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ISSN 2322-1704
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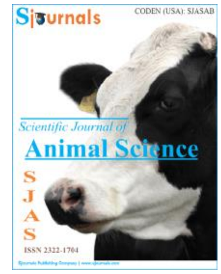
CODEN (USA): SJASAB

Scientific Journal of Animal Science (2020) 9(5) 620-634
ISSN 2322-1704
doi: 10.14196/sjas.v9i5.538




Contents lists available at Sjournals
Scientific Journal of **Animal Science**
Journal homepage: www.sjournals.com

**Review article**

# Indigenous goats and sheep breeds and their crosses in the tropics and subtropics: Growth traits, carcass parameters and meat quality properties

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ARTICLE INFO

*Article history,*
Received 12 April 2020
Accepted 13 May 2020
Available online 20 May 2020
iThenticate screening 14 April 2020
English editing 11 May 2020
Quality control 18 May 2020

*Keywords,*
Indigenous
Goat
Sheep
Growth traits
Carcass
Meat parameters
Tropics
Subtropics

ABSTRACT

The tropics and subtropics is a habitat to diverse populations of indigenous goats and sheep breeds known for their adaptability to the existing harsh agro-ecological conditions and the majority are reared under traditional systems of management. Apart from their inherent ability to cope with a range of climatic conditions including disease challenges and inadequate feed resources whilst being exposed to mostly unsound management practices, indigenous goats and sheep are an integral part of the smallholder resource poor rural economies. Therefore, there is an obligation and considerable potential for increased meat production from the already existing diversity of indigenous goats and sheep animal genetic resources in the tropics and subtropics. However, indigenous goat and sheep performance in most cases is less than ideal due to a number of constraints namely inadequate nutrition and disease prevalence, poor support institutional involvement and lack of adequate government policies and funding to develop this industry. It has been noted that apart from their low genetic potential, indigenous goats and sheep's exposure to suboptimal nutrition has been identified as the major factor that contribute to their low meat production. This is despite that the principal advantage of utilising indigenous goats and sheep in the tropics and subtropics is rightfully based on their small size and ability to utilise less productive areas that exist in existing total farming areas. Their ability to adapt to suboptimal production conditions characterised by persistent substandard nutritional feed resources makes indigenous goats and sheep perfect candidates for meat production in the tropics and subtropics. The potentiality of indigenous goats and sheep in the tropics and subtropics has been downgraded because they have not been selected for high meat performance. In this case efforts are at different stages of genetic characterisation of various indigenous goats and sheep breeds in order to ascertain their meat production potential. At the same time, crossing of genetically improved exotic goats and sheep breeds with indigenous flocks, has been noted as a feasible option to enhance meat productivity in the tropics and subtropics. Recent trends in indigenous goats and sheep utilization in order to match demand for meat and improve productivity in resource poor farming areas in the tropics and subtropics, local farmers have been incentivised to rear improved genotypes, which are predominantly crossbreds between superior meat exotic breeds and the indigenous goats and sheep breeds. Productivity with regards to indigenous goats and sheep can be specified as the magnitude of production or efficiency of production. This is based on the fact that in any indigenous goats and sheep production environment, productivity per se will exceptionally depend on an intricate correlations of biotic, abiotic and socio-economic variables. The factors are interdependent and therefore should be considered comprehensively to establish their ranking and how adjustments in constituents influence the whole indigenous goats and sheep production systems. A number of studies have been carried out to assess the growth potential, carcass and meat quality properties of several indigenous goats and sheep and their crosses in various agro-ecological regions within the tropics and subtropics. The results have been inconsistent due to various reasons which might probably include non-identical production conditions and the genetics of various small ruminants' ecotype breeding groups. The present review gives an insight on some documented growth performance and carcass and meat quality properties of indigenous goats and sheep in the tropics and subtropics.



