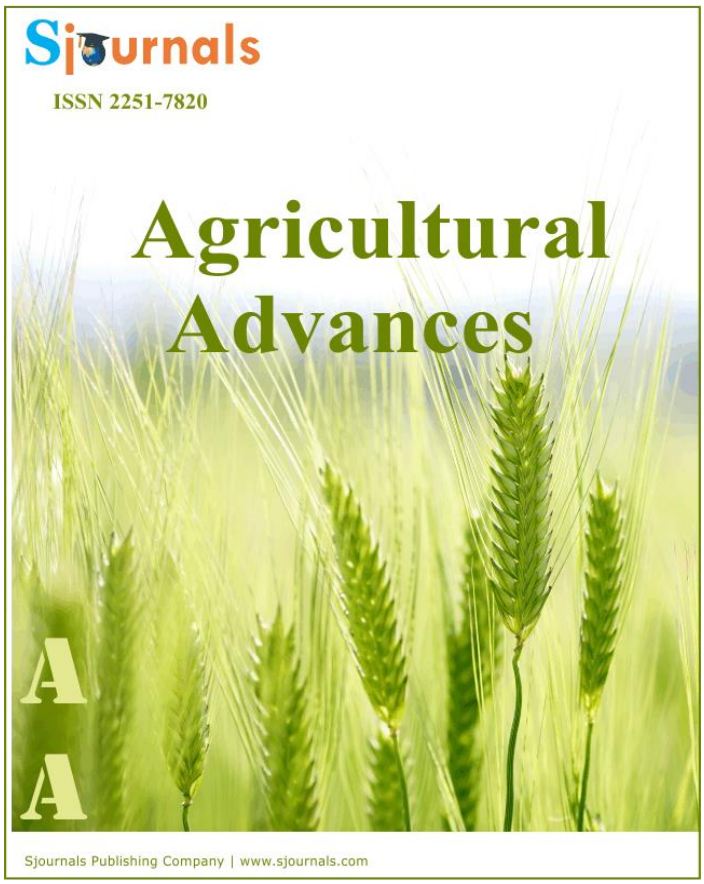

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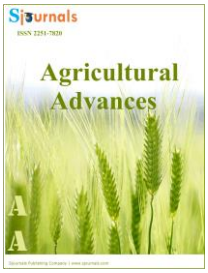

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Review article

Determinants of birth weight and its size as an onset representative of growth potential in goat and sheep meat production

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ABSTRACT

Birth weight is an important growth trait in goats and sheep which is of remarkable productive and economic interest for efficient meat production. Birth size in goats and sheep follows the pattern of prenatal growth and development, which is determined by genetics and a variety of environmental factors. Information on determinants of birth weight is of concern to producers, over and above the animal breeders, because birth weight has much influence on kid/lamb weaning weight hence later the overall flocks' meat production. Paternal and maternal genotypes are important sources of variation on birth weight in goats and sheep. By way of illustration apart from breed effect, environmental factors influencing birth weight include nutrition, dam age and parity, season and year, sex and birth type. These factors and their interactive forces proffer the overall impression as explanatory variables for birth weight variation in goats and sheep. Males have superior birth weight as compared to females and this can be perpetuated up until weaning age. The kidding/lambing season greatly influence birth weight due to its bearing on availability of forage, hence it is suggested that mating schedules for dams should be designed in a manner where pregnancies should coincide with adequate grazing in order to attain optimal birth size. The differential pattern of feed resources from season to season or month to another might affect dam's nutrition throughout their pregnancy consequently the birth outcome. Kids/lambs of primiparous ewes/does have a birth weight disadvantage, hence producers should consider alternatives for managing underweight birth on an individual

flock basis. A pronounced effect of litter size, with compromised birth size in kids/lambs born as triplets being lower as compared with those born as twins, which in turn is lower than that in kids/lambs born as singles. Interactions of determinants of birth weight are important in goats and sheep namely breed by parity, breed by birth type and birth type by parity. The point to note is that birth weight is highly correlated to anticipated future weights until mature or slaughter weight which can presumably influence meat production. An understanding of the determinants of birth weight will warrant modifications in the breeding and management schedules to minimize influences, which reduce meat production efficiency. The present review is undertaken to give an insight on the determinants of birth weight for instance age of dam, type of birth, sex, year and month of birth.

