G.J.A.S.R

GLOBAL JOURNAL OF ANIMAL SCIENTIFIC RESEARCH

Journal homepage: www.gjasr.com

Print ISSN:2345-4377 *Online ISSN:2345-4385*

Review Article

Application of Structural Indices to Assess Type and Function of Indigenous Goat Population in Ethiopia: Review

Gutu Yemane* and **Aberra Melesse**

School of Animal and Range Sciences, Hawassa University, Hawassa, Ethiopia

ABSTRACT

This review is aimed to provide well-organized information on structural and functional indices of indigenous goat population in Ethiopia to assess their type and function. Ethiopian goat populations are managed under different production systems and varied with their type and function. The review indicated that goat types in Jimma zone of Ethiopia were characterized as medium in dactyl thorax, small in weight; longer at the rump than at wither and their general body conformation was intermediary meat type. Central Highland goat in Ataye farm was also classified as meat type animals. In the Gamo Gofa zone, Arba Minch Zuria district goats were categorized as medium-sized and long-shaped body frames, with meat type animals along with signs of adaptation to its environment. On the other hand, Mirab Abaya goats were characterized as medium-sized with dairy type. In the Sidama zone, Bucks age groups 3 and 4 reared in Lokabaya have good thoracic development than any other age and sex group across the districts. Goats in the East Gojjam zone are short-bodied, long linear, curved, less compacted with poor thoracic development, balanced, light, and dairy type animals. However, the Dactyl thorax and Relative cannon thickness index showed that bucks have the better muscling ability and possess meat type. Similarly, these goat types are lower at the whither than the rump thus may be prone to dust infestation. In general, indigenous goat populations in Ethiopia may be settled as both meat and dairy type animals. So, this review could serve as a baseline

Corresponding Author: Gutu Yemane < gutuyemane@gmail.com >

Cite this Article: Yemane, G., and Melesse, A. (2021). Application of Structural Indices to assess Type and Function of Indigenous Goat Population in Ethiopia: Review. *Global Journal of Animal Scientific Research,* 9(2), 115-132.

Retrieved from http://www.gjasr.com/index.php/GJASR/article/view/89

Article History: Received: 2021.09.14 Accepted: 2021.10.28

for the classification of Ethiopian goats into type and function and it requires further studies on goat structural indices.

Keywords: structural indices, functional, type, Indigenous goat

INTRODUCTION

In Ethiopia, goat production represents an important component of the farming system with an estimated population of 36.81 million heads. They are distributed across various agro-ecological zones of the country and managed under mixed crop-livestock, pastoral and agro-pastoral, and specialized urban and peri-urban production systems (FAO, 2019 and CSA, 2020). These huge indigenous goat populations have to be identified according to their type and function and thus, structural indices from linear body measurement could be designed. Morphometric traits of an animal express a strong relationship with productive potential since it contains the structure which supports the biological functionality of the animal (Alpak *et al*., 2009). Structural indices could estimate an animal's conformation when compared to individual measurements alone and also provide tested empirical values, which are limited in the use of single measurements (Chacón *et al*., 2011; Khargharia *et al*., 2015 and Barragán, 2017).

Structural indices are combinations of morphometric measurement in which their results are expressed as a percentage and indicate the type and function of a particular breed (Maciejowski and Zieba, 1982; Chiemela *et al*., 2016 and Banerjee S., 2017). Structural indices are superior over single measurements and offer an accurate estimation of an animal's conformation when compared to individual measurements alone. Due to its association with desirable conformation such as length and balance assessment of animal weight are better done using indices. They are also used for the assessment of type, weight, and function as well as enhance the ability of breeders to select a potential breeding stock (Salako, 2006 and Putra and Ilham, 2019).

Assessment of structural indices is an important component of phenotypic characterization to understand breed structure and proportions, which are the ethnological characteristics as well as functional traits of animals providing information about the type, aptitude, and production performance of the animal (Popoola, 2015). Conclusions from a single morphometric measurement can be misleading as a large skeletal structure alone does not ensure a higher body weight, (Salako 2006). Thus, to minimize the differences in breed characterization, the type and function of livestock need to be assessed. This can be done using the ratios of some linear body measurements giving intensification to several indices known as structural/morphometric/ zoometric indices. Conventionally the type and functional traits of livestock are estimated through the experience of the assessor and the process is therefore mostly subjective, these traits are lowly heritable and hence largely influenced by environmental factors (Banerjee S., 2017).

Structural indices of indigenous goats in Ethiopia have been done in different study areas by different scholars to identify the country's goat population based on their type and function (Chiemela *et al*., 2016; Dereje *et al*., 2019; Yemane *et al*., 2020; Hankamo *et al*., 2020 and Mezgebu, 2020). The word 'type' indicates the body form which is supposed to be ideal for the purpose for which the livestock was developed in the past and says much more than the conventional values of 'size' and 'scale' alone. Calculations of the structural indices can thus, serve as useful tools to assess the balance between aesthetics and production potential of an animal. These indices also help in enabling the selection of young and breeding animals and thus can assist in calculating conformation of the animals; the other advantage is that the values of the indices are not correlated with the age of the animals (Salako, 2006).

Despite its benefit over single measurements, the studies and information on structural indices and the association of these traits with adaptability, longevity, and productivity of indigenous goat populations in Ethiopia are very scanty. Thus, this review will serve as baseline information for further studies, important for breeders to design an appropriate breeding program that suite with (the available goat types in the country, existing production system, and farmer's trait preference and breeding objectives) as well as for researchers, academicians, development planners, and policymakers. Therefore this review aims to provide updated information on structural indices of goats for assessing weight as well as estimating their type and function in Ethiopia.

