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Evaluation of growth traits of dual purpose and Small East African goats and their crosses in Northern Tanzania

E. Hyera, G. D. Malekela, G. J. Shedrack, E. C. Philipo, J. D. Godfrey, M. G. Minja and L. J. Marwa

Tanzania Livestock Research Institute, West Kilimanjaro Centre, PO Box 147, Sanya Juu, Kilimanjaro, Tanzania.
Correspondence: *ehyera2004@yahoo.co.uk*

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Abstract
The purpose of this study was to investigate the differences in growth traits of Malya blended (BLD), Pare White (PW) and BLD–PW crossbred goats. Records of 381 goats born from 2020 to 2022 under the on-station management conditions were used. A model involving the fixed effects of breed, sex, birth type, age of the dam and year of kidding was used to determine pre weaning and post weaning growth. The results revealed that BLD goats were heavier than BLD-PW crosses at birth, 6, 16 and 24 weeks of age and had a higher pre weaning average daily gain (p<0.05); however, both BLD and crosses were superior to PW for all traits (p<0.05). On average BLD, PW and crossbreds weighed 2.77 ± 0.04 kg, 2.09 ± 0.04 kg and 2.58 ± 0.06 kg at birth; 7.27 ± 0.20 kg, 5.53 ± 0.22 kg and 6.42 ± 0.30 kg at 6 weeks; 9.84 ± 0.26 kg, 7.09 ± 0.30 kg and 9.74 ± 0.39 kg at 12 weeks; 13.26 ± 0.39 kg, 8.85 ± 0.30 kg and 10.64 ± 0.26 kg at 16 weeks; 15.00 ± 0.37 kg, 9.82 ± 0.32 kg and 12.27 ± 0.26 at 24 weeks; 17.62 ± 0.41 kg, 14.25 ± 0.38 kg and 16.82 ± 0.32 kg at 48 weeks; and 20.68 ± 0.40 kg, 17.47 ± 0.38 kg and 20.14 ± 0.31 kg at 72 weeks of age, respectively; whereas, their pre weaning and post weaning average daily gain was 95.19 ± 3.33 g/day, 60.35 ± 2.57 g/day and 70.23 ± 2.26 g/day; and 23.77 ± 0.80 g/day, 18.59 ± 1.02 g/day and 21.71 ± 0.97 g/day, respectively. The interaction of breed*sex had a noticeable influence on the growth rate (p<0.05). Single was heavier than multiple births across most traits (p<0.05), but they did not differ in weight at weaning and in pre weaning average daily gain (p>0.05). Age of the dam and year of kidding had pronounced effects on growth traits at different phases (p<0.05). The performance of BLD-PW goats was close to that of BLD. Thus, BLD can remain used to raise the growth potential of the local strains in semi-intensive and extensive farming systems.

Introduction
Domestic goats (*Capra hircus*) are an important genetic resource to the livelihoods of many societies. These animals have tremendous potential and influence in eradicating poverty because of their large contribution to food and financial security to the rural families, Siddiky, 2017 [1]; Kaumbata et al., 2020 [2]. In several regions, namely in Africa and Asia, goats are viewed as the most important source of animal protein obtained through both meat and milk to nourish very large populations with scarce income, Monteiro et al., 2017 [3]. Goats can prosper themselves in vast ecological standings, including harsh, frigid, arid and semi-arid surroundings with an exactly uniform propensity to sustain numerous economic and socio-cultural roles, URT, 2011 [4]. Being small-sized animals, goats are credibly less troublesome to manage as they require minor equipment, little work and quite low capital investment and feeding costs, and constitute minor competition for arable land. As well, goats are prolific breeders, have low metabolic requirements and quick maturity traits, Silanikove, 2000 [5]; Moela, 2014 [6]. Besides, in almost all production systems, goats complement other domestic ruminants to convert unusable parts of plants, crop residues, indigestible by-products and waste resources into high quality food products that is meat and milk for human consumption, Kosgey et al., 2008 [7]; Swanepoel et al., 2010 [8]. On the other hand, goat farming, also being popular, produces industrial raw materials (hides and skins), maintains soil fertility (manure) and generates steady additional incomes for millions of subsistence oriented marginal farmers through marketing of live animals, Swanepoel et al., 2010 [8]. In addition, goat farming brands the most important means through which women can contribute so much to the household income, Siddiky, 2017 [1].
In Tanzania mainland, goat population is estimated at about 24.5 million heads, with more than 97% of them being the local indigenous types belonging to the Small East African (SEA) breed, URT, 2015 [9]; URT, 2021 [10]. The local SEA goats are known to have superior adaptation vigour to the low input production systems due to possession of certain supportive hereditary traits including slight body size,

