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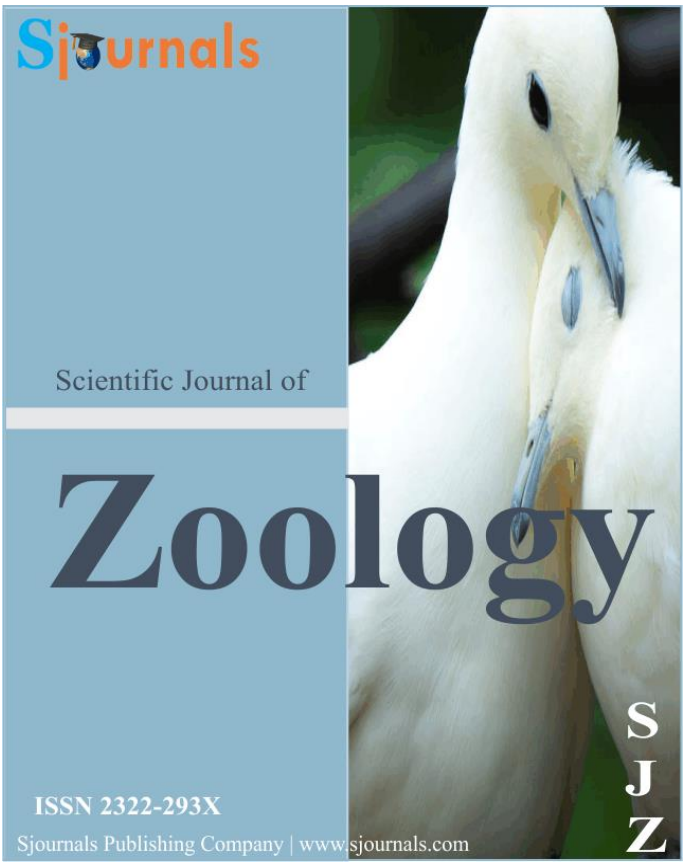

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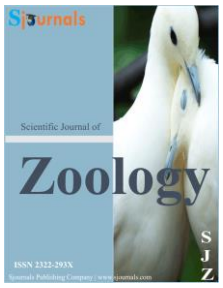
Scientific Journal of Zoology (2020) 9(1) 106-122
ISSN 2322-293X
doi: 10.14196/sjz.v9i1.539



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Scientific Journal of **Zoology**
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Review article

Effect of genetic and non-genetic factors on growth traits in goats and sheep production

Never Assan*
Department of Agriculture Management, Faculty of Science and Technology, Zimbabwe Open University, Zimbabwe

*Corresponding author: neverassan@gmail.com

ARTICLE INFO

Article history,
Received 12 December 2019
Accepted 13 January 2020
Available online 20 January 2020
iThenticate screening 14 December 2019
English editing 12 January 2020
Quality control 19 January 2020

Keywords,
Genotype
Non-genetic factors
Growth traits
Goat
Sheep

ABSTRACT

Birth weight, weaning weight and efficiency of pre and post weaning gains are growth traits of economic importance with regards to the cost and efficiency of meat production in goats and sheep. It is important to note that growth traits are not only influenced by environmental factors, but also genetic potential of individual kid/lamb. Nutrition is ranked highly among the environmental factors affecting growth traits, however, climate and seasonal differences among different years affect the production of the whole flock, while sex, type of birth, age and weight affect the individual growth performance. Birth size/weight represents the greatest initial barrier on weaning and pre-weaning growth among the non-genetic factors in both goats and sheep. Therefore, understanding of the extent of influence of both genetics and environmental factors becomes very important for devising efficient and effective management plans in goats and sheep. Kids/lambs born out of multiple birth might be at a disadvantage against singletons in terms of pre-weaning growth, individual weaning weight as they progress into post weaning growth. Differences in kid/lamb weaning and post weaning performance between years is an indicative of environmental variations (variation of quantity and quality of herbage available), which cannot be manipulated. One outstanding, and often reported feature of weaning weight is the tendency for it to be sex biased, where male kids and lambs are superior weaning weight as

compared with female kids/lambs. In order to increase pre- and post-weaning growth performance as well as weaning weights in goats and sheep production, efforts must be directed at improving nutritional status, breeding and management of animals. The sort management strategy should take cognisance of the various factors that influence growth traits from birth through weaning and then post weaning growth which is predictive of weight at slaughter. The significant effect on pre-weaning and post-weaning growth found to be year of weaning, nutrition/age of dam, and sex of the kids/lamb have practical implications not only for the husbandry of the goats and sheep as an economical commodity, but also for the increased knowledge of factors that are determinants of variation in weaning performance and growth traits in goats and sheep. The present review gives an insight on some determinants of weaning weight, pre and post weaning growth in goats and sheep.

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1. Introduction

Growth in meat animals is designated as an increase in tissue mass (Lachica and Aguilera, 2005) and growth rates at all stages accompanied with sound reproductive capacity are key determinants in efficient meat production. Growth rate can be in-effect separated into two phases: pre-weaning and post-weaning average daily gain. Pre-weaning and post-weaning growth, as well as the actual weaning weight are collectively very important stages in goat and sheep meat production influencing economic returns from commercial sheep flocks (Mousa et al., 2013; Shiotsuki et al., 2014). Generally, kid/lamb growth from birth to weaning, and during the period immediately prior weaning, influences post-weaning growth and may act as a determinant of mature size or slaughter weight. The pre-weaning performance acts as a radical stimulus on which the success of post weaning growth is depended on (Adenaike and Bemji, 2011). A high pre-weaning average daily gain attests the genetic potential of the growing animal and the mothering ability of the doe (Luginbuhl, 1998). However, not merely genetic potentiality will be the major driver of birth weight and early growth traits, besides that maternal and environmental factors cannot be ignored (Mandal et al., 2006). The level of feeding provided during lactation had major implications for lamb growth to weaning and weaning weight (Thompson et al., 2011). Snowder and Glimp (1991) observed a positive correlation between ewe milk production and lamb growth from birth to 56 days. The implications for accelerated growth in the course of early life can lessen the cost of rearing and to such a degree that provide more profit to the producer (Niekerk and Casey, 1988). One of the principal effect on birth and weaning weight as well as pre-weaning weight gain of Dorper lambs was litter size (Mellado et al., 2016), while age of dam was an important source of variation on the pre-weaning traits Iranian fat-tailed Mehraban breed of sheep (Bathaei and Leroy, 1994). Lamb weight before weaning is greatly dependent on the dams' milk rather than the genetics (Kashani and Bahari, 2017). In a similar study, Khanal et al. (2019) observed that doe breed, doe age, litter size and kid sex was a source of variation for weaning weight and average daily gain. The implication for severe restriction of growth before weaning compromised the optimal growth of muscle and bone (Greenwood et al., 1998, 2000; Tygesen et al., 2007), however the terminal mature size may or may not be curtailed (Schinckel and Short, 1961; Everitt, 1967; Krausgrill et al., 1997; Kelly et al., 2006). The present review gives an insight on determinants of growth from birth to weaning and aftereffects on pre and post weaning growth traits in goats and sheep.

2. Determinants of growth traits in goats and sheep production

The growth of lambs is determined by a considerable number of different factors whereas nutrition, health condition and genotype are the highly ranked factors (Kuchtík and Dobe, 2006). Alternative determinants that can

influence the growth ability of lambs to a greater or lesser extent are for example sex, litter size, month or season of lambing, age of dam and year of lamb birth. A number of studies has demonstrated the effect of seasons in sheep production (Hansen and Shrestha, 2002; Fisher, 2004; Rosa and Bryant, 2003). Dixit et al. (2001) cited that that year, season, sex, birth type and dam's age were important source of variation in growth in first year of age of lambs. Elsewhere, Staikova and Stancheva (2009) showed that the year of birth was a major determinant on live weight at all ages. Kuthu et al. (2013) observed a significant effect of year, season, sex, flock and type of birth on weaning weight, while effect of age of dam was non-significant. Consequently, the improvement of the goat and sheep meat production during the early age has an important economic impact on the income of the ambulant herds (Gaddour et al., 2007). The results were partly confirmed in a number of studies (Adenaike and Bemji, 2011; Thiruvenkadan et al., 2009; Wenzhong et al., 2005). The kidding year, birth type and sex had effect on body weights of Tunisian local kids at all ages (Mabrouk et al., 2010) and similar results were documented by Gebrelul et al. (1994) and Gbangboche et al. (2006). Djemali et al. (1994) proved that sex, birth type, age of dam, kidding year and ram effects are important sources of variation for growth traits from birth to 3 months of age. In a similar study, Ali and Khan (2008) observed reported that season of birth had a non-significant effect on weaning weight, however effect of year of birth, sex, type of birth was significant ($P<0.01$) in Beetal goat breed in Pakistan. Hyder et al. (2001) working with Teddy goat kids, observed that effect of year and season of birth and sex were significant but the effect of type of birth was non-significant. According to Thiruvenkadan et al. (2009) and Adenaike and Bemji (2011) year, season, birth type, sex and age of dam were major sources of variation on weaning weight. The variation in weaning weight during different years was a result of differences in feeding and management practices. The influence of year on the trait is impacted on by change in weather during different years, for example good seasons are associated with abundant rains and fodder, while dry season there is less grazing and of poor quality. The abundance of rains would have naturally boosted the fodder production with lowering of temperatures to minimize the heat stress on new born kids. The indirect maternal instinct is also a major source of variation in weaning weight, while this also indicative of the essential growth potential of the kid. The size of birth effect manifest itself where larger birth weight gained more body weight during pre-weaning period, meanwhile underweight at birth were result in compromised weight at weaning. Shafiq and Sharif (1996), reported a significant effect of season of birth on weaning weight in Teddy goat kids in Pakistan. According to Kuthu et al. (2013) age of dam had a non-significant effect on weaning weight. This result was also confirmed in other studies by Al-Shorepy et al. (2002) in Emirati, Bharathidhasan et al. (2009) in Barbari and Hyder et al. (2001) in Teddy goats. Male kids born as singles were superior at weaning against others birth types, meanwhile quadruplets born females and triplets were underweight at weaning, which is expected as triplets and quadruplets are at a disadvantage at suckling due to littermates' competition consequently getting lesser portions of milk, necessary for growth. The effects of various environmental factors have been documented in a number of studies, Rashidi et al. (2008) and Thiruvenkadan et al. (2009), who reported a significant effect of year, type of birth and sex on weight at six months in Markhoz and Tellicherry goat breeds, respectively. The aforementioned reports points to the fact that progeny born heavier depicts more weight gain at weaning and consistently experience faster growth and gaining more weight against underweight progeny at birth and weaning. Weaning weight appears to greatly respond to the influence of environment as against other weight traits, which point to the fact that appropriate management might achieve best result.

