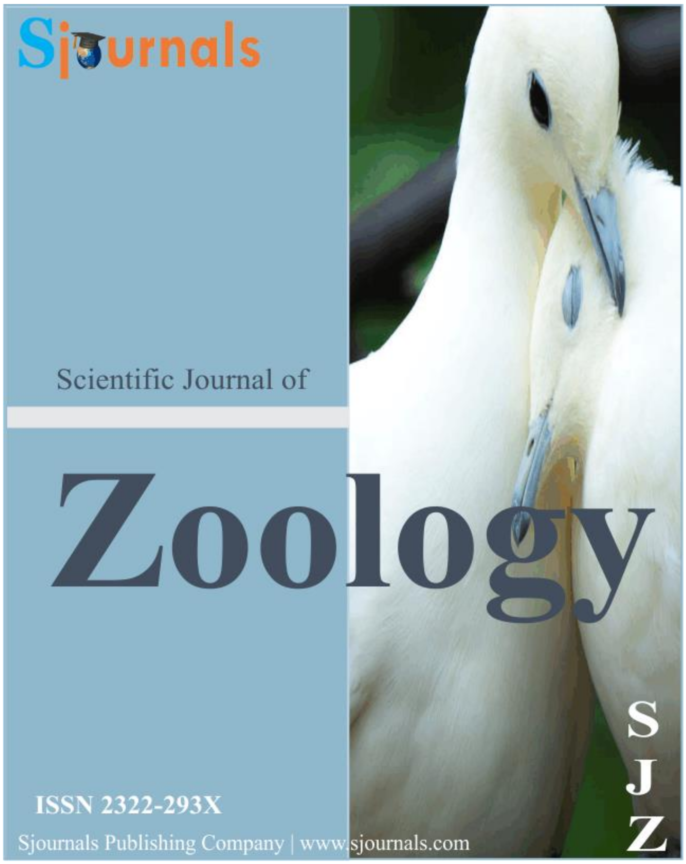
Sjournals
Scientific Journal of
Zoology
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ISSN 2322-293X
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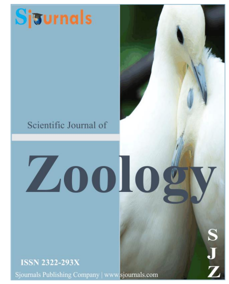
Sjournals
Scientific Journals
Scientific Journal of Zoology (2020) 9(2) 138-151
ISSN 2322-293X
doi: 10.14196/sjz.v9i2.1510



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Scientific Journal of **Zoology**
Journal homepage: www.sjournals.com

Review article

Aspects of litter size (birth type) in goats and sheep production

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ARTICLE INFO

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

Keywords,
Litter size
Non-genetic factors
Goats
Sheep

ABSTRACT

Increasing kid/lamb production is of paramount importance to goat and sheep producers. As a matter of one choice enhancing litter size becomes inevitable, because apart from litter size impacting on flock productivity, it is also implored as a major determinant of profitability due to its influence on kid/lamb survivability. There is a positive correlation between litter size and lifelong dam contribution and overall flock productivity. Increasing litter size to an optimal level might be crucial especially for the intensive goat and sheep production systems. A number of studies have proved that litter size is under the influence of both genetic and non-genetic factors. Currently, genome wide selection targeting established genetic markers is being employed to increase the efficiency of goat and sheep selection for reproductive traits, such as prolificity. This is on the background that litter size is lowly heritable, but on the other hand, immense genetic variability between and within breeds exist that could be exploited in breeding schemes by collaborating additive polygenic differences, breed complementarities, heterosis effects and major gene inheritance. Among the non-genetic factors that influence litter size in goats and sheep, parity order, age of dam and seasonal variation have been rated highly. Litter size tend to improve with age and parity order as a result it is highly likely that dams with large previous litter size may have high chances of producing multiple births in consecutive kidding/lambing. Environmental conditions are also an important source of variation on litter size, with chances of large litter size within natural reproductive seasons.