MAIN TEXT

Structural indices of indigenous Goat in Ethiopia

There are two types of indices which are ethnological and functional. Ethnological indices give general information about livestock breed characteristics in terms of describing structure and proportions which are morphological characteristics of an animal while functional indices provide information about the type, aptitude, and production performance of the animal as reported by Esquivelzeta *et al.,* (2011). In Ethiopia, some authors have done structural indices of indigenous goats in their different study areas (Chiemela *et al*., 2016 in South Wollo; Dereje *et al*., 2019 in Gamo Gofa zone, Yemane *et al*., 2020 in Jimma zone; Hankamo *et al*., 2020 in Sidama zone and Mezgebu, 2020 in East Gojjam Zone of Ethiopia). Body indices could be calculated according to methods and formulas provided by scholars (Lopez *et al*., 1992; Alderson, 1999; Salako, 2006b; McManus *et al*., 2008; Esquivelzeta *et al*., 2011 and Chacón *et al*., 2011). Indices that are more closely associated with bone growth such as foreleg length, height slope, and length index are more appropriate for assessment of type. Some of the structural indices of goats include height slope, length index, girth index, depth index, body index, proportionality, pelvic index, transverse and longitudinal pelvic, dactyl thorax index, thoracic development, body ratio, conformation index, Compact, and area index).

Table 1: Methods to estimate structural indices of goat

Number	Indices	Body measurements with formula
1	Height slope	Rump height – height at withers
2	Length index or Relative body index	(Body length/ height at withers) * 100
3	Depth index	Chest depth/ height at withers
4	Girth index	Paunch girth/ Heart girth
5	Body index	(Body length/ Heart girth)* 100. When this measure is greater than 0.90 (90), the animal is longiline; between 0.86 (86) to 0.88 (88) is medigline; and less than 0.85 (85), it is brevigline.
6	Proportionality	(Height at withers/ Body length)*100
7	Pelvic index	(Rump width/ Rump length) * 100
8	Transverse pelvic	(Rump width/ Rump height) *100
9	Longitudinal pelvic	(Rump length/ Rump height) * 100
10	Relative depth of Thorax	(Chest depth/ Height at withers) * 100
11	Dactyl thorax index	(Cannon bone circumference/ Heart girth) * 100. The DTI may not be more than 10.5 in light animals, up to 10.8 in intermediary; up to 11.0 in light meat animals, and up to 11.5 in heavy meat type.
12	Pectoral index	[(Height at withers + Rump height)/2]/ Sternum height or Pectoral Index = ((Height at withers + Rump height)/2)/(Height at withers-Chest Depth)). This index also indicates thoracic development; when the back height is less than the sternum height, the animal is considered "far from the ground"
13	Thoracic development	Heart girth/ Height at withers. Thoracic development of the animal with values above 1.2 indicating animals with good TD.
14	Body ratio	Height at withers/ Rump height. If the withers are lower than the rump, the animal is low in front and vice versa.
15	Baron & Crevat/Conformation index	(Heart girth) 2 / Height at withers
16	Weight	(Heart girth) 3 * 80. Weight above 45 kg corresponds to large or hypermetric animals, between 35 and 45 kg medium or eumetric animals, and below 35 kg, small or elipometric animals.
17	Compact index 1	(Weight/ Height at withers)/ 100. Compact index

		indicates how compact the animal is. Meat type animals have values above 3.15. Value close to 2.75 indicates dual purpose and close to 2.60 indicates that the animals are more suitable for milk purpose.
18	Balance	(Rump length x Rump width)/ (Chest depth x Shoulder width)
19	Width slope	Rump width/ Shoulder width
20	Area index	Height at withers x Body length
21	Relative cannon thickness index	(Cannon circumference/ Height at withers) * 100
22	Over Increase index	(Height at rump/height at withers) * 100
23	Weight index	(W2) = CG3*80. Weight above 45kg corresponds to large or hypermetric animals, between 35 and 55kg medium or eumetric animals, and less than 35kg, small or elipometric animals.
24	Body Weight index	(Body weight/height at withers) * 100
25	Rump Length index	(Length of rump/body length) * 100
26	Metacarpal–thoracic index	(CBP × 100/CG, Cannon bone perimeter/Chest girth *100)

Source: (Salako, 2006b; McManus *et al*., 2008, Esquivelzeta *et al*., 2011, Chacón *et al*., 2011; Khargharia *et al*., 2015; Barragán, 2017 and Silva-Jarquin *et al*., 2019)

Cephalic index

The cephalic index refers to the harmony of the head, classifying it as brachycephalic, mesocephalic, or dolichocephalic (Arredondo-Ruiz *et al*., 2013). The studies done by Yemane *et al.,* (2020) reported that the Cephalic index value of indigenous goats in the Jimma zone of Ethiopia is (57.1) that classifying them as brachycephalic. Dereje *et al.,* (2019) reported that the Cephalic index of goats in Mirab Abaya was much smaller than those of Arba Minch Zuria (75.0 vs. 86.6). The reason behind this may be the head length of Mirab Abaya goats was much larger than the width and they can be thus classified as dolichocephalous, however, Arba Minch Zuria goats could be classified as mesocephalous.