3. Genotype and growth performance in goats and sheep production

In a number of studies in sheep working with various ewe breeds, distinctive performance was exhibited among straight bred and crossbred ewes for weaning litter traits (Boujenane and Kansari, 2002; Boujenane et al., 2003). Straight bred cohorts' ewe breeds varied, crossbred ewes commonly outclassed the substandard base breed, and crossbred ewes may or may not have remained unchanged from the superior base breed. According to Teklebrhan (2018) breed was a major determinant on weight from birth to six months, consequently, ½Boer x ½Short Eared Somali kids had superior birth, weaning and six months' weights with reference to ½Boer ½ Hararghe Highland crossbred kids. Growth performance of Spanish, Boer Angora and Boer ×Spanish crossbred kids during the pre-weaning stage Boer crosses were heavier than Spanish kids at 2, 6 and 8 weeks of age, nevertheless no variation in body weight were observed between Boer crosses (Luo et al., 2000). Boer crosses gained body weight more rapidly during the period from 3-8 weeks, this was with reference to Spanish kids, which gained 60, 71 and 77 g/day for Spanish, S, Boer x Angora and Boer × Spanish, respectively), despite the fact that weight gain of

Spanish kids was superior as compared with that of Boer crosses (60, 50 and 54 g/day for S, BA and BS, respectively). These observations in this study was interpreted as crossbreeding with Boer goats could enhance growth of young kids and, for this reason, as a matter of principle increase economic returns for goat producers. Alfonso et al. (2019) observed that Katahdin lambs had superior birth weights, but comparable on pre-weaning growth and live weight at weaning with reference to Pelibuey lambs. Pelibuey and Katahdin ewes had corresponding pre-weaning overall performances for litter weaning weight and ewe weaning efficiency as a result of the synergy of ewe milk production and body weight, litter size and lamb growth. Khanal et al. (2019) observed that doe breed, doe age, litter size and kid sex was a source of variation for weaning weight and average daily gain. Kid growth was greatly influenced by initial birth weight subsequently maternal nutrition, breed and sex (Bajhau and Kennedy, 1990). Birth weight had exclusive of twice the effect of milk intake and beyond 10 times the effect of breed on kid growth. Breed effect on growth was not important when kids were contrasted at the same birth weight. Khanal et al. (2019) working with meat goat does of various genotypes (Boer, Kiko, Spanish, Boer × Kiko reciprocal F_1 crosses, and Boer × Spanish reciprocal F_1 crosses) observed that Boer does weaned small sized litter per doe exposed in opposition to with Kiko, Spanish, Boer × Kiko, and Boer × Spanish does with the latter four doe breed types diverge from each other. Boer × Spanish and Spanish were comparable in weaning rate. However, liveweights of Boer × Spanish and Boer × Kiko crosses did not vary from the weights of their corresponding Kiko and Spanish with regards to weaning. The impression given in the study study is that dam genotype is an important component that impart growth potential in kids. While larger breeds grow faster and attain marketable weight earlier, they may not always be suited to the relatively harsh environmental conditions of the rangelands. Genotype was an important source of variation on birth weight and live weight as well as at any point of pre-weaning phases (Momani et al., 2012). This result was in conformity with Mike et al. (2008) for growth traits in Nigeria Sahelian Goats. Boer-Kiko combination attained a superior higher level of heterotic effect for weaning weight way more than the Boer-Spanish combination (Browning and Leite-Browning, 2011). The breed type influenced ADG from birth to 100 days, for all kids (Momani, et. al. 2012). Lower average daily gain was reported by Makun et al. (2008) who reported that the growth rate of Sahelian kids increases from firth week until 12^{th} week. These results were within the range of ADG observed by Cissé et al. (2002) which were 88 g to 100 g and 62 g to 75 g/day, respectively, in the first and the second month. By and large, offspring derived from large goats have superior growth rates as compared to those of smaller breeds (Dhanda et al., 2003). Growth rates differ from around 50 g per day and over 200g/day for the small breeds (e.g. Indian Barbari and Indonesian Kambing) and large breeds (Saanen, Alpine and Boer) (McGregor, 1985), respectively.

4. Nutrition and growth performance in goats and sheep production

Feeding is the most important environmental factor influencing growth both before and after birth. Globally, the need to enhance ruminant production by improving carcass quality and milk production has intensified efforts of ruminant researchers towards formulating improved ruminant feeds. A number of studies have observed that lamb growth to weaning is dependent on milk intake (Doney and Peart, 1976; Snowder and Glimp, 1991), especial elevating the dietary energy intake of ewes during lactation will enhance ewe milk production accompanied by lamb growth (Langlands, 1977; Jordan and Mayer, 1989). Nutritional deficiency especially in energy is the most predominantly nutritional burden on a growing kid/lambs and has the profound repercussions for growth rate. Generally, the influence is more intense and protracted the earlier the deficiency occurs (Widdowson and Lister, 1991). In such circumstances, McGregor (2005) observed that goats can lose live weight at rates of up to 1kg per week, as a result of poor nutrition. Changes in nutritional in grazing goats had an influence on doe weight, milk yield, kid birth weight, and growth of kids up to weaning (Bajhau and Kennedy, 1990).

It was suggested that in most cases the nutritional demands of lactation may not be adequately supplied upon pasture alone, as a result the body starts to mobilise maternal fat reserves (Gibb and Treacher, 1980; Vernon and Finley, 1985) in order to subscribe nutrients to lactation process. In this scenario ewes that have adequate fat to mobilise will enhance their milk production and their influence on lamb growth to weaning very large (Brand and Franck, 2000; Lambe et al., 2005). In a similar study McNeill et al. (1997) suggested that at lambing ewes with high body condition score as result of appropriate nutrition during pregnancy have adequate fat to mobilise. In this case it is highly likely for such ewes to produce sufficient milk to adequately nurse lambs translating to superior weaning weights, especially where grazing intake is coinciding with lactation is insufficient. Oderinwale et al. (2017) demonstrated that supplemental feeding during pregnancy improved performance by improving birth

weights. For early and late gestations, the recommended CP in goats is 9 to10% and 13 to 14%, respectively (NRC, 2007). Growth rate reacted positively to enhanced proportions of dietary in young growing kids (growing from 14 to 30 kg), the protein needed was approximately 15% (on a dry matter basis) (Johnson and Rowe, 1984). In a similar study McGregor (2005b) noted that 16% crude protein was optimal protein requirement for kids, anything more than that was substantial unnecessary as it created losses of nitrogen caused by rumen degradation.

There was distinction between the effect of pasture of low and high nutritional value on live weight gain in goats and their crosses. Bajhau and Kennedy (1990) working with goats and their crosses on grazing observed a depressed live weight gain of 21 and 13% due to high and low nutritional value, respectively, in addition the low value grazing translated to low lighter kids at birth (2.9 vs. 3.2 kg), lesser milk yield by 24% and depressed daily kid growth (192 vs. 225 g) as compared to high nutritional value grazing. Supplementation with concentrates at various stages of growth promoted performance in goats (Mushi et al., 2009; Kawas et al., 2010). Malau-Aduli et al. (2004) observed supplementation with concentrate and crop residues enhanced birth weight and liveweight gains of kids, but litter size was unaffected. It was concluded that crop residues fed at the 2% level is a good and affordable supplementary feed package for increased birth weight and pre-weaning gains in kids for meat production. Sikiru and Makinde (2018) suggested that improved pre-weaning kid performance was achievable using supplement diets produced from locally available crop residue and by-products as diets for goat dam post-partum. Pre-weaning performance is a both biological and economic importance in goat and sheep production, while weight gain of goat kids/lams from birth to weaning has impact on lifetime productivity and productivity (Akpa et al., 2010; Andries, 2013). Dam supplemental feeding is a major determinant of pre-weaning growth rate in goat kids because the goat kids will have access to sufficient quantity and quality of milk produced by the dams. The concentrate diets stimulated rumen microbial environment which lead to liberation of nutrients from the forages (Dutta et al., 1999). This is evident by higher pre-weaning weight gain in kids whose dams were fed both the concentrate diet and straw. Despite provision of enough quality feed after weaning gradually, the kids pre-weaning growth is always faster as compared with post weaning (Mavrogenis, 1983). This result was in conformity with an observation by Allan and Holst (1989) where rangeland goat kids exhibited superior growth during pre-weaning period followed by post-weaning depression. Considering that milk yield in lactating goats summits through 2 to 3 weeks after kidding at which point then declines rapidly to a low volume by 8-10 weeks after kidding (Rankins and Pugh, 2012) higher growth performance of kids cannot only be sustained by milk supply from their dams. This is the appropriate point of nutritional intervention in order to promote optimal growth of kids.