Seasonal influence might be confounded by other factors such as flock nutritional management and genetic improvement strategies. The adverse effect of increase in litter size has been associated with an increase in number of underweight kids/lambs which in turn lower their survival rates. Underweight at birth is the probable explanation for reduced kid/lamb viability in goats and sheep. This entails a balance should be strike on optimal litter size, where too large and/or too small litter size may be impracticable desired and/or uneconomical, respectively. Proffered suggestion is that litter size of two is economically feasible for an intensive goat and sheep enterprise. The present review gives an insight on the influence of litter on flock performance and discuss the factors that are the major determinants of litter size in goat and sheep meat production.

1. Introduction

Litter size at birth is considered to be a useful measure of reproductive performance (Kebede et al., 2012; Mia et al., 2013; Deribe and Taye, 2014). It is one of the most important reproductive traits in goats and sheep with a pronounced consequence on flock productivity in turn acting as a major determinant on profitability. Acil and Demirci (1983) reported that the average litter sizes for sheep and goats were 1.23 and 1.47, respectively. Litter size is influenced by multiple genes and loci inclusive of environmental factors of maternal effects namely maternal age and intrauterine endowment (de Lima et al., 2020). Heritability of litter size ranging from low and close to zero were reported in different studies in goats (Maghsoudi et al., 2009; Rashidi et al., 2011). In spite of its low heritability, litter size has substantial genetic variability between and within breeds as displayed in various studies (Haldar et al., 2014; Sarmento et al., 2010; Hamed et al., 2009). This variability could be exploited in small ruminant breeding schemes by collaborating additive polygenic differences, breed complementarities, heterosis effects and major gene inheritance (Elsen et al., 1994). Among the non-genetic factors that influence litter size in goats and sheep, parity order (Macías-Cruz et al., 2012), age of dam (Haldar et al., 2014) and seasonal variation (Sánchez-Dávila et al., 2015) have been rated highly. Amoah and Gelaye (1990) observed that age and parity order were major sources of variation in litter size in goats, while Awemu et al. (1999) established that in addition to parity order, year and season were important determinants of litter size. Multiparous ewes outperformed primiparous ewes on average litter size, while Chios and East Friesian x Chios crossbred ewes had considerably larger litter size at first and subsequent lactations than Awassi and Awassi crossbred ewes (Mavrogenis, 1992). Haga et al. (2014) noted that the chances of multiple birth increased with increased dam age up to 4 years of age and slightly declined at 5 years of age. Alabe et al. (2008) reported that litter size was a source of variation on live weight at all ages in goats, and this trend displayed a tendency of live weight decreased with increase in litter size, even though the variation was clearly conspicuous as age advanced. A progressive increase of litter size of 1.09 to 1.42 by age of dam was observed by Kominakis et al. (1998) in Boutsico dairy sheep. Conception of plurality of foetuses plays a leading role in reduction in weight at birth (Gootwine, 2005), and as an illustration singletons outperformed multiple-born lambs with respect to birth weight, weaning weight and end-of-pasture weights (Turkyilmaz and Esenbuga, 2019). In sheep, increased fecundity was related to enhancement in the proportion of triplet-born lambs (Amer et al., 1999). Triplets had low survival rates and reduced weaning weights with reference to their singleton and twin-born birth types. Due to goats and sheep breed diversity and differences in adaptability, breeds can exploit different climatic conditions such as prevailing climate change, which impinge on the management and nutrition practices, hence influencing the litter size (Gbangboche et al., 2006; Chniter et al., 2011). Litter size was depressed by 0.55 lambs between May and September as an indication of ewes' sensitivity to changes in day length throughout the breeding season, and similar results were observed by Sormunen-Cristian and Suvela (1999). Lower litter size observed by Çetin et al. (2003) was related to mating season when goats were mated in June, which seemed a little early for the mating of Kilis goats. In conformity with this result, Keskin (2003) reported that breeding month had an effect on the goat's reproductive performance (Keskin, 2003). The present review gives an insight on the influence of litter size on flock performance and survival, and discuss the factors that are the major determinants of litter size in goat and sheep meat production. The present review gives an insight on the influence of litter on flock performance and discuss the factors that are the major determinants of litter size in goat and sheep meat production.

