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Review on phenotypic characterization and reproductive performance of indigenous goat populations in Ethiopia

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Abstract
The review was conducted to Phenotypic Characterization and Reproductive performance of Indigenous Goat Populations in Ethiopia. Concerned with breeding practice of producers of indigenous goat were practiced for improved their goat productivity through cross breeding and pure breeding methods. Indigenous goat doesn't have phenotypic standards and their classification is given based on colours and name of place where they are characterized. Still those local goats are non-descriptive type and show variations in body position, body colour, horn type, their adaptation and productivity. Traditional management systems is the dominant management practices of goat with small feed supplementation. High incidence of goat diseases, predators is the major economically important constraints for local goat production systems followed by feed shortage and predators in the country. Since local goat have good potential to adapt in different agro-ecology and make available well-appointed source of family protein and income for rural people. Indigenous breeds of goat are playing an important role in rural economies in most of the developing countries. They play a major role for the rural poor people with respect to their subsidiary income and provide them with nutritious of goat meat and milk for their own consumption. The present review was made to document the importance of indigenous goat characterizations and breeding Practices in Ethiopia for rural economy and its improvement with respect to performance.

Keywords: Ethiopia, goat, performance, phenotype, population and review

1. Introduction

Ethiopia is endowed with huge livestock resources of varied and diversified genetic pools with specific adaptations to a wide range of agro-ecologies. Farm animals as a whole are an integral part of the country's agricultural system and are raised in both the highland and lowland areas. In developing countries, livestock production is mostly subsistence oriented and fulfills multiple functions that contribute more for food security. With the current goat population size of 29 million [1], Ethiopia stands third in Africa and sixth in the world accounting for 9% and 3% of the African and global goat population, respectively.

Among the farm animal genetic resources, indigenous goats have unique adaptive mechanisms which enable them to fit in varied agro ecologies and contribute to the livelihood of small holder farmers through producing valuable milk and meat products. Within the agro ecology there are also sub agro ecologies and developed in to niches as home of specific adapted ecotypes. [2] described the domestic goat (Capra Aegagrus) as a subspecies of goat domesticated from the wild goat of southwest Asia and Eastern Europe. Goat owners across the selected areas were highly interested in body size (conformation), fast growth rate, milk yield, and drought tolerance (adaptability) and disease tolerance and reproduction rate.

According to the livestock survey result [3], the country has an estimated 30.20 million heads of goats. This puts the country 8th among the top ten countries (China, India, Pakistan, Bangladesh, Nigeria, Sudan, Iran, Ethiopia, Mongolia and Indonesia) in the world and third in Africa next to Nigeria and Sudan regarding goat populations [4]. In Ethiopia goat production contributes for 16.8% of total meat supply and 16.7% of milk consumed in the country. Goat owners in Ethiopia were highly interested in body size (conformation), fast growth rate, milk yield, and drought tolerance (adaptability) and disease tolerance and reproduction rate. The farmers select breeding does on the basis of multiple births, body conformation, mothering ability, kid growth, Coat color, fertility traits (KI and AFK), and appearances [5].

Farmers in different part of Ethiopia have different Livestock composition in general and flock structure of goat in particular due to different agro-ecology, availability of feed and water, the availability of land (communal grazing land and private grazing land) and behavior of farmers. To ensure sustainable utilization of the indigenous goat, there should be a conservation strategy for the present and future use. Phenotypic characterization is the first step for identification of qualitative and quantitative traits of the indigenous goat. Characterization is corner back bone for efficient and effective management of goat breeds for conservation, especially for those which are not adequately characterized and are in danger of becoming threatened but are better performing in stress full environment [6]. Phenotypic characterization of animal genetic resources for food and agriculture (AnGR) is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources.

2. Breeding objectives of indigenous goat

Community-based breeding programs are most appropriate to

implement in situations where livestock keepers already run their animals together, such as in communal grazing areas. These situations also have potential for other community-level collective actions, such as joint procurement of services (veterinary, feeding and marketing). Clear definition of breeding objectives might be difficult under subsistence level of managements with a wide range of production objectives and marketing strategies. In general the result of many studies [7] indicated that farmers have multiple breeding objectives. These include milk production, meat production, and reproduction in order of their importance. In Metema and Abergele district of Amhara region, [5] found that the breeding objectives were derived from the preferred traits by the community from the production system, own flock ranking and group ranking experiments. Any breeding program for goats should be implemented to achieve a certain clearly defined objective. Therefore, the first step in a breeding program is to define accurate and attainable objectives. The main objective is to maximize output (meat, milk, wool, skin) per unit input. Farmers breeding management decision is determined by the merit of livestock species and breed, farmers breeding objectives and the production environment [8]. The main objective of rearing goat's population in Northern Omo, Ethiopia was expected to provide multifaceted benefits to farmers. According to [9] the major reason for goat rearing was income generations through sale of live animals with an index value of 0.6, 0.42 and 0.47 in highland, midland and lowland area of West Shoa Zone, Ethiopia, respectively. The same result also reported by [10] with index of 0.40, 0.48 and 0.44 (sale of live animals) and 0.35, 0.30 and 0.43 (meat) in lowland, midland and highland area of Northern Omo, Ethiopia, respectively.