Negesse et al. (2001) observed that inadequate or excessive inclusion of CP in the diet results in inefficient use of nitrogen intake in post weaning growth phase in goats. However, Soto-Navarro et al. (2003) working with yearling wether goats fed a maize based diet, found that a 9-10% CP content was enough to maximize microbial protein synthesis, while organic matter digestibility increased with CP content. The same author, in a different study, Soto-Navarro et al. (2004) reported optimal ADG of wether goats between 7 and 14 months old fed a 70% concentrate diet with 13% CP. Prieto et al. (2000) reported a desirable post-weaning average daily gain in wethers of between 4 and 12 months old fed a 70% concentrate diet with 14% CP. Animut et al. (2002) reported that dietary inclusion of broiler litter promoted post-weaning weight gain in Alpine Doeling comparable to that with urea treatment of wheat straw and soybean meal supplementation of untreated straw. Along the same line, Nadeem et al. (1993) observed an important linear depression in feed consumption of Barbari kids by increasing levels of broiler litter in the diets, which ended up compromising growth. In a study to assess supplementation of creep feed with or without alfalfa on the pre-weaning growth performance of goat kids, weaning weights of kids fed creep feed with alfalfa were heavier with reference to kids in the creep feed alone (Htoo et al., 2015). This was exhibited in the average 3.3 kg heavier than the creed and 5.7 kg heavier than the dam milk group. The supplementation of creep feed was deemed necessary to maintain and enhance the pre-weaning growth performance of goat kids. It was noted that creep feeding could enhance pre-weaning weight gain by in large for kids reared as twin or triplet and kids with intended early target slaughter weights, consequently improving gross margins (Machen, 2002).

5. Year/season as a determinants of growth performance in goats and sheep production

Goat and sheep production nowadays is faced with many factors that hinder the growth, and one of major concerns include imbalanced diet in terms of quantity and quality arising from feed (forage) scarcity and seasonality (Oderinwale et al., 2017), poor management systems and practices and unfavourable weather

conditions due to cumulative effects of climate change. Goat performance is highly influenced by non-genetic factors under pastoral harsh conditions associated with restricted and irregular feed resources, where animals are dependent on extensive grazing management (Mahjoub et al., 2005). Accordingly, semi-arid zones are substantially characterised by their feed shortages, climatic stress and conditions of instability (Ouni et al., 2008b). A number of studies have registered the importance of year and season on weaning weight and pre-weaning daily weight gain in lambs (Hassen et al., 2004). Pasture status and unfriendly environmental due to variation in raining, humidity and temperature in specific years which influence the quality and quantity of forage and mating status of ewe's breeding and her milking capacity are the major drivers of the nature of growth traits as influenced by year. This has been confirmed in various studies working with different breeds such as Baluchi (Yazdi et al., 1998) and Afrino (Snyman et al., 1995) and Horro and Menz sheep (Tibbo, 2006).

Favourable production in terms of conditions in nutrition as well as management promote pre-weaning growth, weaning weights and post-weaning growth in goats and sheep, while prevailing suboptimal conditions might slow down growth rates of kids/lambs. There is a tendency of experiencing slow growth after weaning for a number of months up until animals attain mature size. Seasonal conditions are an important determinant of the actual growth pattern (McGregor, 2005a). Seasonal feed resources scarcity and quality fluctuation impairs growth especially during the dry season (Uppsala, 2012). Depressed growth rate from March through June/July, were observed by Eliot and Pearce (1999) and this was accompanied by an enhanced growth rate from July to August in rangeland and rangeland x Boer goats. It was noted that when feed was adequate the alteration in growth rate was inconsistent with rainfall events. On the other hand, Ash and Norton (1987) observed that depressed growth rates on animals grazing tropical pasture, conceivably been associated with a seasonal diminishing appetite. However, dietary quality did not change the extent of seasonal liveweight decline, despite diet quality having positively impacted growth rates during the period of maximum growth (between mid-winter and mid-spring). At this juncture, bucks fed the high quality diet had superior growth rates with reference to bucks fed low quality diets (Walkden-Brown et al., 1994). Differences in lamb performance between years reflect environmental variations (variation of quantity and quality of herbage available), which cannot be controlled (Mellado et al., 2016). Season of the year affected weaning weight with the lowest weights being for lambs born in winter. Thus, external environment or climate during early growth may have influenced overall pre-weaning growth rate, as it has been observed in a variety of sheep breeds (Yilmaz et al., 2007). The interactions existed between year and season of birth, between year of birth and sex, and between year of birth and age of dam at birth on weaning weight. Kuthu et al. (2013) described the effect of season on weight traits, where summer born kids were superior as compared to others, which could be associated with availability of substantial quantity of good quality green forage in spring for the pregnant does coinciding with the last trimester of pregnancy. This means good seasons will provide adequate sources of energy and protein for maximum development of the growing foetus. In addition, the general temperature regime during spring are low and do not induce much stress onto pregnant dams, hence feed intake might be promoted through grazing for long periods of time. Kids born in autumn may be underweight which was ascribable to heat stress in hot summer adversely affecting pregnant does and their growing foetuses. In certain cases, a strong interaction between year of weaning and weaning weight exists, and this has been ascribable to variation in quantity and quality of feed across seasons and years, which can be directly related to the amount of precipitation and its distribution (Mellado et al., 2016). The effect of year and season on growth may be explained partly by the climatic conditions and feed resources availability which has a direct influence on the dam's nutrition hence amount of milk available to weanlings and its effect on future animal weights. In this case heavier kids/lambs after birth due to improved supply of dams' milk have high potential for growth. Kids/lambs receiving adequate milk from the dam are less likely to perform better from birth through weaning and post-weaning. There is a tendency of abundance of feed in wet summer which improves dam nutritional status promote kid/lamb growth through lactation supply. The dams are in good body conditions and give adequate milk for the young ones. In dry seasons there is inadequate nutrition on range land which compromised the milk production potential of the mothers resulting in lower birth weights and reducing growth performance. In order to reduce the economic losses due to lamb retarded growth, implementation of improved farm practices and nutrition applicable to seasonal feed resources variation, flock structures (pregnant ewes, newly born lambs etc.) is suggested. Nutrition of the ewe at the end of gestation, during nursing of kid/lamb and number of young ones per dam are factors affecting the pre-weaning growth traits of the lambs and their potential weaning growth potential. Undernourished ewes will give birth to smaller lambs prone to poor growth, whereas the single lamb of an over nourished ewe may perform better than the latter. Suggestions are that the detrimental effects of suboptimal

maternal nutrition during lactation on milking capacity and the indirect kids'/lambs poor weaning weights can be easily corrected through appropriate nutritional modification and intervention enforced during the dam's lactation window. Hermiz (2001) and Hermiz et al. (2009) who reported a significant effect of year and season of birth on weight at six months in different goat breeds. Also in line with this studies, the effect of year, type of birth and sex were significant on weight at six months as observed by Das et al. (1994) in Blended goats.

Fehr (1981) announced that birth weight of a kid primarily depends on the body conformation and size of their parents. In fact, the body weight of the dam and the birth weight of their kids have positive correlation coefficient irrespective of the litter sizes (Morand-Fehr, 1981). The growth of the kids stagnates in the summer season, which coincides with the age of 4 or 5 months according to the kidding season (Najari, 2005). This aspect can be considered as an adaptative strategy to the different management modes and growth conditions of pastoral breeding under arid conditions (Le Gal Planchenault, 1993). Effects of year and month of birth result from the variability of climatic conditions, which influence the forage availability to dams that in turn influence their milk production (Najari et al., 2007a). The kidding year showed a high effect ($P<0.01$) on the body weights of the kids from birth to 150 days of age. Ndlovu and Simela (1996) obtained similar results for goats from Zimbabwe. Najari et al. (2007b) also mentioned an influence of the kidding year because of annual variations, which may be due to the variant productivity of the range lands. The scarcity and irregularity of precipitations, as hot and cold oscillations, are the main natural factors affecting the growth of the animals, especially in young kids. Year oscillations characterize the arid environment, affecting the feed availability which is the main reason for the year effect on variability (Ouni et al., 2007; Najari et al., 2007a). The importance of the year effect on the growth performances under difficult conditions has been highlighted by other reports (Alexandre et al., 1997; Zhang et al., 2006). Ndlovu and Simela (1996) reported that the kids born in the hot dry season were heavier around the ages of 60 and 90. This could be explained by the same argument mentioned for the year effect. Al-Shorepy et al. (2002) indicated that the season of birth effect was not significant for birth weight. The effect of the month is caused by different feeding conditions generated in each season by irregular climatic conditions, especially in the arid areas (Gaddour et al., 2007). Pastoral resources change very much from one month to another, and for the same month from one year to another, thus directly affecting the intake of the kids and indirectly the milk production by the dams (Sajlu et al., 1999; Najari et al., 2007a). Zhang et al. (2008) reported that the weight variation for Boer goat in different years and seasons might be partly explained by differences in management and sample size. The availability of forage of higher nutritive value in the wet seasons is the probable reason for higher birth weights of kids/lambs in those seasons against the dry season when both forage quality and quantity are characteristically low (Balogun et al., 1993). The dams of those offspring dropped during the peak of the wet season are highly likely to have conceived during the late dry season (February-March), enabling the second half of pregnancy to coincide with a period between May to August when forage was nutritious and abundant. The reverse might be true for the dry season. More feed resources provision coinciding with the second half of pregnancy promoted growth of lambs (Hammond et al., 1976). Good nutrition under intensive systems, counteracted the effects of season on birth weight (Akusu and Ajala, 2000).