2. Litter size in goat and sheep breeding and genetics

Breed is a major source of variation in litter size in goats, with lighter breeds e.g. Pygmy breed been associated with larger litters (Amoah et al., 1996). The litter size or the number of kids born per doe kidding is dependent on the ovulation rate, or the number of ova released during ovulation, this phenomenon differs with genotype. Acil and Demirci (1983) working with different breeds of goats in Turkey observed that the average litter size in White Karaman, Red Karaman, Dağliç, Awassi, Karakul, Karayaka and Tuj breeds differed from 0.01 to 1.1, while the most prolific Sakiz breed had an average litter size of 1.7 - 2.3, which was higher than Central Anatolian Merino which produced a litter size of 1.4 - 1.5. and the Kivircik and Gökceada breeds featured in the order of 1.1 - 1.2, respectively. Elsewhere the average litter sizes of Boer and Okinawa meat goats were 1.6 and 2.0, respectively (Hirakawa et al., 2008). Elieser et al. (2012) reported average litter size for Boer goats (1.75) which was comparable to Boer goats in China (1.76) (Zhang et al., 2009), and elsewhere Dwarf goat (1.8) (Khanum et al., 2007), and the Korean native goat (1.78) (Song et al., 2006), but lower than the Matou native goat (2.14) (Moaeenud-Din et al., 2008) reared in the same region, and the West African Dwarf goat (1.93) (Baiden, 2007). The mean of litter size of Kacang goats (1.53) was higher than (1.23) the result reported by Doloksaribu et al. (2005). Genetics has been implicated as an important determinant of litter size in goats (An et al., 2009; Chu et al., 2011; Feng et al., 2011). However, the genetic mechanisms of litter size in domestic sheep (Ovis aries) are still poorly understood (Xu et al., 2018). However, recently various studies are being carried out to explore genetic mechanisms underlying the variation in litter size in different sheep breeds using genomic science. The heritability of litter size is generally low, as expected of reproductive traits, and elsewhere in sheep, Bradford (1985) reported heritability estimates for litter size ranging from 0.15 - 0.35, this was from 30 studies for various breeds using different methods of analysis. In a similar study, heritability of litter size ranging from low and close to zero were reported in different studies in goats (Maghsoudi et al., 2009; Rashidi et al., 2011). Litter size is a low heritable trait, which approximately 0.10, allowing changes of up to 2%/year from simple mass selection. Due to the low literature estimates of heritability for reproductive traits (Hamed et al., 2009; Mia et al., 2013; Menezes et al., 2016), the expected genetic selection targeting the reproductive performance of the parents may not be effective for genetic improvement (Mellado et al., 2006) hence use of records of differences between low and high ranking individual reproducers in their early life might be a feasible option in order to improve productivity in goat flocks. The substantial levels of genetic variation between and within breeds but low to moderate heritability estimates for litter size would limit the accuracy of breeding value estimates for individual does and for individual sires but would permit reasonable rates of genetic improvement across the entire population of goats and sheep. On the other hand, estimated for genetic and phenotypic correlation estimates for litter size and ovulation rates and scrotal circumference are positive, and selection for any of the traits would result in a corresponding improvement in litter size. Ovulation rates have both high levels of phenotypic variation and a relatively high heritability estimate, indicating that substantial genetic progress could be achieved for this trait and would, most importantly, potentially target for indirect selection for litter size. Kominakis et al. (1998) observed heritability and repeatability of 0.07 and 0.11 for litter size in Boutsico dairy sheep. In a summary of a wide range of heritability estimates in literature review, Fogarty (1995) derived an average heritability at an approximate of 0.07 while using REML methodology. In a similar study using the same methodology, Al-Shorepy and Notter (1994) observed that heritability and repeatability of litter size were ranging from 0.05-0.10 and 0.12-0.15, respectively. Working with Spanish Segurena sheep, Analla et al. (1997) reported heritability and repeatability estimates of 0.08 