1. Introduction

Birth weight is an economically important trait in goats and sheep meat production as it is highly correlated to future weights. It is a determinant of prenatal growth which affect partially post-natal development (Barlow, 1978). Bailgy et al. (1990) reported that birth weight determine the future performance of individuals engaged in a specific environment. Apart from genetics being a predominant determinant of birth size, non-genetic factors have a role to play and can be controlled to achieve high birth weight gains. This implies that birth weight can be improved by selection and better management practices (Atoui et al., 2017). Acharya (1987) in his study reported that season of the year, type of birth, parity, age and weight of dam at kidding are the factors which significantly affect the birth weight. Djemali et al. (1994) working with Barbarine sheep proved that sex, kidding mode, age of dam and kidding year were explanatory variable for variation in birth up until 3 month of age. Litter size, not surprisingly, had the most important influence on birth weight among other being year of birth, maternal birth weight, maternal nutrition, sex of the lamb and maternal body composition at mating (Gardner et al., 2007). Single kids were heavier than twin kids, meanwhile average birth weight increased as age of dam advanced (Khandoker et al., 2018). Birth weights of male lambs were superior against the female lambs, the same trend was observed in their end-of pasture weights and daily live-weight gain (Turkyilmaz and Esenbuga, 2019). Increasing rate of multiple births had a negative effect on birth weight of individual kids mates (Awemu et al., 1999), while the body weight of the dam and the birth weight of their kids had a positive correlation coefficient irrespective of the litter sizes. Interactions of determinants of birth weight have been demonstrated to be important in sheep namely breed by parity, breed by birth type and birth type by parity (Ebangi et al., 1996). This entails that a lower weight of dam may have a negative impact on birth weight of their kids which considered as one of the most important contributory factors for survival and for improving growth performances (Husain et al., 1996). Proportionally, superior birth weights were attained from the lambs born to four year-old dams, meanwhile two-year-old dams were associated with the least birth weight, coincidental for which these were their first lambs (Turkyilmaz and Esenbuga, 2019). Gbangboche et al. (2006) observed that ewes age at first kidding had an influence on the kids' birth weight. On the other hand, the phenotypic correlations of birth weight and other growth performance parameters were reported by (Bathaei and Leroy, 1994), for instance correlations between birth weight and weaning weight, birth weight and average, daily gain and weaning weight and average daily gain were 0.65, 0.53 and 0.96, respectively. The correlation coefficients were significant and comparable to those estimates observed by Fard et al. (1976). Variation in birth weight in some measure is genetic although for the most part is influenced by environmental factors mainly nutrition, management and health (Devendra and Burns, 1983), where most of the heritability estimates for birth weight vary from 0.25 to 0.50. The point to note is that birth weight is highly correlated to anticipated future weights until mature or slaughter weight which can presumably influence meat production. Knowledge of prenatal factors influencing the variation in birth weight is of primary importance with regard to immediate (neonatal) and longer term health and viability (Cogswell and Yip, 1995; Godfrey and Barker, 2001). It is therefore necessary to understand the explanatory variables in size of birth and the present review was

undertaken to give an insight on the determinants of birth weight for instance age of dam, type of birth, sex, year and month of birth.

2. Effect of genotype on birth weight in goats and sheep

Breed was an important source of variation for lamb's body weight from birth to 6 months of age and from 9th months up until 12 months of age (Momoh et al., 2013). The genotype of lambs appeared the most important sources of variation on weight and cannon length at birth, despite maternal-foetal interactions (Dickinson et al., 1962). It was noted that variation in birth weight is partly genetic but largely due to environment especially nutrition, management and health (Devendra and Burns, 1983). Foetal genotype is most important in determining foetal growth during early and mid-pregnancy, whereas maternal genotype is more important in determining foetal growth during late pregnancy when most foetal growth normally occurs and foetal growth is increasingly subject to external influences mediated via the dam. Paternal genotype demonstrated as a substantial source of variation on birth weight in sheep. However, this was contrary to other reports that showed negligible paternal effect on birth weight (Brooks et al., 1995). In a similar study, Kandiwa et al. (2020) reported that 95.3% of the births were over 3 kg is well-substantiated by other earlier studies although the rather greater proportion of Dorper lambs weighing below 3 kg is not supported in these studies (Alemseged and Hacker, 2014; Schoeman and Burger, 1992). Kandiwa et al. (2020) working with Damara lambs, in terms of birth weight the greatest proportions of lambs weighed 3 to <4 kg which was in contrary to results by other studies working with the same breed, whereby female and male Damara lambs weighed 4.2 kg and 4.5 kg, respectively (Du Toit, 1995). The variation in birth weight for the same breed in different flocks, may have been influenced by age, parity, weights, and dam nutrition of these lambs in addition to the seasons of birth (Deligiannis and Lainas, 2000; Petros et al., 2014; Sánchez Dávila et al., 2015). The greater proportion of Swakara lambs weighing 4 to<5 kg can be explained by the inverse relationship between litter size and birth weight since the Swakara had the lowest proportion of twin and triplet births. Birth weight obtained in Turkish indigenous Morkaraman(M) ewes with prolific Romanov rams crosses had superior values against the values reported by Macit et al. (2001) working with purebred Awassi, Morkaraman and Tushin lambs and their crosses, and lower than those reported by Esenbuga and Dayioglu (2002) studying Awassi and Redkaraman lambs, and Ozturk et al. (2012) for Morkaraman lamb. The birth weights in a study of Paim et al. (2013) working with crossbred lambs from five paternal breeds with local hair breed Santa Ines ewes were comparable to Morkaraman lambs, and superior to Romanov x Morkaraman lambs. Somehow different, breed and season interaction had a significant effect on birth weight of progeny despite lambing season alone being not important on Boer goat and Kalahari Red kids' birth weights (Kandiwa et al., 2020). Rosov and Gootwine (2013) reported that breed was not a source of variation for birth weight and also growth after weaning. This discrepancy could be attributed to breed and environmental factors. Fulbe breed was superior in birth weight as compared with Massa, although Massa breed with a smaller birth weight was more adapted to the hot and dry environment than the Fulbe (Ebangi et al., 1996).