Previously, Wilson (1987) in contradiction with most observations cited that year of birth had no influence on any pre-weaning trait in traditionally raised goats and sheep. On a related note month of birth was also not a source of variation in any pre-weaning trait. The results were in conformity with findings by Wilson and Durkin (1983) As expected, environmental conditions during the rainy season provide more quantity and better quality of pasture for kids/lambs that translates into a higher weaning weight and post weaning growth of kids/lambs. Elsewhere, seasons of weaning may be designated with regards to monthly temperature and rainfall distribution during the year: dry (February to May) when quantity and quality of forage is poor and/or inadequate; rainy (June to September) when heavy rain occurs and abundant forage exists; windy and rainy (October to January) when rain is isolated, pastures commence to dry and pasture quality declines.

6. Sex dependent growth performance in goats and sheep production

Superior pre-weaning and post-weaning growth, as well as weaning weight for males as compared with females have been extensively observed across goat and sheep breeds, and their crosses. One outstanding, and often reported feature of weaning weight is the tendency for it to be sex biased, where male kids and lambs are superior weaning weight as compared with female kids/lambs. The male lambs were significantly heavier as compared with the female lambs at weaning of 1.71 kg and had a superior rate of growth from birth to weaning of

22 g/day (Bathaei and Leroy, 1994). Sex has been reported as a major determinant of weaning weight and pre-weaning average daily gain of Alpine, Nubian and crossbred single-born or multiple-born kids (Gebrelul et al., 1994). In rangeland goats sex was a source of variation in weaning weight and at 5 months of age (Pym et al., 1982). In a similar study, Eady and Rose (1988) demonstrated that males had a superior growth as compared with female progeny of rangeland origin cashmere goats. In a comparative study of growth rates in intact male and female on range, Allan and Holst (1989) recorded intact male and female liveweight gain which ranged from about 150 g/day to 175 g/day and 135 to 145 g/day, respectively from 30 to 180 days of age. The liveweight difference in female kids was significantly lower as compared with males for the period between birth to 180 days of age. Moura Filho et al. (2005) and Rocha et al. (2009) demonstrated that sex was not a source of variation from birth to weaning. Their reason for nonexistence of differences for male and females was that in the early ages of an animal's life sexual hormones, culpable for the dimorphism between the sexes, are not as functional as in older animals (Nunes, 2008). Costa Júnior et al. (2006) observed lack of variation between the sexes for weight of lambs from birth to one year of age; however, differences were profound in older animals. This could be explained by the fact that differences due to sexual dimorphism increase as the animals age increases. The body weights from birth to the age of 150 days for males are all significantly heavier than those for females (Table 4), which are in agreement to the results repo other authors (Gebrelul et al., 1994; Ugur et al., 2004; Najari, 2005). However, Ndlovu and Simela (1996) observed that the sex of kids did not affect body weights and growth rate from 90 to 180 days of age. Furthermore, the weight gap between males and females becomes larger as they become older, which is consistent with the reports by Hary and Schwartz (2002). These growth advantages of male kids recorded in this study are comparable to those reported for other goat breeds (Husain et al., 1996; Al-Shorepy et al., 2002). Bermejo et al. (2010) and Mohammadi et al. (2010) proved that males and females exhibited differences in pre-weaning growth where male lambs outclassed their female counterparts. Gender of lambs was an important factor affecting weaning weight, with males being 2.1 kg heavier than females (Mellado et al., 2016). The importance of gender influence lamb weaning weight has been documented for a number of sheep breeds (Fogarty et al., 2005; Hopkins et al., 2005) in different production systems. As expected singletons tend to be superior at weaning with reference to twins (Yilmaz et al., 2007; Mohammadi et al., 2010). Mellado et al. (2016) as an illustration single born lambs weighed 6.9 kg more outclassing triplets. The explanation for superiority at weaning for singletons over multiple birth lambs was partly attributable to the proportionally higher birth weight advantage of single-born lambs as compared to multiple birth. However, it should be noted that the variation in growth traits between males and females is confounded with nutritional regime. Feeding males and females in Cashmere goats on rangeland with various rations which differed in protein level, Ash and Norton (1984) observed the same trend where males grew significantly faster compared with the females. Needless to say that intakes were comparable pointing to the fact that males had a higher efficiency of feed utilisation and growth rate which was dependent on the level of protein in the diet. This was illustrated by a 48% increase in growth rate on high protein diet as compared with a conservative increase of 11% on the low protein diet. To explain this, Louca and Hancock (1977) confirmed that male feed efficiency was greater than females in Damascus goats, meanwhile difference widened at low protein intakes. It has been suggested that the male faster growth advantage emanates from their superior birth weight as compared to females, and on the other hand possess greater feed conversion efficiency. In comparison with castrates, intact males seemingly grow faster until the onset of sexual maturity, thereafter the advantage is reduced or lost. Melladdo et al. (2016) observed an advantage of male lambs in pre-weaning growth which was attributable to larger birth weights of males. Sex dependent weaning weight performance and post weaning growth might be related to hormonal profiles. Cieslak et al. (2015) observed that there was lower cortisol secretion in male lambs as compared with the greater cortisol secretion in female lambs at 16 weeks of age. Early weaning results in the sexually dimorphic stress reaction that is more potent and long-lasting in female in contrast to male lambs hence might be a source of variation on growth in males and females.

7. Birth weight and type influencing growth performance in goats and sheep

Birth size/weight represents the greatest barrier on weaning and pre-weaning growth among the non-genetic factors in both goats and sheep. Growth during the first month of animal life is greatly influenced by the individual birth weight and weight gain during the first week (Morand-Fehr, 1981). There was a distinct relationship between superior birth weight and accelerated growth rates in Anglo-Nubians cross kids' (Bajhau and Kennedy, 1990). The birth weight effect on growth was twice in excess of milk consumption, while being ten times that of the breed's

influence on growth. Comparably, in Tswana goats birth weight was positively correlated with growth rate (Madibela et al., 2002). Birth weight of kids varies with breeds and environmental conditions (Morand-Fehr, 1981). Large birth sized lambs showed accelerated growth rates which are signified prenatally and justify the rapid growth rates (Mellado et al., 2016). In a similar study birth type was the major impediment on pre-weaning growth of any of the environmental factors studied, this may be explained by its influence on weaning weight, where low weaning weights are associated with compromised pre-weaning growth rates. This was explained by the fact that birth type is a source variation in weaning weight and post weaning growth, generally singles have superior weaning weights with reference with twins and also twins outclassing triplets (Das and Sendalo, 1990). According to Kuthu et al. (2013) single born kids were heavier with reference to multiple births, as they have got an advantage, no competition for nutrients in the uterus of their dams against multiple births. A highly significant effect of interaction of type of birth with sex, with male kids born as single being superior, while female kids born as quadruplets had lower weight. Robinson et al. (1977) subscribed to the notion that as the number of fetuses increases, the caruncles attached to each foetus decrease in number culminating in depressed supply of nutrients to the foetus and hence resultant birth weight especially in multiples decreases in size. Single born kids were heavier than multiple born the reason being that they had better conditions for growth in the uterus of their mothers as compared to multiple kids (Afzal et al., 2004). The larger live weights from birth to 100 days of all singles over twins were in agreement with the results of Tera (2008) with 11.5 kg for single 12.6 kg for ½ AN and ¾ AN respectively, at 90 days. Momani et al. (2012) reported that single born kids had superior average daily gain from birth to 100 days than twins. These results are consistent with those observed by Sangaré and Pandey (2000), who indicated that single born grow faster as compared to twins in Sahelian goats. In a similar study the growth rate was higher in males than in females from birth to 90 days for brown short haired goat (Kuchtik et al., 2005). In disagreement Sangaré and Pandey (2000) that sex of kid had no significant effect on growth rate in Sahelian goats in Mali. The magnitude of whole-herd litter traits at weaning were deemed lower than in the earlier study for the 3 straight bred doe groups (Browning et al., 2011). Pym et al. (1982) showed that rangeland goats' weaning weight was significantly affected by birth type where single, twin and triplets' birth weights were 2.97 kg, 2.59 kg and 2.14 kg respectively. Thiruvenkadan et al. (2009) observed that the margin of variation in rate of gain per day of single born kids with reference to multiple born kids was 8.97 g and this trend was up to weaning, however 1.20 g was reported by 12 months of age, the latter being not significant. There was 1.77 kg (56.9%) depression in efficiency during post-weaning growth with respect to pre-weaning phase showed that the maximum growth rate had taken place during the pre-weaning stage. One of the principal effect on birth and weaning weight as well as pre-weaning weight gain of Dorper lambs was litter size (Mellado et al., 2016). Single born kids were significantly had higher daily weight gain (141 v 105 g/day) compared with twins (Eady and Rose, 1988). The impact of birth type on growth rate may have limited commercial bearing. The higher growth rate of single born kids could be more than offset by the higher number of goats produced in multiple births. Furthermore, there is no evidence the initial advantage will persist to maturity. The greater relative variation in litter size and the individual lambs highly dependent on their mother's milk supply until the time of weaning (Bradford, 1972) warrants improved maternal management intervention.