Body index

Body index indicates the relative capacity of the animal format (Latorre *et al*., 2011). The body index of goats shows the proportionality of the breed and allows to classify of goats according to baronian systematics into brevilinear (≤85), mesolinear (>86 and <88), or longilinear (≥90) (Silva-Jarquin *et al*., 2019). The body index of the indigenous goat population found in the Jimma zone of Ethiopia was 0.84(84) based on this result they were classified as brevigline (Yemane *et al*., 2020). Furtherly, Dereje *et al.,* (2019) reported that the results of body index indicated that goat types in

Arba Minch Zuria and Mirab Abaya could be classified as mediolineous or medigline (≥85 and ≤89). The body index values of does age 1-2 years were (93.86; 92.05) and age 3-4 years was (94.7; 94.13) in Aroresa and Lokabaya districts, respectively. While the body index values of bucks age 1-2 years were (93.37; 93.32) and age 3-4 years was (92.10; 87.04) in Aroresa and Lokabaya districts, respectively (Hankamo *et al*., 2020). The authors' furtherly express that the Does and the Bucks have a very good chest capacity which is approximately 50% of the body length, this indicating that this breed of goats is ideally suitable for long-distance grazing and that too at the undulating surface (Chaco´n *et al*., 2011). The overall mean value of body index of goat in East Gojjam of Ethiopia were (89.96±5.12 for does and 90.44±4.91 for bucks) indicated that indigenous goats in the study areas have a longilinear profile, transversal measures surpass over length measures as reported by (Mezgebu, 2020). The variations in body index values may be due to age, breed type, and differences in the management conditions of goats from different areas.

Height slope

The height slope value of indigenous goats in the Jimma zone was negative that indicates wither height is smaller than rump height so these goat types are shorter in front than backward (Yemane *et al*., 2020). This further indicates that such animals have strong forequarters that enable them to climb heights more than their shorter fore legged and access forages to browse which was also reported by (Salako, 2006). Mezgebu (2020) reported the height slope values of goat East Gojjam zone for does (2.76) and for bucks (2.79). Furtherly, Khargharia *et al.,* (2015) reported (3.43) height slope value for Assam Hill Goats from India.

The relative depth of thorax

According to (Chacón *et al*., 2011 and Sastre, 2003) relative depth of thorax index indicates a relationship between chest depth and wither height and serves as an indirect measure of leg length, whereby higher indices for this trait corresponds to animals with longer legs. They furtherly assessed animals with a higher relative depth of thorax index values have a higher moving capacity, being more adapted to plains and long treks with bodies further from the ground to avoid heat radiation. As reported by (Yemane *et al*., 2020) relative depth of thorax index of goats in the Jimma zone was 45.9 that does not indicate them towards meat phenotype. Chiemela *et al.,* (2016) and Chacón *et al.,* (2011) reported a relative depth thorax of 43.8 for central highland goats in south Wollo and 47.7 for adult Cuban creole goats, respectively, which is comparable with the current findings. Additionally, Dereje *et al*., (2019) reported that Mirab Abaya goats had a higher relative depth of thorax index (79.0 ver. 68.9), which suggests that they are characterized by long legs and their body is far from the ground. This has been reflected in female goats of Mirab Abaya which had a significantly

higher wither height value than those of Arba Minch zuria. Moreover, the higher relative depth of thorax index observed in Mirab Abaya goats could suggest classifying them towards dairy phenotype.

Proportionality

The proportionality index relates the body height to the body length and denotes the shape of the animal (Barragán, 2017 and Silva-Jarquin *et al*., 2019). A proportionality index value less than 1.00 or 100 (the value can be multiplied by 100) indicates that the breed's body tends to be rectangular which is a characteristic of meat type, while a value greater than 1.00 or 100 denotes that the shape of the animal tends to be square, which is a characteristic of dairy type (Bravo and Sepúlveda, 2010; Barragán, 2017). The proportionality index of goat type in the Jimma zone was 109 which are above 100 and thus, classify them into dairy type breeds (Yemane *et al*., 2020). Dereje *et al*., (2019) also reported the Arba Minch Zuria goats showed a smaller proportionality value (0.97 or 97), which is a characteristic of meat type while those of Mirab Abaya demonstrated a higher value (1.03 or 103) with almost a square shape relating them to a dairy type. As reported by (Mezgebu, 2020) the overall mean proportionality indices observed for both does (103.88±6.17) and bucks (107.94±5.65) of goats in the East Gojjam Zone of Ethiopia were greater than 100 that indicating the indigenous goats have dairy characteristics. Additionally, the proportionality of Central Highland goats in south Wollo of Ethiopia is (1.08 or 108) as reported by Chiemela *et al.,* (2016) that classify them as dairy type breeds.

Longitudinal and transverse pelvic index

The longitudinal pelvic index serves to estimate the meat capacity of the animal, relating the length of the rump to the height at withers. Longitudinal pelvic indexes not exceeding 37 are suitable indicators for meat animals (Lopez *et al*., 1992; Salako, 2006; Barragán, 2017). The transverse pelvic and longitudinal pelvic indices are functional indices used to estimate the meat aptitude of the animal by relating the width and length of the rump to the wither height, respectively (Barragan, 2017). Silva-Jarquin *et al.,* (2019) also stated that transverse pelvic and longitudinal pelvic indices are an estimator for the meat suitability of the breed i.e. a transverse pelvic index greater than 33 and longitudinal pelvic index less than 37 are indicators of meat-type breeds. The longitudinal pelvic index of goats in the Jimma zone was 20.58 which would classify them as meat animals (Yemane *et al*., 2020). Dereje *et al.,* (2019) reported that longitudinal pelvic index values of both Arba Minch Zuria and Mirab Abaya (Gamo Gofa) goats showed that lower values that lean this goat type toward meat phenotype. These authors also reported transverse pelvic index for local goats in Gamo Gofa was (26.1±1.20). The transverse pelvic and longitudinal pelvic indices values for does (19.66±1.62 and 26.04±2.17) and bucks (18.74±1.43 and

