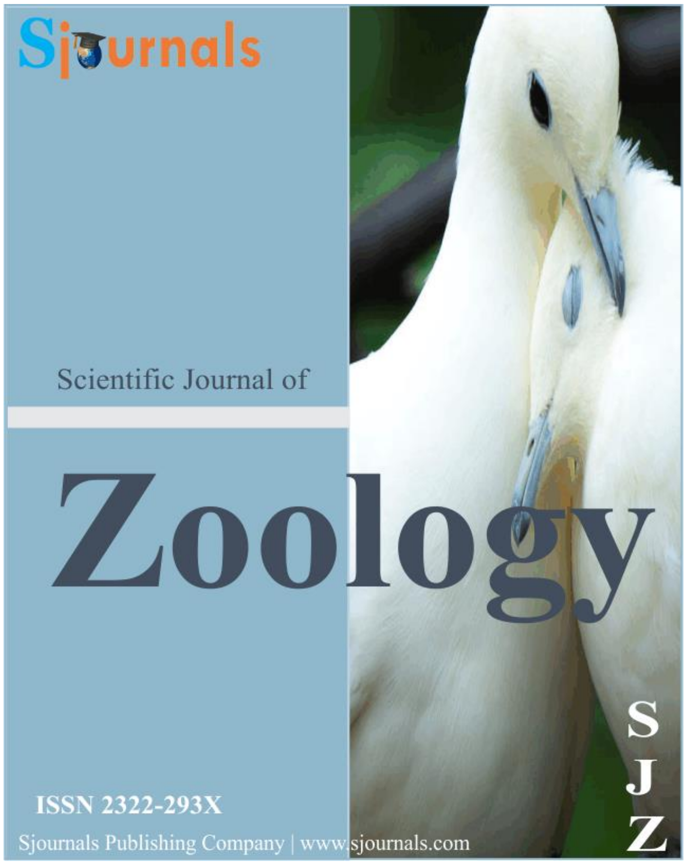
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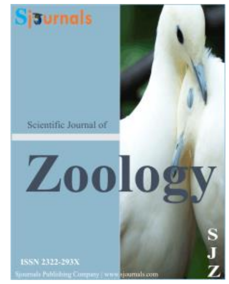

Review article

Morphology and its relationship with reproduction and milk production in goat and sheep

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Morphological characterisation and multifactorial analyses of conformation traits in relation to productivity indicators are critical in goats and sheep breeding programs in particular, as the desired outcome could instigate animal performance change through indirect selection based on the phenotypic measurements. Animal morphology development is complex biological process probably with multiple genes being at play, which might be dependent on the environment, and changing over time, hence recording multiple descriptive morphological dimensions can make relating genotype to phenotype more feasible and, importantly, more relevant in terms of understanding functionality of domestic animals. Morphological traits sometimes referred to linear type traits, biometric, zoometric and conformation traits (measurements) have been of interest in both livestock and poultry production. Due to the fact that some morphological traits are highly correlated to performance traits, their application in animal production among other aspects include: prediction of growth rate, body condition, carcass and milking capacity. This implies that morphological traits correspond to functionality of animals for the purposes of production as a result they have been a useful tool in selection of animals, especially where records are unavailable. Morphological traits can be extremely valuable in animal breeding decision making since they can be used to derive specific scores for heritable traits. In most cases, in view of simplicity of measurement, morphological traits have been part of performance recording appraisal systems. This has worked well to overcome the gap that exist in keeping performance records especially in community based breeding schemes. In most cases records in smallholder production systems are unobtainable hence morphological dimensions become handy for selection purposes. Some of the morphological traits have proved to be the source or representative group of suitable selection markers to elaborate the appropriate breeding program to improve the reproduction and milk production potential of goats and sheep. If morphological traits are to be regarded for incorporation in prospective goat and sheep breeding programs, the relationship between them and reproduction and milk production need to be established. In the advent of multiple regression models the prospects are high to establish correlation analysis between morphological traits with production traits in goats and sheep. In conclusion, the review verified that morphological traits can be used as accurate indicators of animals' reproductive capacity and milk production potential in goat and sheep production. The purpose of the present review is to highlight the relationship between morphometric characteristics and reproductive and milking potential in goats and sheep production.