large surface area to weight ratio, restricted subcutaneous fat deposition, selective browsing habit, efficient digestive system and tolerance to manifold diseases and parasites, and heat stresses. Also, they can sustain themselves on the prolonged scarcity of water, Sherton, 1978 [11]; Silanikove, 2000 [5]; Kaumbata et al., 2020 [2]. The SEA goats are mostly raised for chevon production, which ranks second to beef in quantity, Chenyambuga et al., 2004 [12]. They are treasured for their great nutritional, economic and cultural value to the families in resource-poor areas, Ng'ambi et al., 2013 [13]; Assan and Sibanda, 2014 [14]. Despite the wide roles, there are great variations in performance traits among the SEA goats, which cater for selection and utilization of the greatest performing and sound adapted animals in numerous production systems to improve the performance traits, Philipsson et al., 2011 [15].

The Pare White (PW) goat is among the strains of SEA breed and it is formerly raised in the area, which is mostly inhabited by Pare ethnic society. The strain is dominant in the pastoral and agro-pastoral areas, in Northern Tanzania. It adapts well to the hot, dry semi-arid tropical surroundings and East African climate, Msemwa and Mbaga, 2018 [16]. Typically, PW has a medium to large body size, high reproductive efficiency and great tolerance to diseases. The majorities are white in coat colour; whereas, few may have several intermixes of white, red, brown and black. On the other hand, Malya (or blended, abbreviated as BLD) goat, is a three-way synthetic breed, which was developed and stabilized in late 1960s at Malya Livestock Research Centre in Lake Victoria zone in Tanzania. It has combined 85% blood of two large exotic breeds (30% Boer of South Africa and 55% Kamori of Pakistan) and 15% blood of Tanzania indigenous goat, Das et al., 1996 [17]. The BLD goat is recognized for its large body size, outstanding body conformation, higher multiple births, fast growth rate, good carcass qualities, considerable milk yield, high resistance to diseases and it adapts easily to the hot, dry semi-arid tropical climate and any breeding system, Das and Sendalo, 1990 [18]; Shirima, 2005 [19]. Most of them contain colour variations due to the combination of blood from different breeds. The breed has been kept mainly for meat production even though it was developed as a dual purpose breed valuable for both meat and milk production, Das et al., 1996 [17]. Due to its versatility on various environments, it is used for comparative purposes with indigenous and other improved breeds to determine feasibility of important genetic parameters influencing profitability in meat animals. So far, still, few performance evaluation works have been done in Tanzania to determine better performing breeds and breed combination.

The production attributes of BLD together with its growth traits were reported in several written works, Das and Sendalo, 1990 [18]; Lyatuu et al., 1992 [20]; Das et al., 1996 [17]; Hyera et al., 2018 [21]. Besides, Hyera et al. (2018), [21] reported the potential of BLD and PW for meat production in the semi-arid tropical environment. However, there is no study that has been undertaken to determine the production potential of BLD-PW blood combination. Therefore, this study was carried out to compare the variation in growth traits of BLD, PW and BLD-PW crossbred goats under on-station management at the Livestock Research Centre, West Kilimanjaro in Northern Tanzania.