27.12±2.54) of goats in the East Gojjam zone were below the ranges implies that indigenous goats are suited for meat production (Mezgebu, 2020). According to Chiemela *et al.,* (2016), the longitudinal pelvic index of central highland goat in South Wollo was 17.03 which was less than the value obtained from the Jimma zone. However, lower values of the longitudinal pelvic index can be correlated to animals with a high incidence of dystocia (Chacon *et al*., 2011 and Chiemela *et al*., 2016).

Depth index

Depth index is an index given by dividing chest depth by height at withers. Depth index values of indigenous goats in the Jimma zone of Ethiopia is (0.46) as reported by Yemane *et al.,* (2020). The depth index values of (does aged 1 and 2 years) in Aroresa and Lokabaya districts were 0.43 and 0.44 respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 0.44 and 0.45, respectively (Hankamo *et al*., 2020). As expressed by these authors the depth index of goats reared in two districts of Sidama zone shows that the chest depth is approximately 45% of the height of the animals, for that reason as stated by Chaco´n *et al.,* (2011) such Does have a very good lung capacity and thus can graze for longer distances without getting tired and this too especially under strenuous conditions.

Relative body or length index

The indices derived from measurements that are more closely associated with bone growth (forelimb length, height slope, and relative body index or length index) are more appropriate for the assessment of the type for which the breed was developed. The relative body index and balance indices indicated the carcass yield capacity of live animals (Salako, 2006). The relative body or length index of the goat in the Jimma zone and Central highland goat in South Wollo was 0.92 and 0.93 respectively (Yemane *et al*., 2020 and Chiemela *et al*., 2016). Moreover, the Relative body or length index of the goat in Arba Minch Zuria and Mirab Abaya was 1.03 and 0.97 respectively with an average of 1.00 (Dereje *et al*., 2019). As reported by (Hankamo *et al*., 2020) the length index I value of (does aged 1 and 2 years) in Aroresa and Lokabaya districts was 0.99 and 1.00, respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 0.99 and 1.02, respectively. These authors furtherly showed that the Length index indicates that the Does have a compact shape which is near to the square. It's expected that such animals have lower incidences of spinal problems vis-a-vis those who have a longer body and shorter height (Alderson, 1999 and Chacón *et al*., 2011). Generally, the lower value of the relative body index of a goat shows that the carcass yield of a goat is expected to be lower and vice versa. Mezgebu (2020) reported that the relative body or length indices of goats in the East Gojjam zone of Amhara region Ethiopia were 96.60±5.72 (0.96) and 92.90±4.86 (0.92) for does and bucks, respectively.

Dactyl thorax index

The dactyl thorax index provides an idea of the degree of fineness of the skeleton and is highly associated with dairy characteristics. It indicates the format or shape of the animal through creating relationships between the pectoral mass and limbs, classifying the animals as hypermetric (large format), eumetric (medium format), elipometric (small format), being <10 and >11 in dairy and meat animals, respectively. In light animals, its value is equal to or less than 10.5; in medium animals b/n 10.5 & 10.8 and in heavy meat type animals, it is 11.5 or above (Barragan, 2017). The dactyl thorax index of goats in the Jimma zone was 10.6 that classified them as medium (intermediary) meat type animals (Yemane *et al*., 2020). Other scholars in Ethiopia also reported the values of dactyl thorax index like Chiemela *et al.,* (2016) reported 10.64 for Central Highland goat in South Wollo of Ethiopia and Chacón *et al.,* (2011) for Cuban creole goat that was 9.58. Additionally, Mezgebu (2020) also reported, the overall dactyl thoracic indices values of does and bucks were 10.33 and 11.89, respectively for indigenous goats in the East Gojjam Zone of Ethiopia that indicated that does were grouped udder light animals (<10.5) with dairy biotype whereas, bucks were grouped under heavy meat-type animals (>11.5).

Pectoral index

The pectoral index is an index that is calculated by adding height at withers and rump height and dividing it by two and thus dividing the result by sternum height. It indicates thoracic development; when the back height is less than the sternum height, the animal is considered “far from the ground”. The pectoral index value of indigenous goats in the Jimma zone of Ethiopia is (1.89) as reported by Yemane *et al.,* (2020).

Thoracic development

Thoracic development is important in terms of fitness, good respiratory system, particularly in those goats adapted to higher altitudes (Khargharia *et al*., 2015). The value above 1.2 is an indicator of good thoracic development. Thoracic development of goats in the Jimma zone was 1.09 which is less than 1.2, indicating their poor thoracic development (Yemane *et al*., 2020). This observation is consistent with the reports of Chiemela *et al.,* (2016), who reported a value of 1.08; but was slightly lower than reported by Chacón *et al.,* (2011). As studied by Dereje *et al.,* (2019), Arba Minch Zuria goats (1.17) had a higher thoracic development value than those of Mirab Abaya (1.10) indicating a better thoracic capacity enabling them to survive in relatively high altitude terrains. The overall value of thoracic development of this goat population is 1.14 which indicates poor thoracic development. Additionally, Mezgebu (2020) reported that the overall thoracic development values for does (1.08) and bucks (1.03) were lower than the recommended level (1.2). This indicates that goats in the

East Gojjam Zone of Ethiopia have poor thoracic capacity, an indication of thin and tall animals that may not be effectively survived in the highland areas.

