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Review article

Various factors influencing birth weight in animal production

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ABSTRACT

This is a review article that looks at various factors that influence birth weight in animal production. Birth weight is an important indicator of potential growth of an animal and is affected by both genetic and non-genetic factor, and the birth size depends on their interaction. Environmental conditions such as kind and quality of feed and details of management may have an influence on birth weight in livestock production. In order to minimize the adverse effects of factors that influence birth weight, it is perhaps important to understand the implications of different mechanisms, how and why they affect birth weight. Low birth weight than optimum is the main factor that determine the pre weaning losses of young ones and large birth have been associated with difficult birth. Traditional measures to ameliorate birth associated negative effects should also focus on maternal dietary manipulation which may influence optimum birth weight. Nutritional programs designed to improve dam's body condition during pregnancy will have a positive influence on birth weight of progeny. A good knowledge of genetic parameters is essential to develop accurate selection indices and to optimally design breeding programs and performance recording systems for maximum economic gain or profit from growth traits. Estimates of genetic parameters for birth weight is model dependent and ignoring of maternal genetic effect in the model leads to overestimation of direct heritability for birth weight. Estimates of direct and maternal heritability for birth weight in different species have been reported and vary from low to high. The review article therefore, concludes that the large variability of birth weight in livestock species suggests that many factors or conditions may be responsible for this variation. The reported low heritability estimates for birth weight may be explained by the poor nutritional levels of dams creating a large environmental variation.

1. Introduction

Birth weight as an early measureable trait is of great interest because of its positive genetic correlation with further live weights (Assan and Makuza, 2005). It has become a significant predictor of later health outcomes, lower birth weights than optimum are associated with reduced energy reserves, lowered thermoregulatory capability, and increased calf deaths at or near birth (Ferrel, 1993). Information on factors influencing birth weight is of interest to farmers as well as the animal breeder, because birth weight is of great economic importance (Bermejo et al., 2010). Variation in birth weight within a population can be attributed to genetic, environmental and the physiological factors that impinge on individuals. Heavy individual birth weight is important not only for survival (Roeche and Kalm, 1999; Milligan et al., 2002), but also for lifetime performance (Rydhmer et al., 1989). On the other hand, low birth weight in piglets are particularly at risk from pre-weaning morbidity and mortality (Wolf et al., 2008). Therefore, understanding of factors affecting birth weight may be crucial for evaluation of lifetime performance. Effect of birth year, lamb's sex and birth type has been reported significantly in different animal species, in sheep (Rahmatrnejad et al., 2009), in sheep (Assan and Makuza, 2005), in goats (Banerjee and Jana, 2010) and pigs (Wright, 1921). Foetal growth, hence birth weight, is influenced by numerous factors including number of foetuses, sex, parity or age of the cow, breed of sire, breed of dam, heat or cold stress, and nutrition.

Birth weight due to its relative simplicity may be of interest to livestock producers and similar situations as a preliminary selection criteria in animal production. The accurate and reliable estimates of genetic parameters, particularly heritability estimates are key factors, required to decide optimum selection and breeding strategies for genetic improvement in animal production. The influence of direct, maternal genetic and maternal environment effects on birth weight in different animal species has been well documented (Dezfuli and Mashayekhi 2009; Assan, 2012) in cattle, (Assan et al., 2002; Buvanendran et al., 1992) in sheep, (Nicoll et al., 1989; Caro Petrvic et al., 2012) in goats and (Roeche, 1999) in pigs. The purpose of the review is to assess the various factors which include genetic and non-genetic parameters influencing birth weight in livestock production.

2. Environmental factors

2.1. Birth status and parity influencing birth weight

Type of birth had the greatest influence on birth (Ruttle, 1967) and higher litter size was connected with lower birth weights average (Wolf et al., 2008). An increase in litter size will decrease the average piglet birth weight, leading to an increase in pre-weaning mortality (Hermesch et al., 2001); Knol et al., 2002). The number of piglet born alive and average piglet weight at birth are antagonistic traits, the weighting of both traits in the total merit index should be done cautiously in order not to overemphasize birth weight traits and unintentionally decrease litter size by selecting heavier piglets from smaller litter (Suarez et al., 2004). Birth weight was significantly affected by type of birth and generally birth weight decreased with increase in litter size. Robinson et al (1977) reported that for lambs in utero, as the number of foetuses increases, the number of caruncles attached to each foetus decreases, thus reducing the feed supply to the foetus and hence reduction in the birth weight of the lambs. In goat and sheep, a positive correlation was found between birth weight and the weight of cotyledons (Alexander, 1964; Alkass et al., 1999; Osgerby et al., 2003; Madibela, 2004; Oramari et al., 2011). Also, it has been reported that the number of cotyledons per foetus varies between and within breed, litter size, sex and environmental conditions (Alexander, 1964). Therefore, the survival of a newborn is affected by sufficiency of placenta (Mellor and Stafford, 2004).

