breeding, notwithstanding local adaptation to existing environmental limits (Manzi et al., 2011). Breed characterization through phenotypes, as defined by FAO (2012), is based on the reporting of qualitative and quantitative features. The majority of phenotypic characteristics are polygenetically inherited, and many of them are affected by environmental factors and genotype-environment interactions. Natural selection also has an impact on phenotypic traits (Alemu, 2004). The phenotypes of goats have a significant impact on Ethiopian communities' socio-cultural and economic values; as a result, most farmers have specific considerations and choices for goat coat colors, followed by body sizes (Zewdie and Welday, 2015).

Sex, coat color pattern and type, horn form, horn and ear orientation, facial (head) and back profile, and presence or absence of wattles, beard, and ruff are among the qualitative aspects to be documented. Body length (BL), height at wither (HW), chest girth (CG), chest depth (CD), chest width (CW), head length (HeL), height at rump (HR), rump length (RL), pelvis width (PW), horn length (HL), and ear length (EL) are all quantitative features (Asefa, 2013; Alemu, 2015; Gataw et al., 2015; Jeda and Asefa, 2016)

The forms and patterns of coats have been linked to adaptation and thermal regulation (Ofori et al., 2021). Western Highland, Hararghe Highland, Woyto-guge, Keffa, Arsi-bale, and short-eared Somalia were the goat breeds with the highest proportion of plain coat color patterns. Abergelle, Central highland, Afar, and Agew have patchy coat color patterns. The plain coat color pattern is the most common among Ethiopia's indigenous goat population, followed by Patchy, while the Gumuz goat in the Amhara region has a spot coat color pattern (Hassen et al., 2012). This implies that different breeds, geographies, and agro- climates have varied coat color patterns.

Most morphological features are higher in the Begait

Table 2. Qualitative characteristic of Ethiopian goat breed.

Breed of goat	Coat color pattern	Horn present (%)	Horn shape	Ear form	head profile	Coat color type	Ruff present (%)	References
Western highland	Plain	86	Straight	NA	Concave	White	99	Gizaw (2009)
Abergelle	Patchy	99	Curved	carried horizontal	Straight	Red/brown	23.62	Alemu (2015)
Central high land goat	Patchy	100	Curved	Pendulous	Concave	White and brown	9	Zergaw (2014)
Begait	NA	99	NA	Dropping	NA	White	NA	Hagos et al. (2016)
Hararghe Highland	Plain	59	Straight	Horizontal	Straight	Brown	0.3	Tsegaye et al. (2013)
Woyto-Guji	Plain 91.2%	NA	Straight	NA	Straight	Brown	-	Lorato et al. (2015)
Afar	patches	NA	NA	NA	Concave	white	67	Gizaw (2009)
Kaffa	plain	83	NA	NA	Straight	Brown	97	Gizaw (2009)
Arsi-Bale	Plain	94	Straight	Lateral	Flat	White	70.63	Asefa (2013)
Short eared Somali	Plain	81	NA	Forward Erected	Straight	White	NA	Getaw et al. (2015)
Gumuz	Spot	NA	Curved	Horizontal	Straight	Spot black	NA	Hassen et al. (2012)
Agew	Patchy	NA	Pooled 23.33	Horizontal	Slight concave	White with spot	NA	Hassen et al. (2012)

Note: NA= not available.
Source: Authors 2022

Table 3. Morphometric traits of some goat breeds in Ethiopia.

Goat breed	BW(kg)	BL (cm)	HW (cm)	CG (cm)	EL (cm)	HL (cm)	RL (cm)	RH (cm)	PW (cm)	References
Kaffa	28.2	NA	66.7	72.2	13.0	11.6	NA	NA	NA	Gizaw (2009)
Afar	23.7	NA	60.9	67.4	12.3	17.4	NA	NA	NA	Gizaw (2009)
Arsi_Bale	25	59.0	61.1	74.9	12.7	11.2	14.3	66.6	NA	Jeda and Asefa (2016)
Abergelle	27.52	58.32	65.31	70.2	12.81	23.3	12.95	NA	12.34	Alemu, (2015)
Central highland	33.95	61.4	71.02	74.90	15.04	15.74	13.03	NA	12.2	Alemu, (2015)
Hararghe highland	23.9	55.9	59.0	65.2	12.8	8.33	14.0	63	12.8	Tsegaye et al. (2013)
Woyto-Guji	24.8	57.4	61.9	68.3	13	10	17.3	NA	13.4	Zergaw (2014)
Begait	34.05	64.1	69.73	73.85	23.63	19.52	Na	NA	NA	Hagos et al. (2016)
Western highland	28.7	56.9	67.2	70.8	14.9	10.2	Na	69	6.4	Seid et al. (2015)

Note: BW=Body weight. BL=Body length HW= Height at wither, CG= Chest girth .EL =Ear length. HL= Horn length, RL=Rump length, HR= Height at rump, PW=Pelvic width, NA=Not available.
Source: Authors 2022

and Central highland goat breeds. However, when compared to other goat breeds, the BW, HW, and CG of Afar and Hararghe highland goats are lower. In comparison to other goat breeds, the Abergelle goat breed has the longest horns (Alemu, 2015). Horn is a useful tool for defending

oneself and surviving in tough situations. The longest horn, rather than the short horn, may be employed for defense. Ear length has been related to the adaptation potential of goat in a specific production environment such as exposure to extreme heat stress conditions (Elbeltagy et al., 2016). Those phenotypic variations in a goat population may arise due to genotypic and environmental effects, and differences in morphological variability under different environmental conditions. Moreover, the existence of phenotypic variation between populations is essential to successfully adapt to frequently changing climatic conditions and to successfully respond to artificial selection (Tade et al., 2021). Tables 2 and 3 highlight some morphological characterizations of indigenous goat breeds.

CONCLUSION

The main fodder resources for goats are natural pastures, crop residues, local fodder trees, shrubs, roads and riversides, and others. Breeding goals are the initial stage in developing genetic improvement methods and identifying which features farmers want to improve. Castration used for to fattening goats, to get better price and to control temperament of bucks. Reproductive performance is a requirement for every successful livestock production program, and influenced heavily by management. Any successful animal breeding program must have high reproductive performance. Ethiopians place a high importance on the goat trait, both socio-culturally and economically. Indigenous goat breeds/types are widely distributed and may be found in all Ethiopian agro-ecologies, suggesting that natural selection valued adaptation and survival over output. Selection criteria principally used to cull less desirable male and female animals to exclude them from passing genes to the next generation. Phenotypic characterization is critical for creating a list of traits for a group of animals and ensuring the long-term viability of its animal genetic resources. The majority of phenotypic features are inherited, however many are altered by social environments. The description of qualitative and quantitative features is used to characterize goat breeds and types using phenotypes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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