Singletons of Alpine, Nubian and crossbred kids were superior at weaning and grew faster in the pre-weaning growth phase as compared with multiple born kids (Gebrelul et al., 1994). The comparative growth rates of lambs born as singles and as multiples weaned exhibited differential preweaning, weaning weights and post-weaning growth. The variation at weaning pre-weaning growth and post weaning growth amongst singles and twins, twins and triplets, and triplets and quadruplets were dependent on breeds and management systems (Rios-Utrera et al., 2014; Teklebrhan et al., 2014). Singletons have an advantage of weight gain than multiple birth, similarly, concentrate supplementation in kids has demonstrated that it can greatly improve growth performance especially when milk yield is low (Goethe et al., 2011), the effect is predominant when the kid born and reared as singles. Goetsch et al. (2011) observed that kids from single litters perform better than those from multiple litters and concentrate supplementation increases postweaning body weight and growth performance, especially if milk yield is low. Alexandre et al. (1999) working with Creole kids, daily weight gain differed from 95 g and less than 70g for single and twins, respectively, when measurements were taken between 10 and 30 days of age. In a previous study Wilson and Light (1986) proposed that young primiparous dams may be lighter than the general doe population may be indicative of low reproductive capacity, and their general weaning rates and weights may be assumed to low.

Different goat and sheep breeds have been bred for their growth potential, however there has been variation in the magnitude of genetic success in this endeavours. Boer goat has been popular and outstanding as one of the excellent meat breeds, especially in intensive production systems. Boer crossbreds have also been utilised to realise desirable pre-weaning growth, weaning weight and post weaning growth in order to improve the overall meat production efficiency. The issue of multiple birth on pre-weaning, weaning weights and post-weaning growth has been thoroughly dealt with in numerous studies. The inferior pre-weaning, weaning weights and post-weaning growth due to multiple birth has been explained partly by competition for nursing between multiple birth lambs from birth to weaning period. The failure by the dams to adequately supply milk to littermates has been the major reason for low pre-weaning growth, weaning weight and post-weaning growth in goats and sheep. Apart from the genetics of the dam, nutrition has been implicated in the ability for dams to yield more milk to nurse a larger litter. This means the genotype of the dam may be important in this regard, as expected different genotypes have different capacity for milk production. This calls for producers to decide on the choice of dam breeds especially in crossbreeding.

Litter size and litter weight at weaning are important economic parameters in the whole goat meat production process. The major determinates of these factors includes doe fertility, mothering ability, and the ability of does to stay healthy. Litter size promote the number of functional mammary glands through their suckling simulative effects. The number of littermates contributes to the determination of milk production in the sense that milk yield increase as litter size increases. In retrospect embryo development is enhanced during the last six weeks of gestation as a result the nutritional requirement of dams at this phase increases. The provision of adequate nutrition at this phase will result in dams dropping kids/lambs which are not only at birth but also at weaning. Due to the physiological demand on lactation, the nutritional requirements of dams also increases if they are suckling twins or triplets, the level of nutrition can have implication on multiple birth kid/lamb growth rates. It would reasonable to assume that a below average maintenance rations resulted in low post-weaning growth rates due to starvation, poor mothering ability and desertion than in dams provided with above maintenance rations. Growth can be retarded due to starvation were even worse in dams with deformed udder than dams with morphologically sound udder.

8. Highlights

Poor pre-weaning and post-weaning growth, as well as weaning weight itself are collectively primary cause of low meat productivity and economic loss in small ruminants. Therefore, any appropriate intervention such as improved management accompanied by utilizing suitable breeds and their crosses become critical component for enhanced meat production in goat and sheep.

Growth traits from birth to weaning and related post-weaning growth performance are highly correlated, as a result low or high birth weight have differentiated impact on the actual kid/lamb weaning weight and post weaning growth performance up until slaughter age.

Pre-weaning and post-weaning growth, and weight at weaning are strongly dependent on genotype, although the overall growth potential will be determined by environmental factors such as nutrition, management, health and other animal related factors such as birth weight of kid/lamb, sex of kid/lamb, birth type, and also maternal related factors of parity order, age of dam, weight and/or body condition score of dams and dam nutrition during pregnancy and lactation up to weaning kid/lambs period. It is also known that the effect of the aforementioned non-genetic factors fluctuates in accordance with the agro ecological region, production enterprise and genetic structure of the population, therefore, it is necessary to assess the degree to which these factors affect weaning weight, and related pre and post weaning growth, under specific production circumstances.

The kids/lambs with low weaning weights due to starvation might be unable to compensate for post weaning growth performance, as compared with adequately fed counterparts during the same period. Hence feeding kids/lambs concentrates at the rate commensurate with their live weight will exhibit superior weaning weight and post-weaning growth rate. For that reason, pre-weaning nutrition is critical for desirable weaning weights and superior post weaning growth rates in goats and sheep production.

There is a strong association between year of weaning and weaning weights this has been ascribable to variation in quantity and quality of feed across seasons and years, which can be directly related to the amount of rainfall and its intensity and/or distribution. The effect of year/season act as both direct and indirect avenue in improvement of growth performance in kids/lambs. The direct effect is on kid/lambs' growth as influenced by

adequate nutrition when the season is favourable, on the other hand, the indirect implication comes from the dam nutritional side, when a favorable season in terms of forage availability coincides with pregnancy or lactation resulting into high birth size and improved weaning weights, respectively. Well-fed dams during pregnancy are highly likely to drop kids/lamb with heavier birth weight, also properly fed dams have the capacity to produce more milk adequately nursing their young ones consequentially improving weight at weaning. Year x season interaction indicates that season effects on performance of kids/lambs or ewes/does were heterogeneous throughout the years within a specific assessment period.

Distinguishable performance is exhibited in kids/lambs born as singletons against multiples birth when weaned showed superior differential weaning weights and post-weaning growth in favour of kids/lambs born single. The explanation is that singles have non-competitors on suckling and tend to acquire adequate milk for growth. Improved nutritional management, particularly ewes/does nursing twins and triplets, is critical to improve weaning weights and post-weaning growth of kids/lambs.

Superior pre-weaning and post-weaning growth for males as compared with females have been extensively observed across goat and sheep breeds, and their crosses. One outstanding and often reported feature of weaning weight is the tendency for it to be sex biased, where male kids/ lambs outclass females in pre-weaning and post-weaning growth.

The significant effects on pre-weaning and post-weaning, as well as weaning weight being dependent on various non-genetic factors of birth type, year of weaning, nutrition/age of dam, parity order and sex of the kids/lamb have practical implications not only for the husbandry of the goats and sheep as an economical commodity, but also for the increased knowledge of factors that are determinants of variation in weaning performance and growth traits in goats and sheep in order to enhance meat production efficiency. Pre and post-weaning management should therefore be oriented to scale back growth setbacks during the weaning adjustment periods. Post weaning shock has been associated with compromised feed utilization in kids/lambs which has translated into poor post weaning growth.

References

Acero-Camelo, A., Valencia, E., Rodríguez, A., Randel, P.F., 2008. Effects of flushing with two energy levels on goat reproductive performance. Livest. Res. Rural Dev., 20(Article), #136.

Adenaike, A.S., Bemji, M.N., 2011. Effects of environmental factors on birth weights and weaning weights of West African dwarf goats under intensive and extensive management systems. Adv. Agr. Biol., 1, 9-14.

Afzal, M., Javed, K., Shafiq, M., 2004. Environmental effects on birth weight in Beetal goat kids. Livestock Production. Pakistan Vet. J., 24, 104-106.

Akpa, G.N., Alphonsus, C., Dalha, S.Y., Garba, Y., 2010. Goat breeding structure and repeatability of litter size in smallholder goat herds in Kano, Nigeria. Anim. Res. Int., 7(3), 1274-1280.

Akusu, M.O., Ajala, O.O., 2000. Reproductive performance of West African Dwarf goats in the humid tropical environment of Ibadan. Israel J. Vet. Med., 55(2), 6.

Alfonso, J., Chay-Canul, Aguilar-Urquizo, E., Parra-Bracamonte, G.M., Piñeiro-Vazquez, A.T., Sanginés-García, J.R., Magaña-Monforte, J.G., García-Herrera, R.A., López-Villalobos, N., 2019. Ewe and lamb pre-weaning performance of Pelibuey and Katahdin hair sheep breeds under humid tropical conditions. Ital. J. Anim. Sci., 18(1), 850-857.

Allan, C.J., Holst, P.J., 1989. Comparison of growth and dressing percentage between Intack male, Castrate male and female kids of Australian bush goats. Small Rumin. Res., 2, 63-68.

Allden, W.G., 1970. The effects of nutritional deprivation on the subsequent productivity of sheep and cattle. Nutr. Abstr. Rev., 40, 1167-1184.

Al-Shorepy, S.A., Alhadrami, G.A., Abdulwahab, K., 2002. Genetic and phenotypic parameters for early growth traits in Emirati goat. Small Rumin. Res., 453, 217-223; CAB Abst(3), 141-182.

Andries, K.M., 2013. Growth and performance of meat goat kids from two seasons of birth in Kentucky. Sheep Goat Res. J., (28).

Animut, G.G., Merkel, R.C., Abebe, G., Sahlu, T., Goetsch, A.L., 2002. Effects of level of broiler litter in diets containing wheat straw on performance of Alpine Doelings. Small Rumin. Res., 44, 125-134.