**1. Introduction**

In the tropics and subtropics indigenous goats and sheep are the widest spread meat animal genetic resources due to their ability to adapt themselves which is exceptionally revealed in stressful climatic conditions. This representative group is of significantly appraised animal genetic resources for the reason that they are highly adaptable to harsh tropical and subtropical climatic conditions, surviving on restricted and repeatedly substandard quality forage, in addition to enduring a spectrum of local diseases and parasites. As of late, goats and sheep community development programs have underscored the potential of indigenous goats and sheep as both an alternative and/or complementary activity in meeting the meat shortfall in formal commercial meat markets in the tropics and subtropics. It is against this backdrop that indigenous goats and sheep comprise the largest proportion of distinguished diversity of animal genetic resources in the tropics and subtropics. They have proved to be prolific and tolerant of local environment, however their poor meat production traits are ascribable to mostly their small mature body size (Sirlwarde and Rajmlultu, 1989). Since time immemorial indigenous stock have been exploited mainly for meat production and recently local farmers have been encouraged to cross improved meat breeds of goats and sheep with the indigenous goats and sheep in order to improve growth traits and carcass and meat properties. When indigenous goats and sheep breeds are compared with the improved meat breed types, the documented differences in body weight and growth rate as well as carcass and meat quality properties are simply because they have not been genetically improved for aforementioned purposes. As a result, crossing of local goats/sheep with improved meat type has become an important strategy to enhance meat productivity of indigenous goat and sheep breeds in the tropics and subtropics. Shumuye et al. (2014) noted that the crossbred (F1) derive important growth genes from their parents that enable them to outmatch the local disease and harsh environmental conditions. Indigenous sheep and goats, with their higher adaptability and good reproductive capacity under suboptimal conditions, are as a matter of choice eligible for utilization in resource-poor environments (Devendra, 1999; Tibbo, 2006). There has been inconsistence of results from different studies of indigenous goats and sheep and their crosses on growth performance, carcass and meat quality properties (Mustefa et al., 2019; Tesema et al., 2018; Gebreyowhens et al., 2017; Girma et al., 2016; Sen et al., 2011; Yilmaz et al., 2010). This discrepancy is expected because indigenous goats and sheep breeds are diverse and populated all around the tropics and subtropics culminating in distinctive performances influenced by non-identical production conditions. Some agro ecological regions in the tropics and subtropics usually use both pure indigenous breeds and assorted crossbred goats and sheep that include characteristics from more than one breed, which might be locally available or exotic breeds. Overall performance of indigenous goats and sheep breeds and their crosses will vary according to production conditions, as a result influencing the extent of growth performance, carcass and meat properties one way or another. The present review gives an insight on some documented growth performance and carcass and meat quality properties of indigenous goats and sheep in the tropics and subtropics.

## 2. Goats and sheep production in the tropics and subtropics

The tropics and subtropics is a habitat to diverse populations of goats and sheep breeds adapted to harsh agro-ecological conditions with the majority reared under traditional systems of management. Indigenous goats and sheep constitute a principal socio-economic and ecological niche in smallholder animal agriculture in the tropics and subtropics, symptomatically scattered in the harsher agro-based conditions. More often than not sheep and goat production are the only mode of animal production in marginalized agricultural areas, even though in certain cases extensive beef cattle production systems may be exploited side by side with sheep or goat production. By virtue of minimum capital investment and probably shorter generation interval which may be associated with rapid economic returns, sheep and goats has been an integral sector of flexible and vulnerable animal agriculture production systems in the tropics and subtropics. Their prevailing low level of contribution is deemed to be low, and is not proportionate with the imaginable scope for higher levels of production. However, the contribution to general agricultural productivity and socio-economic factors by indigenous goats and sheep is expected to be high taking into account diversity of breeds and their large population numbers, in addition to being widely distribution across the tropics and subtropics production systems. The indigenous goats and sheep apart from their small body size as an advantage, are well adapted to most resource poor production systems and products, while collaborating with the environment. The resource poor smallholders rural farmers are the major custodian of indigenous goats and sheep, rearing them in very small herds on single-family farms. Their contribution to the national economies have deemed to be very low and the central to the midst of the reasons specified for their dissatisfying contribution to commercial meat markets is their low genetic potential. However, despite this circumstance indigenous goats and sheep breeds are indispensable due to their potentiality for multipurpose function especially in resource poor agro-based conditions, where disease tolerance and low maintenance requirements are critical. It is assumed that future priorities of animal production will be dependent on a comprehensive exploitation of indigenous animal genetic resources that can survive and produce under harsh semi-arid conditions, in which climate change has adversely affected water resources accompanied by restricted feed resources that impinge on animal production. As often is the case the tropics and subtropics are not one homogenous environment - nonetheless defined by high ambient temperatures and other geophysical variables impacting on rainfall which at the same time, being seasonal, influences grazing on which the indigenous goats and sheep greatly survive. This becomes critical in extensive systems under which most of the indigenous goats and sheep are reared in the tropics and subtropics. From documented evidence not much scientific research has been conducted on indigenous goats and sheep breeds until recently, due to advent of molecular methods that some progress has been made in characteristion of few indigenous goats and sheep ecotypes. Therefore, indigenous goats and sheep all the same emerge to be inferior in performance. On the contrary, the exotic goats and sheep breeds have been improved for high performance (high-yielding goat meat breed i.e. Boer) and are suitable for use in intensive meat production systems. The exotic goats and sheep breeds appear superior and more productive against the indigenous ones although they are more prone to diseases and thus require extensive inputs in the form of management. Characteristically, indigenous animal genetic resources have adapted to harsh conditions such as drought and heat, which are prevalent in majority of resource poor rural farming areas. For this reason, the mainstreaming of indigenous goats and sheep breeds into the national agendas is of paramount importance if livestock production in the tropics and subtropics is to be sustainable in harsh environmental conditions. It is a matter of regret that in most cases the indigenous goats and sheep animal genetic resources does not feature and/or partly accounted for in the national livestock related policies in the tropics and subtropics. To make matters even worse, there is a perpetual loss of indigenous goat and sheep animal genetic biodiversity on the basis of inappropriate livestock policies that are mainly focused on exotic goats and sheep genetic resources, while undermining the crucial role of indigenous goats and sheep genetic resources. It is without regret that despite the majority of the smallholder farming community in the tropics and subtropics, above all resource poor rural farmers rely appreciably on indigenous goats and sheep for their livelihoods; however, the potential of this niche is still underestimated as a result its incapacitation to contribute meaningfully to economic development and social wellbeing of the smallholder farmers. This is despite the fact that indigenous goats and sheep breed have proved beyond doubt their survival under extreme climatic conditions; thus resource-poor small ruminant farmers should be incentivized to farm with these resources as they require low inputs. It cannot be overemphasized that indigenous goats and sheep can contribute to sustainable livelihoods and ensure that poor, subsistence and smallholder rural agro-economies have necessary means to superintend risk and vulnerability. Indigenous goats and sheep through natural selection have acquired distinctive physiological, morphological, and reproductive behaviors that have enhanced their survivability and perpetuation in harsh tropical and subtropical conditions. Nothing else but development and promotion of indigenous goat and sheep rearing might be a practical strategy to cushion resource poor farmers from the adverse effect of climate change and variability. Very few of the indigenous goats and sheep have received comprehensive and warranted research attention in terms of the spectrum of their performance indicators, hence there is a lot which need to be done to evaluate all facets of performance indicators (growth, reproductive, mortality, carcass and meat properties, milk etc.) in order to integrate this significantly appraised animal genetic resources in the so called formal animal production systems. The expectations are high with advent of new technologies management practices, namely breeding technologies and health management exploited in the context of community based research approaches that indigenous goats and sheep breeds can be sustainably developed and promoted to close the animal protein void which is prevalent in the tropics and subtropics. Below is a list of studies on various performance indicators in some indigenous goats and sheep breeds in Africa.