and 0.14, respectively. As expected the heritability for traits associated with reproduction are generally low hence selection on litter size directly will not be expected to be efficient. Reproduction traits are generally characterised by low to medium heritabilities and do not display a distinguishable response to phenotypic selection. In such cases indirect selection could be employed for genetic improvement of litter size. There is evidence that ovulation rate and scrotal circumference are highly correlated with litter size hence due to their high heritability genetic improvement can be alternately achieved through targeting such traits. This will on the other hand improve selection accuracy of litter size. The only challenge on targeting ovulation rated for indirect selection for litter size is that it may be difficult to measure ovulation rates under extensive animal production environment, hence suggestion have been made that use of scrotal circumference may be a feasible and possible more efficient than selection on litter size alone (Waldron and Thomas, 1992). It should be noted that use of multiple records on relatives in the pedigree will enhance selection accuracy for litter size for selecting breeding animals. Therefore, inclusion of multiple genetic sources of information of the genes related with reproductive ability could efficiently enhance the selection response. A low heritability it's an indication of low chances of achieving rapid genetic progress based on phenotypic selection. In other words, additive genetic effects have little effects on reproduction traits, while environmental and non-additive genetic effects considerably affect these traits. Close to zero environmental correlations were established between litter size and weight traits. Analla et al. (1997) reported genetic correlations were 0.18, 0.48 and 0.36 between litter size and birth weight, weaning weight, and weight at 90 d, respectively. Therefore, genetic correlations between litter size and weight traits being all positive, no deterioration of breeding values of weight traits could be expected, when selecting for litter size (Miguel Mellado et al., 2011). In spite of its low heritability, litter size has substantial genetic variability between and within breeds as displayed in various studies (Haldar et al., 2014; Sarmento et al., 2010; Hamed et al., 2009). This variability could be exploited in small ruminant breeding schemes by collaborating additive polygenic differences, breed complementarities, heterosis effects and major gene inheritance (Elsen et al., 1994). A number of mutations of a major effect on litter size have been identified in various sheep breeds (Xu and Li, 2017). In its intent selection for higher prolificacy in domestic sheep (Ovis aries) has brought about variability in litter size within and among breeds. This has resulted into individual litter size of 1 to 8 which has been observed in the Hu sheep and Finn sheep (Yue, 1996; Davis et al., 2006). Breed differences in litter size amongst goat breeds was explained by variation in ovulate rates, while Amoah et al. (1996) cited that other goat breeds rarely ovulate more than three eggs as a result it is highly unlikely to carry quadruplets. Rashidi et al. (2011) working with Markhoz goat a native breed in Iran observed twinning rate of approximately 26%, and triplet births were also experienced. Corresponding results were reported previously in studies involving fecund breeds or strains (Maund et al., 1980; Brand et al., 1985; Scales et al., 1986). SA Mutton Merino ewes had larger litters at birth than Dormers (Cloete, 1992). The higher multiple birth rate of SA Mutton Merino ewes and lambs compared to Dormers is in conformity with previous results (Brand et al., 1985). Olkuska sheep are rated by extraordinarily high prolificacy and good maternal abilities, with single lambing per year, the mean litter size of two and over two years old ewes is at least two (IZ-PIB 2005). The high prolificacy is genetically influenced by a single gene of a major effect which increase ovulation rate in carriers (Martyniuk, 2009). Sheep fertility is dependent on breed being influenced by either polygenic or a major segregating gene designated the Fec gene. Kumar et al. (2008) evaluating litter size in FecB introgressed Garole x Malpura crossbred sheep, observed that average litter size of BB ewes (2.17+/-0.24) was significantly higher ($P<0.01$) than that