Materials and Methods

Study location

The study was undertaken at the Tanzania Livestock Research Institute (TALIRI), West Kilimanjaro Centre in the Northern zone of Tanzania. The Centre lies on the foot slope of the Kilimanjaro Mountain at 3°S latitude and 39°E longitude, at an altitude of approximately 1270 meters above sea level. The farm stands for the northern part, which has typical dry semi-arid climatic condition with erratic, bimodal rainfall pattern. Annual average precipitation ranges between 450 - 700 mm, which is practically little to support complete growing of pasture forage resources. This situation requires storage of basal feeds for use in drought periods. Usually, long rainy season extends from Late-March to May and short rainy season occurs throughout November to December. Cooler dry season prolongs from June to September/October and is associated with long coldest and dry weather with periodic cloudiness, slight fog, tiny snowfall and strong winds blowing at speed up to 25 km/hr. The hot season lasts on usual from January to Mid-March. Temperature is ranging between 11.7 °C - 27.8 °C. The larger part of the farm is flat with undulating plain characterized by isolated hills. The soils are typically silt loam with dark brown colour and are often prone to drought due to poor moisture retention resulting from deprived organic matter content. The natural vegetation is typical grassland savanna with Acacia trees as main browse plants and Combratum spp., and natural perennial grassland species largely predominated by Cenchrus ciliaris (Buffel grass) and isolated patches of Cynodon dactylon.

Study animals

In total, 381 records on periodical live weights of goats of both sexes (195 males and 186 females) were used. Of the total records, 124 were BLD, 195 PW and 62 BLD-PW crosses. The dataset involved only goats born from 2020 to 2022 in the long rainy season and reared in semi-intensive breeding conditions.

Flock mating

The genetic stock was maintained through continuous breeding under uniform semi-intensive management system. Prior to mating, body physical condition of each female goat was examined and all females were dewormed and flushed with concentrates. Mating season begun from Mid-October to Mid-December by natural controlled mounting. Flock controlled mating system was adopted where males were allowed to tread along with the females in separate groups. Each breed was bred pure to determine its production potential. For production of crossbred progenies, pure BLD buck was mated with pure PW does in a separate mating group. The bucks were kept with does throughout the day and night for the period of 60 days. The ratio of one intact buck to does during mating was about 1:20-25 and all mating groups were herded cautiously to avoid interbreeding. The field attendants were assigned for mating groups to collect the required information.

Management of pregnant animals

Pregnant animals were monitored closely. During the last six weeks of gestation supplementary diet of energy-protein concentrate was increased and a complete mineral mix was provided to support fast weight gain of the developing foetuses. As well, in the advanced phase of pregnancy steaming-up supplementation with energy concentrate and mineral mix was carried out for two weeks prior to giving birth to ensure adequate nutrient supply and promote full growth of the foetus, and boost colostrum and milk production during lactation.

Management of neonatal kids

Equally, kidding begun from Mid-March to May where naturally mated does were allowed to kid while grazing and browsing on natural vegetation and pasture forages within the farm rangeland. At the birth of each kid, ear tag identification was carried out; pedigree and birth information, and birth weight were registered at 12 to 24 hours of kidding. The newborn kids were nursed freely by their dams and from the age of one month Leucaena esculenta subsp. paniculata (pallida) legume fodder was provided indoor as browse in the morning and ad libitum free browsing of greenish luscious pasture forages were allowed in the afternoon. Water and mineral salts were provided on a daily basis for ad libitum consumption. All animals were housed in standard roofed wooden houses with raised floors (Plate 1). Subsequently, performance records were registered during the 6^{th}, 12^{th}, 16^{th} (weaning), 24^{th}, 48^{th} (yearling) and 72^{nd} weeks of age. At the weaning of kids, they were completely isolated from their mothers when the average age was almost 112 days. The post weaning growth period was from 112 to 504 days.

Plate 1. Kids of (A) BLD, (B) PW and (C) BLD-PW crosses nurtured in loose houses with raised wooden floor

Data collection and statistical analysis

Performance attributed investigated were growth traits of the dual purpose, indigenous and crossbred goats. Pedigree information (kid, dam and sire IDs), birth information (birth dates, breed, sex and birth type i.e., single, twin or triplet) and weights (birth, pre weaning, weaning and post weaning weights) were recorded. A Salter 25 Kg capacity x 100 g accuracy mechanical weighing scale, model 235 6S (Salter England) and a hanging fabric sling were used for assessing weight of each goat kid at birth and during subsequent stages of growth. For this study, the type of birth was categorized as single and multiple births because the sample size for twin and triplet kids was limited. Likewise, the age of the dam was categorized as < 3 years, 3 – 5 years, 6 – 8 years and ≥ 9 years. Pre weaning average daily gain of kids was calculated as weaning weight minus birth weight, divided by the weaning age i.e., 112 days. Post weaning average daily gain was calculated as the difference between weight at 72 weeks of age and weaning weight, divided by the post weaning age i.e., 392 days.