2.1. Reproductive performance of goat

2.1.1. Age at puberty

Puberty is the point of sexual development at which the animal becomes capable for reproduction and starts sexual activity. Puberty is also more related to growth than age in tropical goats with first estrous occurring with the attainment of 60-70% of adult live weight which is relatively later than in males. According to study of [11] Begait goat in western Tigray reach for first service point was at 7.41±1.85 month for males and 8±1.78 months for females. In the study of [12] age at sexual maturity for female and male of Arsi-Bale goats was 8.2±0.15 and 10.30±0.15 months respectively. According to [13] the delayed age at puberty was explained as genetic factor, climate and management practices of the farm and it can be reduced by out crossing within the different goat breeds.

2.1.2. Age at First Service (AFS)

Reproductive performance heavily influences genetic improvement through their impact on selection intensity. As a consequence, adequate knowledge on reproductive performances of the indigenous breeds is crucial for planning a feasible breeding scheme. The reproductive performance in terms of age at first service, age at first kidding, kidding interval and litter size was reviewed. Age at first service for both sexes is not fixed. The AFS reported by several workers have been summarized in Table 1. According to [9] ages at first service for Western highland goat were 8.39±0.06 months for males whereas it was 8.2±1.64 months for Western lowland goat. The AFS of female indigenous goat in Horro Guduru is 7.11±0.02 month indicating that indigenous goat in Horro Guduru have a short AFS as compared to other goat breed in different area. According to the [5] age at sexual maturity of Western lowland goat in Metema and Abergelle goat in Abergele is 7.4± 2.01 and 12.3±4.48 months respectively. In western zone of Tigray region, age at first service of Begait goats reached between 6 and 8 months [6]. This finding is similar to that of [14] who reported that most of does and bucks reach puberty at about 5 and 9 months, respectively. Generally the age at first service is indicate that the AFS of different goat breed is different and this variation may be depends on type of breed, season of birth, forage availability and management system.

Table 1: Age at First Kidding (AFK), Kidding Interval (KI) and Litter Size (LS) of some of Ethiopian goat breeds in different area

Breed	Location	AFS (Month)	AFK (Month)	KI (Month)	LI(No)	Source
Arsi-Bale	Bale	-	19.17	9.33	1.60	[15]
S Southwestern Ethiopia	Southern region	8.61±0.03 (F)	14.68±0.02	8.08±0.03	-	[16]
Goat in Horro Guduru	Horro Guduru	7.11±0.02(F)	12.11±0.02	5.76± 0.04	1.77 ±0.03	[17]
Abergelle Goat	Abergelle	12.3±4.48(M)	15.5±5.48	8.3±3.37	1.04	[5]
Western Lowland	Metema	7.4± 2.01(M)	12.4±1.39	6.3±0.64	-	[5]
Western highland	West shoa	8.39±0.06(M)	13.85±0.12	8.25±0.52	1.28±0.33	[9]
West Omo and Bench–Sheko zone	Southern region	9.5±0.2(F)	15.1±0.21	8.1±0.89	-	[18]

2.1.3. Age at first kidding

Age at first kidding (AFK) can be described as the age at which goats give birth for the first time. It is a function of puberty. Age at first kidding is also the period between birth and first kidding and influences both the productive and reproductive life of the female. The AFK was recorded in some traditional production systems were reported by several workers. This indicated that the existing uncontrolled breeding practice in this system is in favors of early kidding of indigenous goats than the controlled breeding practices in the improved system. Age at first kidding is closely related to the rearing intensity, generation interval and response to selection. According to [19], the AFK of western lowland goat in Metema were 13.6±2.44. On the contrary the AFK of Short-eared Somali were 20.15±0.12 month [20]. Age at first kidding is highly variable and dependent on the growth rate and management system used

[21].