of B+ ewes (1.73+/-0.04) and ++ ewes (1.03+/-0.23). In their work, Chen et al. (2015) observed that the prolific B allele transmitted to hybrids by crossing with Han sheep, the litter size was enhanced in the developing sheep breed by marker-assisted selection. This entails apart from growth traits, the prolificacy is equally an important economic trait in sheep breeding and meat production, which breeders should focus to consider into a breed with high efficiency. Sustenance of desirable optimal degree of actualized fertility (defined as the percentage of ewes that lamb) and acceptable levels of fecundity are crucial for efficient sheep production (Notter, 2008). The realized intensity of fecundity in most circumstances is considerably less the utmost achievable peak. This can be corrected by combining selection among and within breeds with use of an expanding array of single-gene mutations influencing ovulation rate and litter size. It has been established that specific major genes increase litter size in certain sheep breeds, hence study focus on genes associated with litter size in small ruminants is of high importance, as they could be used in breeding programmes as selection markers for increasing production efficiency (Kaczor, 2017). When specific genetic makers related to litter size are established, then marker-assisted selection can be applied to improve the selection of litter size (Yuan et al., 2019). However, genomic selection is efficient in improving litter size but severely unaffordable in large sample size. Moreover, genome wide association studies and genomic best linear unbiased predictions of breeding values are becoming effective tools for genetic improvement of sheep reproductive performance traits (Abdoli et al., 2016). Another feasible method to improve litter size is to identify single nucleotide polymorphisms (SNPs) associated with litter size in candidate gene, especially if financial resources are inadequate. On the other hand, well known fact, ovulation rate and embryo survival are directly linked to sheep litter size (Haresign, 1985). The explanation of differences between breeds litter size is due to positive correlation between cotyledon density and placental efficiency which may differ between breeds (Ocak et al., 2009). Larger litter size in the Boer goat was a sign of the capacity to ovulate more ova and more survival rates of embryo or fetuses as compared with the Kacang goats (Elieser et al., 2012). This was explained by the fact that high or low litter size were greatly depend on the number of ovum ovulated, the ovum fertilized, and its survival rates. The number of ova ovulated is dependent on the genetic and nutrient adequacy of the dam during the period of before ovulation (Nalbandov, 1990). For illustration it was observed that placental traits were affected by live weight and Romanov crossbreed ewes had greater placental tissue weight against local sheep breeds. This could influence the prolificacy in the two breeds. Breed differences confounded by season were reported by de Nicolo et al. (2008) where litter size in pregnant EF ewes was optimal in early spring and lowest in winter (1.8 versus 1.2), while for pregnant Romney ewes was at its peak in winter and depressed in early spring (1.9 versus 1.3). It was also noted that seasonal differences in the potentiality of ewes to conceive are not the result of failure to exhibit oestrus or to ovulate, but presumably are a consequence of non-success of fertilisation or the formation of pregnancy. Ewe sire breed effect was an important source of variation for litter size, with means ranged from 1.22 to 2.08, with the ranking of sire breeds inconsistence with different traits. Đuričić et al. (2019) working with Jezersko-Solčava sheep observed that the average conception rate was 92.85% and average litter size 1.21. This was in spite of the sheep breed designated as a seasonally polyoestrous, where the patterns of matings and lambings of this breed of sheep was inconsistence throughout the seasons. Litter size is one of the critical aspect of productivity in sheep, however its selection faces some challenges due to its low heritability coefficient, this trait has a wide genetic variability between and within breeds (Elsen et al., 1994). For this reason, it has been exploited breeding programs through combining additive polygenic differences, breed complementarities, heterosis effects and major gene inheritance.