1. Introduction

Morphology of animal clearly expose a well-founded relationship with productive potentiality, after all it bears the structure which sustain the biological functionality of the animal (Alpak et al., 2009) such as reproduction (Babale et al., 2018), muscle development (meat) (Bose and Basu, 1984) and milk production (Altinçekiç and Koyuncu, 2011). Morphological characterization involves the process of documentation of the descriptive physical characteristics of a breed (Rege, 1992). This implies that morphological traits (measurements) and how they relate to the functional efficiency of the animal is very important in animal production. It seems more often than not, phenotypic variation in milk production is useful today in the same way as it was done decades ago, using simple quantifications such as length, number, categorical classifications, etc. (Houle et al., 2010, 2011; Cole et al., 2011; van Rooyen et al., 2012) hence the need to understand their association with production indicators. A number of studies have recommended indirect selection based on indicator traits and/or morphological traits in animal production, the reason being they are easy to measure (Assan, 2015). Poutrel (1983) previously had stated that this type of selection is possible in young animals, especially in the early life of their breeding. Most morphological traits used in goats and breed characterization are likely to have a complex genetic pattern, which interlink to many production potentiality interacting genes, however imparting to the definitive phenotype. Morpho-structure has been extensively studied for characterization of goats and sheep breeds and permits selection decision on the productive potential grounded on clear physical relationships within the morphological structure (Zaitoun et al., 2005; Yakubu et al., 2010a; Abdel-Mageed and Ghanem, 2013). An implicit understanding of morphological traits cannot neglect the underlying related associated performance influencing genes and further facilitating the determination of relationships between morphological traits and performance traits in goats and sheep production. Morphometric and/or conformation traits can be described using simple phenotypic measurements and also has been a tool for visual appraisal of animals in a flock (Assan, 2015). Apart from linear body measurements and/or morphological traits being useful as predictors of growth (Attah et al., 2004) and carcass parameters (Thiruvenkadan, 2005), they been valuable indicators of milk production potential (van Rooyen et al., 2012) and reproductive capacity (Ibrahim et al., 2012) in an animal life. A number of linear body measurements have been utilised in predicting the quantitative variables in animal performance with the intention of developing suitable selection criteria (Sharaby and Suleiman, 1987; Islam et al., 1991). Morphological characteristics are essential as they reflect the breed standards (Verma et al., 2016) and are also important in giving information about the morpho-structure and developmental ability of the animals (Riva et al., 2002). Since the last decade a number of udder morphological traits have become of interest to the breeder because of their effects on milk yield (Kumar et al., 1983), in addition to udder health (Charon and Skolasinski, 1988; Fernandez et al., 1995) and mechanical milking (Jatsch and Sagi, 1979; Labussie `re, 1988; Mikus, 1978; Sagi and Morag, 1974). A number of studies, working with different breeds of sheep confirmed that deep and well-attached udders are highly correlated with milk production (Altinçekiç and Koyuncu, 2011; Legarra and Ugarte, 2005) and goats (McLaren et al., 2016). Udder attachment which is higher and more tight are determinants of lower somatic cell scores, while udder depth is regarded as an easy measureable indicator of udder health in goats (Rupp et al., 2011). Akpa et al. (2003) observed that correlation coefficients of udder circumference with any of total milk yield, initial milk yield and peak milk yield were highly positive. In rreproduction, heart girth measurement was the best indicator for differentiating goats with history of multiple and single litter size in goats (Haldar et al., 2014). Less slopped rump angle has been associated with high probability of multiple birth in does (Constantinou, 1989) and ewes (Gaskins et al., 2005; Aliyari et al., 2012). Osinowo et al. (1981) and Togun and Egbunike (2006) verified that testes size was a useful determinant of the current and anticipated sperm production in animals. Selection on correlated morphological traits in young rams such as testis size has been the basis for improvement of fertility in sheep (Land and Carr, 1975). Brito et al. (2004) emphasised that the need for evaluation of breeding soundness of an animal based on weight of testes, since heavier testes produce more spermatozoa against the smaller testes. Haldar et al. (2014a) reported a detailed relationship between descriptive morphological traits and the pregnant goats bearing single or multiple foetuses, dams with >54.86 cm body length, >50.67 cm croup height and >4.56 cm distance between tuber ischii bones registered two times more likelihood to bearing multiple litter size. The purpose of the present review is to revisit the relationship between morphometric characteristics and reproductive and milk production in goats and sheep.