3. Effect of parity on birth weight in goats and sheep

In goats, a number of studies concluded that parity was a source of variation in birth weight (Hussain et al., 1996; Mavrogenis, 1983; Ikwegbu et al., 1995). On the other hand, sheep studies carried out in different breeds in various locations demonstrated that parity had influence on lamb birth weight (de la Fuente et al., 1997; Franci et al., 1999; María and Ascaso, 1999; Ploumi and Emmanouilidis, 1999; Sevi et al., 2000). The effect of parity order/dam age was reported in progeny born to mature adult ewes which were heavier than those born from maiden ewes, maiden ewes dropped lighter and smaller lambs at birth (Annett and Carson, 2006). This trend seems to perpetuate until weaning (Safari et al., 2005) and even up to 12 months of age (Loureiro et al., 2011). The major concern on replacement ewes has been that most modern sheep production systems its focused on a replacement strategy of breeding approximately one-third of ewe-lambs at 8-9 months of age. On the other hand, early breeding of ewe-lambs is advantageous as it enhances genetic gain through a reduction in generation interval, by selecting ewe progeny born to ewe-lamb dams to be kept as breeding replacements (Kenyon et al., 2004). Birth weight of kids/lambs generally increased with both the age and the parity of the dam. Paradoxically, however, despite this increase in birth weight, the prevalence of dystocia decreases with both the age and the parity of the dams. In another study, mean birth weight increased up to the fourth pregnancy and, thereafter,

declined (Bermejo et al., 2010). Lambs out of primiparous ewes had lower birth weight as compared with ewes of 5. 3 parturitions. This was ascribable to the fact that maiden ewes had not reached adult size as a result perpetuate growth during gestation consequently competing with the fetus for obtainable nutrients. This is in consonance with the reports for other hair sheep (Macedo and Hummel, 2006). In a comparative study on the influence of maternal environment in different breeds at fourth parity, Dickinson et al. (1962) observed that Lincoln ewes were more superior than Welsh ewes, and on the other hand, even better as compared with the first parity order in Blackfaces ewes. The recorded mean birth weight was 2.6, 1.7 and 1.4 kgs for Lincoln, Welsh and 1st parity in Blackface, respectively, in the same maternal environment. Lincoln and Welsh lambs, in their separate own normal maternal environment, varied by 2.9 kgs. Parity of dam greatly affected birth weight, where birth weight increased with parity. The trend was that highest birth weight was attained within the 4th parity and least in 1st parity, however, there was negligible variation in birth weight between 1st and 2nd parity (Mahal et al., 2013). The effect of parity order on birth weight is imposed as maternal influence whose direct influence is confined to the nursing duration. Does, in their late parities, may have favourable maternal environment for producing heavy kids (Khan, 1980). Birth weight is influenced by the nutrition and genotype of the ewe and by litter size, which is in turn is determined by the parity order and genotype of the ewe (Dickinson et al., 1962). The amount of fleshing and fattening in their body can hinder proper development of the foetus (Moulick and Syrstad, 1970). Additionally, the increasing rate of multiple births may have a negative effect on birth weight of individual kids mates (Awemu et al., 1999). Working with sheep, Hemminki and Gissler (1996) reported that advances in parity other represents correspond to increasing age and age, of itself, has been proposed as an autonomous source of variation on birth weight and neonatal outcome. Wallace et al. (2001) noted that the effect of parity on birth weight is attributed to altered nutrient partitioning in ewe-lamb dams during pregnancy. In mature females, which have reached their biological maturity, during pregnancy more nutrient mobilization is towards foetal development rather than the dam's growth, as a result promoting optimal fetal growth (Bell, 1993; Owens, 1991) consequently improved birth weight. Mode of nutrient mobilization during gestation in maiden dams which can be utilised at the cost of the developing fetus (Wallace et al., 2001). This actualise the environment where the fetus development is compromised due to suboptimal exposure to inadequate levels of nutrition. 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 relationship between plane of nutrition of the dam and birth weight of the kids/lambs has also been of interest. Robinson et al. (1977) observed that undernourishment during late gestation adversely affect birth weight in sheep, On the other hand, dam's own birth weight was a source of variation on her lambs birth weight. This was previously explained by Bradford (1972), Brooks et al. (1995). Collectively, it seemed that maternal body condition preceding pregnancy and late gestational energy intake are decisive with regards to birth weight in sheep. The relationship between maternal nutrition and birth weight has been investigated thoroughly in the sheep in order to determine productive efficiency in sheep, i.e. to achieve maximal output (lambing percentage) with minimal input (Feeding regimes and husbandry; Russel, 1971; Russel and Foot, 1973; Robinson, 1977; Mellor and Matheson, 1979). This appears to be because feed restriction not only reduces the growth of the fetus, but also reduces the growth and skeletal maturity of the growing primiparous animals. Feed restriction of parous animals is much less consistent in its effect upon calf birth weight, with some studies showing a reduction in birth weight of calves born to feed-restricted dams and others showing no effect. Pregnancy developmental stages greatly respond to the level of nutrients supplied to the gravid uterus by the dam, and thus, the reproductive development and performance of offspring later in life may be affected (Bell, 2006; Rhind, 2004; Rhind et al., 2001). In the same context ewe offspring born to undernourished mature dams had decreased ovulation rates (Rae et al., 2002), while ewes born to mature dams undernourished in mid-to-late pregnancy and lactation, gave birth to fewer multiple-born lambs (Gunn et al., 1995). Therefore, it might be expected that ewe progeny born to ewe-lamb dams, exposed to potentially sub-optimal nutrient delivery during gestation, could bear underweight kids/lambs. Taken together, it seems that attempting to manipulate calf birth weight by altering the plane of nutrition of the dam is a relatively unrewarding exercise. Excess feeding does not consistently increase calf birth weight, but can result in dystocia. Underfeeding may reduce calf birth weight in primiparous animals (although the effect is inconsistent in multiparous animals), but any benefit of reduced birth weight seems to be offset by deleterious effects upon the growth of the dam, resulting in an overall increase in the risk of dystocia. Young ewes/does will give birth to smaller kids/lambs, on average, than mature ewes/does, due to at least in part to size and nutritional requirements for growth of young dams, limiting nutrient availability for