The General Linear Model procedure (PROC GLM) was used to perform analysis of variance and the differences between means was tested using Least Squares Means (LSMeans). The data on growth traits were fitted for statistical analysis using the following fixed model: Yijklm = μ + Bi + BXj + Tk + A1 + Ym + eijklm; where Yijklm = observed value for the trait measured, μ= overall least squares mean for the trait, Bi = effect of the ith breed type of the goat (i: 1 = BLD, 2 = PW, 3 = BLD-PW cross), BXj = effect of the jth interaction of breed*sex of the goat (j: 1 = BLD*Male, 2 = BLD*Female, 3 = PW*Male, 4 = PW*Female, 5 = BLD-PW*Male, 6 = BLD-PW*Female), Tk = effect of the kth type of birth (k: 1 = single, 2 = multiple), A1 = effect of the lth age of the dam (l: 1 = < 3 years, 2 = 3 – 5 years, 3 = 6 – 8 years, 4 = ≥ 9 years), Ym = effect of the mth year of kidding (m: 1 = 2020, 2 = 2021, 3 = 2022) and eijklm = random error associated with the ijklmth observations.

Results and discussion

The overall least-squares mean with standard error for the effect of breed on weight and average daily gain of BLD, PW and their crosses from birth to 72 weeks of age is presented in Table 1. BLD goats were heavier than BLD-PW crosses at birth, 6, 16 and 24 weeks of age and had a higher pre weaning average daily gain (p<0.05), and both of them were superior to PW for all growth traits (p<0.05). This effect occurred without apparent alteration in nutritional and herd health management practices. The growth rate of crossbreds lied in the middle of those of the BLD and PW, and in certain stages (at 12. 48 and 72 weeks) it was almost equal to that of BLD, as the difference was not significant. The birth and weaning weight of BLD observed in this study was higher than values reported by Lyatuu et al. (1992), [20] at Kongwa Pasture Research Centre in central Tanzania and Das et al. (1996), [17] at Malya Livestock Research Centre in Lake Victoria zone in

Tanzania. However, the weight at 72 weeks observed in this study was much lower than values reported at Kongwa and Malya. The supremacy of growth in BLD is because it was developed by the mating of Boer and Kamori goats, which are large breeds. The current results for weight at birth and 12 weeks (3 months) observed for BLD-PW crosses showed similarity with values reported by Tesema et al. (2021), [22] for Boer-Central Highland crossbred goats in Ethiopia. However, the weight at 24 weeks (6 months) and 48 weeks (12 months) for crosses in this study was lower than values reported for Boer-Central Highland crosses. Normally, the growth of an animal is influenced by a multiplex range of factors that can be concentrated into three highest categories, which include genetic potential, nutrition and environment. The endocrine (hormonal) system is the common factor linking and communicating these factors, Pell et al., 1994 [23]. Thus, the variability of growth traits across studies can be explained from genetic variations among parental strains, ecological conditions and variations of flock nutritional and health management.

Table 1. Effect of dual purpose and SEA goat breeds, and their crosses on growth traits