Ash, A.J., Norton, B.W., 1984. The effect of protein and energy intake on cashmere and body growth of Australian cashmere goats. Anim. Prod. Aust., 15, 247-250.

Ash, A.J., Norton, B.W., 1987. Productivity of Australian Cashmere goat grazing Panagola grass pasture and supplemented with untreated and formaldehyde treated protein meals. Aust. J. Exp. Agr., 27, 779-784.

Bajhau, H.S., Kennedy, J.P., 1990. Influence of pre- and postpartum nutrition on growth of goat kids. Small Rumin. Res., 3(3).

Balogun, R.O., Olayemi, M.E., Osinowo, O.A., 1993. Environmental factors affecting birth weight and litter size in Yankasa sheep. Niger. J. Anim. Prod., 20(1), 14-19.

Bathaei', S.S., Leroy, P.L., 1994. A study of factors affecting body weight of Iranian fat-tailed Mehraban breed of sheep. Revue Élev. Méd. Vét. Pays Trop., 47(1), 113-116.

Bermejo, L.A., Mellado, M., Camacho, A., Mata, J., Arévalo, J.R., de Nascimento, L., 2010. Factors influencing birth and weaning weight in Canarian hair lambs. J. Appl. Anim. Res., 37, 273-275.

Bharathidhasan, A., Narayanan, R., Gopu, P., Subramanian, A., Prabakaran, R., Rajendran, R., 2009. Effect of non-genetic factors on birth weight weaning weight and pre weaning gain of Barbari goat. Tamilnadu J. Vet. Anim. Sci., 5(3), 99-103.

Boujenane, I., Bradford, G.E., 1991. Genetic effects on ewe productivity of crossing D'man and Sardi breeds of sheep. J. Anim. Sci., 69, 525-530.

Boujenane, I., Kansari, J., 2002. Lamb production and its components from purebred and crossbred mating types. Small Rumin. Res., 43, 115-120.

Boujenane, I., Roudies, N., Benmira, A., EI Idrissi, Z., EI Aouni, M., 2003. On-station assessment of performance of the DS synthetic and parental sheep breeds, D'man and Sardi. Small Rumin. Res., 49, 125-133.

Bradford, G.E., 1972. The role of maternal effects in animal breeding. VII. Maternal effects in sheep. J. Anim. Sci., 35, 1324-1334.

Brand, T.S., Franck, F., 2000. Production responses of two genetic different types of Merino sheep subjected to different nutritional levels. Small Rumin. Res., 37, 85-91.

Browning, R. Jr., Leite-Browning, M.L., 2011. Birth to weaning kid traits from a complete diallel of Boer, Kiko, and Spanish meat goat breeds semi-intensively managed on humid subtropical pasture. J. Anim. Sci., 89, 2696-2707.

Carneiro, P.L.S., Malhado, C.H.M., Souza Junior, A.A.O., 2007. Desenvolvimento ponderal e diversidade fenotípica entre cruzamentos de ovinos Dorper com raças locais. Pesquisa Agropecuária Brasileira, 42(7), 991-998.

Cissé, M., Ly, I., Nianogo, A.J., Sané, I., Sawadogo, J.G., N'diae, M., Awad, C., Fall, Y., 2002. Grazing behavior and milk yield of Senegalese Sahel goat. Small Rumin. Res., 43, 85-95.

Combellas, J., 1980. Production and reproduction parameters of tropical sheep breed in improved production systems. Trop. Anim. Prod., 5, 266-273.

Coop, I.E., Clark, V.R., Claro, D., 1972. Nutrition of the ewe in early lactation. 1. Lamb growth rate. New Zeal. J. Agr. Res., 15, 203-208.

Costa Júnior, G.S., Campelo, J.E.G., Azevedo, D.M.M.R., 2006. Caracterização morfométrica de ovinos da raça Santa Inês criados nas microrregiões de Teresina e Campo Maior, Piauí. Rev. Brasil. Zootec., 35(6), 2260-2267.

Danso, A.S., Morel, P.C.H., Kenyon, P.R., Blair, H.T., 2016. Relationships between prenatal ewe traits, milk production, and preweaning performance of twin lambs. J. Anim. Sci., 94, 3527-3539.

Das, S.M., Sendalo, D.S., 1990. Comparative performance of improved meat goats in Malya, Tanzania. Proceedings of the First Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya, 10-14.

Dhanda, J.S., Taylor, D.G., Murray, P.J., 2003. Part 1. Growth carcass and meat quality parameters of male goats: effects of genotype and liveweight at slaughter. Small Rumin. Res., 50, 57-66.

Dixit, S.P., Dhilon, J.S., Sing, G., 2001. Genetic and non-genetic parameter estimates for growth traits of Bharat Merino lambs. Small Rumin. Res., 42, 101-104.

Doyle, P.T., Egan, J.K., 1983. The utilization of nitrogen and sulphur by weaner and mature merino sheep. Aust. J. Agr. Res., 34, 433-439.

Dutta, N., Sharma, K., Hassan, Q.Z., 1999. Effect of supplementation of rice straw with Leucana leucocephala and Prosopis cineraria leaves on nutrient utilization by goats. Asian-Aust. J. Anim. Sci., 12(5), 742-746.

Eady, S.J., Rose, M., 1988. Reproductive performance of cashmere goats in south-western Queensland. Anim. Prod. Aust., 17, 182-185.

Eliot, G., Pearce, D., 1999. Animal production: Results and management recommendations from the Winderie Trial. In: Findings and observations from the Winderie goat domestication trial 1995-1998 (Eds. Pearce, D., Eliot, G., Nickels, R.J., White, K., Blood, D., Shackleton, K.R.,).

Fernandes, A.A.O., Buchanan, D., Selaive-Villarroel, A.B., 2001. Avaliação dos fatores ambientais no desenvolvimento corporal de cordeiros deslanados da raça Morada Nova. Rev. Brasil. Zootec., 30(5), 1460-1465.

Fisher, M.W., 2004. A review of the welfare implications of out-of-season extensive lamb production systems in New Zealand. Livest. Prod. Sci., 85, 165-173.

Gaddour, A., Najari, S., Ouni, M., 2007. Kid's growth of pure breeds and crossed caprine genotypes in the coastal oases of southern Tunisia. Res. J. Agron., 2, 51-58.

Gebrelul, S., Sartin, L.S., Iheanacho, M., 1994. Genetic and non-genetic effects on the growth and mortality of Alpine, Nubian and crossbred kids. Small Rumin. Res., 13, 169-176.

Gibb, M.J., Treacher, T.T., 1980. The effect of ewe body condition at lambing on the performance of ewes and their lambs at pasture. J. Agr. Sci., 95, 631-640.

Godfrey, R.W., Gray, M.L., Collins, J.R., 1997. Lamb growth and milk production of hair and wool sheep in a semi-arid tropical environment. Small Rumin. Res., 24, 77-83.

Goethe, A.L., Merkel, R.C., Gipson, T.A., 2011. Factors affecting goat meat production and quality. Small Rumin. Res., 101, 173-181.

Greenwood, P.L., Hunt, A.S., Hermanson, J.W., Bell, A.W., 2000. Effects of birth weight and postnatal nutrition on neonatal sheep: II. Skeletal muscle growth and development. J. Anim. Sci., 78, 50-61.

Greyling, J.P.C., Mmbengwa, V.M., Schwalbach, L.M.J., Muller, T., 2004. Comparative milk production potential of indigenous and Boer goats under two feeding systems in South Africa. Small Rumin. Res., 55, 97-105.

Hamad, M.N.F., El-Moghazy, M.M., 2015. Influence of sex and calf weight on milk yield and some chemical composition in the Egyptian buffalo's. J. Anim. Vet. Sci., 2(3), 22-27.

Hammond, J., Mason, I.L., Robinson, T.J., 1971. Hammond's Farm Animals. 4th edition, 98-138.

Hansen, C., Shrestha, J.N.B., 2002. Consistency of genetic parameters of productivity for ewes lambing in February, June and October under an 8-month breeding management. Small Rumin. Res., 44, 1-8.

Hassen, Y., Sölkner, J., Fuerst-Waltl, B., 2004. Body weight of Awassi and indigenous Ethiopian sheep and their crosses. Small Rumin. Res., 55, 51-56.

Htoo, N.N., Khaing, A.T., Abba, Y., Htin, N.N., Abdullah, J.F., Kyaw, T., Khan, M.A., Lila, M.A., 2015. Enhancement of growth performance in pre-weaning suckling Boer kids supplemented with creep feed containing alfalfa. Vet. World, 8(6), 718-722.

Hyder, A.U., Akhtar, P., Abdullah, M., 2001. Environmental factors influencing weaning weight in Teddy goat kids. J. Anim. Plant Sci., 114, 151-154.

Johnson, T.J., Rowe, J.B., 1984. Growth and cashmere production in goats in relation to dietary protein supply. Anim. Prod. Aust., 15, 400-403.

Jordan, D.J., Mayer, D.G., 1989. Effects of udder damage and nutritional plane on milk yield, lamb survival and lamb growth of Merinos. Aust. J. Exp. Agr., 29, 315-320.

Kashani, S.M.M., Bahari, M., 2017. The effect of sex and weaning age on growth performance of first generation lambs derived from crossing ½Romanov and Zel. J. Anim. Res. Nutr., 2, 24.

Kawas, J.R., Andrade-Montemayor, H., Lu, C.D., 2010. Strategic nutrient supplementation of free-ranging goats. Small Rumin. Res., 89, 234-243.

