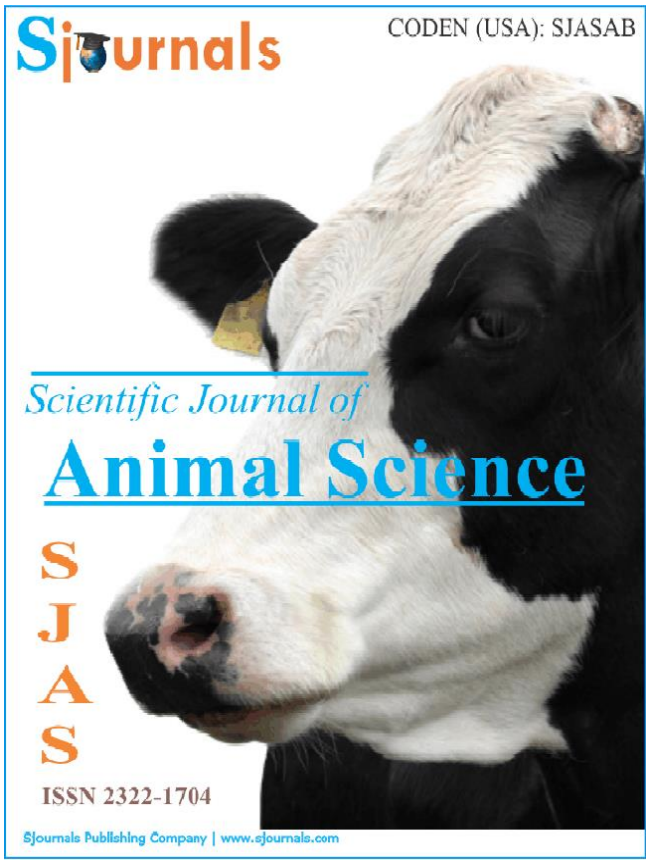

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Review article

Effect of litter size (birth type) on milk yield and composition in goats and sheep production

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ABSTRACT

Litter size is one of the major external (non-genetic) factors which has a multifaceted influence as it regulates both reproduction and production in goats and sheep. Apart from being a principal source of variation on kid/lamb growth performance and survivability, litter size has been implicated in influencing milk yield and composition. However, it is important to note that the influence of litter size on milk constituencies such as protein, fat, lactose, pH, colostrum, etc. has been inconsistent in a number of studies. In absolute terms, milk production is a function of animal genetics and an array of non-genetic factors, and among the latter litter size is ranked highly. There is a tendency of prolificacy promoting high milk production, which implies multiple birth will enhance milk production. The positive relationship between litter size and milk production with regards to multiple bearing dams outperforming single bearing dams is due to prolactin stimulation of the udder which depends on the intensity of the suckling stimulus in response to the number of kids/lambs in a litter. It is more likely that the relationship between milk yield and litter size is for the most part dependent on the extent of prepartum development of the mammary gland where prolactin plays a major role. There is a distinct and strong established physiological link between the number of foetuses in a dam, the resultant placental mass and lactogenic (hormonal) function of plasma to advancement and development of mammary gland in the course of pregnancy and of litter size to milk production. The underlying drivers of milk production are developed in a way specified during

fertilization and embryogenesis's based on the development of placental mass which has a hormonal influence on mammary development in turn milk production. Larger litters promote extensive formation of placental mass as compared with small sized litter. The greater the placental mass as a function of larger litter size the greater the extent of mammary growth hence the greater the dams' milking capacity. The relationship between litter size and milk composition has been inconclusive as indicated by inconsistency of study results by various authors. The present discussion explores the significance of litter size (birth type) on milk yield and composition in goats and sheep production.