Traits	**Breed**			***p*-value**
	BLD n = 124	**PW** n = 195	**BLD-PW** n = 62	
Birth weight (kg)	2.77 ± 0.04^{a}	2.09 ± 0.04^{c}	2.58 ± 0.06^{b}	0.0067
Weight at 6 weeks (kg)	7.27 ± 0.20^{a}	5.53 ± 0.22^{c}	6.42 ± 0.30^{b}	0.0119
Weight at 12 weeks (kg)	9.84 ± 0.26^{a}	7.09 ± 0.30^{b}	9.74 ± 0.39^{a}	0.05
Weight at 16 weeks (weaning) (kg)	13.26 ± 0.39^{a}	8.85 ± 0.30^{c}	10.64 ± 0.26^{b}	<.0001
Weight at 24 weeks (six months) (kg)	15.00 ± 0.37^{a}	9.82 ± 0.32^{c}	12.27 ± 0.26^{b}	<.0001
Weight at 48 weeks (yearling) (kg)	17.62 ± 0.41^{a}	14.25 ± 0.38^{b}	16.82 ± 0.32^{a}	0.05
Weight at 72 weeks (kg)	20.68 ± 0.40^{a}	17.47 ± 0.38^{b}	20.14 ± 0.31^{a}	0.05
Pre weaning average daily gain (g/day)	95.19 ± 3.33^{a}	60.35 ± 2.57^{c}	70.23 ± 2.26^{b}	0.0016
Post weaning average daily gain (g/day)	23.77 ± 0.80^{a}	18.59 ± 1.02^{b}	21.71 ± 0.97^{a}	0.05

$^{a–c}$LSMeans (± se) within a row and trait not sharing a common superscript differ at p<0.05, se = Standard error, n = number of observations

The results also show that the interaction of breed*sex had a pronounced influence on growth traits as presented in Table 2. In each breed type numerical superiority was apparent in males for all growth traits when compared with females. The effect of breed*sex interaction was largely observable in PW breed kind where buckling exhibited higher weight than the doeling at 6, 12, 16, 24, 48 and 72 weeks of age, and in pre weaning average daily gain ($p<0.05$). The overall results imitate the Rensch's rule where the males of a breed of a particular class (e.g. most mammals) are generally heavier than the females in a population or species that display sexual dimorphism in body size, Rensch, 1950 [24]. In the previous work, Mustefa et al. (2019), [25] reported higher weight in males at birth, six months and yearling when compared with females. Also, their findings indicate no difference in pre weaning average daily gain between sexes while males had more average daily gain at the post weaning period. On the other hand, Girma et al. (2016), [26] reported the supremacy of males over females for the weight at birth and yearling. In addition, Tesema et al. (2021), [22] reported greater weight in males than their female counterparts at all ages except for the weight at six months and average daily gain. Typically, males grow faster than respective females due to inherent genetic potential. In relation to genetic potential, the sexual size dimorphism may be attributed to dissimilarities in sex chromosomes in the location of genes related to growth, physiological and endocrine variations such as the type and level of hormone secretion, Hyera et al., 2018 [21]. In relation to endocrine system function between two sexes, estrogen hormone has partial influence on the growth of long bones in females, Rashidi et al., 2008 [27]; Hyera et al., 2018 [21]. Besides, despite testosterone is not a growth hormone, it has anabolic effects as it stimulates linear growth, muscle mass and bone development thus promoting fast growth rate in males, Fasae et al., 2012 [28]; Mustefa et al., 2019 [25]. In most mammals including goats, and for small ruminants, in general, males are larger than females and thus often considered dominant over females.

Table 2. Effect of breed*sex interaction on growth traits in dual purpose and SEA goats, and their crosses