Body ratio

As described by Yemane *et al.,* (2020) body ratio of indigenous goats in the Jimma zone was 0.96. Similarly, Mezgebu (2020) indicated that both does and bucks had a similar value of 0.96. Additionally, Chacón *et al.,* (2011) reported 0.97 for Cuban creole goats and Chiemela *et al.,* (2016) for Central highland does aged 2 years in the South Wollo of Ethiopia as 0.94. Furtherly, the body ratio index values of (does aged 1 and 2 years) in Aroresa and Lokabaya districts of Sidama zone were 0.96 and 0.96, respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 0.96 and 0.95, respectively (Hankamo *et al*., 2020). The lower body ratio value was reported by Khargharia *et al.,* (2015) for Assam Hill Goats (0.93) in India.

Relative cannon thickness index

The relative cannon thickness index shows the relationship between the cannon bone perimeter and the height of the animal and it's considered a good indicator of breed type (higher in meat than dairy biotypes) (Barragan, 2017) and animal balance (Dauda, 2018). The relative canon thickness index value of indigenous goats in the Jimma zone of Ethiopia is 11.6 as reported by (Yemane *et al*., 2020). Mezgebu (2020) also reported that the relative cannon thickness index of does (11.09) was slightly lower than bucks (12.20) which indicate bucks have good muscling ability than does and can be confirmed by the higher dactyl thoracic indices value of bucks. The author stated that bucks were well balanced than does, which enable them to resist long hard walks and reduce susceptibility to joint problems in the anterior and posterior limbs (Dauda, 2018). Khargharia *et al.,* (2015) and Putra and Ilham (2019) were reported relative cannon thickness index values for Assam Hill Goat (12.95) in India and Katjang does (12.64±1.08) in Indonesia, respectively. Generally, the higher relative cannon thickness index value in the goats indicates that goats have higher muscling aptitudes.

Foreleg index

The foreleg index value of indigenous goat in the Jimma zone of Ethiopia is 33.1 as stated by (Yemane *et al*., 2020) and Dereje *et al.,* (2019) also reported 15.7 foreleg values for goat in the Gamo Gofa zone which was far below the aforementioned value.

Compact index

The compact index is a useful indicator of the overall value of the animals because it combines morphology and structure; and provides an accurate picture of the type and

function of livestock breeds (Chiemela *et al*., 2016). The compact index indicates how compact the animal is and Meat type animals have values above 3.15; Dual purpose animals have values close to 2.75 and Values close to 2.60 indicate that animals are more suitable for milk (goats & cattle). As the report of (Yemane *et al*., 2020) the compact index value of the Jimma goat was 4.06, which classify them as meat type animals. Accordingly, Dereje *et al.,* (2019) reported that the compact index value of Arba Minch Zuria goat populations was 5.01 which classify them as meat type animals. Moreover, Chiemela *et al.,* (2016) and Chacón *et al.,* (2011) also reported a compact index of 3.91 for Central highland goats in South Wollo; and 5.20 for adult Cuban creole goats, respectively and thus classify both goat populations as meat type animals. Khargharia *et al.,* (2015) reported 5.63 compact index values for Indian Assam Hill goats which is higher than the report of (Chiemela *et al*., 2016; Chacón *et al*., 2011; Yemane *et al*., 2020 and Dereje *et al*., 2019) and indicates these goats as meat type. Furtherly, the study done in the East Gojjam Zone of Ethiopia by Mezgebu (2020) reported that the compact index 1 values for both does (0.005±0.00) and bucks (0.004±0.001) were very far below 2.60, indicates the dairy type. The author also stated that these lower compact index values could be due to the age, breed, feed, and feeding practices of goats.

Weight

The average weight of goats in the Jimma zone was below 35kg, thus they are classified as a small or elipometric type (Yemane *et al*., 2020). The respective weight index of goat populations in Arba Minch Zuria and Mirab Abaya was 44.7 and 35.9 kg, which correspondingly classifies them as medium or eumetric type (Dereje *et al*., 2019).

Pelvic index

The pelvic index (PI) is a racial diagnostic index that is used to determine the proportionality of the hindquarters and thus, could be related to the reproductive capacity of female goats (Cerqueira *et al*., 2011). The pelvic index is the ratio of pelvic width to pelvic length, which determines the proportionality of the hindquarters hence related to reproductive fitness (Silva-Jarquin *et al*., 2019). Mezgebu (2020) reported that the overall mean pelvic indices of does and bucks are (75.97) and (69.65) respectively. This indicates that these goat types have a convex curve with a predominance of rump length over the width or disproportionality of the hindquarter that results in reproduction difficulties of does (Silva-Jarquin *et al*., 2019). According to the (Dereje *et al*., 2019) result of the pelvic index, the rump of the Mirab Abaya goats had a convex curve (p≤100), with a predominance of the rump length over the width. However, the pelvic index of Arba Minch Zuria goats was 102 indicating a balance between rump length and its width. Chiemela *et al.,* (2016) reported (123)

values for Central Highland goats in south Wollo which was higher than observed in the findings of Dereje *et al.,* (2019). The observed differences in pelvic index values of goats may be due to age, breed, management, and measurement imprecision between researchers.