Selected studies in indigenous goats and sheep breeds in Africa

| **Name** | **Species** | **Location** | **Source** |
|---|---|---|---|
| Matebele | Goat | Zimbabwe | Assan (2013) |
| West African Dwarf | Goat | Cameroon | Manjeli et al. (1996) |
| Tswana | Goat | Botswana | Nsoso et al. (2004) |
| East African | Goat | Tanzania | Ingratubun et al. (2000) |
| Short Eared Somali | Goat | Ethiopia | Tadesse et al. (2016) |
| Bati | Goat | Ethiopia | Tadesse et al. (2016) |
| Hararghe | Goat | Ethiopia | Tadesse et al. (2016) |
| Sahel | Goat | Mali | Shaker et al. (2012) |
| Red Sokoto | Goat | Guinea | Makun et al. (2008) |
| Landin | Goat | Mozambique | Garrine et al. (2010) |
| Pafuri | Goat | Mozambique | Garrine et al. (2010) |
| Mossi | Goat | Burkina Faso | Traore et al. (2016) |
| Zaraibi | Goat | Egypt | Mourad (1993) |
| Nilotic Dwarf | Goat | Sudan | Osman et al. (2008) |
| Abergele | Goat | Ethiopia | Deribe and Taye (2013) |
| Nguni | Goat | South Africa | Idamokoro et al. (2017) |
| Balady | Goat | Egypt | Helal et al. (2010) |
| Galla | Goats | Kenya | Blackburn and Field (1990) |

| | | | |
|---|---|---|---|
| Sabi | Sheep | Zimbabwe | Assan and Makuza (2005) |
| Damara | Sheep | South Africa | Tshabalala et al. (2003) |
| Red Maasai | Sheep | Kenya | Zonadend et al. (2017) |
| Garole | Sheep | India | Sharma et al. (1999) |
| Muzaffarnagari | Sheep | India | Mandal et al. (2000) |
| Zulu(Nguni) | Sheep | South Africa | Kunene et al. (2007) |
| Somali Blackhead | Sheep | Kenya | Blackburn and Field (1990) |
| West African Dwarf | Sheep | Ghana | Ngere (1973) |
| Djallonke | Sheep | Ghana | Birteeb and Donkor (2016) |
| Horro | Sheep | Ethiopia | Tadesse (2019) |
| Sudan Desert | Sheep | Sudan | Khalafalla and El Khidir (1985) |
| Karakul sheep | Sheep | Botswana | Martins and Peters (1992) |
| Namaqua Afrikaner | Sheep | South Africa | Burger et al. (2013) |
| Mosi | Sheep | Burkina Faso | Traore et al. (2016) |
| Barki | Sheep | Egypt | Mansour et al. (1977) |
| Rahmani | Sheep | Egypt | Swidan et al. (1979) |
| Ouled Djellal | Sheep | Algeria | Safsaf et al. (2012) |
| Babary | Sheep | Libya | Bushwereb and Rabeie (1978) |