Traits	**Breed*Sex**						***p*-value**
	BLD*M n = 66	**BLD*F** n = 58	**PW*M** n = 95	**PW*F** n = 100	**BLD-PW*M** n = 34	**BLD-PW*F** n = 28	
Birth weight (kg)	2.93 ± 0.05[a]	2.60 ± 0.06[b]	2.14 ± 0.06[c]	2.04 ± 0.05[c]	2.58 ± 0.09[a]	2.55 ± 0.08[a]	0.01
Weight at 6 weeks (kg)	7.33 ± 0.25[a]	7.28 ± 0.28[a]	6.00 ± 0.27[c]	5.07 ± 0.26[d]	6.64 ± 0.36[ac]	6.08 ± 0.43[bc]	0.05
Weight at 12 weeks (kg)	10.11 ± 0.33[a]	9.59 ± 0.37[a]	7.54 ± 0.38[b]	6.63 ± 0.34[c]	10.05 ± 0.49[a]	9.17 ± 0.60[a]	0.05
Weight at 16 weeks (weaning) (kg)	13.19 ± 0.46[a]	13.15 ± 0.62[a]	9.32 ± 0.38[c]	8.36 ± 0.35[d]	10.76 ± 0.35[b]	10.53 ± 0.36[b]	0.05
Weight at 24 weeks (six months) (kg)	15.43 ± 0.60[a]	14.57 ± 0.44[a]	10.25 ± 0.37[c]	9.36 ± 0.40[d]	12.60 ± 0.36[b]	11.93 ± 0.35[b]	0.05
Weight at 48 weeks (yearling) (kg)	18.24 ± 0.64[a]	17.09 ± 0.48[ab]	14.78 ± 0.44[c]	13.67 ± 0.51[d]	17.02 ± 0.44[ab]	16.61 ± 0.43[b]	0.05
Weight at 72 weeks (kg)	21.23 ± 0.62[a]	20.19 ± 0.46[a]	18.11 ± 0.46[b]	16.70 ± 0.50[c]	20.25 ± 0.42[a]	19.99 ± 0.42[a]	0.05
Pre weaning average daily gain (g/day)	95.23 ± 3.97[a]	93.79 ± 3.97[a]	64.07 ± 3.21[c]	56.50 ± 2.99[d]	70.77 ± 3.05[bc]	69.80 ± 3.02[bc]	0.05
Post weaning average daily gain (g/day)	24.60 ± 1.06[a]	22.85 ± 1.10[ab]	22.35 ± 1.10[ab]	21.26 ± 1.28[b]	20.79 ± 1.58[bc]	17.31 ± 1.18[c]	0.05

[a–c]LSMeans (± se) within a row and trait not sharing a common superscript differ at p<0.05, se = Standard error, M = Male, F = Female, n = number of observations

In this study, single kids were heavier than multiple ones at birth, 6, 12, 24, 48 and 72 weeks of age, and at post weaning average daily gain (p<0.05), but they did not differ in weight at weaning and in pre weaning average daily gain (p>0.05) as presented in Table 3. In the previous study by Mustefa et al. (2019), [25] single weighed more than multiple births for all growth traits except for post weaning average daily gain. Also, according to the results of Deribe and Taye, (2013a), [29] and Tesema et al. (2021), [22] single had a higher growth performance compared to multiple births across all traits except for the average daily gain from the age of 3 months and above. Further, the supremacy of single births in growth performance was reported somewhere else, Kebede et al., 2012 [30]; Belay et al., 2014 [31]; Deribe et al., 2015 [32]. The superiority of single over multiple births in growth performance might be influenced by the pre-natal maternal effect such as finite capacity of the inter-uterine space and inferior availability of intra-uterine nutrients during pregnancy for multiple foetuses. Does with multiple foetuses had certainly the relative decrease of caruncles in utero attached to each fetus, which might cause the diminished nutrition supply via blood vessels resulting to physiological starvation and reduction in the birth weight of the multiples, Gardner et al., 2007 [33]; Zahraddeen et al., 2008 [34]; Hyera et al., 2018 [21]. Likewise, competition for milk sucking between multiple-born kids during the post-natal period could be another reason for their lighter weight. Single-born kids are sole users of the entire milk from their dam, Deribe and Taye, 2013a [29]; Hyera et al., 2018 [21]. Typically, birth weight has a substantial influence on the post-natal growth performance, Tesema et al., 2021 [22].

Table 3. Effect of birth type on growth traits in dual purpose and SEA goats, and their crosses

Traits	Birth type		*p*-value
	Single n = 301	**Multiple** n = 80	
Birth weight (kg)	2.65 ± 0.03^{a}	2.32 ± 0.05^{b}	<.0001
Weight at 6 weeks (kg)	6.72 ± 0.15^{a}	6.09 ± 0.26^{b}	0.0263
Weight at 12 weeks (kg)	9.37 ± 0.21^{a}	8.40 ± 0.35^{b}	0.0112
Weight at 16 weeks (weaning) (kg)	11.13 ± 0.20^{a}	10.71 ± 0.37^{a}	0.2951
Weight at 24 weeks (six months) (kg)	12.85 ± 0.19^{a}	11.88 ± 0.40^{b}	0.0260
Weight at 48 weeks (yearling) (kg)	17.41 ± 0.22^{a}	15.05 ± 0.47^{b}	<.0001
Weight at 72 weeks (kg)	20.46 ± 0.22^{a}	18.40 ± 0.45^{b}	<.0001
Pre weaning average daily gain (g/day)	75.35 ± 1.70^{a}	75.16 ± 3.17^{a}	0.9546
Post weaning average daily gain (g/day)	23.91 ± 0.56^{a}	18.80 ± 1.17^{b}	<.0001