3. Litter size and parity order and/or age of dam in goat and sheep production

Litter size is considered as important dam traits because there is a positive correlation between litter size and lifelong dam contribution and overall flock productivity. The litter size is an important determinant on whether a kid born alive will survive or die to weaning age. Age of dam is one of the internal factors that have a marked influence on overall meat efficiency of the flock (Van der Westhuizen et al., 2004) due to its effect on litter size. Solomon and Gemeda (2000) working with Horro sheep observed average litter size of 1.34 and there was a tendency of litter size increasing as parity order advanced, where average litter size of 1.26 were exhibited at the first parity to 1.44 for parities five and plus. Assessing the relationship between litter size and parity order of ewe, Sulieman et al. (1990) established the increase in litter size to be linear from first to fourth parity. This explains why lambs born from multiparous ewes experienced higher growth rate and reached sexual maturity at early age, and this is likely related to maternal care of advanced parity ewes. The crossing of Boer and PE goats the highest litter size of 2.14 and the least of 1.86 were observed in the fourth parity and the second parity, respectively (Azis et al., 2020). It was concluded that fourth parity order accompanied by twining and improved birth weight could be potentially economical in prospective livestock production. Litter size at birth was influenced by parity order where the primiparous had the smallest litter (Song et al., 2001). In goats, Amoah and Gelaye (1990) observed that age of dam and parity order were major sources of variation for litter size, this was supported by Awemu et al. (1999) who reported that apart from parity, year and season were found to influence litter size in goats. It has been well established that the litter size make progress with advance in age as a consequence of enhanced ovulation rate, uterine capacity and maternal traits influencing reproduction efficiency of ewes (Fahumy, 1990). There is a tendency in goats and sheep return does/ewes who has the capacity to throw large litters. Dam age and parity order are therefore being some important factor contributing to reproductive efficiency through promoting large litter sizes. Nurgiartiningsih (2012) working with Boer goats observed that since the initial pregnancy, the litter size had a tendency to increase and reach a maximum at the third and fourth parity, then it is constant until the seventh birth and then start declining thereafter. The explanation is due to ovulating of more ovum in advanced parity than in primiparous phase. This entails that the rate of ovulation continues to increase up until the seventh parity, but in general, the ewes are culled at the fifth and sixth parity because at this juncture the reproductive capacity start depreciating resulting in low pregnancy rates. In most cases, maturity of ewes is associated with improved body weight, even body condition scoring accompanied by well-developed reproductive function of the reproductive organs, as might be expected enhancing the potential of the uterus for optimal development (Radhika et al., 2015; Yonghong et al., 2001). The age of the parent is one of the variables that influence the litter size because it is related to the the development of the female reproductive organs (Harowi, 2016). There is a tendency for dams mated at a young age to bear singleton due to the fact that their reproductive organs are not yet fully mature. A positive relationship between reproduction and advanced parity order through improved litter size has been reported for small ruminants (Alphonsus et al., 2010). There was a strong and positive correlation (r= 0.61) between litter size and parity symbolising that an increase in parity of the dam may promote large litter size (Alphonsus et al., 2010) and this may be related to a well-developed reproductive system. Alternatively, the low order parity seems not to seem to produce multiple birth possibly due to the limitation of reproductive status. Amoah et al. (1996) observed that decreased prolificacy of primiporous does may be related to an underdeveloped status of the reproductive attributes vital for consecutive litter bearing with reference to those of multiparous does that have attained physiological maturity. As specified live weight in association with desirable body score at certain age and parity order may be essential to enhance optimised metabolic provision consequently promoting the effect on hypophyseal-pituitary-gonadal axis for more ovulation that in turn influence the number of optimal fertilization and as a result litter size (Perry et al., 1991; Tummaruk et al., 2007). Various authors working with the hair sheep breeds observed that maximum litter size at 3.5 years of age with three parities, was dependent on the breed (Koycegiz et al., 2009; Macías-Cruz et al., 2012; Gootwine, 2005; Godfrey, 2005). The conducive relationship between litter size and parity is in conformity to the study of Amoah and Gelaye (1990) but in disagreement with observation of Zahraddeen et al. (2008) and Akpa et al. (2008) who reported that litter size was nowhere correlated with parity in indigenous goats. Alphonsus et al. (2010) observed a positive relationship of parity with litter size which might be construed that dam parity is an important variable in improving for litter size in small ruminants in order to enhance overall meat productivity. In the same study a strong positive correlation between the dam mating weight with litter size existed, which may imply that sound mating weight is required for optimum increase in litter size. For management consideration it emphasise the essence of taking up flushing as part of breeding management of does prior breeding season, as a critical flock management in enhancing small ruminant production. Higher parity order and higher previous litter size were strong determinants of larger litter size in Bengal goats (Haldar et al., 2014). The effect of ewe parity had no direct effect on survival of lambs behaviour in Kivircik ewes, however, the parity was an indirect determinant of lamb survival due to its influence on litter size (Ekiz et al., 2007). It was observed that litter size in terms of single and twins differed in mortality rate, twin lambs (19.2%) experienced a higher mortality rate against singletons (5.7%). This disparity emanated from the fact that ewes did not provide adequate maternal care to twins, and singletons had more adequate time in terms of grooming hence their high survival rates. Previous litter size, in addition to advanced age, body weight and parity had a positive influence on multiple births in Black Bengal goats (Haldar et al., 2014). This result was in conformity with previous observation on does (Mellado et al., 1991) and ewes (Gaskins et al., 2005). It may be assumed that the does with higher previous litter size may have potential to give multiple births in subsequent kidding. Assessing the productivity on litter size of crossbreed of Boer and Indonesian goats the mean yield of litter size of ewes producing singleton, twins and triplets were 25, 50 and 25%, respectively (Azis et al., 2020). The observation showed that that the litter size of the ewes who produced twins and triplets were 80% and only 20% single.