1. Introduction

Litter size plays a major role in influencing milk yield and composition in small ruminants (Keskin and Bicer, 2002; Fatal, 2008; Semsemia, 2010). A number of studies proved a consistent effect of litter size on milk yield and composition in goat (Klir et al., 2015; Sarmento et al., 2010; Carnicella et al., 2008) and sheep (Snowder and Glimp, 1991; Hatziminaoglou et al., 1990). The size of production and the percentage content of fat, proteins and lactose were affected by the number of kids born and weaned (Macciota et al., 2005) and the birth type (litter size) of goats (Goonewardene et al., 1999). There was a strong association between the number of fetuses, placental mass, and lactogenic (hormonal) activity of plasma to development of mammary gland during pregnancy and of litter size to milk yield (Hayde et al., 1979). In goats and sheep increased litter size will promote the extent of mammary development at the end of gestation (and milk yield) by 20 to 25% (Davis, 2017). An interesting note in Tenerife goat breed, approximately 12% of the variation in milk yield was due to litter size, does producing twins outperformed those dams with single kids (Ferson et al., 1991). Multiple births induced a higher milk yield in meat sheep breeds throughout the lactation period (Snowder and Glimp, 1990), while daily milk yield was reduced in ewes lambing singles as opposed to ewes lambing multiples in three breeds of Tsigai, improved Valachian and Lacaune (Oravcová et al., 2006). In sheep, Alexander and Davies (1959) concluded that milk yield is either influenced by the number of lambs suckled or by the extent of the suckling stimulus, this entails prolactin stimulation of the udder which depend on the intensity of the suckling stimulus produced by different sized litters. There was a tendency of enhanced prolificity increasing milk yield but at the same time diluting the concentration of other secondary milk components (Csapó et al., 1994; Zygoyiannis, 1994; Argüello et al., 2006). Dhaoui et al. (2019) observed that dams rearing multiple lambs yielded more milk as compared to those reared singles, while dams nursing triplets or more had the highest milk total proteins, and the lowest total solids and fat levels. In a similar study, Carnicella et al. (2008) reported that litter size was an important source of variation on the milk yield of goats, however litter size did not influence milk composition. It was interesting to note that the influence of litter size on milk yield in goats was experienced up until weaning (Zygoyiannis and Katsaounis, 1986; Mourad, 1993). The present review explores the significance of litter size (birth type) on milk yield and composition in goats and sheep production.

2. Litter size and milk yield in goats and sheep production

Milk production in sheep is known to be influenced litter size (Butler et al., 1981) and a number of studies have proved that milk yield and composition are influenced by litter size, among other external determinants. Birth type was an important source of variation on milk yield in goats where dams with single kids at birth had lower partial milk yield than those with twins. (Zahraddeen et al., 2009). This is in concordance with previous in goats by Zygoyiannis (1994). The measure of milk production and its constituency of fat, proteins and lactose are affected by the number of kids born and weaned (Macciota et al., 2005) and the birth type (litter size) of goats (Goonewardene et al., 1999). The total milk production of the ewes increased with litter size, subject to twins, this effect has been verified for both goats (Ueckermann, 1969) and sheep (Alexander and Davies, 1959; Gardner and Hogue, 1964; Peart et al., 1972; Maxwell et al., 1979). Much the same phenomenon was noticed with triplet