Studies conducted on lambs, single lambs weighed heavier at birth more than lambs of multiple birth (Vesely et al., 1970). Single born and male kids grew faster than twin born and female kids. It would seem that birth type effects are commonly observed at pasture (Beischer et al 1992) and it is so mainly because of competition for the limited supply of doe milk. This is supported by Norton and Banda (1993) who found no differences in growth between single and twin born kids when subjected to artificial rearing of the kids. Elsewhere, the increase in litter size, reduced body weight of kids (Caro Petrovic et al., 2012). As expected single born lambs as well as male lambs were heavier at birth than multiple born or female lambs, respectively. This was attributed to the fact that the maternal uterine space has finite capacity to gestate lambs and as litter size increases individual birth weight decline due to a maternal constraint of foetal development. Their weaning weight and average daily gain also followed the same trend (Dickson-Urdaneta et al., 2004). Singles were significantly heavier in indigenous Sabi sheep while had non-significant effect in exotic Mutton Merino and Dorper sheep (Assan and Makuza, 2005). Atkins (1980) reported similar findings that birth status had a significant effect on birth weight. The differences between the exotic and indigenous sheep breeds could be due to the fact that not many cases of multiple birth have been reported in the indigenous Sabi breed. Sabi sheep rarely produce twins under communal farming setup in Zimbabwe. The low birth weight and subsequent growth rate of twin born lambs can be attributed to competition for nutrients in utero (Galal et al., 1972). As litter size increases, there is decrease in birth weight of individual offspring (Donald and Russel, 1970). The difference s in foetal weight because of differences in litter size appears early as the first month of pregnancy (Hulet et al., 1969; Dingwal et al., 1981). Low birth weight was found to be leading negative cause of lamb viability (Wilson, 1986). Therefore, particular nutritional attention should be given to ewes lambing twins. Nutritional stress limits the lambs from expressing their full genetic potential (Chang and Rae, 1972) for birth weigh. In pigs a single focus on litter size can obviously result in lower birth weights and decrease uniformity because litter size and piglet quality traits appear to be negatively correlated. The heavier pigs farrowed in the smaller litter although the relationship seemed not quite rectilinear. Litter size might affect birth weight either by changing the intensity of competition among the developing foetus for the available nutrient supply oxygen and space or by affecting the length of gestation period so that larger litters might be born at an earlier stage of development than smaller litters (Wright, 1921). Apparently the conditions which lead to the conception of exceedingly small litters are not the optimum for developing large pigs among those which are conceived. Litter size can influence piglet survival after birth as piglet losses tend to be greater in larger litters which may be attributed to within-litter variation in piglet birth weight. (Marchant et al., 2000; Lay et al., 2002). A difference of one more or one less in each litter has much less effect on the average birth weight in some than in guinea pigs. Wright (1921) reported that size of litter had much more effect on birth weight by reducing the rate of growth of the foetus than by causing early parturition. Competition between foetus is indicated as the major way in which litter size affects birth weight. Litter mates are more apt to have the same genes than are pigs less closely related than full brothers and sisters. Yet litter mates are unlikely in many genetic factors. Litter mates also tend to be alike because they develop in the same uterus and were thus exposed to an environment remarkably uniform for members of the same litter but perhaps differing distinctly from litter to litter.

In general, parity had highly significant effect on body weight at different age groups. The body weight increased with advancement of parity and lambs born at 4th and above parities had higher body weight at different ages (Thiruvenkadan et al., 2011). Birth weight of second parity was higher than first and third parity in goats (Bharathidhasan et al., 2009). Tomar et al., (1995) observed that the parity of gestation was found to have significant effect on birth weight. Similar results have been reported by Prakash and Singh (1985) and Pandev and Kanaujia (1988). Selection for sow’s ability to give birth to higher number of piglets has led to an increased within-litter variation in piglet birth weight (Tribout et al., 2003). Optimise selection for litter size, studies showed that larger litters with more than 13 piglets are not always desirable given the high mortality rates of these litters. Mortality rates were increased for litters with larger variation hence reduction within litter variation in piglet weight at birth reduced mortality.