$^{a–c}$LSMeans (± se) within a row and trait not sharing a common superscript differ at p<0.05, se = Standard error, n = number of observations

The age of the dam had a pronounced influence on growth traits at different phases (Table 4). The results showed that does aged below 3 years old had kids with lighter weight at birth and weaning compared to does aged 3 years old and above (p<0.05), except for pre weaning average daily gain, which was similar for kids from all does aged below 9 years (p>0.05), although numerical inferiority was observed for does aged below 3 years. Also, does aged above 9 years old had heavier grown kids at 24 weeks of age compared to all does aged below 9 years (p<0.05), but had kids that did not differ in weight at birth, at 6, 12, 16, 48 weeks and average daily gain compared to does aged 6 to 8 years (p>0.05), although numerical superiority was observed for does aged above 9 years. Further, does aged 3 to 5 years had heavier grown kids at 24 weeks of age compared to does aged 6 to 8 years (p<0.05), but the difference was not evident in weight at birth, 6, 12, 16, 24, 48 and 72 weeks of age and in pre weaning and post weaning average daily gain (p>0.05). Other scholars such as Liu et al. (2005), [35]; Deribe and Taye (2013a), [29]; Deribe and Taye (2013b), [36] observed lighter birth and weaning weight, and pre weaning average daily gain in kids from lower parities than those from higher parities, which is somewhat similar to the results of this study. However, Mustefa et al. (2019), [25] reported no differences across the parities for the traits studied at different growth phases.

The lighter weight at birth and weaning observed for kids of does aged less than 3 years old in this study can be explained by the reason that primiparous does have not reached their mature weight and have poor mothering ability. During pregnancy, the partitioning of nutrients is required to complement their growth and growth of their foetuses, which increases the metabolic strain thus affecting the weight of kids at birth, Browning et al., 2011 [37]; Hyera et al., 2018 [21]. The does become weightier as they progress and attain their breed-dependent mature weight, mainly under a rising plane of nutrition. Also, poor mothering ability of the maiden does such as meager nursing ability and inferior capacity of milking in the first parity contributes to lower weight of kids at weaning, Deribe and Taye, 2013a [29]. Dam weight and age, and management system all have significant effect on the reproductive performance of goats, Snyman, 2010 [38].

Table 4. Effect of age of the dam on growth traits in dual purpose and SEA goats, and their crosses

Traits	Age of the dam				*p*-value
	< 3 years n = 81	**3 – 5 years** n = 137	**6 – 8 years** n = 65	**≥ 9 years** n = 98	
Birth weight (kg)	2.30 ± 0.06^{b}	2.54 ± 0.04^{a}	2.54 ± 0.08^{a}	2.55 ± 0.05^{a}	0.05
Weight at 6 weeks (kg)	5.87 ± 0.31^{b}	6.33 ± 0.18^{b}	6.42 ± 0.36^{ab}	6.99 ± 0.23^{a}	0.05
Weight at 12 weeks (kg)	8.74 ± 0.41^{a}	9.18 ± 0.24^{a}	8.57 ± 0.49^{a}	9.07 ± 0.31^{a}	0.05
Weight at 16 weeks (weaning) (kg)	9.99 ± 0.40^{c}	10.99 ± 0.24^{b}	10.84 ± 0.50^{abc}	11.85 ± 0.32^{a}	0.05
Weight at 24 weeks (six months) (kg)	11.90 ± 0.43^{bc}	12.60 ± 0.25^{b}	11.50 ± 0.48^{c}	13.45 ± 0.31^{a}	0.05