2.1.4. Kidding Interval (KI)

Kidding interval is defined as the interval between two consecutive parturitions; and is one of the main components of reproductive performance of small ruminant which is affected by season; type of management to be used and nutrition can prolong the interval between kidding for goat [22]. In Metema district the KI of western lowland goat were 6.3±0.64 month (Solomon, 2014); and in the same district for the same breed [19] reported 8.4±1.37 month and this indicated that the same breed in the same district have difference kidding interval. [5] reported that a kidding interval of 6.3±0.64 months for western lowland goat and indigenous goat which could reflect that the breed can produce three lambing in two years even under the traditional management system.

Reproductive efficiency is related to the length of kidding interval; i.e. doe with long kidding interval has lower reproductive efficiency [23]. There are reports on the possibility of attaining three parturitions from indigenous small ruminants in two years [24]. To attain this, kidding interval of goat should not exceed 8 months (245 days). Generally, past research reports revealed variations in KI among indigenous goats of Ethiopia. The longer KI reported from some research stations are mainly due to the result of controlled breeding with the objective to achieve the best breeding season and synchronization of birth for research purpose. Shorter KI is also reported from some other research stations where good management systems are in place and breeding males are available in the herd for most period of the year.

2.1.5. Litter size

Litter size is defined as the number of progenies born per kidding. Goat is the most prolific ruminant of all domesticated ruminants in tropical and sub-tropical regions. The LS have been recorded to be 1.21 [25]. The average LS estimated for local goats in Alaba, Southern Ethiopia, is about 1.47 [23]. Litter size of 1.04, 1.28 and 1.77 was reported for Abergelle, western highland and indigeneous goat in Horro GuduruWollega under village conditions [26]; [9]and [17].

It is also found that LS of Somali and Afar goats are smaller than the values reported for most of the indigenous goats in Ethiopia even under traditional systems. This is consistent with the results of other studies [27] and appears to be one mechanism of adaptation to the harsh environmental conditions of the rangelands and to the seasonal scarcity of feed resources. Litter size is significantly affected by parity and weight of doe at mating [26]. The results of previous studies generally show that LS is the most variable traits reported for indigenous goats in Ethiopia. This shows the presence of huge opportunity to improve these traits through selection and improved management focusing on breeds having better potential for the traits.

2.2. Trait preference and selection criteria of goats

Goat owners across all the country's area were highly interested in body size (conformation), fast growth rate, milk yield, and drought tolerance (adaptability) and disease tolerance and reproduction rate. From those selection criteria appearance and color took the first and the second rank and better milk yield as the 3rd criteria, respectively [28]. However, in Sawena district of the region appearance, better milk yield and color took the first, second and third rank, respectively [28]. For Western Lowland goat owners, the most important selection criteria for breeding does were multiple births, body conformation, mothering ability and kid growth with index values of 0.34, 0.16, 0.15 and 0.11, respectively [5]., Coat color, fertility traits (kidding interval and age at 1st kidding) were also mentioned as selection criteria but with lower rank. Appearance, color and better milk yield used as the major selection criteria for breeding does in the Mada Walabu and Rayitu districts of Oromia region. In breeding programs for most species, animals in dam and sire selection pathways are selected very intensely with a higher accuracy than in the other selection pathways.

The most important coat color preferences in Bati area for both sexes were brown but plain white coat color was the most preferred one by both Borena and Siti pastoralist and agro-pastoralists [20]. Similarly, [29] reported, black coat color was not preferred by the producers in all selected district of Amhara region. Body conformation followed by coat color were found as the most important selection criteria of breeding bucks with the index values of 0.33 and 0.22 for Western Lowland goat keepers and 0.31 and 0.25 for Abergelle, respectively [5].

Productive and reproductive traits (Age at first service, Kidding interval, litter size, body weight, milk yield, weaning age and weaning weight as well as daily weight gain) of a goat were more important than beauty and adaptation related traits for selection of breeding stock. Selection of breeding stock by farmers is through using their indigenous knowledge. They depended on information about the performance of potential buck/doe dams and growth performance, information from relatives/ancestor and assessment of young buck and/or doe. There were no records on performance of individuals and their pedigree. Identification was mainly by phenotypic appearance.

2.3. Phenotypic characterization of goat

Indigenous goat in Ethiopia has a multipurpose role for smallholder farmers as sources of income, meat, skin and manure. They are also a means of risk avoidance during crop failure. Thus, increasing the current level of productivity of goat is essential to meet the demands of the ever-increasing human population. On the other hand, by improving the productivity of goat, export earnings as well as the income of the household will be improved. Characterization is corner stone for well-organized and current management of goat breeds for conservation, especially for those which are not adequately characterized and are in danger of becoming threatened but are better performing in stress full environment [6]. Phenotypic characterization of animal genetic resources for food and agriculture (AnGR) is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources. The information provided by characterization

studies is essential for planning the management of AnGR at local, national, regional and global levels [30]. The classical description of breeds using the phenotype is based upon morphological characters such as coat color, horn, tails, body measurements and other specific visible traits. Phenotypic relationships, based upon the comparison of morphological characters, are used to estimate variations within breeds and distances between breeds, and are used to describe them in terms of the frequency of the most typical characteristics. Morphological or phenotypic characterization has been suggested and used to describe and classify breeds of farm animal species.