2. General understanding and use of linear type traits in animal production

Morphological traits (measurements) referred differently in literature as linear type traits, biometric, zoometric, morphological, conformation traits and/or linear body measurements have been studied in different livestock and poultry species (Assan, 2015). It seems more often than not, phenotypic variation in milk production is useful today in the same way as it was done decades ago, using simple quantifications such as length, number, categorical classifications, etc. (Houle et al., 2010, 2011; Cole et al., 2011). Morphological characterisation and multifactorial analyses of conformation traits in relation to productivity indicators are critical in goats and sheep breeding programs in particular, as the desired outcome could instigate animal performance change through indirect selection based on the phenotypic measurements. Animal morphology development is complex process probably with multiple genes at play, which might be dependent on the environment, and changing over time, collecting multiple descriptive morphological dimensions can make relating genotype to phenotype more feasible and, importantly, more relevant in terms of understanding functionality of animals. Linear type traits are used among other aspects namely prediction of growth rate, body condition, and carcass traits (Lambe et al., 2008; Abdel-Mageed and Ghanem, 2013). Studies have proved that in all respects of animal growth different parts of an animal change in symmetry in addition to size (Idowu et al., 2017). It is highly likely some of the linear traits are representative group of closely related to important selection markers to elaborate the appropriate breeding program to improve economic traits in both meat and dairy animal populations. Meanwhile the development in body structures is more pronounced in postnatal phase as compared to the extremities. The targeted linear measurements of the skeletal structure are mainly all the height and length body measurements, with regards to tissue measurements, heart girth, chest depth, punch girth, and width of hips have been important linear measurements (Blackmore et al., 1995). Morphological traits and/or conformation are advantageous because can be designated using simple measurements and visual appraisal. Akpa et al. (2011) defined growth as the sum total of increase in magnitude of different structural body segments measured from gain in live body weight and linear type traits. It has been noted that how these measurements relate to the functional efficiency of the animal is of paramount importance to livestock production (van Rooyen et al., 2012). Characterization studies in livestock breeds have been based on the use of linear type traits (Yakubu et al., 2010), with further intention of incorporating these dimensions in conventional animal breeding schemes (Wiggans and Hubbard, 2001). Most characterization studies of local genetic resources are based on the knowledge of the morphological trait variation (Azor et al., 2008; Delgado et al., 2001). The validation of the powers of linear type traits in the prediction of live body weight and the accuracy of body weights in the estimation of size have been extensively reported in both livestock and poultry (Assan, 2015). Marketing of livestock in most rural economies have been founded on the ability of the producers and buyers to express body dimensions of live animals to growth parameters hence producers have managed to derive optimum value of their animals based on marketing system. Despite the significant contribution of most indigenous animal genetic resources to the resource poor rural economies; animal breeding research and developments initiatives on indigenous animal genetic resources are by large at their infancy stages in most developing countries. Capturing performance traits in small holder systems constitute a major challenge as it is more involving compared with measuring linear traits. However innovative approaches are emerging for the capture of linear and/or appraisal of morphological traits which are highly correlated with performance traits. Some of these linear measurements and morphological attributes include body length, heart girth for meat animals, udder measurements have been very useful in dairy production. Morphological measurements of body can be used as point of reference for growth pattern in animal's life (Attah et al., 2004) and some of these have exhibited sufficient genetic variation to allow for substantial selection responses if incorporated in genetic evaluation schemes (Carta et al., 1999). In reproduction, morphometry of the reproductive organs, especially scrotal circumference is a valuable determinant and prominent selection criteria to predict the reproductive organs development and breeding soundness in replacement animals (Babale et al., 2018). Some of the male reproductive organs morphometric studied in literature include: scrotal length (SL), scrotal circumference (SC), Scrotal and testicular weight (STW), testicular circumference (TC), testicular volume (TV), penile length (PL) and (PW) penile weight, etc. and for females' pelvic measurements have been useful in predicting reproductive capacity of animals. In most developing countries genetic evaluation systems are still inadequately organized hence specification of some simple descriptive linear body parameters may be helpful to smallholder resource poor farmer as a mechanism for selecting goats and sheep with desirable traits. It was suggested that with the exception of conventional use of scales in ascertaining the weight of livestock and poultry (Assan, 2015), weight determination by estimating some morphometric parameters could be used (Winrock International, 1992). Considering ease of measurement, chest girth (CG) could be used in performance recordings and bridge the gaps still present in keeping the performance of the breed to facilitate within breed selection scheme. Emerging and innovative approaches for measuring traits directly and indirectly need to be calibrated and adapted to the conditions prevailing in small holder systems. The relationships between udder characteristics and milk yield can be useful tools in selecting animals in dairy production systems (Mingoas et al., 2017). Akpa et al. (2003) observed that correlation coefficients of udder circumference with any of total milk yield, initial milk yield and peak milk yield were highly positive. Correlation analysis using a multiple regression inclusive of teat circumference, dam's wither height, lamb's heart girth and dam's neck length contributed almost 33% of the total variability with teat circumference recording the greatest partial contribution of 24%. The relationships between linear measurements heart girth and body length, height at whiters, and thoracic circumference, and morphological udder traits such as udder height and diameter and teat lengths and diameter can be useful tools in selecting animals for meat and dairy production, respectively. This implied that inclusion of more variables in the model substantially improved in the accuracy of prediction (Idowu et al., 2017). Multifactorial analyses of morphological traits can differentiate amongst various animal populations species in case where all the measured morphological variables are considered simultaneously (Traoré et al., 2008). Much attention as of late has been focused on in depth studies on dairy sheep udder morphology (Caja and Such, 1999; Carretero et al., 1999), phenotypic appraisal of udder traits has been suggested which should be linked to genetic improvement in order to derive genetic parameters (Carta et al., 1999).