Area index

Animals with larger body surface areas relative to their body mass have a better ability to withstand heat stress effectively by dissipating the excess heat load from their body surface through sensible and insensible heat dissipation mechanisms. As reported by Dereje *et al.,* (2019) the area index values of goats in Arba Minch Zuria district was 3757, while for Mirab Abaya district goat was 3480. This value indicated that Arba Minch Zuria district goats have a larger body surface than Mirab Abaya district. Moreover, the lower value of area index 3355 was reported by Khargharia *et al.,* (2015) for the Indian Assam Hill goat and Katjang does' (3394.46) by (Putra and Ilham, 2019). However, Mezgebu (2020) stated that the areal index values of both does and bucks were 4633.05 and 3999.82, respectively indicating higher values in the East Gojjam zone. This shows that goats in this area have a larger body surface area relative to their body mass, enabling them to withstand heat stress effectively by dissipating excess heat from their body surface. The variations between goat types on areal index values are explained by the type and function of goats, environmental factors, and management conditions employed for goats in different production environments as stated by (Mezgebu, 2020).

Conformation index

The conformation (Baron and crevat) index indicates the overall body shape of an animal. The greater the conformation index, the more vigorous the animal breed would be (Dereje *et al*., 2019). These authors reported that the conformation index of the goat population in Arba Minch Zuria was (83.3) that are higher than the value of the Mirab Abaya district (72.6) of the Gamo-Gofa zone of Ethiopia. So, the Arba Minch Zuria goats are much vigorous with a healthier physical appearance than those of the Mirab Abaya goats, but on average the value was 77.9. Mezgebu (2020) also reported that the conformation index values of indigenous goat in the East Gojjam Zone of Ethiopia were 80.18 and 69.38 for does and bucks respectively. Additionally, conformation index values of goat were also reported by (Khargharia *et al*., 2015) for Assam Hill goat in India (93.18±2.86) and Chacon *et al.,* (2011) for Cuban Creole (97.01±3.96) and Cuban Creole Crossed (105.37±10.15) does. Moreover, Chiemela *et al.,* (2016) reported 69.86 conformation index values for dose of Central Highland goats in South Wollo.

Height index

The studies done by Hankamo *et al.,* (2020) in the Sidama zone of SNNPR of Ethiopia on height index of goats reported the values by grouping goats into sex and age, and then (does aged 1 and 2 years) in Aroresa and Lokabaya districts were 100.43 and 99.92 height index respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 100.17 and 97.98 respectively. This study further indicated that the length of the Bucks and the height at withers of the Does and Bucks are more or less similar, indicating the animals have a square shape.

Over increase index

As reported by Hankamo *et al.,* (2020) the over increased index values of (does aged 1 and 2 years) in Aroresa and Lokabaya districts were 104.23 and 104.20 respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 103.54 and 104.47 respectively. The authors' furtherly designated that the observed over increase index value indicated that the height at rump is more or less similar to those of the withers; however, there are incidences where the rump height is higher than the withers height. The front parts of such animals are usually lower than the hind part and hence are prone to dust infestations (Tewelde, 2016). Additionally, Mezgebu (2020) reported the over increase index values of does and bucks were (104.03) and (104.28) respectively showed that both sexes are slightly lower at the whither than the rump.

Rump length index

It's an index given by dividing rump length by body length and then multiplied by 100. The rump length index values of (does aged 1 and 2 years) in Aroresa and Lokabaya districts were 29.8 and 27.35 respectively. While (bucks aged 1 and 2 years) in Aroresa and Lokabaya districts were 28.10 and 25.67 respectively (Hankamo *et al*., 2020). It shows that the rump is approximately 25% of the whole body, which is proportionately good and thus the Does are expected to have a good uterine capacity and therefore the chances of the kid born healthy are also high (Chaco´n *et al*., 2011 & Chiemela *et al*., 2015).

Table 2: Average values of structural and functional indices of some goat types in Ethiopia

Indices	Indices values of some indigenous goat in Ethiopia (Mean)													
	JZ (Yemane, *et al*., 2020)	GGZ (Dereje *et al*., 2019)	SWZ (Chiemela *et al*., 2016)	SZ (Hankamo *et al*., 2020)								EGZ (Mezgebu, 2020)	
				Does AG 1 and 2		Does AG 3 and 4		Bucks AG 1 and 2		Bucks AG 3 and 4		Does	Bucks
				Ar	Lok	Ar	Lok	Ar	Lok	Ar	Lok		
CI	57.1	80.7	46.58	69.17	67.12	71.13	65.17	68.75	66.14	67.93	60.66	-	-
BI	0.84/84.00	0.87/87.7	0.86/86.83	93.86	92.05	94.7	94.13	93.37	93.32	92.10	87.04	89.96	90.44
HS	-2.50	-	-	2.62	2.50	2.05	2.45	2.25	2.8	3.48	2.83	2.76	2.79
RDT	45.9	73.9	43.8	-	-	-	-	-	-	-	-	-	-
P	109	100	108.12	-	-	-	-	-	-	-	-	103.88	107.94
LPI	20.6	27.9	17.03	-	-	-	-	-	-	-	-	26.04	27.12
DI	0.46	-	-	0.43	0.44	0.44	0.45	0.44	0.45	0.47	0.47	-	-
RB/LI	0.92	1.00	0.93	0.99	1.00	1.01	1.05	0.99	1.02	1.02	0.98	96.60	92.90
DTI	10.6	-	10.64	-	-	-	-	-	-	-	-	10.33	11.89
PI	1.89	-	1.84	-	-	-	-	-	-	-	-	-	-
TD	1.09	1.14	1.08	1.06	1.09	1.07	1.12	1.07	1.09	1.11	1.13	1.08	1.03
BR	0.96	-	0.94	0.96	0.96	0.97	0.96	0.96	0.95	0.95	0.96	0.96	0.96
RCTI	11.6	-	-	-	-	-	-	-	-	-	-	11.09	12.20
FI	33.1	15.7	-	-	-	-	-	-	-	-	-	-	-
CI	4.06	4.90	3.91	-	-	-	-	-	-	-	-	0.005	0.004
W	35	40.2	-	-	-	-	-	-	-	-	-	-	-
GI	-	-	-	-	-	-	-	-	-	-	-	1.09	1.07
PcI	-	93.0	122.74	-	-	-	-	-	-	-	-	75.97	69.65
TPI	-	26.1	20.55	-	-	-	-	-	-	-	-	19.66	18.74
BC/CI	-	77.9	69.86	-	-	-	-	-	-	-	-	80.18	69.38