suckled sheep ewes (Peart et al., 1972). The effect litter size on daily milk yield was in line with those of several authors in goats (Goonewardene et al., 1999; Ilahi et al., 1999; Silva et al., 2013). Litter size was the single most important effect on milk yield of maiden ewes (Valencia et al., 2002), and elsewhere the influence of litter size on milk yield in goats was sustained up until weaning (Zygoyiannis and Katsaounis, 1986; Mourad, 1993). An interesting note in Tenerife goat breed, approximately 12% of the variation in milk yield was due to litter size, does producing twins outperformed those dams with single kids (Ferson et al., 1991). Twin bearing dams produce more milk as compared to dams with singletons. This was consistent with studies in Zaraibi goats in Egypt (Hamed et al., 2009), while Baro et al. (1994) and Carriedo et al. (1995), observed that multiple births in Latxa and Churra ewes promoted enhanced milk production against singletons. Twin- and triplet-bearing ewes produced more milk per lactation of up about 20l as compared to single-bearing ewes (Pollot and Gootwine, 2004), however a positive sex dependent effect was also experienced on milk yield (Abecia and Palacios, 2018). The explanation for multiple kidded dams outperforming single kidded dams in milk yield was that as a result of the greater stimulus offered by the suckling kids that increases production. On the other hand, ewes with twin and triplet lambs exceeded singleton bearing ewes in daily and lactation milk yield (Prpić et al., 2016). This was attributable to twins and triplets bearing ewes having larger and more developed udder contrary to ewes with singles, this was shown by sound conformation traits of larger circumference, width and depth of udder in twin and triplets delivering ewes. Into the bargain, udders of ewes with twins and triplets had higher cistern, greater teat angle and larger teat dimensions in contrast to ewes with singletons, notwithstanding the variation which was not significant. In the same line of observation Hayden et al. (1979) suggested that the total weight of placentomes increased with total fetal weight and, hence, fetal number, while the weight of the lobulo-alveolar component of the udders was correlated positively with placental mass and fetal number (litter size). In sheep, Alexander and Davies (1959) established that milk yield is influenced by one or the other of the number of lambs suckled and the extent of the sucking stimulus. Leon et al. (2012) working with Murciano-Granadina dairy goats observed that the milk yield increased up to the lactation peak for more prolific goats; and in a similar study with Zaraibi goats, Shaat (2014) observed that the litter size was positively associated with an increase in milk yield in early lactation. Despite longer lactations multiple birth outperformed single births in average milk yields (Hayden et al., 1979; Browning et al., 1995; Carnicella et al., 2008). In a study typified by the age of the ewes differing between two and six years while litter size was designated by singles, twins and triplets, milk production increased with both age and litter size (Raats et al., 1983). It was observed that the effect of age on milk production decreased with an increase in litter size even though mature dams displayed a less noticeable reaction to litter size as compared to maiden ewes. Litter size does not only influence growth performance and survival in kids/lambs, it also affects milk production parameters in small ruminants. In hand milked goats which were bearing triplets or twins, mean milk yield was 47% and 27%, respectively, this was higher as compared with single bearing does after adjusting for lactation number (Hyder, 1979). Litter size was a major source of variation in milk production in Black Bengal goats with single and multiple litter size, recording milk yield of 308.2 and 470.0 g, respectively (Mahal et al., 2013).

Milk yield increase of 27% were recorded for twin bearing ewes over single bearing mothers, while 16% was the increase of triplets over twin bearing ewes (Thomas et al., 1977). However, this trend was not influenced by age or lactation number. Daily milk yield was reduced in ewes lambing singles as opposed to ewes lambing multiples in three breeds of Tsigai, improved Valachian and Lacaune (Oravcová et al., 2006). As an illustration variation in daily milk yield suckling singles against multiples were 0.020, 0.019 and 0.001 kg, for Tsigai, improved Valachian and Lacaune, respectively, which showed an advantage of daily milk yield related to multiples. This reflects the stimulus of litter size (Gabina et al., 1993; Gonzalo et al., 1994). The effect of litter size on daily milk yield can be attributed to the quantity of hormones preparing the udder to lactation phase which differs from females carrying multiples to those carrying singles (Haldar et al., 2013), thus affecting the milk production after delivery. There are high levels of the hormonal placental lactogen produced by fetuses during the final phase of gestation (Hayden et al., 1979) consequently influencing milk synthesis hence milk yield. In late pregnancy lactogenic activity, increases with number of fetuses. Increased in lactogenic hormone twin bearing dams as compared to single delivering dams contribute to the superior lactational drive that favoured prolific ewes. This explains the fact that milk yield is proportional to the mammary alveolar surface area which is positively correlated with fetal number (Margatho et al., 2019) hence improved milk production in multiple kid/lamb bearing dams. The secretory capacities of the mammary gland are limited by the amount of alveolar tissue, the development of which is virtually complete by parturition, with little synthesis of DNA thereafter (Cowie, 1971). Milk yield is proportional to the mammary alveolar surface area (Richardson, 1973). According to Hayden et al. (1979), the extent of