3. Morphological traits and reproduction in goats and sheep

Heart girth measurement was the best indicator for differentiating goats with history of multiple and single litter size in goats (Haldar et al., 2014). It was interesting to note that in the same study that paunch girth, neck length, distance between trochanter major bones, clearance at udder, pelvic triangle area, wither height and ear length measurements were also among the important parameters that could impact litter size. Improved body condition score, higher live weight, physical strength and less slopped rump angles have been associated with higher probability of multiple births in does (Constantinou, 1989) and in ewes (Gaskins et al., 2005; Aliyari et al., 2012). Some genes that have been identified for regulating litter size in goats (An et al., 2009; Chu et al., 2011; Feng et al., 2011) hence it might be reasonable to suggest that these gens might be linked to some of the aforementioned body linear measurements. Some of the male reproductive organs morphometric studied in literature include: scrotal length (SL), scrotal circumference (SC), Scrotal and testicular weight (STW), testicular circumference (TC), testicular volume (TV), penile length (PL) and (PW) penile weight, etc. Babale et al. (2018) working with West African Dwarf goats fed groundnut haulms and cowpea husk with brewers dried grain supplement observed that morphometric traits of the reproductive organs, especially scrotal circumference are functional index and valuable selection criteria to determine the reproductive organs development and breeding soundness in young animals. Furthermore, the variability in linear type measurements is a recipe for exploitation in predicting live body weight and hence the economic value of livestock. Information on the relationship between linear body measurements and/or morphological traits with some reproductive traits in goats is scarce, this is despite the wide use linear appraisal for type traits in this species (Haldar, 2014a). Although an attempt has been made in dairy goats to use linear type traits such as physical strength and less sloped rump angle which have displayed positive relationships with litter size in dairy goats (Mellado et al., 2008). There is a scarcity of studies on phenotypic measurements to contrast the pregnant goats bearing single or multiple fetuses under field conditions, in this case ultrasonographic scanning is has been used for the prediction of fetal number in goats (Abdelgafar et al., 2007). It has been noted that ascertaining of fetal number during pregnancy in prolific goat breed was always useful for distinguishing the pregnant goats bearing single or multiple foetuses, as a result the knowledge can be management to minimise pregnancy toxemia, dystocia and possibly guarantee the optimal birth weights and curtail mortality in kids in multiple bearing ewes (Karen et al., 2006; Moallem et al., 2012). Morphological traits and/or conformation have been used in both males and females, as simple measurements to derive scores and also for visual assessment for reproductive traits. Pelvic measurements and scrotal conformation are the major linear traits used to ascertain reproduction in females and males, respectively. Small pelvic area in ewes has been implicated in the below normal lifetime performance associated with unsuccessful rearing accompanied by high perinatal mortality of lambs (van Rooyen et al., 2012). Therefore, it would be reasonably to consider pelvic area as a criterium for selecting ewes for breeding, however measuring it in vivo poses some challenges. Elsewhere, a number of studies confirmed that restricted passage of the pelvises in females promoted high incidences of dystocia, high perinatal ewe and lamb mortality rates and poor lifetime rearing performance of ewes (Haughey et al., 1982; Kilgour et al., 1993; Hartwig, 2002). As a result of dystocia due to small pelvises ewes exhibited prolonged postpartum periods, uterine infections and increased non-reproductive days as well as reductions in overall conception rate and milk production (Sieber et al., 1989; Walker et al., 1992). Haldar et al. (2014a) reported a detailed relationship between descriptive morphological traits and the pregnant goats bearing single or multiple foetuses: withers height (>48.85 cm) was associated with four times increased chances of multiple litter size, while distance between tuber coxae bones (>11.38 cm), neck length (>22.78 cm) exhibited three times more chances of multiple litter size. Dams with >54.86 cm body length, >50.67 cm croup height and >4.56 cm distance between tuber ischii bones registered two times more likelihood to bearing multiple litter size. The odd ratio (<1) for clearance at udder measurement displayed an inverse relationship of such variable with the prospects of multiple fetuses. In their study the enhanced possibility of producing multiple fetuses for specified increased dimensions in body length, withers height, croup height, distance between tuber coxae bones and distance between tuber ischii bones in pregnant goats was ascribable to increase in body size during pregnancy to accommodate twin or triplet fetuses. Physical strength has been a determinant in greater possibility of multiple births in does (Mellado et al., 2008) and ewes (Hall et al., 1994). An inverse association between clearance at udder measurement and the chances of multiple fetuses implies lowering of udder in pregnant goats carrying multiple fetuses. Thus, morphological traits could be quite useful for preselection of goats bearing single or multiple foetuses.