Kelly, R.W., Greeff, J.C., Macleod, I., 2006. Life time changes in wool production of Merino sheep following differential feeding in fetal and early life. Aust. J. Agr. Res., 57, 867-876.

Khanal, P., Leite-Browning, M.L., Browning Jr. R., 2019. Influence of crossbreeding on meat goat doe fitness when comparing Boer F1 with base breeds in the Southeastern United States. J. Anim. Sci., 97(1), 78-89.

Koritiaki, N.A., Ribeiro, E.L.A., Scerbo, D.C., 2012. Fatores que afetam O desempenho de cordeiros Santa Inês puros e cruzados do nascimento ao desmame. Rev. Brasil. Saúde Prod. Anim., 13(1), 258-270.

Kuchtík, J., Dobe, I., 2006. Effect of some factors on growth of lambs from crossing between the Improved Wallachian and East Friesian. Czech J. Anim. Sci., 51(2), 54-60.

Kuthu, Z.H., Javed, K., Babar, M.E., Sattar, A., Abdullah, M., 2013. Environmental effects on growth traits of Teddy goats. J. Anim. Plant Sci., 23(3), 692-698.

Lachica, M., Aguilera, J.F., 2005. Energy needs of the free-ranging goat. Small Rumin. Res., 60, 111-125.

Lambe, N.R., Brotherstone, S., Young, M.J., Conington, J.E., Simm, G., 2005. Genetic relationships between seasonal tissue levels in Scottish Blackface ewes and lamb growth traits. Anim. Sci. (Penicuik, Scotland), 81, 11-21.

Langlands, J.P., 1977. The intake and production of lactating merino ewes and their lambs grazed at different stocking rates. Aust. J. Agr. Res., 28, 133-142.

Louca, A.I., Hancock, J., 1977. Genotype by environmental interactions for postweaning growth in the Damascus breed of goat. J. Anim. Sci., 44, 927-931.

Luo, J., Sahlu, T., Cameron, M., Goetsch, A.L., 2000. Growth of Spanish, Boer×Angora and Boer×Spanish goat kids fed milk replacer. Small Rumin. Res., 36(2), 189-194.

Mabrouk, O., Sghaier, N., Costa, R.G., Amor, G., Amel, B.A.E., Delgado, J.V., 2010. The effect of non-genetic factors on the early body weights of Tunisian local goats. R. Bras. Zootec., 39(5), 1112-1117.

Machen, R., 2002. Creep feeding kid goats. Texas Agricultural Extension Service.

Mahjoub, O., Lu, C.D., Hameed, M.S., 2005. Performance of Omani goats fed diets containing various metabolisable energy densities. Small Rumin. Res., 58, 175-180.

Makun, H.J., Ajanus, J.O., Ehoche, O.W., Lakpini, C.A.M., Otaru, S.M., 2008. Growth rate and milk production potential of Sahelian and red Sokoto breeds of goats in northern Guinea Savanah. Pakistan J. Biol. Sci., 11, 601-106.

Malau-Aduli, B.S., Eduvie, L., Lakpini, C., Malau-Aduli, A.E., 2004. Crop-residue supplementation of pregnant does influences birth weight and weight gain of kids, daily milk yield but not the progesterone profile of Red Sokoto goats. Reprod. Nutr. Dev., 44(2), 111-121.

Mandal, A., Ceser, N.F.W., Rout, P.K., Roy, R., Notter, D.R., 2006. Estimation of the direct and maternal (co) variance components for pre-weaning growth traits in Muzaffarnagari sheep. J. Livest. Sci., 99, 79-89.

Mavrogenis, A.P., 1983. Adjustment factors for growth characters of the Damascus goat. Livest. Prod. Sci., 10, 479-486.

McGregor, B.A., 1985. Growth, development and carcass composition of goats: A review. In: Proceedings of the Goat Production and Research in the Tropics, Feb. 6-8, 1984, University of Queensland, Brisbane, ACIAR. 82-90.

McGregor, B.A., 2005a. Compendium of growth rates of Australian goats. Department of Primary Industries, Attwood.

McGregor, B.A., 2005b. Nutrition and management of goats in drought. RIRDC Report No 05/188. (RIRDC: Canberra).

McNeill, D.M., Kelly, R.W., Williams, I.H., 1997. The partition of nutrients in ewes maintained in a moderate compared with a lean body condition in late pregnancy. Aust. J. Agr. Res., 48, 743-752.

Mellado, J., Marín, V., Reyes-Carrillo, J.L., Mellado, M., Gaytán, L., Ma de los Ángeles De Santiago, 2016. Effects of non-genetic factors on pre-weaning growth traits in Dorper sheep managed intensively in central Mexico. 3(8), 229-235.

Mexia, A.A., Macedo, F.A.F., Alcade, C.R., 2004. Desempenhos reprodutivo e produtivos de ovelhas Santa Inês suplementadas em diferentes fases da gestação. Rev. Brasil. Zootec., 33(3), 658-667.

Miguel, R.J.A., Calvo, R.J.L., Ciria, C.J., Asenjo, M.B., 2011. Effect of feeding systems on live-weight, reproductive performance, milk yield and composition, and the growth of lambs in native Spanish Ojalada sheep. Span. J. Agr. Res., 9, 769-780.

Mike, O.O., Osakwe, I.I., 2008. Estimation of genetics parameters of growth traits in Nigeria Sahelian goats. Department of Animal Production and Fisheries. Ebonyi State University, P.M.B 053 Abakaliki, Nigeria. J. Anim. Vet. Adv., 7, 535-538.

Mohammadi, K., Beygi-Nassiri, M.T., Fayazi, J., Roshanfekr, M., 2010. Investigation of environmental factors inuence on pre-weaning growth traits in Zandi lambs. J. Anim. Vet. Adv., 9(6), 1011-1014.

Momani, M.S., Sanogo, S., Coulibaly, D., Al-Olofi, S., Alkhewani, T., 2012. Growth performance and milk yield in Sahelian × Anglo-Nubian goats following crossbreeding in the Semi-Arid zone of Mali. Agr. Trop. Subtrop., 45(3), 117-125.

Momany-Shaker, M., Abdullah, A.Y., Kridli, R.T., Sada, I., Sovjak, R., Muwalla, M.M., 2002. Effect of crossing indigenous Awassi sheep breed with mutton and prolic sire breeds on the growth performance of lambs in a subtropical region. Czech J. Anim. Sci., 47, 239-246.

Morand-Fehr, P., 1981. Growth. In: Gall, C. (Ed.) Goat production. London: Academic Press. 253-283.

Morgan, J.E., Fogarty, N.M., Nielsen, S., Gilmour, A.R., 2006. Milk yield and milk composition from grazing primiparous non-dairy crossbred ewes. Aust. J. Agr. Res., 57, 377-387.

Moura Filho, J., Ribeiro, E.L.A., Silva, L.D.F., 2005. Suplementação alimentar de ovelhas no terço final da gestação: desempenho de ovelhas e cordeiros até o desmame. Semina: Ciências Agrárias, 26(2), 257-266.

Mousa, E., Monzaly, H., Shaat, I., Ashmawy, A., 2013. Factors affecting birth and weaning weights of native Farafra lambs in upper Egypt. Egypt. J. Sheep Goat Sci., 8, 1-10.

Mushi, D.E., Safari, J., Mtenga, L.A., Kifaro, G.C., Eik, L.O., 2009. Effects of concentrate levels on fattening performance, carcass and meat quality attributes of small East African × Norwegian crossbred goats fed low quality grass hay. Livest. Sci., 124, 148-155.

Nadeem, M.A., Ali, A., Azim, A., Khan, A.G., 1993. Effect of feeding broiler litter on growth and nutrient utilization by Barbari goat. Am. J. Anim. Sci., 6(1), 73-77.

Negesse, T.M., Rodehutscord, E.P., 2001. The effect of dietary crude protein level on intake, growth, protein retention and utilization of growing male Saanen kids. Small Rumin. Res., 39, 243-251.

Niekerk, W.A.V., Casey, N.H., 1988. The Boer goat. II. Growth, nutrient requirements, carcass and meat quality. Small Rumin. Res., 1, 355-368.

Oderinwale, O.A., Oluwatosin, B.O., Onagbesan, M.O., Akinsoyinu, A.O., Amosu, S.D., 2020. Performance of kids produced by three breeds of goat fed diets supplemented with graded levels of turmeric powder. Trop. Anim. Health Prod., 52, 1239-1248.

Oderinwale, O.A., Oluwatosin, B.O., Onagbesan, O.M., Akinsoyinu, A.O., Oluwatosin, O.O., Amosu, S.D., Sanusi G.O., Madou Camara, 2017. Effects of diets containing levels of Turmeric-Powder on growth performance of three breeds of goat kids from birth to 4weeks post-weaning. In: Omenu, A.M., Babajide, J.M., Sokoya, O.O., Oderinwale, O.A., Kosoko, S.B. (eds). Proceedings of 5th National Conference of Nigerian Women in Agricultural Research for Development (NiW, RD) held at Park Inn Radisson Hotels, Kuto, Abeokuta, Nigeria between 12th-15th September.

Ouni, M., Najari, S., Gaddour, 2008. Some non-genetic factors effects on morphostructural growth of local kids in Tunisian arid area. Int. J. Zool. Res., 4(1), 12-20.

Pacheco, A., Quirino, C.R., 2008. Estudo das características de crescimento em ovinos. Pubvet, 2(29), 1982-1263.