**3. Growth traits in indigenous goats and sheep in the tropics and subtropics**

In the weight traits category, birth weight assumes the first indicator of productive performance because it is an early measurable parameter in indigenous goats and sheep breeds. Indigenous kids/lambs which are heavier at birth have mainly exhibited weight advantage at weaning, however this tend to diminish as age of kid/lamb progresses. This entails that maternal influence is more likely to be less in post weaning growth. It is assumed that provision of adequate nutrition during pregnancy in indigenous goats and sheep tends to promote desirable birth weight as a result facilitating appropriate growth especially during pre-weaning period as well as an advantage on the actual weaning weight. Mustefa et al. (2019) and Deribe et al. (2015) observed comparable birth weight of the crossbreds of Boer x CHG, while elsewhere, lower birth weights were exhibited by Ssewannyana et al. (2004) among Boer x Mubende 50% and Boer x Teso 50% crosses. These results were also confirmed by Debele et al. (2015) and Girma et al. (2016) among Boer x Arsi Bale kids and Boer x Woyito-Guji 25 % crosses. Premasundeba et al. (1998) in a crossbreeding program involving German Boer, Jamnapari and the local Kottukachchiya breeds, observed that weights at birth of the F I crossbreds were comparable to that of Jamnapari, however, higher against those of the local types (Kottukachchiya and Jamnapari x Konukachchiya crosses). Noteworthy, weight at birth of FI crossbreds were midway to those of the Boer and the local types. As an illustration, crossbred kids were about 0.3 kg heavier at birth than the local types. There was conspicuous merit for upgrading local goat types with Boer goat to achieve improved weights, hence the observations point to the fact that the weight at birth of Boer half breeds were to greater extent determined by the kid's genotype with reference to maternal genotype. In a similar study the crossbreds greatly outperformed purebred in birth weight, and growth related traits (weaning weight, weight at mating, mature body weight), prolificacy and fecundity along with carcass quality (Cameron et al., 2001).

In most traditional goat and sheep management systems weaning animals has not been seriously taken as a management tool as a result kids/lambs have been subjected into natural weaning. For commercial purposed prolonged suckling of kids/lambs is undesirable because it increases the generation interval hence reducing the individual dam's lifetime reproductive capacity which translates to loss in overall productivity. Timing of weaning and age at weaning have a bearing on the total kid/lambs weaned and marketed per annually, hence this decides the producers' income. Superior weaning weight was observed for Boer x Arsi bale, Boer x CHG and Boer x Woyito-Guji 25 % crossbreds as reported by Debele et al. (2015), Deribe et al. (2015) and Girma et al. (2016) in different locations. Boer goats have been predominantly used in crosses with indigenous goats with impressive results. Most studies reported Boer kids and their high crosses exhibiting superior growth performances. This was attributable to higher proportion of paternal genes (from the Boers). This was partly concurred by the results of Sanchez et al. (1994) who observed that Boer crosses had superior body weight at all ages. However, it was acknowledged to match management with the potential of the crossbreds especially under the local farmers' condition in which they are likely to perform poorly as compared to the local breeds failure to adapt, by which the total performance could be inferior against the F1 crosses (Lipson et al., 2011). Mareko et al. (2006) studying yearling Tswana goats exhibited a final live weights ranged from 24.2 to 27.8kg, while being fed Teminalia sericea, Boscia albitrunca Browses or Lurcene as supplements.