Weight at 48 weeks (yearling) (kg)	15.85 ± 0.48^{a}	16.15 ± 0.29^{a}	16.17 ± 0.61^{a}	16.74 ± 0.36^{a}	0.05
Weight at 72 weeks (kg)	19.34 ± 0.47^{ab}	19.49 ± 0.29^{b}	18.53 ± 0.59^{b}	20.36 ± 0.35^{a}	0.05
Pre weaning average daily gain (g/day)	69.47 ± 3.40^{b}	75.14 ± 2.09^{b}	74.32 ± 4.27^{ab}	83.09 ± 2.70^{a}	0.05
Post weaning average daily gain (g/day)	22.05 ± 1.21^{a}	22.53 ± 0.74^{a}	20.23 ± 1.52^{a}	20.61 ± 0.90^{a}	0.05

$^{a–c}$LSMeans (± se) within a row and trait not sharing a common superscript differ at p<0.05, se = Standard error, n = number of observations

The effect of year of kidding had a noticeable influence on the studied growth traits (Table 5). Kids born in 2021 had a higher birth weight than those born in the other years (p<0.05). Also, kids born in 2020 and 2022 had higher weight at 48 and 72 weeks of age compared to those born in 2021 (p<0.05). Moreover, kids born in 2022 had a higher pre weaning average daily gain than those born in the other years (p<0.05). The effect of year of kidding was also reported in literature, Deribe et al., 2015 [32]; Mustefa et al., 2019 [25]; Tesema et al., 2021 [22]. The observed variations between years might be partly attributed to climatic variations, management problems primarily due to insufficient resources to deal with several husbandry practices like supplementary feeding and variations in sample size, Hyera et al., 2018 [21]; Nugroho et al., 2018 [39].

Table 5. Effect of year of kidding on growth traits in dual purpose and SEA goats, and their crosses

Traits	**Year of kidding**			***p*-value**
	2020 n = 142	**2021** n = 123	**2022** n = 116	
Birth weight (kg)	2.36 ± 0.05^{b}	2.65 ± 0.05^{a}	2.44 ± 0.05^{b}	0.05
Weight at 6 weeks (kg)	6.26 ± 0.23^{b}	5.51 ± 0.22^{c}	7.45 ± 0.23^{a}	0.05
Weight at 12 weeks (kg)	8.21 ± 0.31^{b}	9.36 ± 0.31^{a}	9.10 ± 0.30^{a}	0.05
Weight at 16 weeks (weaning) (kg)	10.43 ± 0.31^{b}	10.82 ± 0.31^{ab}	11.50 ± 0.30^{a}	0.05
Weight at 24 weeks (six months) (kg)	11.58 ± 0.31^{b}	12.01 ± 0.32^{b}	13.51 ± 0.30^{a}	0.05
Weight at 48 weeks (yearling) (kg)	16.59 ± 0.36^{a}	15.61 ± 0.37^{b}	16.49 ± 0.37^{a}	0.05
Weight at 72 weeks (kg)	19.95 ± 0.35^{a}	18.93 ± 0.36^{b}	19.40 ± 0.37^{a}	0.05
Pre weaning average daily gain (g/day)	69.47 ± 3.40^{b}	74.32 ± 4.27^{b}	83.09 ± 2.70^{a}	0.05
Post weaning average daily gain (g/day)	23.36 ± 0.90^{a}	21.17 ± 0.93^{ab}	19.54 ± 0.94^{b}	0.05

$^{a–c}$LSMeans (± se) within a row and trait not sharing a common superscript differ at p<0.05, se = Standard error, n = number of observations

Conclusion

Comparison indicated that BLD and BLD-PW were superior to PW in all growth traits. The performance of BLD-PW goats was close to that of BLD. The growth potential of BLD as a large sized composite breed has contributed to the supremacy of BLD-PW. Thus, BLD can remain used to upgrade the genetic potential of the local strains for improved impact on productivity in semi-intensive and extensive farming systems. The potential of PW can be taped for the complementarity of economically important meat goat traits and adaptability. These results are valuable for improved understanding of factors that should be considered while developing goat breeding programs.

Conflicts of interest

The authors declare that no conflicts of interest exist concerning the work presented in this manuscript.

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