mammary development depends in part on the number of foeto-placental units and on placental mass. It therefore seems likely that the relationship between milk yield and litter size is, for the most part, due to the extent of prepartum development of the mammary gland and that this will limit the response to postpartum attempts to modify lactational performance. Mammary growth during gestation is said to be affected by the number of kids, and this has a subsequent effect on milk production which is independent of age, bodymass and season (Gall, 1981; Mourad, 1992). There was a strong association between the number of fetuses, placental mass, and lactogenic (hormonal) activity of plasma to development of mammary gland during pregnancy and of litter size to milk yield (Hayde et al., 1979). Mammary development is predominantly finalized, at term, in sheep, goats, and cattle, but in pigs, the udder persist to develop through the first 3 wk of lactation, which is dependent, in part, on litter size (Davis, 2017). In goats and sheep enhanced litter size will increase the extent of mammary development at the end of gestation (and milk yield) by 20 to 25%. Suckling induces prolactin secretion and prolactin plays a part in the initiation, if not the maintenance, of lactation in goats (Hart, 1973). Kaskous et al. (2015) suggested that the increase in milking status is attributed to the continued improvement in udder and its milking capacity during the trimester of pregnancy as a result of hormonal induced activities (placenta lactogen) which is related to the increase in the size of the placenta mass which favours twin bearing ewes in comparison with single bearing mothers. Raats et al. (1983) modelling lactation curves on Boer goat ewes milk yield, showed that the initial increase in milk yield because of multiple suckling was of shorter duration in the mature ewes. The variation in milk yield as a result of litter size was explained as due to the extra pressure or stimulation on the mammary gland induced by the additional suckling of the additional kids. It should be noted that that the increase in milk yield due to multiple births is specifically dependent on number of kids suckled and not on the number born (Rai and Chorey, 1965). However, this trend did not exist in hand milked Saanen goats fed concentrates diets throughout pregnancy and lactation (Hayden et al., 1979). This entails that suckling stimulus by multiple birth is overshadowed by nutritional regime. Possibly explanation of the diminishing effects to litter size due to advancing age in numerous studies is a consequence of inadequate nutrient supply. There was a surge in milk production and then a noticeable prompt decline in milk yield of the triplet-suckled six-year-old ewes coinciding with first three weeks of lactation, this could be explained by the diminishing of dam body reserves to sustain lactation. It is assumed the scenario could be worse in natural grazing where it is highly likely that nutrient source, could not support the inceptive high level of lactation. Even though the non-significant, higher litter size yielded more milk (Adewuni et al., 2017), the non-significant difference obtained between the twin and single suckled ewes is a result of the number of kids suckled by the dam that determines the milk yield rather than the number born (Linzell and Peaker, 1971). Montaldo et al. (1995) explained the physiological applicability to the enhanced milk production from dams bearing twins to frequency of suckling. This is in contrary to observation on Red Sokoto and lactating goats (Akpa et al., 2001; Wahome et al., 1995) kept under intensive management system experiencing minimum stress for pregnant and lactating does bearing twins. These have adequate body reserve to mobilize for milk after kidding with reference to hence the single litter does milk yields was high. However, enhanced milk production due to increase response to suckling stimuli was not applicable variable in dairy goats especially if the kids are separated and fed by hand (Devendra and Burns, 1983). Elsewhere, Williams (1993) in contrary reported no proof of an effect of litter size on milk yield. However, Browning et al. (1995) reported that Alpine does that had given birth to singletons had compromised milk production (775kg) as compared with does with twins (834kg) and triplets (903kg). This was despite the removal of kids at birth.