One of the major characteristics of indigenous goats and sheep is their slow growth rates, unlike the exotic meat breeds they have not been genetically improved for growth traits. The slow maturing indigenous goats and sheep breeds tend to deposit a lot of carcass fat which result in undesirable carcass for meat commercial meat oriented markets. The poor growth rates in indigenous goats and sheep have limited them in their use in intensive systems for the purpose of meat production. Mustefa et al. (2019) studying growth performance of Boer goats and their F1 and F2 crosses and backcrosses with Central Highland goats, Boer kids were superior in pre-weaning daily weight gain across the preceded by those of F2 genotypes. However, no differences were observed for post-weaning weight gain among the genotypes. Specific average daily gain reported by Karaca (2004) was 203 g/head/day with Akkeçi male kids, and those reported by Kaić et al. (2012) was 204 g/head/day with male Boer kids, but lower than the ADG of 258 g/head/day with Boer × Balcalı crossbreeds (Güney and Ocak, 2010) under intensive feeding systems. Despite the fact that similar growth rates of Hair goats and Boer kids may be surprising, comparable performances of indigenous breeds of goats and sheep to improve small ruminant breeds even in high-input feeding systems have been reported by some authors (Kebede, 2000; Ate et al., 2015). Gebreyowhens et al. (2017) working with pure male Dorper mated with local sheep produced first and second generation with 50 and 25% blood level of Dorper, respectively, reported an average live body weight of the 50% crossbred male and female sheep of 45 and 38 kg, respectively, at adult age. Crossbreds of Dorper (male) sheep with local sheep (female) enhanced body weight by 55% and 53% at yearly age for males and females, respectively. The initial average live body weight of the adult male (25kg) and female local sheep (highland) (20kg). It was concluded that it was possible to increase meat production performance of the local sheep as a result of cross breeding with high performing exotic Dorper sheep under resource poor farmers' conditions. The superiority of Dorper sheep imparting improved body weight performances with excellent outcome has been reported world over (Lakew et al., 2014). It has been acknowledged that crossing Dorper with local sheep is an appropriate for producing crossbred lambs with excellent growth rates under smallholder farming conditions. Studying growth performance of Boer goats and their F1 and F2 crosses and backcrosses with Central Highland goats, Mustef et al. (2019) observed that for the most part growth traits of studied genotypes were below-par which could be explained by sub-optimal adaptability to local conditions. This implies non-genetic factors adversely affected performance of crossbreed and backcrosses despite the highly recognized genetic potential Boer goats, hence in this case so growth performances can be promoted by curtailing environmental effects. The birth weight and weaning weights of the crossbred and backcrosses were 2.5 and 8.37 kg, and 2.94 and 9.8 kg, respectively. The result observed in this study were in contrary to be reported by other worker who noted that Boer goats could impart superior productive performance, crossbreds outperformed the native breeds in all aspects (Erasmus, 2000; Lu and Potchoiba, 1988; Casey and van Niekerk, 1988; Lu, 1989). Amosu et al. (2017) in Red Sokoto reported that liveweight, slaughter weight, dressed weight and chest weight of the bucks at the age of 2-3 years were uppermost, meanwhile empty carcass weight, hot carcass weight and half carcass weight were maximum and significant for bucks of ≤1year. The peak liveweight was attained between ≤1year to 2-3years, this was consistent with previous report by Assan (2012) for indigenous Matebele goat slaughtered at different teeth eruption ages. The values of livesweight observed by Amosu et al. (2017) are lower than other breeds of goats of lesser or the same age like the Spanish meat-type goat, South Africa indigenous goats and Karayaka lambs reared under feedlot management (Oman et al., 1999; Sen et al., 2011; Simela et al., 2011). Thiruvenkadan et al. (2009) reported comparable birth weight of crossbred and purebred Mecheri sheep, however this was depended on age of animals. At the age of 12 months crossbred had superior liveweight as compared with purebreds, however as age progressed the variation was minimal. Issakowicz et al. (2018) working with crossbred of Dorper × Santa Inês and Dorper × Morada Nova local lambs, crosses had similar daily live weight gains and feed conversion. However, crosses attained a desirable slaughter age earlier. Gatew et al. (2019) working with indigenous Bati and