placental and foetal growth. Severe maternal nutritional restriction may impact more on birth weights of kids/lambs of young dams as compared to mature ewes/does, particularly among male kids/lambs and those of sires with inherently high birth weight of offspring, presumably due to their greater requirements for nutrients compared with young dams and those of sires with inherently low birth weight of offspring. In adolescent sheep fed to attain excessive fatness prior to and during gestation, placental and foetal growth and birth weight are reduced (Wallace et al., 1996, 1999), although the extent to which over-nutrition of adolescent heifers influences birth weight is not clear. Evidently, late in contrast with early nutritional status greatly affected birth weight in the sheep as this coincide with the period of greatest absolute fetal growth (Mellor and Matheson, 1979).

4. Effect of season on birth weight in goats and sheep

There has been inconsistence in reporting the effects of lambing/kidding season on birth weight, Doaa et al. (2009) and Fasae et al. (2012) observed higher birth weights in winter-bred lambs, in contrary, Barzdina and Kairisa (2015) and Hagan et al. (2014) observed higher birth weights in summer-bred lambs. As expected this discrepancy of the effect of season on birth weight in various studies may be explained by differences of age of dam, parity, weights, and maternal nutrition as well as the overall farm management (Deligiannis and Lainas, 2000; Petros et al., 2014; Sánchez Dávila et al., 2015). It's possible to have within a specific season different classes of dams in terms of their age, body condition and parity, hence these various parameters might have varied impact on the birth weight of individual kids'/lambs birth weight. Kids/lambs born to well fed dams through pregnancy will be heavier than their counterparts, and kids/lambs from born from low parity order dams tend to attain compromised birth weight as compared to higher parity orders. Elsheikh et al. (2013) subscribe to the idea that season was a major source of variation in birth, while studying crossbred male goat kids. The least births were observed in summer season and this response was amply documented with Nubian male kids in Sudan (Elabid, 2002). However, kidding in summer was adversely affected by high temperatures which might negatively affect the dam's appetite and reduced the food intake, as a result leading to low weight kids. Comparatively, young ones born in autumn and winter the pregnancy coincides with favorable nutritional conditions of autumn and winter, as a result their birth weights were improved. It should be noted that discrepancies might be observed in the influence of season on birth weight as a result of differences possibly due to the different breeds, management and environment. The effect of the kidding season is associated with quantity and quality for dam which are known to follow a seasonal pattern, especially in the arid tropics (Najari, 2005). The differential pattern of feed resources from season to season or month to another might affect dam nutrition throughout their pregnancy (Sajlu et al., 1999; Najari et al., 2007). Djemali et al. (1994) Sufficient and quality foraging during the spring season just prior to the onset of summer has consequentially realizing higher birth weights in summer months. This explains the need for scheduling mating in order to coincide conception with adequate nutritional periods that's in itself may promote above average birth weights. Dam which are under nutrished throughout pregnancy are likely to throw kid/lambs of compromised birth weights. This becomes even a major problem in prolific breeders, which bear predominately twins and triplets. Season of birth plays an important role in birth size the lower birth of rainy season born kids emphasized the need to provide supplementary feed and adequate dam management during pregnancy (Mahal et al., 2013). Season did not have significant effect ($p>0.05$) on body weights at birth. However, animals born in the wet season performed better than those born in the other two seasons at 3 and 6 months of age. At 9 months, animals born in the dry cold season were better than those born either during wet or dry season. The pattern of seasonal effect compares well with the reports of Ndlovu and Simela (1996). The non-significant effect of season at birth agrees with Khombe (1985), Ebozoje and Ngere (1995) and Hussain et al. (1996), but is contrary to preweaning superiority of kids born during the wet season over those born during the other seasons reported by Ikwegbu et al. (1995). Kids born in the wet seasons performed better other kids at 3 months and 6 months of age perhaps due to availability of pasture of the right quality and quantity (Chawla et al., 1984) since kids born during these periods are not normally given supplementation. The superiority of animals born in the dry cold season over those born in the dry hot and wet seasons at nine months, which agrees with the reports of Das and Sendalo (1992), Karua and Banda (1994) and Lyatuu et al. (1994), may not be unconnected with tethering carried out during the wet season that led to poor growth (Karua and Banda, 1992). During the hot season restriction is removed and animals also have access to farm left over for fast growth. Previous work on the effects of sea-son of birth on kid performance has primarily focused on differences between wet and dry seasons. The wet season increased birth weight in kids when compared to the dry season according to reports by Baiden (2007) and

Awemu et al. (1999). However, Al-Shorepy et al. (2002) reported that birth weight was not affected by season. The explanation for comparable birth weight among kids/lambs born during different seasons of the year is the maintenance of good body condition throughout the year hence dams will have performed at or near their production potential mitigating the effect of season. The seasonal effect as a source of variation on birth weight may be due to changes in the weather (long dry season), which directly influence feed availability. Feed availability has an impact on the nutritional status of the pregnant ewe which becomes limiting especially during the hot dry and cold dry seasons. This is transmitted to the lamb through the prenatal developmental maternal environment (Ebangi et al., 1996).