2.3.1. Qualitative characteristics

Breeds of farm animal species can be identified and classified based on physical characteristics. The physical characteristics include body color, size and shape of body parts, and presence or absence of body parts. Few physical features can be used to identify major groups of breeds. This category of traits covers the external physical form, shape, color and appearance of animals which are recorded as discrete or categorical [31]. Qualitative characteristics are those that can be categorized like coat color, presence/absence of horns, beard, ruff, muzzle, toggle, facial profile, ear form etc. The observed overall coat color patterns (Table 2) for both sexes were 64.20% plain, 33.33% patchy/pied and 2.47% spotted in Bati; 72.36% plain, 23.98% patchy/pied and 3.66% spotted in Borena; and 45.08% plain, 39.90% patchy/pied and 15.03% spotted in Short-eared Somali goat populations [20]. [32] reported higher proportion (93%) of plain coat color pattern for central highland goats around South Wollo (Bati) and North Shewa (Shewa Robit and Ankober). [33] reported coat color pattern observed in Abergelle goat was plain (38.34%), patchy (39.88%) and spotted (21.78%).The majority of Bati and Borena goats were characterized by lateral/sideway ear orientation accounting a total of 59.9 and 78.9%, respectively [20]. Majority of Abergelle goat coat color was brown/red (30.40%) and its combination with other coat colors (50.61%), whereas relatively high proportion of central highland goat had white coat color (21.66) and its combination with other coat colors 55.09 % [33]. The red/brown coat color has dominancy in Abergelle goat.

Table 2: Coat color pattern, coat color type, horn shape, presence or absence of for different goat breeds in different area of Ethiopia

Breed	Location	Characteristics						Source
		Color	%	Coat pattern	%	Horn shape	%	
Bati	Bati and Kalu	Dark red/brown Light red White+ Light brown White Others	29.63 22.22 19.14 11.11 17.95	Plain Spotted Patchy	64.2 4.48 23.88	Straight Curved Spiral	96.73 2.61 0.65	[20]
Borena	Yabello	White White+ brown White +Black Gray Others	71.54 16.67 6.91 2.03 2.85	Plain Spotted Patchy	72.36 3.66 23.98	Straight Curved Spiral	68.72 27.69 3.59	[20]
Woyto-Guji	Loma	White Brown Grey White Black	19.9 45.7 6.5 7.8 20.1	Plain Spotted Patchy	91.2 6.3 2.5	Straight Polled Spiral	71.4 9.9 18.8	[10]
Short-eared Somali	Siti (Somali)	White White +Black White+ brown Others	36.2 21.24 20.21 22.29	Plain Spotted Patchy	45.08 15.03 39.90	Straight Curved Spiral	54.49 35.26 10.26	[20]
Central Highland	Ziquala and Lay Armachiho (Amhara)	White White and red Red/brown Black and white Others	21.66 34.71 13.38 11.46 18.79	Plain Spotted Patchy	38.22 21.97 39.81	Straight Curved Spiral	18.15 74.32 7.53	[33]
Abergelle	Tanqua Abergelle (Tigray)	Red/brown White and red black Black and white Others	30.98 30.06 6.44 11.04 21.37	Plain Spotted Patchy	38.34 21.78 39.88	Straight Curved Spiral	8.38 70.19 21.43	[33]
Abergelle	Abergelle	Red brown White and brown Brown Red bro and white Others	23.85 15.65 19.66 12.79 12.02	Plain Patchy	54.2 45.8	- - -	- - -	[5]

Woyto-Guji	Bench-mage	Brown dominant fawn White dominant black Black dominant Others	25.28 15.17 13.48 11.80 9.55 24.72	Plain Spotted Patchy	65.73 22.47 11.80	curved straight pooled	19.10 78.09 2.81	[34]

2.3.2. Quantitative characteristics

Body size is found to be a key classifying physical characteristic of Ethiopian goat families and breeds. Body size refers to the height, length and width of the animal. Such measures of body size are called linear body measurements and include height at withers and heart girth. Linear body measurements are taken using a measuring tape. This category of traits covers the size and dimensions of animals' bodies or body parts, which are more directly, correlated to production traits than qualitative traits and have continuous expression because of numerous genes that determine their expression [31]. The Body weight (kg), Chest girth (cm), Body length (cm) and Height at Wither (CM) for various Goat breeds in different area of the country Ethiopia is presented in table 3.