4. Litter size and season of kidding/lambing in goat and sheep production

Lambing year was an important source of variation on litter size, in addition to its influence on weaning weight, considering that in the same way both traits improved through the years (Sánchez-Dávila et al., 2015). The results pointed to the fact that environmental conditions are important source of variation in litter size, as well as growth traits in hair sheep under semi-arid climate. The trends on litter size was significantly different among birth years, displaying an increase of lambs/ewe as the reproductive management of the flock improved, levelling of midway 1.5 and 1.6 lambs/lambing throughout the period of study. Elsewhere ewes had higher litter size within natural reproductive seasons of September to December, which were more noticeable in latitudes of 35° N (Godfrey and Dodson, 2003) and 40° N (Kosgey et al., 2004). Mellado and Meza-Herrera (2002) reported that prolificacy in goats' declines if dams are exposed to high seasonal ambient temperatures. Solomon et al. (2006) observed that the litter size increased up to 11 % in rainy years as an alternative to dry years. However, it should be noted that the influence of year of lambing on litter size is not only based on adequate rainfall patterns, but also confounded with other factors such as nutritional strategies and the extent of flock genetic improvement (Vanimisetti et al., 2007; Sodiq et al., 2011). Optimum litter size at have been associated with spring breeding and a tendency of being lower in winter mating (Bermejo et al., 2010). Lower litter size observed by Çetin et al. (2003) was related to mating season when goats were mated in June, which seemed a little early for the mating of Kilis goats. Previously it was reported that breeding month had an effect on the goat's reproductive performance

(Keskin, 2003). However, generally the litter size minimum variation among seasons, this may be related to the propensity of birth litter weight being homogenous throughout the year which seemed to be as result, partly to the heavier weight of singles at birth against multiples birth. There was a tendency of sexual activity being modest through spring and early summer when air temperatures were very and extremely warm, and alternatively sexual activity improved from August to September, especially coinciding with extremely wet and very wet seasons (Đuričić et al., 2019). In this study it was noted that litter size was outstanding during winter against other seasons (1.70 vs. 1.54) and in turn being significantly varied in each of selected years. The trend was supported by the statistically significant difference in the number of pregnant ewes between mating seasons.

5. Litter size, birth weight and mortality in goats and sheep production

Litter size is the major non-infectious causes of perinatal mortality in goats and sheep production, due to its influence on birth weight of kid/lamb. Litter size influence lamb vigour, at least partially, prior birth by effect on placenta development. This is in turn translated into large litter culminating into underweight at birth which impair lamb survival (Dwyer et al., 2005). Lamb mortality figures for singles and twins were similar, with substantially higher mortality levels for triplets. Mortality rate's propensity to increase at extremely low or extremely high birth weights has been reported by Mendel et al. (1989). Larger litter size has been incriminated in reduced birth weight consequently the survival of lambs (Turkson and Sualisu, 2005). Relatively low birth weight culminating in depressed growth rate and hence low weaning weight due to large litter size could be identified as the major constraints directly associated with higher kid mortality and this is responsible for reduction of the total productivity (Husain, 1993). Ershaduzzaman et al. (2007) working with Black Bengal kids reported that triplets had higher mortality rate than singles and twins of 38%, 21.05% and 19.78%, respectively. This trend was in agreement with previous studies (Vihan et al., 1992; Husain et al., 1995; Malik et al., 1990) but in contrary, Chowdhury et al. (2002) cited non-significant variation among single, twins and triplets kidding on mortality. Large litter size has a disadvantage on birth size due to competition for uterine space and available nutrients (Awemu et al., 1999), therefore there is a tendency of multiple birth performance on birth size being outperformed by singletons. The compromised performance due to large litter size on birth size may persist from birth to yearling (Hussain et al., 1996). This is in contrary with reports by Ikwegbu et al. (1995) who observed that litter size influence is only important for birth size but not any other age. The effect of large litter size on birth size as age progresses is made redundant due to milk offered to the kids before weaning (Ebozoje et al., 1995). The appraise of litter size-dependent birth weight depression in a flock is assessed by estimating the linear relationship between the reciprocal of lamb's birth weight and the corresponding litter size (Gootwine, 2005). Both genetic and environmental factors may contribute to the variability of litter size-dependent birth weight decline as a trait. Singletons outperformed multiple-born lambs with respect to birth weight, weaning weight and end-of-pasture weights (Turkyilmaz and Esenbuga, 2019). Underweight at birth and follow-on growth rate of twin born lambs can be ascribable to competition for nutrients in utero (Galal et al., 1972). The influence of large litter is manifested in underweight of individual offspring at birth (Donald and Russel, 1970). The variation in conceptus mass as a result of in utero litter size is established effective of the first month of pregnancy (Dingwal et al., 1981). Underweight at birth is the probable reason for reduced offspring viability (Wilson, 1986) in small ruminants.