5. Effect of year on birth weight in goats and sheep

Year of kidding /lambing is one of the important factor that influence birth weight. It is well established that year of birth causes variations on weight and performance of hair lambs due to climatic variations and management during pregnancy (Segura et al., 1996). The variation in birth weight due to year of kidding/lambing is related to feed resources following a seasonal trend within years, or inconsistency in management practices with regards to feeding and fluctuating climatic conditions (Atoui et al., 2017). This result has been supported by Alexander et al. (1997), Zhang et al. (2006) and Najari et al. (2007). In a similar study Ouni (2006) cited higher variation on birth weight due to year of birth as a consequence of variations in amount of annual rainfall which has a bearing on pasture production and availability of feed for the dam especially in late pregnancy, which then affect the birth weight of kids. Momoh et al. (2013) reported that lambs born in the rainy season (early and late) outclassed those born in the dry season (early and late) in terms of birth weight. Additionally, lambs dropped in early rainy season were superior in birth weight, succeeded by those born in the late rainy season. Predictably dry season supplementation of pregnant ewes with concentrate feed will enhance birth weight in flocks. More often than not, effect of year of birth on birth weight is associated with the effect of climatic condition (rate of rainfall, humidity and temperature), environmental and management conditions. Climate and environmental variation are determinants of quality and quantity of pasture forages, therefore affecting the provision of grazing and other requirements for pregnant dams hence influencing their progeny's weight at birth. There is some indirect effect on birth weight due to changes in dam's nutrition status in the last weeks of pregnancy at different seasons and years. Nutritional status coinciding with pregnancy, general management and health in various years, are the justification for the effect of birth year on birth weight and other body weights at determined ages (Hassan and Seyed, 2009). Year of birth was a source of variation on overall birth weight, this was caused by the predominantly bearing of singleton which on average, went up to 1.0 kg. However, this happened despite no obvious changes in flock management, nutrition and other factors known to influence birth weight in the sheep. Therefore, the assumption was that climatic variation should have had an overall determination on birth weight before or during pregnancy (Gardner et al., 2007). On the other, despite year of birth being a major determinant on birth weight, years are not repeatable and their decisive effects are of limited interest (Ebangi et al., 1996). With the exception of body weight at 6 months of age, year of birth had significant effect ($p<0.05$) on weights at different ages. This is comparable to reports in the literature. Mvrogenis (1983) made similar observation on Damascus goats. Ikwegbu et al. (1995) reported significant year effect on growth of WAD goats in the Sub humid Nigeria. Opther investigators that made similar reports include Khombe (1985), Kassahum et al. (1989) and Karua and Banda (1994). The significant effect of year on weight is not unusual since, there is bound to be differences in management, feeding, sanitary conditions and body conditions of animals from year to year. Growth is also likely to fall when there is adequate or too much rain. This reduces grazing period and feed availability (Karua and Banda, 1994). The result of this study however contradicts the non-significant year effect on body weights of Black Bengal goats (aged one to 12 months reported by Das and Sendalo (1992) and Hussain et al. (1996).

6. Effect of sex on birth weight in goats and sheep

Various authors reported that sex of kid was an important source of variation for birth weight (Andries, 2013; Al-Shorepy et al., 2002; Browning and Leite-Browning, 2011; Mourad and Anous, 1998; Wilson and Light, 1986). The average birth weight and weights at other ages including pre- and post-weaning growth rates exhibited that the male lambs were superior in growth than female lambs (Momoh et al., 2013). In a similar study the sex was an important source of variation on birth weight and all growth traits, which were consistent from birth to yearling