Testicular morphometry studies based on a variety of measurements namely scrotal circumference (SC), testes weight (TW), testes length (TL), tunica albuginea weight (TAW), testes volume (TV), testes density (TD), epididymal weight (EW), epididymal length (EL), caput (CA), corpus (CO), cauda weight (CU), epididymal volume (EV) and epididymal density (ED) have been an area of great interest in different livestock poultry fertility studies in males (Ibrahim et al., 2012 (sheep); Addass, 2011 (cattle); Orlu and Egbunike, 2010 (poultry); Uqwu, 2009 (goat); Purbey and Choudhury, 1985 (buffalo); Egbunike et al., 1976 (pig)). In a number of morphological studies scrotal circumference has been prominently identified as a useful indicator of rams breeding ability. On the other hand, testicular mass, acted as a reliable index of semen producing ability which was dependent on breeds. Correlated with testicular size in age at puberty and ovulation in female progeny, this implies males with larger testes tended to sire daughters that reach puberty at an earlier age and ovulate more ova during each oestrus period (Söderquist and Hultén). However, it should be noted that testicular weight and size are dependent on breed, age of animal and seasonal variation. Abdou et al. (1982) observed that the differences in the testes weight are profoundly noticeable between younger bulls and decreases as age progresses and this is despite all the animals being fully matured. This is on the backdrop that the larger and faster growing breeds would have larger testes as compared with smaller breeds of comparable age. Ibrahim et al. (2012) working with three sheep breeds reported a bilateral symmetry for Uda and Balami sheep in testes weight and volume. In their conclusion, the testicular biometry of Uda and Balami were symptomatic of high spermatozoa per unit mass of the testes and epididymis and consequently higher fertility. This implied that testes's biometric information could be useful with goat producers as a tool for selection of good male breeding animals for genetic improvement. Osinowo et al. (1981) and Togun and Egbunike (2006) verified that testes size was a useful determinant of the current and anticipated sperm production in animals. They further observed that the knowledge of basic morphometric is useful as an initial selection criterion for replacement males. Brito et al. (2004) emphasised that the evaluation of the breeding soundness of an animal will be based on weight of testes, since heavier testes produce more spermatozoa against the smaller testes. Berdston et al. (1987) verified that a testis with increased number of sustentocytes, were heavier and had enhanced spermatic activity against testes with minimal sustentocytes. This implies higher testes weight could be associated with more seminiferous tubule, interstitial endocrine cells, sustentocytes and possibly more spermatozoa production. The variation in the testes volume for the different breed have been reported by Ibrahim (2012) in different strains of chicken, while De Reviers and Williams (1984) revealed a species dependent scenario, that as a result of the larger size of internal and external reproductive organs, larger species consistently produce larger quantities of sperm per ejaculate. This has been ascribable to superiority of sustentocytes in the testes, which is related to the capacity for semen production. Hence the superiority of the larger breed as compared with their counterparts in this regards is an indication of higher sperm production potentials and a higher storage capacity. A linear relationship was observed in the rate of increase in testicular and epididymal weight with body weight preceded afterwards by a noticeably greater rate of increase at higher body weight. However, the relationship between the development of the testes and the epididymis was clearly exhibited at the body weight greater than 20.9 kg. In a testicular morphometry study, Ott et al. (1982) observed a ratio of left to right testes weight of 10%, that is left testes is larger as compared with the right in rams. This was confirmed in other livestock species such as buffalo, cattle and goats, (MacMillan and Hafs, 1969; Ahmad, 1984; Ahmad et al., 1985; Purbey and Choudhury, 1985; Ali, 1989; Siddiqui et al., 2005).