Petit (1997) observed that feeding beet pulp diet led to comparable milk yield for twin and triplet bearing ewes, while feeding commercial concentrate promoted higher milk yield for ewes nursing twins against those nursing triplets. This scenario implied that an important interaction exists between diet and birth type. In the same study milk yield was lower for ewes nursing triplets than for those ewes nursing twins outperformed ewes nursing triplets when a cereal supplement was fed, which could be partly associated by the lower average daily gain of triplet against twin lambs. Partly in disagreement, Gardner and Hogue (1964) in their study observed that milk production showed an increment with the number of suckling lambs, which was associated with more frequent and more complete emptying of the mammary gland. On the same note ewes nursing twin lambs exhibited higher DMI and higher milk production in early lactation against ewes nursing singles in Targhee sheep (Ramsey et al., 1994). This was in conformity with Loerch et al. (1985) who reported a trend for increased DMI and milk production for ewes nursing triplets with reference to those nursing twins. Carnicella et al. (2008) reported that litter size was an important source of variation on the milk yield of goats, however litter size did not influence milk composition. In contrary, although litter size had an influence on daily milk production, the increase of milk yield of

multiple suckled ewes was non-significant as compared to single bearing ewes (Olechnowicz and Sobek, 2008). The significance effect of litter size on goat milk production was recorded in different goat breeds; Goonewardenea et al. (1999) for Nubian goat, Hayden et al. (1979) for British Sannen. In contrary to these resulted were reports by Fatal (2008) in Syria, Yassin (1997) in Yemen for Shami goat, Gootwine et al. (1995) and Williams (1993) for British goat.

3. Litter size and milk composition in goats and sheep production

Romero et al. (2013) studying the effect of litter size and other determinants on milk parameters, observed that litter size influenced the milk pH value, protein and lactose content, while the lactation number influenced most colostrum parameters. Ewes with twin and triplet lambs (Prpić et al., 2016) working with East Friesian sheep had lower average milk fat content and total solids content with reference to ewes with singletons lambs. A decline in protein content was reported in milk of goats from multiple births (Olechnowicz and Sobek, 2008), while after the second kidding, triplets suckled ewes produced more milk per lactation (25.19 kg) as compared to singleton bearing ewes (19.22 and 20.84 kg, respectively in Black Bengal goats (Hossain et al., 2004). Does bearing singletons had higher proportion of milk fat (4.29 vs. 4.15%), higher percentages of milk protein (2.95 vs. 2.87%), and lower somatic cell count (5.6 vs. 7.5 × 105 cells/mL) as compared to does delivering multiple kids (Zamuner et al., 2020). Goats bearing single kids had lower CMY, experienced lower SCC, and had elevated levels of fat and protein in milk with reference to does delivering multiple kids (Zamuner et al., 2020). Elsewhere, the explanation for the influence of litter size on SCC is still insufficient because the authors have found that goats delivering multiple kids showed higher SCC regardless of whether the goats were suckled by their kids or machine milked (Granado et al., 2014). Dhaoui et al. (2019) observed that dams rearing multiple lambs yielded more milk as compared to those reared singles, while dams nursing triplets or more had the highest milk total proteins, and the lowest total solids and fat levels. Goats bearing twins yielded more milk against those with singles during the suckling period but not after weaning, while milk composition was not affected by the number of the kids suckled (Zygoyiannis and Katsaounis, 1986).