weight. This was explained by sex determinants chromosomes, probably in the location of genes associated with growth characteristics, endocrinological influence dependent on type and concentration of hormone secretion, mainly sex hormones which might impact on variation in growth characteristics. As expected with regards to sex hormones, estrogen predominantly in females had a limited effect on the growth of long bones. Rashidi et al. (2008) cited that this could be the major cause of smaller body and lighter weight in females as compared with males. In a similar study (Hafez, 1962) attributed sex effect on growth in livestock was dependent on hormonal effect. This implies superior birth weight and growth in males' prenatal phase is under the influence of anabolic effect. On the other hand, after sexual maturity, males start secretion of androgenic substances which facilitate superior growth and development than female counterparts (Ebangi et al., 1996). Tunisian local goat population kids the average birth weight for male and female were 2.46 ± 0.44 and 2.20 ± 0.39Kg respectively (Atoui et al., 2017) indicating that males were heavier than females. Robinson et al. (1977), de Zegher et al. (1999) and Cruickshank et al. (2005) in their study after considering all relevant factors male offspring were larger (~300-400 g) than female offspring at birth in the sheep. Bucklings were superior in birth (3.23 kg) with reference with doelings (2.75 kg) at birth and this was consistent with result by Ugur et al. (2004). Most of reports point to the fact that males were heavier than females not only at birth but also on post weaning ages. Herold et al. (2007) observed that birth weight of kids was highly influenced by sex, genotype and age of doe. This was in support with previous reports of Singh (1985), Panandam et al. (1992) and Schröder (1995) subject to sex and with Snell (1996) subject to sex and age of doe. Turkyilmaz and Esenbuga (2019), Birth weights of male lambs were significantly heavier than the female lambs and their end-of pasture weights and daily live-weight gain were also significantly higher. Single-born lambs were heavier than multiple-born lambs in terms of birth weight, weaning weight and end-of-pasture weights. Superior birth weight was recorded in male against female by Herold et al. (2007) and in agreement with previous studies by f Wenzhbong et al. (2005) and Djemali et al. (1994). Ebozoje et al. (1995) reported significant effect of age at birth, 3 and 5 months. Alexandre et al. (1999) similarly found gender differences at birth, 10, 30 and 70 days of age. Hussain et al. (1996) and Awemu et al. (1999) however, found non-significant effect of sex in Common African X Alpine crossbred and Red Sokoto goats respectively. In their findings Murad and Anous (1998) reported non-significant sex effect only at birth while Ndlovu and Simela (1998) reported non-significant sex effect at birth and between 90 and 180 days of age. Males are heavier than females because of longer gestation length (Ebozoje et al., 1995). Disparity in weights of the two kids, especially at birth, may also be due to foetal hormones which promote higher skeletal; growth in males (Awemu et al., 1999). Evidently, the existence of a Y-chromosome and the products of *sry* gene activation, e.g. androgens and mullerian-inhibitor substance (Haqq et al., 1994), has sex-definitive effects on fetal growth. Males performance in relation to growth turn up to grow faster as compared with females *in utero* (de Zegher et al., 1999; Loos et al., 2001). Male outclassed females in birth weight, this was supported by result elsewhere by Gebrelul et al. (1993), where the margin of variation of males and females was about 200g, and this resulted was in agreement with Alexandre et al. (1997). In explanation, Ugur et al. (2004) cited that the difference in weight between both sexes was ascribable to the fact that the pregnancy period of does with prospective male kids is delayed (1-2 days longer) as compared with dams carrying female. The interaction between sex and type of birth was a noticeable source of variation for birth weight (Atoui et al., 2017). Male kids born as singles were heavier at birth as compared to multiples by Mbayahaga (2000). Najari (2005) mentioned that this trend continued in the same way till four and six months of age.

7. Effect of birth type on birth weight in goats and sheep

Single-born lambs were heavier than multiple-born lambs in terms of birth weight, in addition to weaning weight and end-of-pasture weights (Turkyilmaz and Esenbuga, 2019). Herold et al. (2007) observed that mean birth weight of kids were superior singletons as compared with twins. This was in agreement to reports by Gebrulul et al. (1994) who proved that twins or triplets tended to have lower birth weights. With the exception of type of birth had no influence on birth weight. This is contrary to Singh (1985) who observed that a considerable effect of birth type on birth weight and a negative correlation between both. In Teddy goats, birth weight was greatly influenced by birth type and singletons were the heaviest within affected birth type (Hyder et al., 2002). In singleton pregnancies from multiparous ewes, maternal constraint is barely evident and fetal growth is limited only by fetal genotype - itself conditioned by evolutionary factors (Kuzawa, 2005). The trend showed that birth weight declined with an increase in number of kids born. Twin, triplet and quadruplet born kids weighed 1.55 ±

0.05, 1.46 ± 0.05 and 1.03 ± 0.13 kg, respectively. The superior birth weight of single born kids with reference to multiple births is ascribable to the allocation of uterine space and utilisation of uterine nutrient by the fetus of multiple births resulting to lowered birth weight. This might be related to dams' weight at kidding, where heavier dams give birth to heavier kids at birth as compared to underweight dam. The reason for such variation is that properly fed dams have a high body condition score as indicated by heavier weight at kidding resulting in provision of a better nutritional environment for the foetal growth and size. The same trend was reported by other authors: Mittal (1979) in Barbari and Jamunapari goat; Mukundan el al. (1981) in Malabari and its crosses; Roy et al. (1989) in Jamunapari goats and Singh et al. (2000) in Beetal halfbred goats. The alliance over maternal nutrition and birth weight has been studied intensively in the sheep that one may understand productive efficiency in sheep, i.e. to maximise on performance (lambing percentage) with nominal input (Feeding regimes and husbandry; Russel, 1971; Russel and Foot, 1973; Robinson, 1977; Mellor and Matheson, 1979). A positive relationship has been reported of higher birth weight and single-born lambs as compared with multiple-born lambs (Aldridge et al., 2015; Hebart and Brien, 2018; Juengel et al., 2018). Other researchers have found that type of birth has an impact on birth weight in similar works (Browning and Leite-Browning, 2011; Martiney et al., 2010; Mellado et al., 2011; Mourad and Anous, 1998; Sanchez et al., 1994). However, Baiden (2007) reported no difference between single- and twin-born kids but showed that single-born were heavier than triplet-born kids. Low birth weights influence insufficient energy reserved which makes highly susceptible to the effects of harsh environments reducing kids'/lamb survival (Curtis, 1969). Litter size had significant effect on birth weight. Birth weight tended to decrease with increasing litter size, though differences became visible with advancing age. The maternal uterine space has a finite capacity to gestate lambs and as litter size increases individual birth weights decreases due to a maternal limitation of fetal development (Bermejo et al., 2010). At birth, singles performed better than multiple due to competition for uterine space and available nutrients (Awemu et al., 1999). There is an inverse relationship between birth weight and litter size (Balta and Topal, 2018; Chay Canul et al., 2019; Hagan et al., 2014). Hussain et al. (1996) also reported persistency of effect of birth type from birth to yearling age. Mourad and Anous (1998) and Alexandre et al. (1999) made similar observations in Common African, Alpine and Alpine crossbred goats respectively. However, Ikwegbu et al. (1995) found that the effect of litter size was not significant at any age except at birth. This greater proportion of underweight lambs by Dorper standards may have resulted from the greater proportions of twins and triplets (Kandiwa et al., 2020). The lambs of multiparous ewes were significantly heavier than primiparous ewes at birth ($P < 0.01$) and were significantly heavier at weaning age (Lv et al., 2016). Low birth weight is common in goats and sheep and has been found to cause lasting growth and developmental deficits later in life. It is thought that the primary cause is intra-uterine growth restriction (IUGR) due to a shortage of oxygen and supply of nutrients to the fetus. Twins and multiples birth are rare in majority goats and sheep breeds except where exogenous regulation of ovarian function or embryo transfer biotechnologies are exploited. Multiple birth have compromised foetal growth with reference to singletons as a result of number of placentomes and mass of placenta per foetus (Hafez and Rajakoski, 1964; Greenwood et al., 2000b) and greater nutritional requirement for dams carrying multiple fetuses. Nutritional deficiency restricts foetal growth prior and the effect is predominantly in twins or higher in multiple foetuses as compared to singletons (Wilkins et al., 1994). Inconsistent to this study, Kremer et al. (2010) reported that type of birth as much as breed had no influence on birth weight.