Togun and Egbunike (2006) cited that knowledge of basic biometric parameters of male reproductive organs is useful in breeding soundness assessment and potentiality of fertility in breeding animals. Egbunike et al. (1976) confirmed that biometric analysis on the testes of any species or breed is essential in evaluating and determining qualitative variation in testicular morphological parameters and spermatogenic activity. In a similar study, Gage and Freckleton (2003) verified mammalian testes as decisive determinants of spermatozoa production. Further illustrated that the epididymis was an exceptionally convoluted structure, which is firmly attached to the dorsal portion of the lateral surface of the testes (Setchell, 1977; Oyeyemi et al., 2000) and its known functions include storage, maturation and absorption of sperm cells. Testes morphometry parameters are dependent on genotype, reports of differences between breeds were previously verified in goats (Raji et al., 2008) and cattle (Addass, 2011). Ibrahim et al. (2012) verified that breed was a source of variation in scrotal circumference, paired testes weight and epididymal weight. In their comparison of the three breeds of rams in their study found out that there was significant in the aforementioned testes morphological traits and were heavier as those reported by Ahemen and Bitto (2007) for west African dwarf rams. However, their dimensions at the lower side against the values reported by Besta (2006) as testes weight (406 ± 40 g), testes volume (378 ± 44 mm3), epididymal weight (33.85 ± 2.15 g) and epididymal volume (26.67 ± 3.42 mm3) in Doper rams of South Africa. There is a tendency of differentiated testes morphological traits attributable to small and large breeds, in this case West African Dwarf ram are designated as smaller breed (Osinowo, 1990), while Balami and Uda belong to larger breeds (Ibrahim et al., 2012). As expected Doper rams in South Africa are classified as larger sheep genotypes. Schoenian (2011) specified that scrotal circumference of less than 30cm and 32cm for ram lamb and adult rams, respectively, were within the range unsuitable for use in breeding in males. In partly supporting this aspect, Söderquist and Hultén (2006) observed that for mature rams (17-54 months old), the average scrotal circumferences were 34.4 cm and 34.5 cm in Gotlandie and Dorper breed rams, which implies they were above the recommended values for breeding. Koyuncu et al. (2005) working with Kivircik ram lambs reported testis measurements: testis diameter, testis length, scrotum circumference, scrotum length and scrotum volume of 2.55 cm, 5.83 cm, 15.23 cm, 7.24 cm and 87.57 cubic square cm at 2 months; and 2.99 cm, 6.59 cm, 14.24 cm, 10.60 cm and 157.49 cubic square cm at 6 months, respectively. Selection on correlated morphological traits in young rams such as testis size has been the basis for improvement of fertility in sheep (Land and Carr, 1975). Louda et al. (1981) verified minimal but systematic variation in sexual activity and sperm production as testis developed, and suggested that young rams of prolific breeds (Romanov and Finnish Landrace) might vary in their potential reproductive performance, even though slightly. It was interesting to note that sexual development of ram lamb seemed to be more closely related with body growth as compared with chronological age (Dyrmundsson and Lees, 1972). This implied that the body weight was a better indicator for the attainment of puberty against chronological age alone (Dyrmundsson, 1973). A number of studies on the testicular morphology in relation to fertility traits have been reported in sheep: Ghannam et al. (1977) in Awassi lambs, Schoeman and Combrink (1987) in Dorper, Dohne Merino and Meat Master lambs and Aygün and Karaca (1995) in Karakaş lambs. The validity of testis diameter on its relationship with reproductive parameters may vary if taken at different times and age and weight of an animal. Moore and Sanford (1985) working with Suffolk sheep verified that testis diameter was age dependent where it increased up until 34 weeks of age, however it was also linked to seasonal variation. Probably the seasonal variation relates to the availability of nutrition, suspect good season will provide adequate nutrition for optimal testis development. Activity and inactivity of males also influenced testis diameter in Border Leicester rams, where testis diameter was compromised in inactive rams. Genetically, sires contribute to testis diameter of their progeny however sire effect was confounded with seasonal influence (Colas et al., 1990). Sires also influenced the percentage of abnormal spermatozoa, but the effect was lower as compared with that on the testis diameter. It should be noted that body weight had a profound relationship with testis measurements as compared with age, and this has been confirmed in a number of studies (Kritzinger et al., 1984; Zeng and Lu, 1987; Öztürk et al., 1996; Salhab et al., 2001) who observed high significant correlations between body weight and testis parameters. In conclusion, most literature results point to the fact that testicular and scrotal measurements are suitable measures for early selection of small ruminant males for reproduction efficiency. However, the selection of breeding males based on scrotal and testicular measurements alone might is not suffice, there is need to possibly augment on testosterone and spermatogenetic activity to improve selection of animals.

The results of this study lead us to postulate that the suitability of testicular and scrotal measurements as criteria for early selection of ram lambs was emphasised. On the other hand, the selection of breeding rams based only on scrotal and testicular measurements is not sufficient. Further studies on testosterone and spermatogenetic activity are needed to confirm the present results. Scrotal morphology has been on limelight assessing its relationship with fertility traits. Scrotal circumference and volume and testicular length have been the major focus on morphological studies in livestock production. On the same note, the measuring of scrotal volume was an option to address the issue for increasing the accuracy of the selection of reproducers (Martins et al., 2003). This implies that testicular volume is a variable that lessens the errors of scrotal circumference in case the testicles have various shapes (Alves et al., 2006). Moreira et al. (2001) working with Santa Ines sheep, observed that changes in testicular length and scrotal circumference can be regarded as viable determinants of the effect of thermal stress on the gonads. Males exhibiting long and thin testicles, the scrotal volume portrayed as a viable determinant of the quantity of testicular parenchyma, showing a more accurate measure, as compared to the scrotal circumference, which in this case would undermine the reproductive capacity of individual animals (Bailey et al., 1996). The formula of a cylinder in estimating scrotal volume was deemed quite accurate in beef bulls, with the width of the testicles as the radius and their length as the height. However, due to the nature of testicular morphology the formula of a cylinder method of estimating scrotal volume seemed to be inapplicable in sheep (Fields et al., 1979; Unanian et al., 2000). Pacheco et al. (2009) verified scrotal circumference of 23, 83, 27, 78, 28, 93 and 29, 74 cm, respectively, at 6, 8, 9 and 12 months of age, while assessing body and testicular development of Santa Ines sheep. In fact, a larger distance between the testicles and the abdominal cavity provides for maximizing heat loss in this area, hence greater thermoregulatory effort (Johnson, 1980) allowing the animal a greater spermatogenic activity. Long testicles facilitate enhanced heat dissipation, and improved thermoregulation, promoting spermatogenesis, due to appropriate temperatures regulation in this area (Bailey et al., 1998).