2.2. Age of dam and maternal nutrition influencing birth weight

It has been previously demonstrated that inappropriate maternal nutrition at key stages of pregnancy is one of the measureable factors leading to decreased live weight (Wallace et al., 1999). The relative competition for nutrients between the still growing ewes and developing foetus may be the reason for depression in birth weight in lambs born to younger ewes (Thiruvenkadan et al., 2011). In cattle, a calf weighs 7-8% the weight of the dam, as weight depends on age, there is a positive relation between the age of the cow and weight of calf at birth. Dam's age was significant on birth weight (Dixit et al., 2001) but some contradictions with others (Elfadili et al., 2000; Abegaz et al., 2005). After 10-11 years of dam age, calf birth weight tends to decline, but this varies among breeds. Age of does had a significant effect on birth weight and effect of parity of dam on body weights in lambs were observed by Yazdi et al., (19980 in Baluchi sheep and Mandal et al., (2003) in Muzaffarnagari sheep. Differences between ages 2 and 3 was significant but ages between 2 and other ages (4,5,6) it was very significant (Caro Petrovic et al., 2012). Van der Westhuizen et al., (2004) stated that kids born to young does (2 years-old- does) had lower body weights up to 16 months of age of dam than kids born to 4 to 8 year old does. Authors concluded that age of dam is one the internal factors that have a marked influence on overall efficiency of the flock. The lambs produced by dams of 5 years and more had more weight than other lambs . This was related to higher capacity of milking in association with 5 years and more ewes in comparison to younger ewes (Dixit et al., 2001; Rashid et al., 2008). Thiruvenkadan et al., (2011) reported that maximum birth weight was observed in lambs born to ewes in 4th parity and above parities. Birth weight determines how much milk the calf can consume, the bigger the calf the bigger suck and the more milk the cow will produce. Research has shown that the birth weight of the calf will be approximately 7% of the dam's body weight as a result bigger cows will have heavier birth weight calves.

The effect of nutrition was relatively small, yet statistically quite significant (Dwyer, 2003). There was a significant effect of year on birth weight due to improvements in management and feeding of ewes during pregnancy (Combellas et al., 1980). Maternal nutrition during pregnancy plays an important role in the regulation of foetal and placental development, therefore has the potential to influence foetal growth as indicated by birth weight. Maternal under nutrition in pregnancy resulted in low birth weights and impaired postnatal survival in sheep (Dwyer, 2003). It was indicated that the nutrition of dam and the size of placenta are well known to determine the foetal growth rate (Mellor, 1980). Knight et al. (1988), Konyali et al. (2007), Jawasreh et al., (2009), Alkass et al. (1999) and Oramari et al. (2011) showed that birth weight was strongly associated with placental traits such as placental weight. Over nourishing the adolescent dam to promote rapid maternal growth through out pregnancy resulted in a major restriction in the placental weight, and leads to a significant decrease in birth weight relative to moderately fed normally growing adolescents of equivalent gynaecological age (Wallace et al., 1999). Inappropriate maternal nutrient intake at key developmental points during ovine pregnancy had a profound influence on the outcome of pregnancy and aspects of post natal productivity. However, it was noted that the responses to alterations in maternal nutrition in adult sheep are often highly variable and inconsistent between studies. Lamb birth weight was reduced in low intake ewes compared with high intake ewes, but the incidence of malpresentation at delivery was greater in low intake lambs. Lambs birth weight had a significant effect on neonatal development progress. Low birth weight lambs were slower than heavier lambs to stand and suckled less frequently. This could have been associated with the reason to say that lower birth weight than optimum are associated with reduced energy reserves and increased calf deaths or near birth (Dwyer et al., 2003). It may suggest that less frequent suckling by under weight young ones may result into death due to starvation. The same author concluded that low level of nutrition result in decreasing in birth weight will also affect neonatal lamb behaviour. The level of nutrition of dam and calf birth weight are positively correlated, especially in the last trimester when 70% of the calf's absolute growth takes place. There is need to reduce feed to minimize difficult birth cases, or use bulls known to produce smaller calves, especially in heifers. The birth weight of kids were influenced by the nutrition of the dam received during the pregnancy term (Otuma and Osakwe, 2008; Roy et al.,1997; Singh and Ramachnandra, 2007). The regression of birth weight of kids was positive on dam weight at kidding and each of cotyledon number and cotyledon density were negatively correlated on dam weight at kidding , respectively (Alkass et al.,2013). Also, the report claimed that the weight of dam at kidding was significantly correlated with birth weight of their kids (Jawasreh, 2003).