8. Effect of dam age, weight and nutrition on birth weight in goats and sheep

The birth weight was uppermost in 5 years' age dam group, and also the weight of the dam was an important determinant of birth of kids of both sexes (Atoui et al., 2017). Dam's weight is also related to birth weight of kids and this may be due to favourable maternal environment as evidenced by the higher body weight at kidding reported by Prasad et al. (1972) and Khan (1980) in Barbari and Jamnapari breeds, respectively. The higher birth weight of kids may also be due to the size and weight of dam and buck used at the time of mating. Higher birth weight in intensive system is possible due to higher nutrition which might ensure subsequent better embryonic development during the pregnancy period. This implies that the intrauterine environment is a nutritionally fortified maternal environment to sustain a single kid, limited competition meanwhile more space might facilitate growth (Mahal et al., 2013). The uterine space and available nutrient allotted to more than one kid may be the main reason for the reduced birth weight with increasing litter size. In a similar, Ismail et al. (2011) suggested that improved average birth weight in Sudanese Desert goats was a result of improved management accompanied by supplementation of concentrates in-door. Dam nutrition during pregnancy is very crucial because it influences the

size of birth. As a matter of fact, the dam nutrition throughout this period characterise an influential aspect in the regulation of foetal and placental development (Atoui et al., 2017). Maternal adaptive regulations ensure uterine nutritional partitioning to maximize maintenance of fetal growth. As the maternal environment became poorer, genotypic differences remained distinct but decreased in magnitude. The age of dam had an influence on birth weight, where the uppermost birth weight was observed in 5-year dam group and minimum in first kidding dams (Wenzhbong et al., 2005). Similar results were reported by Djemali et al. (1994) who observed that kids born from young dams exhibited lower body weights as compared with matures dams, furthermore weight traits improved with the age of dam up to 5 years of age. Kids born from underweight dams or in poor condition are consistently the most impaired and this effect has been described elsewhere (Djemali et al., 1994; Mbayahaga, 2000). The inferior dam weight may have an adverse effect on birth weight of their kids as it influences survival and post weaning growth performances (Husain et al., 1996). The improvement of feeding program of does before mating (flushing) and during pregnancy is essential to improve birth size in goats and sheep. Growth of the bovine foetus has well-studied consequences for survival (Holland and Odde, 1992) and can be slowed during the latter half of gestation by restricted nutrition and/or inadequate placental development (Bell et al., 2005).