Table 3: Body weight (kg), chest girth (cm), body length (cm) and height at wither (cm) for different goat breeds in different area of Ethiopia

Breed	Location	Body weight(kg)	Chest girth (cm)	Body length(cm)	Height at Wither (cm)	Source
Western Lowland	Metema	24.00	65.27	54.80	62.60	[5]
Central Highland	Ziquala and Lay Armachiho (Amhara)	33.95	74.90	61.44	71.02	[33]
Abergelle	Abergelle	18.34	61.03	51.00	58.99	[5]
Southern Ethiopia	Southern Ethiopia	32.41•	73.28	52.38	59.52	[35]
Short-eared Somali	Siti (Somali)	24.67	67.27	57.85	62.88	[20]
Abergelle	Tanqua Abergelle (Tigray)	27.52	70.21	58.32	65.31	[33]
Woyto-Guji	Loma	26.7	73.11	58.20	66.65	[10]
Woyto-Guji	Gamo-Gofa	28.596	73.63	60.66	65.60	[7]
South Western	Gambella	23.00	64.07	55.01	56.48	[36]

Review of live body weight and linear body measurement of goat

2.3.3. Correlation between body weight and linear body measurements

The correlation between body weight and other LBM was higher in male than female counter parts and this variation may be explained due to the difference in fat deposition variation between male and female goats. Body weight was highly correlated with all continuous traits of both female and male goats except some quantitative traits [28]; [17]; [15]; [33]; [10] and [7]. Body weight was highly correlated with HG, BL, HW and HDL (0.96, 0.92, 0.90 and 0.74 in male Begait goats respectively) and (0.89, 0.85, 0.83 and 0.54 in female Begait goats) respectively [6]. Among measured linear quantitative variables chest girth (r=0.769 up to 0.928), body length (r=0.494 up to 0.796) and height at withers(r=0.471 up to 0.856) was the highest positively associated variable with body weight both for male and female Abergelle and Central Highland goat breeds, respectively [33]. The correlation coefficient between linear body measurement and body weight were positive and significant except ear length for both sexes in bale zone of Oromia region [28].

2.3.4. Prediction of body weight from LBMs

Multiple linear regression analysis was carried out to predict live body weight of an animal. Regression of body weight over independent variables, which have higher correlation with body weight, was done to set adequate model for the prediction of body weight separately for each sex. According [37] regression analysis is a decisive instrument in livestock research to mark out the relationship between quantitative response variable and explanatory variable like body weight and linear body measurement, this mechanism of analysis is more important in absence of weighing balances. The prediction of body weight could be based on regression equation developed for male and female by using heart girth and other variables (HG, BL and TL) for male and (HG, BL, HW and EL) for female [6]. For Abergelle and Central Highland Goat five (CG, BL, HW, RL and PW) and four (CG, BL, SC and PW) predictors (quantitative traits) were selected in order to develop the prediction equation for Abergelle female and male goats respectively [33]. In the selected districts of west Gojjam Chest girth selected first, which explain more variation than any other linear body measurements in both does (88%) and bucks (91%). In addition to chest girth only eight quantitative trait (CG, HW, CW, RL, RW, HDL, BL and TL) and only seven linear body measurements were taken to be incorporated in to the model for bucks (CG, BL, RL, RH, HW, HDL and CBL) [15].

Conclusion

In Ethiopia, the agricultural sector is a corner stone of the economic and social life of the people since they are used for generation of extra cash incomes, provision of animal protein and religious/cultural/ considerations. Understanding the situation of goat rearing was crucial for improvement of goat products and to design goat breeding strategy. Indigenous breeds of goats are playing an important role in rural economies in most of the developing (underdeveloped) countries. They play a major role for the rural poor and marginalized section of the people with respect to their subsidiary income and provide them with nutritious of chi goat meat and milk for their own

consumption of their family. To increase and sustain the productivity of goat so as to respond to the growing domestic and foreign demands for live goat and its products, improvement programs are necessary and should be crafted, especially for countries like Ethiopia where extensive system of husbandry is the commonest type. Indigenous goat does not have phenotypic standards and their classification was given based on colours and name of place where they were characterized. Still those local goats are non-descriptive type and show variations in body position, body colour, horn type, their adaptation and productivity.

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