Ploumi, K., Emmanouilidis, P., 1999. Lamb and milk production traits of Serrai sheep in Greece. Small Rumin. Res., 33(3), 289-292.

Poli, C.H.E.C., Monteiro, A.L.G., Barros, C.S., Dittrich, J.R., Fernandes, S.R., Carvalho, P.C.F., 2009. Comportamento ingestivo de cordeiros em três sistemas de produção em pastagem de Tifton 85. Acta Scientiarum. Anim. Sci., 31, 235-241.

Prieto, I., Goetsch, A.L., Banskalieva, V., Cameron, M., Puchala, R., Sahlu, T., Dawson, L.J., Coleman, S.W., 2000. Effects of dietary protein concentration on postweaning growth of Boer crossbred and Spanish goat wethers. J. Anim. Sci., 78, 2275-2281.

Pym, R.A., Holst, P.J., Nicholls, P.J., 1982. Effects of sex birth-rearing type and damage upon early growth of Australian goats. Proceedings of the 3rd International Conference on Goat Production and Disease.

Rankins Jr, D.L., Pugh, D.G., 2012. Feeding and nutrition. In: Pugh, D.G., Baird, A.N., editors. Sheep and Goat Medicine. 2nd ed. Maryland Heights: Elsevier, 18-49.

Rashidi, A., Mokhtari, M.S., Sa-Jahanshahi, A., Mohammad-Abadi, M.R., 2008. Genetic parameter estimates of pre-weaning growth traits in Kermani sheep. Small Rumin. Res., 74, 165-171.

Rashidi, A., Sheikhahmadi, M., Rostamzadeh, J., Shrestha, J.N.B., 2008. Genetic and phenotypic parameter estimates of body weight at different ages and yearling fleece weight in Markhoz goats. Asian-Aust. J. Anim. Sci., 2110, 1395-1403.

Ríos-Utrera, A., Calderón-Robles, R., Lagunes-Lagunes, J., Oliva-Hernández, J., 2014. Ganancia de peso predestete en corderos Pelibuey y sus cruces con Blackbelly, Dorper y Katahdin. Nova Sci., 12, 271-286.

Rocha, L.P., Fraga, A.B., Araújo Filho, J.T., 2009. Desempenho de cordeiros cruzados em Alagoas, Brasil. Arch. Zootec., 58(221), 145-148.

Rosa, H.J.D., Bryant, M.J., 2003. Seasonality of reproduction in sheep. Small Rumin. Res., 48, 155-171.

Rosov, A., Gootwine, E., 2013. Birth weight and pre- and postweaning growth rates of lambs belonging to the Afec-Assaf strain and its crosses with the American Suffolk. Small Rumin. Res., 113, 58-61.

Sangaré, M., Pandey, V.S., 2000. Food intake, milk production and growth of kids of local, multipurpose goats grazing on dry season natural Sahelian rangeland in Mali. Anim. Sci., 1(71), 165-173.

Shafiq, M., Sharif, M., 1996. Genetic evaluation of goats on productive traits by BLUP procedures. 17th Annual Report Livestock Production Research Institute Bahadurnagar Okara Pakistan.

Shiotsuki, L., Pernambuco de Oliveira, D., Braga, Lôbo, R.N., Facó, O., 2014. Genetic parameters for growth and reproductive traits of Morada Nova sheep kept by smallholder in semi-arid Brazil. Small Rumin. Res., 120, 2004-2008.

Sikiru, A.B., Makinde, O.J., 2018. Effect of low-cost supplemental feeding practices on pre-weaning weight gain of goat kids in Tafa LGA Nigeria. Int. J. Agr. Res. Sustain. Food Suff., 5(1), 237-247.

Silva, F.L.R., Araújo, A.M., 2000. Características de Reprodução e de Crescimento de ovinos mestiços Santa Inês, no Ceará. Rev. Brasil. Zootec., 29(6), 1712-1720.

Snowder, G.D., Glimp, H.A., 1991. Influence of breed, number of suckling lambs, and stage of lactation on ewe milk production and lamb growth under range conditions. J. Anim. Sci., 69, 923-930.

Snyman, M., Erasmus, G.J., Wyk, J.B.V., 1995. Non-genetic factor in fleecing growth and fleece traits in Afrino sheep. S. Afr. J. Anim. Sci., 25, 70-74.

Soto-Navarro, S., Goetsch, A.L., Sahlu, T., Puchala, R., 2004. Effects of level and source of supplemental protein in a concentrate-based diet on growth performance of Boer x Spanish wether goats. Small Rumin. Res., 51, 101-106.

Soto-Navarro, S.A., Goetsch, A.L., Sahlu, T., Puchala, R., Dawson, L.J., 2003. Effects of ruminally degraded nitrogen source and level in a high concentrate diet on site of digestion in yearling Boer x Spanish wether goats. Small Rumin. Res., 50, 117-128.

Souza, J.E.R., Martins Filho, R., Oliveira, S.M.P., 2003. Influência dos fatores de ambiente no desempenho ponderal de bovinos da raça Nelore no Estado do Ceará. Rev. Ciên. Agron., 34(2), 133-138.

Staikova, G., Stancheva, N., 2009. Effect of some factors on the live weight in sheep at different ages from the Northeast Bulgarian Fine Fleece Breed - Shumen Type. Bulgar. J. Agr. Sci., 15, 365-372.

Teklebrhan, T., 2018. Growth performance of crossbred kids (Boer x Indigenous goat breeds). J. Agr. Environ. Int. Dev., 112(1), 101-107.

Teklebrhan, T., Urge, M., Mekasha, Y., Baissa, M., 2014. Pre-weaning growth performance of crossbred lambs (Dorper x indigenous sheep breeds) under semi-intensive management in eastern Ethiopia. Trop. Anim. Health Prod., 46, 455-460.

Tera, S., 2008. Activités en station de recherche au Programme Petits Ruminants de l'IER (CRRA-Kayes) (Samé); Rapport de fin de cycle.

Thiruvenkadan, A.K., Murugan, M., Karunanithi, K., Muralidharan, J., Chinnamani, K., 2009. Genetic and non-genetic factors affecting body weight in Tellicherry goats. S. Afr. J. Anim. Sci., 39(1), 107-111.

Thompson, A.N.A.D.E.H., Ferguson, A.D.E.M.B., Campbell, A.J.D.B., Gordon, D.J.A.F., Kearney, G.A.A.G., Oldham, C.C.M., Paganoni, B.L.C., 2011. Improving the nutrition of Merino ewes during pregnancy and lactation increases weaning weight and survival of progeny but does not affect their mature size. Anim. Prod. Sci., 51, 784-793.

Tibbo, M., 2006. Productivity and health of indigenous sheep breeds and crossbreeds in central Ethiopian highlands. Ph.D. Thesis, Faculty of Medicine and Animal Science Department of Animal Breeding and Genetics. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Tygesen, M.P., Harrison, A.P., Therkildsen, M., 2007. The effect of maternal nutrient restriction during late gestation on muscle, bone and meat parameters in five month old lambs. Livest. Sci., 110, 230-241.

Van der Linden, D.S., Lopez-Villalobos, N., Kenyon, P.R., Thorstensen, E., Jenkinson, C.M.C., Peterson, S.W., Blair, H.T., 2010. Comparison of four techniques to estimate milk production in singleton-rearing non-dairy ewes. Small Rumin. Res., 90, 18-26.

Vernon, R.G., Finley, E., 1985. Regulation of lipolysis during pregnancy and lactation in sheep: response to noradrenaline and adenosine. Biochem. J., 230, 651-656.

Vostry, L., Milerski, M., 2013. Genetic and nongenetic effects influencing lamb survivability in the Czech Republic. Small Rumin. Res., 113, 47-54.

Walkden-Brown, S.W., Norton, B.W., Restall, B.J., 1994. Seasonal variation in voluntary feed intake and growth in cashmere bucks fed ad-libitum diets of low or high quality. Aust. J. Agr. Res., 45(2), 355-366.

Wenzhong, L., Zhang, Y., Zhou, Z., 2005. Adjustment for non-genetic effects on body weight and size in Angora goats. Small Rumin. Res., 591, 25-31.

Widdowson, E.M., Lister, D., 1991. Nutritional control of growth. Growth Regulation in Farm Animals. Pearson, A.M., Dutson, T.R., (edts). In 'Advances in Meat Research' Elsevier; London, 67-94.

Wilson, R.T., 1987. Livestock production in central Mali: environmental factors affecting weight in traditionally managed goats and sheep. Anim. Prod., 45, 223-232.

Wilson, R.T., Durkin, C.P., 1983. Livestock production in central Mali: weight at first occupation and ages at first and second parturitions in traditionally managed goats and sheep. J. Agr. Sci. Camb., 100, 625-628.

Wilson, R.T., Light, D., 1986. Livestock production in central Mali: economic characters and productivity indices for traditionally managed goats and sheep. J. Anim. Sci., 62, 567-575.

Yazdi, M.H., Shahrodi, E.E., Hejazi, M., Liljedahl, L.E., 1998. Environmental effects on growth traits and fleece weight in Baluchi sheep. J. Anim. Breed. Genet., 115, 445-465.

Yilmaz, O., Denk, H., Bayram, D., 2007. Effects of lambing season, sex and birth type on growth performance in Norduz lambs. Small Rumin. Res., 68, 336-339.

How to cite this article: Assan, N., 2020. Effect of genetic and non-genetic factors on growth traits in goats and sheep production. Scientific Journal of Zoology, 9(1), 106-122.

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