Borana goats, but Short-eared Somali goats, reported a non-significant effect on average daily weight gain from birth to 90 days, however Short-eared Somali goats had significantly lighter average daily weight gain at during nursing as compared to Bati and Borana goats. In another study the average daily weight gains of 82.34g and 76.6 g at maternal phase were reported for indigenous Bati (Gemiyu, 2009) and Borana (Deribe and Taye, 2013). A lower average daily gain (61.25 g) between birth and 90 days was reported for Short-eared Somali kids by Zeleke (2007). The variation in growth rates under different levels of concentrate feeding in East African goats were 15 and 21 g/day for low and high protein, respectively (Hango et al., 2007). The discrepancy of variations in early daily weight gain in these studies was ascribable to the management difference of both dams and kids at early age. In a comparative study by Fitsum et al. (2019) of F1 crossbreds of Boar with native goats, where the genotypes utilized involved 50% Boer (Abergelle x Boer), 25% Boer (50% Boer x 100%local) versus native goats, observed that F1 sires (Boer: local) on local dams gave better growth of the progeny against kids of 100% native breed. In their conclusion, crossbreeding using 50% Boer males was deemed an appropriate strategy for upgrading the body weight potential of native goats under local management condition. As expected superior body weight and growth rates exhibited in Boar goat crosses against local breed goats could be explained by their genetic superiority of the Boar goat breed in body weight which is a highly heritable trait. The breed is familiar for its non-additive genetic response in crossbreeding strategies (Bekele et al., 2010). Elsewhere, the results are in agreement with those reported by Chhbardra and Sapra (1973) in India. The effect of sex in favor of males over females in body weight is in line with results from other authors (Solomon, 2010). The local Morada Nova pure bred lambs exhibited lower performance with reference with other genetic groups (Dorper × Santa Inês versus Dorper × Morada Nova) which delayed their slaughter age. The explanation for enhanced performance of crosses was due to greater genetic distance between Morada Nova and Dorper genotypes. This was noticeable preceding weaning possibly due to diminishing maternal effect during post-weaning period. Average daily gain for Central Highland and Boer*Central Highland goats was enhance as a resulted of improved nutrition (Tesema et al., 2018). As expected high quality diet will promote growth in crossbred, while low to moderate quality will not make crossbred realise their genetic potential for growth (Joemat et al., 2004; Negesse et al., 2007; Ngwa et al., 2009). This entails crossing as a performance seeking strategy need to be accompanied by favorable production condition. There is a tendency of genotype by environment interaction where animals ranked for superior growth rates in favorable environment especially based on nutrient rich diets, to lose fitness hence experiencing challenges when raised in unfavorable production environment (James, 2009; Wilson, 2009). Kor et al. (2011) studying Akkeçi (Saanen × Kilis) crossbred male kids reared in individual crates (IC) or in group pen housing (GP), the observed final body weights and average daily weight gains of the GP and IC kids were 30.84 ± 0.82 kg and 25.84 ± 0.76 kg; 182.42 ± 14.77 g and 92.09 ± 13.76 g, respectively. However, the carcass conformation of kids was comparable between groups, while GO and IC was a major source of variation for some slaughter and carcass characteristics. Supplemented Boer and Xhosa-Boer crossbred goats had significantly higher slaughter weights and cold carcass weight with reference to non-supplemented groups (Xazela et al., 2012). This shows that nutrition is an important aspect of promoting growth in complementing the genetic potential of individual animals. The crossbred outperformed pure Central Highland goats. In a similar study Lemma et al. (2014). Reported that the Bonga × Menz crosses exhibited superior growth performance against pure Menz and Washera × Menz, at the same time the latter showed no significant differences. Dvalishvili et al. (2015) reported that crossbreeding Romanov ewes with crossbred Argali Romanov Rams (3/4 R X ¼ A) had positive influences on growth performance and muscularity of the new-born lambs (7/8 R: 1/8 A). Growth rates of 19.6 - 25.1 g/d and 19-32 g/d were observed by Ayo (2002) and Ntakwendela et al. (2002) for Small East African goats supplemented with leguminous proteins. The inconsistence in growth rate among studies was ascribable to differences in age of animals at slaughter as well as the disparity in dietary energy density.