4. Morphological traits and milk production in goats and sheep

Animal body morphology is closely related to milk performance (Guli´nski et al., 2005) and longevity, which determines the contributions to lifetime milk production of a dairy animal (Sawa et al., 2013). In modern dairy science breeders are now interested in morphological traits, their metrics are not only relevant as descriptive parameters in their own accord but can also have an important influence on an animal's breeding value (Nye et al., 2020). Previously, developments in dairy animal improvement, the selection of dairy goats and sheep was dependent basically on morphological traits, the reason being that no records were obtainable for productive trait. Since the last decade a number of udder morphological traits have become of interest to the breeder because of their effects on milk yield (Kumar et al., 1983), in addition to udder health (Charon and Skolasinski, 1988; Fernandez et al., 1995) and mechanical milking (Jatsch and Sagi, 1979; Labussie `re, 1988; Mikus, 1978; Sagi and Morag, 1974). However, recording detailed morphometric characters which may influence progeny success are time consuming and costly, and in the absence of quantitative tools, producers often utilizse morphometric measurements qualitatively. As of late in the advent of sophistication of recording systems morphological and/or conformation traits have maintained their importance to dairy industry breeders not merely as interpretive traits in their own accord, but as well as indicators of milk production, longevity, and profitability of a dairy enterprise. The anatomical and morphological characteristics of the udder and teats and their relation with milk production, in small ruminant milk production have become of greater interest from dairy farmers' management point of view and to dairy researchers. It has proved that morphological characteristic data can be remarkably valuable to animal breeding decisions since can be used to derive specific scores for heritable traits. Morphometric traits have been used as determinants of milk production, and sometimes considered for genetic improvement in small ruminants' dairy (Lambe et al., 2008; Abdel-Mageed and Ghanem, 2013). Much attention as of late has been focused on in depth studies on dairy sheep udder morphology (Caja and Such, 1999; Carretero et al., 1999), phenotypic appraisal of udder traits has been suggested which should be linked to genetic improvement in order to derive genetic parameters (Carta et al., 1999). A number of studies, working with different breeds of sheep confirmed that deep and well-attached udders are highly correlated with milk production (Altinçekiç and Koyuncu, 2011; Legarra and Ugarte, 2005) and goats (McLaren et al., 2016). Udder attachment which is higher and more tight are determinants of lower somatic cell scores, while udder depth is regarded as an easy measureable indicator of udder health in goats (Rupp et al., 2011). Udder depth and length were the predominant morphological traits that were most correlated to milk production, meanwhile deep udders and short teats were associated to lower somatic cell counts (Fernandez et al., 1997). In other dairy species, Mingoas et al. (2017) observed that milk production was positively correlated with udder size. Lameness either due to leg malformations or injury (Sogstad et al., 2006; Green et al., 2010) was implicated as the highest negative economic impact for milk producers. Senthilkumar et al. (2019) suggested that the productive capacity of the ewe is related to the distance between teats, however, the variation dependent of species and breed difference. Akpa et al. (2003) observed that correlation coefficients of udder circumference with any of total milk yield, initial milk yield and peak milk yield were highly positive. Amao et al. (2003) and Adewumi et al. (2006) observed that increase in milk yield was associated with increase in udder characteristics, weight and linear body measurements. In the same study udder circumference was a good estimate for predicting the weights of lambs as it registered a high correlation with weight of the lambs. However, correlation analysis between milk off take and body weight of lambs displayed a non-significant relationship. Kumar et al. (1983) cited that different levels of association of udder parameters and milk production seem rational in view of the different measurements and udder volumes being a consequence of milk secreting action of the mammary gland and the amount of milk produced and stored in the udder. Udder traits of length, width, and circumference, and teat parameters of length, width, and circumference, with udder capacity exhibited a significant relationship in Red Sokoto goats (Amao, 2003). Siddik et al. (2005) working with Akkeci goats noted a positive and significant correlation between udder parameters of udder depth, udder circumference, teat circumference with daily milk yield. In a similar study, Upadhayay et al. (2014) suggested a positive and significant correlation between average daily milk yield and doe's body weight at different intervals with udder morphological traits. Murciano-Gradina dairy goat portrayed the same trend of significant correlations between udder traits, udder volume, with body weight, milk yield, and milking traits (Peris et al., 1999). Partly, inconsistent with this result, Emediato et al. (2008) reported low and negative correlation for udder characteristics, with milk yield throughout pre-weaning phase, however this was exclusive of udder depth. The trend differed after weaning, where udder circumference, depth and volume registered significantly positive coefficients of correlation with milk yield. McLaren et al. (2016) working with mixed breed dairy goats observed a range of positive and negative phenotypic and genetic correlations between udder traits, the most prominent correlations were between udder depth and udder attachment, teat angle and teat placement and back legs and back feet, which registered 0.78, 0.70 and 0.64, respectively. Idowu et al. (2017) studying dam's linear body measurements in relation to milk yield and milk composition in West African Dwarf sheep at first lambing, observed that milking capacity had a significant correlation with dam's body length, udder width, teat length, distance between teats and teat circumference.