6. Litter size and life time performance in goats and sheep production

Twin bearing ewes at the ages of 2, 3 or 4 produced litters which averaged 0.04 to 0.08 more lambs at each consecutive lambing as compared with ewes lambing singles (Amer et al., 2007). The equivalent increase for ewes bearing triplets against single bearing ewes ranged from 0.23 to 0.26, this trend prolonged through to subsequent litters. Traditional selection for enhanced prolificacy in sheep results in an ancillary increase in its variability, although in most cases the aim of selection is to optimise the frequency of a median litter size on behalf of the frequency of high litter sizes, which might have an adverse effect on survival of littermates (Magali et al., 2001). It has been observed that large litters are experienced in prolific ewes (Romanov; Finnish) to the range of five or even more lambs per lambing, which is not convenient for ewe and in most cases compromise lamb viability. Litter size need not to be too large, the assumption is that desirable litter size of two exactly-and not on average-or as often as possible is appropriate from the animal welfare point of view and economics of production. In most cases twins are the most likely profitable for a sheep enterprise. There has been a major concern on highly prolific ewes as focus on increased productivity due to the effects of "burning out" and either dying or being culled at relatively young ages (Amer et al., 2007). This whole phenomenon has a long term adverse effect on overall productivity of the flock. Morel and Kenyon (2006). observed that ewes with triplet litters early in life are a whole lot better chances for forecasting high lifetime number of lambs born by the ewe as compared to ewes with twin litters. From the practical point of view this observation is flout with limitation because triplet litters are not just about as economically higher ranking beyond twin litters. In addition, twins are economically superior when compared with singletons (Amer et al., 1998). In essence ewes lambing triplets on numerous occasion uncommon and it is impracticable to be cost effective. The environmental factors to be expected to disturb the genetic potential for homogeneous lifetime lambing performance are in the form of unpredictable ewe condition over years influencing ovulation (Coop, 1962; Rattray et al., 1980) and unsystematic embryo mortality (Meyer et al., 1983). This also in the context that singleton bearing versus twins is much less repeatable as compared with bearing triplets versus twins. However, as good as expected that bearing twins at a previous litter may, on average, culminate in one half of the future litter size increases relative to what we have observed for ewes bearing triplets in a previous litter.

7. Highlights

The review verified that:

- Litter size is under the influence of both genetic and non-genetic factors in goats and sheep.
- Litter size is lowly heritable, however there is immense variability between and within breeds which can be exploited in genetic improvement of litter size in goats and sheep.
- Kidding/lambing season, age of dam and parity order are important non-genetic sources of variation for litter size in goats and sheep.
- Litter size has an indirect influence on mortality rate through its effect on birth weight hence mortality rate's propensity to increase at extremely low or extremely high birth weights in goats and sheep.
- Large litter has a disadvantage due to low individual birth weights of littermates hence reducing both pre-weaning growth performance and survival of kids/lambs.
- Litter size is normally least in the first litter, ascends to an optimum between the third and fifth litter and then remains constant or declines marginally with advanced parity orders and/or age of dam.
- Ewes/does in advanced age and parity order tend to give large sized litters, due to their well-developed reproductive system, in addition to their ability to care (mothering ability) for the litter which improves kid/lamb survival.
- Use of modern genome science based selection on targeted genetic markers is becoming an effective tool for genetic improvement of litter size and/or reproductive performance traits in goats and sheep. Hence the proportion of large sized litter will constantly be realized through marker assisted selection based on identification of marker genes affecting prolificacy in goats and sheep.

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How to cite this article: Assan, N., 2020. Aspects of litter size (birth type) in goats and sheep production. Scientific Journal of Zoology, 9(2), 138-151.