9. Birth related performance in goats and sheep

Birth weight as an early measurable trait and is of great interest because of its positive genetic and phenotypic correlations with further live weights (Madeli and Patro, 1984; Roy et al., 1989). Its considered as important traits because there is a positive correlation between birth weight and growth rate, age at maturity and mature body weight (Banerjee, 1989), which influence the future productive and reproductive performance of the animal. Several factors influence birth weight, goat and sheep producers prefer near flock average birth weight because they are associated with better performance during subsequent rearing phases. Birth weight as well as weaning weight, growth rate and average daily gain are the major factors that derive the viability of a goat and sheep meat enterprise. These traits are dependent on poly genes, besides being influenced by feeding practices, climatic factors and management under farm conditions (Dabbir, 2018). Birth weight is a relevant parameter which explains variation in vitality, post weaning performance and survivability of kids/lambs. The point to note is that birth weight is highly correlated to anticipated future weights until mature or slaughter weight which can presumably influence meat production. The correlation between kid/lamb birth weight and their subsequent performance has been extensively reported in the literature. The positive association between birth weight and post-weaning weight gain and body weight, is perpetuated up until slaughter age. The birth weight in goats and sheep is influenced by both genetic and environmental factors and their interactions. It is therefore necessary understand the explanatory variables in size of birth and the present review was undertaken to give an insight on the determinants of birth weight for instance age of dam, type of birth, sex, year and month of birth. Birth weight as an early measurable trait is of great interest because of its positive genetic correlation with further live weights (Madeli and Patro, 1984; Roy et al., 1989). Birth weight is an economically important trait in goats and sheep meat production. It is a determinant of prenatal growth and which affect partially in post-natal development (Barlow, 1978). Bailgy et al. (1990), reported that birth weight determine the future performance of individual engaged in prevailing environment. Birth weight was influenced by genetic and non-genetic factors which show that environmental factors can be controlled to achieve higher gains, this implies that birth weight can be improved by selection and better management practices (Atoui et al., 2017). A positive relationship has been reported of higher birth weight and single-born lambs as compared with multiple-born lambs (Aldridge et al., 2015; Hebart and Brien, 2018; Juengel et al., 2018). The phenotypic correlations of birth weight and other growth performance parameters were reported by (Bathaei and Leroy, 1994), for instance correlations between birth weight and weaning weight, birth weight and average, daily gain and weaning weight and average daily gain were 0.65, 0.53 and 0.96, respectively. The correlation coefficients were significant and comparable to those estimates observed by Fard et al. (1976). Birth weights of male lambs were superior against the female lambs, the same trend was observed in their end-of pasture weights and daily live-weight gain (Turkyilmaz and Esenbuga, 2019). Herold et al. (2007) Birth weight had a significant influence on daily weight gain during the period of landscape management. Kids with higher birth weight showed a slightly better weight gain during this period of restricted feeding. That heavier kid/lambs at birth were also heavier at weaning. However, these authors did not observe a correlation between birth weight and daily weight gain during suckling and attributed this result to the litter birth weight equalization. Villette and Theriez (1981) found that the carcass of lambs exhibiting a low birth weight contained more fat and

less bone. The chemical composition of the carcass as well as that of the body weight showed a higher fat content and lower water content. However, those results were not significant birth weight had a significant effect on a few carcass parts (oyster with shoulder, back, breast) and also on gigot girth and gigot length. Therefore, higher birth weight in kids implies a high probability of a better carcass performance especially in some valuable parts. Birth weight of kids was found to be negatively correlated with survival and positively correlated with subsequent weight gain (Sebei et al., 1994). Low birth weights influence insufficient energy reserved which makes highly susceptible to the effects of harsh environments reducing kids'/lambs survival (Curtis, 1969). Singh et al. (1990) and Awemu et al. (1999) proofed a significant influence of birth type on survivability of kids. Lamb survival is impaired in low birth weight lambs, and those that are slow to stand and suck. Many of the factors that influence lamb vigour, such as parity, litter size, and breed, may exert their effects, at least partially, before birth by influencing placenta development (Dwyer et al., 2005). Kandiwa et al. (2020) subscribed to the notion that high average birth weight as a result of small sized litter mostly single birth, were conceivable interpretation for the relatively low mortality rate in a goat and sheep study in Namibia. The understanding the determinants of birth weight pose practical implications not only for goat and sheep meat production in terms of livestock and economical commodity on top of that, and essentially, for the increased knowledge of factors that are sources of variation in birth weight; as birth weight itself has become a predominant predictor of later kid/lamb performance, survivability and health outcomes. Generally, the studies on the determinants on birth weight are also often complicated due to the external confounding factors that may influence birth weight, most interaction of breed and other factors on birth weight tend to be significant.

10. Implications for birth size in goats and sheep production

Birth is an important weight trait in goat and sheep meat production as it is highly correlated with future weight up until weaning. The greater the birth weight highly likely that kid/lambs might attain desirable pre-weaning growth rates and the actual weaning weights, assuming that they are exposed to optimal nutrition. Predictably birth weight and weaning weight are highly correlated, hence they equally predict the overall post-weaning growth performance and carcass performance. Apart from the genetics of the animal, other factors such as nutrition, parity order, sex of animal, age and weight of dam, year/season and management have an impact on birth weight. Reflecting various explanatory variable on birth weight, most studies in goats and sheep are agreeable that there is an important relationship between the dam body condition status or nutrition of the late pregnant dam and birth weight. A pronounced effect of litter size, with compromised birth size in kids/lambs born as triplets being lower as compared with those born as twins, which in turn is lower than that in ids/lambs born as singles. The association between maternal birth weight and kid/lamb birth weight has also been verified, instance as maternal birth weight increases, so does the kid/lamb's birth weight. Male tend to outclass females in birth weight due to the influence of male growth hormones. Kids/lambs of primiparous ewes/does have a birth weight disadvantage, hence producers should consider alternatives for managing underweight birth on an individual flock basis. It is reasonably to suggest that creep feeding during suckling might significantly promote superior post weaning growth if the initial weight at birth of kids/lambs are comparable high. This entails as a feed cost reduction measure that supplementation should only be provided to low birth weight kids/lambs in order to obtain less variation in weaning weight. The kidding season greatly influence birth weight due to its bearing on availability of forage during the last trimester, hence it is suggested that mating schedules for dams should be designed in a manner where pregnancies should coincide with adequate grazing in order to attain optimal birth size. The identification and attending to factors that impact on birth weight will result in enhance meat productivity, furthermore, knowledge of the indicators of birth weight assist in making better management decisions, which means a better return on investment for producers. In conclusion, all of factors of concern as determinants of birth size should be considered in farm management decision making processes in order to reduce the effect of poor year/season and low parity order hence improving overall goats'/sheep farm's productivity and profitability.

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