## 4. Carcass and meat traits in indigenous goats and sheep in the tropics and subtropics

There has been inconsistence in the reports on carcass and meat quality properties of indigenous goats and sheep breeds. However, impressive results have been observed in crosses of indigenous goats and sheep crosses with their exotic meat breeds. Boer goat has been a prominent breed which has been utilised in crossing with indigenous goats for improving carcass and meat traits. In sheep Dorper has also been crossed with native sheep world over for meat production purpose. Bonvillani et al. (2010) studying Criollo Cordobes kids slaughtered at < 9.5 kg, > 9.5 < 11 kg and > 11 kg of empty body weight, observed that the carcasses had a medium conformation index, while the shoulder constituted 66-67% muscle, 24-27% bone and 4-6% fat. The slaughter weight was a source of variation on dressing yield, carcass measures and indices, subcutaneous fatness, meat colour, and muscle/fat ratio. The meat of female kids was inferior in terms of muscle and bone and an elevated content of fat as compared to male kids. In East African goat dressing percentage, proportions of carcass muscle, fat and bone were not influenced by concentrate supplementation (Hango et al., 2007). However, there was an increase in the amount of carcass lean and fat as compared with the control. Dressing percentage ranged from 45.9 to 51.2% and low Teminalia sericea fed kids had superior primal cuts weights (Mareko et al., 2006). Meat dry matter, organic matter, crude protein and crude fat averaged 24.00, 97.77, 71.06 and 6.90%, respectively, however this wan non-significant. Aktaş et al. (2015) working with indigenous Hair and Honamlı goat male kids reared under intensive system, observed that dressing percentage and carcass lean and fat percentages of kids increased with slaughter age, while proportion of bone diminished with each consecutive fattening period. However, there was no distinction on carcass characteristics at the time of slaughter, besides the fairly superior fat deposit rates around the kidney and pelvic areas for Hair kids. Of interest in the study was the exhibited faster growth rates for Hair goat kids within early fattening periods which might possibly express compensatory growth, as foremost liveweights were lower as compared to those of Honamlı kids at a similar age. Fitsum et al. (2019) observed that Jabal Akdhar goats attained superior slaughter, empty body, and carcass weights, in addition to enhanced growth rates against Dhofari and Batina goats. Jabal Akdhar goats outclassed other two breeds in terms of internal organs. The dressing percentage based on empty body weight of goats varied between 53 and 57%, with the Dhofari goats having the upper most value, while Dhofari goats exhibit shorter and wider carcasses than Batina and Jabal Akhdar goats. Yilmaz et al. (2009) working with purebred Hair Goat, Saanen×Hair Goat ($F_1$ and $B_1$) kids under an intensive production system to assess the effect of genotype on carcass measurements and meat quality characteristics, observed that genotype was not a source of variation on pH measurements, drip loss, water holding capacity, cooking loss and Warner Bratzler shear force values. The same scenario was witnessed on meat sensory properties, apart from tenderness. However, redness index was superior in meat specimen of indigenous Hair goat kids. Male progeny attained superior characteristics of slaughter and carcass traits as compared to purebred, when Romanov ewes were crossbred with Argali Romanov rams (Dvalishvili et al., 2015). Crossbred (Boer* CH) goats outperformed indigenous Central Highland goats in carcass traits, as well as the total edible proportion of slaughter weight and fat index, (Tesema et al., 2018). Turkyilmaz and Esenbuga (2019) crossing Turkish indigenous Morkaraman ewes with prolific Romanov rams on performance traits, growth traits, slaughter and carcass characteristics under semi-intensive production systems, purebreds Morkaraman as compared with Morkaraman*Romanov crossbred lambs had superior weight at slaughter, hot and cold carcass, tail fat, and organs (testis, heart and lung). Morkaraman lambs had larger longissimus dorsi area as compared to Morkaraman* Romanov lambs. It was proved that the Morkaraman lambs had superior growth and slaughter values and some carcass parameters with reference to Morkaraman* Romanov crossbred lambs. A comparative study on the effect of reared systems (semi-intensive vs extensive conditions), Daskiran et al. (2010) observed that kids under intensive systems outperformed kids under extensive system, in final weight (35.30 kg versus 32.81 kg), daily weight gain (153.10 g versus 132.14 g), and warm carcass yield (44.84% versus 46.55%). The assessment of body organs, carcass parts, prime cuts, and chemical composition of the chop area did not significantly vary against each group. The results showed that semi-intensive feeding systems could be exploited to enhance kid fattening performance and carcass characteristics. Elsewhere, De Sousa et al. (2012) observed that Dorper × Santa Inês lambs' crosses outperformed purebred Santa Inês lambs because of the 50% blood of a breed specialized for meat (slaughter). In addition, Dorper × Santa Inês crossbred lambs had a larger fat cover accompanied by a superior condition scores. Dorper × Santa Inês (DS) crossbred had acceptable fatty acid profile associated with healthy meat consumption against Dorper × Morada Nova (DM) crossbred lambs, although both displayed compromised intramuscular lipid level (as measured by ether extract levels from Longíssimus lumborum) as against purebred lambs (Issakowicz et al., 2018). Impressive results were highlighted for male Creole kids on carcass yield (55%), conformation score (more than 3), fat cover score (less than 3), proportion of primal cuts (63%) or muscle/bone ratio (3-4 points), which was an indicative of the potential use of Creole goats in meat production (Liméa et al., 2009). The use of mixed diets was the basis of the overall improvement of virtually all the body and carcass traits: 85% additional ADG and carcass weight. The weights of fat tissues were enhanced nevertheless reflected only 4% of empty body weight. Indigenous Hair Goat crossed with Saanen improved carcass quality properties of kids under an intensive production conditions. However, the differences in dressing percentages and other carcass measurements were insignificant (Yilmaz et al., 2010). M. longissimus dorsi area, fatness parameters, subcutaneous fat colour, carcass joint weights and percentages and dissected leg compositions of kids displayed a similar trend. Elsewhere, genotype was not a source of variation on conformation and fatness scores and majority of the carcass properties of Saanen and Bornova kids (Kosum et al., 2003). Cameron et al. (2001) reported that dressing percentage between Boer x Spanish, Spanish and Boer x Angora kids in intensive fattening was non-significant. A dressing percentage range of 46.47 to 47.55% was displayed in crosses of Hair Goat and Saanen x Hair Goat crossbred kids, this was determined on empty body weight. The result was consistent with that of Santos et al. (2007) for Capretto who reported that genotype on dressing was not a source of variation for dressing percentage, especially measured based on as part of empty body weight. The discrepancy on genotype on dressing percentages might be ascribable to variation in slaughter within studies (Ekiz et al., 2010; Kosum et al., 2003). In contrary, Dorper and Blackhead Ogaden crossbreds outperformed purebreds in dressing percentage (Tsegay et al., 2013).