AI	-	3618		-	-	-	-	-	-	-	-	4633.05	3999.82
WS	-	-	0.91	-	-	-	-	-	-	-	-	1.05	0.99
OII	-	-		104.23	104.20	103.13	103.9	103.54	104.47	105.04	104.03	104.03	104.28
BlI	-	-	0.38	-	-	-	-	-	-	-	-	-	-
HI	-	-	-	100.43	99.92	98.98	95.21	100.17	97.98	97.63	101.55	-	-
RLI	-	-	-	29.8	27.35	30.09	27.46	28.10	25.67	29.33	28.49	-	-

CI- Cephalic index, BI- Body index, HS- Height slope, RDT- Relative depth of thorax, P- Proportionality, LPI- Longitudinal pelvic index, DI- Depth index, RB/LI- Relative body or length index, DTI- Dactyl thorax index, PI- Pectoral index, TD- Thoracic development, BR- Body ratio, RCTI- Relative canon thickness index, FI- Foreleg index, CI- Compact index, W- Weight, GI- Girth index, PcI- Pelvic index, TPI- Transverse pelvic index, BC/CI- Baron and Crevat (Conformation) index, AI- Areal index, WS- Width slope, OII- Over increase index, BlI- Balance index, HI- Height index, RLI- Rump length index, AG-Age group, Ar- Aroresa, Lok- Lokabaya, JZ-Jimma zone, GGZ- Gamo Gofa zone, SWZ-South Wollo zone, SZ-Sidama zone, EGZ-East Gojjam zone

CONCLUSION

The review reveals that the structural indices value of the indigenous goat in Ethiopia varies within the type, weight, and function of each goat type. Accordingly, depending on structural indices values goat types in the Jimma zone were generally described as intermediary meat type. Additionally, Central Highland goat in Ataye farm was also classified as meat type animals. In the Gamo Gofa zone Arba Minch Zuria goats are a medium-sized and long-shaped body frame, with meat type animals along with signs of adaptation to its environment. Conversely, Mirab Abaya goats were oriented as medium-sized whose morphology corresponds to dairy type. Moreover, in Sidama zone structural indices goat reveals that the Bucks age groups 3 and 4 reared in Lokabaya district have good thoracic development than any other age and sex group across the districts. Furthermore, goats in the East Gojjam zone are short-bodied, longilinear, curved, less compacted with poor thoracic development, balanced, light, and dairy type animals. However, the Dactyl thorax and Relative cannon thickness index showed that bucks have the better muscling ability and possess meat type. Likewise, goats in this area are lower at the whither than the rump thus may be prone to dust infestation. Generally, indigenous goat populations in Ethiopia could be categorized as meat type as well as dairy type animals that will serve to design appropriate conservation, genetic improvement, and sustainable utilization strategies.

CONFLICT OF INTEREST

The authors declare that no conflict of interest

ACKNOWLEDGEMENT

The Authors prominently acknowledges Hawassa University College of Agriculture in all stages of this work.

REFERENCES

Alderson, G. L. H. (1999). The development of a system of linear measurements to provide an assessment of type and function of beef cattle. Anim. Genet. Resour. Info. 25: 45-55. DOI: https://doi.org/10.1017/S1014233900005782,

Alpak, H, Onar, V & Mutus, R. (2009). The relationship between morphometric and long bone measurements of the Morkaraman sheep. Turkish Journal of Veterinary and Animal Science 33:199-207.

Arredondo-Ruiz, V, Macedo-Barragán, R, Molina-Cárdenas, J, Magaña-Álvarez, J, PradoRebolledo, O, García-Márquez, L.J, Herrera-Corredor, A & Lee-Rangel, H. (2013). Morphological characterization of Pelibuey sheep in Colima, México. Tropical Animal Health and Production 45(4): 895-900.

Banerjee S. (2017). Body Indices of Garole Sheep Reared in West Bengal (India). *Proc Zool Soc* 70, 61–73. https://doi.org/10.1007/s12595-015-0162-7

Barragán, R.M. (2017). Zoometry: a useful tool for determining the productive aptitude of domestic ruminants. Journal of Dairy, Veterinary and Animal Research 5(3):86–87. DOI: 10.15406/jdvar.2017.05.00140

Bravo, S & Sepúlveda, N. (2010). Zoometric indices in Araucanas Creole ewes. International Journal of Morphology 28(2): 489-95.