Weight of dams had significant correlations with all the variables entered except total solid, fat and teat circumference. However, the multiple regression analysis showed that the addition of other linear variables to milk off take would consequently improve the accuracy of prediction. An interesting factor was of lamb's wither height which emerged to be the best predictor of lamb's weight describing approximately 48% of individual contribution. In conclusion in their study the teat circumference and lamb's wither height gave the best fit for milk off take and lamb's weight, respectively. Correlation analysis using a multiple regression inclusive of teat circumference, dam's wither height, lamb's heart girth and dam's neck length contributed almost 33% of the total variability with teat circumference recording the greatest partial contribution of 24%. This implied that inclusion of more variables in the model substantially improved in accuracy of prediction (Idowu et al., 2017). In Beetal goats, Jena et al. (2019) observed that all the udder morphological traits were positively correlated with morning as well as daily milk yield, while teat morphological traits were also positively correlated with morning in addition to daily milk yield excluding teat height which was negatively correlated. An interesting note in the same study the udder and teat morphological traits displayed positive correlation with body condition parameters. Milk yield had positive correlation with measures of body condition score, sternal and lumbar thickness were positively correlated with milk yield, which presumably could be concluded that the udder and teat morphological traits had an important relationship with milk yield and body condition parameters in Beetal goats.

5. Implications

Morphological and/or conformation traits are of paramount importance to goat and sheep production not hardly as descriptive traits unaccompanied, but as well as indicators of reproductive and milk production potential of individual animals. It has been proved through extensive studies that to some extent there is both strong phenotypic and genetic relationship between some morphological measurements with growth, reproduction and milk production parameters. Morphological characterisation and multifactorial analyses of morphological traits in relation to productivity indicators are critical in goats and sheep breeding programs in particular, as the desired outcome could instigate animal performance change through indirect selection based on the phenotypic measurements. Animal morphology development is complex process probably with multiple genes at play, which might be dependent on the environment, and changing over time, collecting multiple descriptive morphological dimensions can make relating genotype to phenotype more feasible and, importantly, more relevant in terms of understanding functionality of animals on growth, reproduction and milk production performance. Morphometric traits provide explicit baseline information on characterisation of goats and sheep breeds with the intention of using such information in conventional animal breeding schemes, especially in developing countries where breeding programs are still not fully established. With the advent of multiple regression models, the prospects are high to establish correlation analysis between morphological traits with reproductive traits and milk production parameters which can be used in breeding decisions since this information can derive specific scores for heritable traits related to goats and sheep performance. In view of simplicity of measurement, morphological traits could be incorporated in community based animal breeding performance recordings schemes. This is because in most cases morphological traits correspond to functionality of animals for the purposes of production and partly confirming a possible but an initial appraisal to selection of animals reproductive and/or milk production capacity. The testicular (male), pelvic (female) and udder morphometry have been the basis of application of morphological indices in reproductive and milk production performance assessment of type and function in goat and sheep production. Literature reveals that udder morphological characteristics values are significant indicators of milking capacity of individual animals in dairy goat and sheep enterprises and explains that udder size is strongly and positively correlated to milk yield. The implications for such observations is that morphological traits can be useful complementary source of information to consider in animal genetic improvement programs in goats and sheep breeding schemes. However, prior knowledge or studies are expected on what other factors impinge on udder morphological characteristics, while mathematical model building of udder morphology and milk yield correlations in small ruminants might also be relevant to sufficiently explain the overall influence of udder characteristics in milk production. Any aspects of goats and sheep husbandry management practices that promote the structural dimensions of any of the udder morphological traits will in turn advance milk production in goats and sheep.

The thrust to promote indigenous animal genetic resources proper breeding policies which taking into account the relationships among conformation and functional traits should be part of breeding decisions in these populations. This implies that community based breeding schemes in developing countries should incorporate highly correlated linear type traits through development of genotypic characterization which feeds to genetic improvement strategies and productivity schemes. In a number of studies morphological indices confirmed significant differences in morphology in specific animal populations which could serve as baseline information for breeding programs and selection and genetic improvement in goats and sheep. Conventional breeding programs depend on large-scale, accurate records, which are critical for deriving breeding values for quantitative traits. This has been a major challenge in developing countries, hence the need to focus on morphological traits for animal breeding ventures.

Suggestions have been made to develop methods to measure morphological which are rapid and accurate in quantification of multiple conformation measurements while minimizing costs. In most cases, the number of conformation traits recorded in conventional breeding schemes are relatively small, because it might be expensive. In conclusion, the review verified that morphological traits can be used as accurate indicators of animals' reproductive capacity and milk production potential in goat and sheep production.

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