Farid et al. (1991) observed significant effect on proportion of kidney and tail fat, omental and mesenteric fat and subcutaneous fat amongst Baluchi, Karakul and Mehraban sheep. A non-conformity result was cited by Canton et al. (1992) who reported no variation in fat growth and deposition in pure and crossbred Black Belly genotypes, nonetheless the indigenous hair sheep accrued more non-carcass fat in the internal organs against subcutaneous fat in wool sheep. Negussie et al. (2003) studying indigenous Menz and Horro sheep, the former seemed to deposit more fat into the carcass in comparison with the latter, which promoted more fat accretion into non-carcass fat depot or body cavities. This is expected because the ability to deposit and its distribution nature varies with genotype. The nature of fat and its deposition has been central in red meat consumption, due to its health implications. Saturated fatty acids by the side of cholesterols have been associated with the rise in cases of heart disease (Penfield, 1990). Manipulation of fatty acids in red meat through breeding and nutrition has been the major focus in goat and sheep meat production to amass knowledge their effects on human health and association with life style diseases. Small body sized indigenous goat breed (Dhofari) was associated with elevated total body fat and total non-carcass fat against the large body size breed such as indigenous Batina goats (Mahgoub and Lu, 1998). This was consistent with results of Pengbunsom et al. (2006) who observed that small body sized indigenous Thai goat had an inferior carcass weight characterised by a higher proportion of fat as compared to medium body sized goat of Thai indigenous x Anglo-Nubian. This discrepancy in breeds mature body size is ascribable to the effects of nutritional regime and physical status (Sañudo et al., 2000). This could be the basis of the increasing rate of fat deposition which may vary among the breed types (Horcada et al., 2012) and the age, even though entirely breed types mostly store fat at the visceral portion in favour of subcutaneous fat, inter-, and intra-muscular fat (Banskalieva et al., 2000; Goetsch et al., 2011). Goats fed with high concentrate diets seemed to deposit more fat on GIT, consequently the inclination for this component to be heavier with increase in the amount of concentrate supplied (Mtenga and Kitalyi, 1983). However, this was in contrary to reports by Priolo et al. (2005) that goats on high level of concentrate supplementation tend to have less developed digestive tract due to the less roughage intake against low concentrate intake. Small East African goats displayed a low fat carcass value of 6.7 %, as a result of supplementation, of which Mtenga and Kitalyi (1990) suggested that it could be increased to 14%. This is consistence with reports by Sen et al. (2004) who suggested that despite goats displaying less deposition of carcass fat and more internal fat, manipulation of concentrate supplementation, could enhance carcass fatness substantially. Burger et al. (2013) assessing carcass composition of Namaqua Afrikaner, Dorper and SA Mutton Merino ram lambs reared under extensive conditions, observed that the indigenous Namaqua Afrikaner was inferior to Dorper on meat yield, however in defiance of its small carcass in addition to a higher percentage bone as compared to than the SA Mutton Merino carcass, it outperformed SA Mutton Merino with regards to meat yield. This is an interesting result because there has been a shift in consumer preference along lean meat which makes Namaqua Afrikaner desirable for commercial meat markets. The high ratio of bone to low muscle was explained by the fact that the indigenous Namaqua Afrikaner breed was still at bone developmental stage, preceding muscle development which had not yet started when the animals were slaughtered (Berg and Butterfield, 1968; Lawrie and Ledward, 2006).

**5. Implication**

There has been a divergence of documented reports on performance indicators in indigenous goats and sheep and their crosses in terms of growth performance, carcass and meat quality properties in various production conditions. The inconsistency of performance is to be expected considering the broader genetic base of indigenous goats and sheep breeds which are utilised in non-identical production environments hence culminating in distinctive performances as influenced by numerous unspecified non-genetic factors. There is a tendency for specific agro ecological regions to use both indigenous goats and sheep breeds and assorted crossbreds characteristically from more than one indigenous breed, which might be locally available or easily accessible exotic breeds for crossing. It is also important to note that in their majority the indigenous goats and sheep breeds and possibly their crossbreds are managed under extensive systems, typified time and again with distinctive features of severe imbalance between the period of optimal productivity (reproduction and production) and the period of increased feed availability. Therefore, the combination of poor production condition as well as inherent low genetic potential for growth traits make it highly unlikely to attain high productive performance in indigenous goats and sheep flocks. However, it has been proved that it is possible to augment productive performances of indigenous goats and sheep through sound, simple and cost-effective management and crossbreeding options. On the other hand, indigenous goats and sheep breeds have a potential to contribute significantly in all performance parameters however their genetic characterisation is inevitable in order to increase their productivity. Genetic characterisation of indigenous goats and sheep through modern molecular methodologies might be the solution in facilitating optimal exploitation of this animal genetic resources group. They performance attributes are under the influence of both the genotype and environmental factors, as a result minimising the adverse effects of non-genetic factors effect is one of the strategies to improve performance parameters such as growth, carcass and meat quality. However, in the quest of crossing of indigenous goats and sheep breeds to improve their performance there is need to also consider indigenous animal genetic resources conservation and focus on improvement of flocks through within breed selection although this might be very slow process. Sporadic crossing of indigenous goats and sheep with improved types has been the major driver of indigenous goats and sheep genetic diversity losses in the tropics and subtropics. The loss or extinct of goat and sheep indigenous animal genetic resources in the tropics and subtropics will spell disaster as the production environment is adversely changing due to climate change and variability. As climate variability impinge on grazing lands due to water scarcity it seems the tropics and subtropics will be the mostly affected by climate variability due to the regions incapacitation to deal with the phenomenon. Development and promotion of indigenous goats and sheep animal genetic resources is highly likely to be a feasible option to cushion the tropics and subtropics against the detriment of climatic change effect in livestock production. It is important to give preference to enlarge in collaborative breeding programmes on indigenous goats and sheep at the national and regional levels, in terms of within breed selection for parameters such as reproduction efficiency and also carcass and meat production. This should be accompanied by refinements to make goats and sheep conventional markets and marketing systems to respond to the altered environmental and consumer preferences. By all means facilitation of the integration of indigenous goats and sheep breeds into the formal meat markets will increase their value and purpose in livestock production in general.

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**How to cite this article:** Assan, N., 2020. Indigenous goats and sheep breeds and their crosses in the tropics and subtropics: Growth traits, carcass parameters and meat quality properties. Scientific Journal of Animal Science, 9(5), 620-634.