Cerqueira, J.O.L, Feás, X, Iglesia, A, Pacheco, L.F & Araújo, J.P.P. (2011). Morphological traits in Portuguese Bordaleira de Entre Douro e Minho sheep: divergence of the breed. Animal Production Science, 51: 635-641.

Chacón E, Fernando M, Francisco V, Samuel RP, Eliecer P & Concepta M. (2011). Morphological measurements and body indices for Cuban Creole goats and their crossbreds. Revista Brasileira de Zootecnia, 40 (8): 1671-1679.

Chiemela PN, Banerjee S, Taye M, Egbu CF, Ugbo EH, Akpolu ES & Umanah IJ. (2016). Structural indices of Boer, Central highland and their F1 Crossbred goats reared at Ataye farm, Ethiopia. J. Agric. Res., 2: 1-19

CSA (Central Statistical Agency) (2020). Agricultural sample survey 2019/2020. Report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin 587, volume II, Addis Ababa, Ethiopia. pp 1-181.

Dauda A. (2018). Morphological indices and stepwise regression for assessment of function and type of Uda sheep. J Res Rep Genet, 2 (3):1-4.

Dereje Dea, Aberra Melesse & Yoseph Mekasha. (2019). Application of morphometric traits and body indices in assessing the type and function of local goats reared in two districts of Gamo-Gofa Zone, South Ethiopia. Eth. J. Anim. Prod.,19(1):73-90.

Esquivelzeta, C, Fina, M, Bach, R, Madruga, C, Caja, G, Casellas, J. & Piedrafita J. (2011). Morphological analysis and subpopulation characterization of Repollesa sheep breed. Animal Genetics Resources Journal, 49: 9-1

FAO (Food and Agriculture Organization of the United Nations). (2019). FAOSTAT database. http://www.fao.org/faostat/en/

Hankamo, Amsale, W/yohannes, T, & Banerjee, S. (2020). Morphometrical Characterization and Structural Indices of Indigenous Goats Reared in Two Production Systems. Global Journal of Animal Scientific Research, 8(1), 20-19

Khargharia, G, Kadirvel, G, Kumar, S, Doley, S, Bharti, P.K & Mukut, D. (2015). Principal component analysis of morphological traits of Assam Hill goat in eastern Himalayan India. T*he Journal of Animal and Plant Sciences* 25(5): 1251-1258. http://dx.doi.org/10.11648/j.ijast.20200401.12

Latorre, E, Uribe, H, Martínez, M.E, Calderón, C & de la Barra R. (2011). Morphology differentiation and structural functionality of ewes due to incomplete crossbreeding. International Journal of Morphology 29(3):954-959.

Lopez FJL, Arguello HA & Capote AJ. (1992). Contribution to the study of the black canary pig. Arch. de Zootec., 41: 531- 536.

Maciejowski, J & Zieba, J. (1982). Genetics and animal breeding: Part A. Biological and genetic foundations of animal breeding. agris.fao.org

McManus, C, G. S. Filho, H. Louvandini, L. T. Dias, R. A. Teixeira & L. S. Murata. (2008). Growth of Saanen, Alpine and Toggenburg goats in the federal district, Brazil: genetic and environmental factors. Ciencia Anim. Brasileira, 9 (1): 68-75.

Mezgebu Getaneh. (2020). Phenotypic characterization of conformation traits and production system of indigenous goat types in selected districts of East Gojjam zone, Amhara region, Ethiopia. Msc thesis, Bahir Dar University, Ethiopia. Bahir, Dar University Institutional Repository. http://hdl.handle.net/123456789/11794: 2020-12-12,

Popoola Moshood. (2015). Zootechnical Index Analysis of West African Dwarf Rams in Southwestern Nigeria. Agricultura Tropica Et Subtropica, 48 (1-2): 24-29. https://doi.org/10.1515/ats-2015-0004

Putra Widya & Ilham Fahrul. (2019). Principal component analysis of body measurements and body indices and their correlation with body weight in Katjang does of Indonesia. J Dairy Vet Anim Res., 8 (3): 124-134. DOI: 10.15406/jdvar.2019.08.00254

Salako AE. (2006). Application of morphological indices in the assessment of type and function in sheep. Int. J. Morphol., 24: 13- 18.
http://dx.doi.org/10.4067/S0717-95022006000100003

Sastre HJ. (2003). Description, current status and conservation strategies of Colombian Creole cattle breed Casanare. Thesis (Doctor of Veterinary Medicine) - University of Córdoba - Córdoba, Spain.

Silva-Jarquin JC, Román-Ponce SI, Durán-Aguilar M, Vera-Ávila HR, Cambrón-Sandoval VH, & Andrade-Montemayor HM. (2019). Morphostructural Characterization of the Black Creole Goat Raised in Central Mexico, a Currently Threatened Zoogenetic Resource. Animals (Basel). Jul 19; 9(7):459. doi: 10.3390/ani9070459. https://doi.org/10.3390/ani9070459

Tewelde G. (2016). Studies on Morphometric Characteristics, Performance and Farmers' Perceptions on Begait Cattle Reared in Western Tigray, Ethiopia. MSc Thesis. Hawassa University. Ethiopia. 51pp.

Yemane G, Melesse A & Taye M. (2020). Characterization of indigenous goat populations by applying morphometrical traits and structural indices. J. Vet. Res. Adv. 02(01): 22-31.