In a comparative analysis of milk yields, multiple and single at 250 and 305 days' lactation produced 80.6 and 972.1 kg, as compared with 664.6 and 800.9 kg, respectively), and in this study single and multiple bearing ewes were comparable of either fat or protein contents (Goonewardene et al., 1999). The variation in total solids content in milk of triple kids nursing dams was 0.14% lesser against single kids producing dams (Semsemia, 2010). In a similar study, fat and protein contents were lower in ewes nursing three and four kids against those having twins or single kids (Milerski and Mares, 2001). As expected, Raats et al. (1983) reported increase in daily milk yield during the first 12 weeks in twin bearing does against single kidders; however, the was no variation in milk components. This was an indication of an association between the mechanism of milk synthesis and storage in udder alveoli and cistern, as with the increase of milk yield in the udder the components will be lowered, consequently the lower protein content. Ewes with twin and triplet lambs (Prpić et al., 2016) working with East Friesian sheep had lower average milk fat content and total solids content with reference to ewes with singletons lambs. Milk yield of 71 and 149% higher were recorded for ewes suckling twins as compared with those suckling singles, respectively (Snowder and Glimp, 1991) this was from d 70 to 98 postpartum. Generally, ewes suckling twins invariably yielded higher milk as compared with those suckling singles. This symbolised a reciprocation to milking stimulus. However, the variation in composition of milk for ewes nursing twins and those with singles were non-significant, while ewes with single birth and multiple birth had a significant variation in milk yield. Carnicella et al. (2008) reported that litter size was an important source of variation on the milk yield of goats, however it did not influence milk composition.

The colostrum from milk from single bearing ewes displayed a higher pH value and proportion of protein and lactose with reference to colostrum of ewe with multiple births. Despite limited studies on the effect of litter size on colostrum characteristics, in most cases the results are inconsistent (Csapó et al., 1994; Zygoyiannis, 1994; Argüello et al., 2006). However, the most noticeable aspects in these studies is that the increase in prolificity is related to increase in milk production and, as a result is less concentration of other secondary milk components. Immunoglobulin G (IgG) concentrations in milk colostrum from the primiparous ewes was comparable higher with reference to the multiparous ewes, while among the multiparous ewes, the colostrum yielded from ewes bearing twins displayed higher energy content and IgG concentrations as compared to those carrying singletons (Higaki et al., 2013). The explanation for higher colostrum protein in the ewes bearing twins against those bearing singletons

is yet unclear, however, Gardner and Hogue (1964) suggested that elevated colostral fat associated with twin carrying ewes may be ascribable to enhanced body fat mobilization under a strong negative energy balance. In support of the fat mobilization fat aspect, Dwyer and Morgan (2006) observed that the requirement for energy for fetal development for ewes carrying twin fetuses was approximately 1.4 times against ewes carrying a single fetus (Russet, 1985). The IgG is actively transported from the ewe's serum to the colostrum during late gestation, hence the number of fetuses carried may directly influence the rate of transportation (Gilbert et al., 1988). This implies for multiple-birth kid/lambs may signal to the dam release of increased quantity of available immunoglobulin.

4. Highlights

A number of studies have been carried out to establish the effect of litter size on milk production in goats and sheep, and it has been proved that the larger the litter size the greater the dams milking capacity. Therefore, it is reasonable to assume that breeding for prolificacy in goats and sheep can be explored to take advantage of enhanced milk production associated with multiple birth. The positive association between litter size and milk production with regards to multiple bearing dams outperforming single bearing dams is due to prolactin stimulation of the udder which is determined by the intensity of the suckling stimulus in response to the number of kids/lambs in a litter. Hence the larger the litter the greater the udder suckling stimulus the more the milk let down. It is more likely that the relationship between milk yield and litter size is, for the most part, dependent on the extent of prepartum development of the mammary gland where prolactin is a major player. There is a distinct and strong established physiological link between the number of foetuses in a dam, the resultant placental mass and lactogenic (hormonal) function of plasma to advancement and development of mammary gland in the course of pregnancy and of litter size to milk production. However, the relationship between litter size and milk composition has been inconclusive has indicated by inconsistency of study results by various authors. It should be noted that milk production, in absolute terms, is a function of animal genetics and an array of non-genetic factors (nutrition, management, animal health, milking methods, etc. to name a few) and among the latter litter size is ranked highly.

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