2.3. Sex influencing birth weight

Many decades ago, Haines (1931) found the sex differences in the birth weight of guinea pigs slight and was not quite certain of its significance. However reported that males were rather consistently heavier than females. Assan and Makuza, (2005) reported that sex had a non significant effect on birth weight in indigenous Sabi sheep. The results are in agreement with literature findings (Trail and Sacker, 1986). Khombe (1985) reported similar findings. Sex had a significant effect ($p<0.05$) on birth weight in Mutton Merino and Dorper sheep. The males were significantly ($p<0.001$) heavier than females in Mutton Merino and Dorper sheep. Thiruvenkadan et al., (2009) reported that sex, the period of birth and type of birth of kids were the major factors affecting birth weight in Tellichery goats. Banerjee and Jana (2010) observed that buck kids weighed more than doe kids as singles born, twins of the same and different sex and also as triplets. This was in agreement with the report by Baiden (2007), Kamal Elhassan Elabid (2008) and Karna et al, (2001). Hafez (1962) attributed this to anabolic effect of male sex hormones.

2.4. Genotype and birth weight

The differences in birth weight in livestock may be attributed to the effect of breed besides of the non genetic factors (Banerjee and Jana, 2010). Ferrell (1993) studying the factors influencing foetal growth and birth weight in cattle reported that calf birth weight differed substantially among the nine breeds of cattle. Weights of calves from cows on the very high feed level had the highest birth weight, followed by medium and lowest feed levels gave the lowest birth weights. The nutritional effects were much less than the breed effects and were in general larger in magnitude in breeds having larger calves. It was suggested that low levels of maternal nutrition may result in reduced birth weight, but nutritional levels above adequate result in no further increase. Crossbred litters showed higher live weight at birth than those of pure bred litters (Abdel-Azeem et al., 2007). These results were in agreement with those reported by Seleem (2005). Superiority of crossbred litters weight may be due to hybrid vigour which appeared in different ages of kits and to superiority in litter size traits. The effect of breed are highly significant although not quite as important as litter size in pigs The importance of breed in birth weight may be attributed to the way the breeds react to differences in the environment from year to year. Indigenous livestock are well adapted to semi arid stressful conditions. They have a high degree of heat tolerance, are partly resistant to many of the disease and parasites, and have the ability to survive dry periods of feed scarcity and water shortage. These characteristics have become genetic for the simple reason that they have been acquired by natural selection over hundreds of generations. This suggests that they could be less influence of environmental stressors on birth weight in indigenous livestock than their counterpart imported from the temperate climates. The genotype of both the mother and the foetus play a vital role in determining the birth weight, while the consequent litter weights basically depend, beside the foetuses genotype, on the suckled milk from the dam (Abdel- Azeem, 2006). Gregory and Castle (1933) stated that embryonic development in the rabbit proceeds at a more rapid rate in rabbits of large races than in rabbits of small race. It was noted that the higher rate of development of these rabbits was influenced by the sperm, as well as by the egg and may be supposed to be induced by chromosomal genes. It was evident that the primary contributor of differences in foetal growth is foetal genotypes which consisted of contributions from both the sire and dam (Ferrell, 1993). Pig birth weight is largely the expression of genetic differences between dams and then some of the other environmental common to litter mates is really genetic in origin but depends on the genotype of the dam rather than on the genotype of the offspring. This is mainly expressed in crossbreeding systems. Sundaram et al., (2012) suggested that the variation in body weight can be attributed to adaptations of kids to the region with time and environmental conditions with changes in weather parameters with interactions amongst different animals within the same breed.

In pigs litter mates are subjected to similar environmental conditions during their intra-uterine life, which might well make the dam more important than the sire in affecting birth weights even though both sire and dam contribute equally to the unborn piglets. With the sire hold constant within year was but slightly more than the eliminated by year alone and it appeared certain that the boar had some effect on the birth weight of the offspring. Assan (2011) working with indigenous Tuli cattle reported that sire had a significant effect on birth weight.

2.5. Year and season variation influencing birth weight

It is well established that year of birth causes variation on weight and performance of livestock due to climatic variations and management during pregnancy (Abegaz et al., 2005) Variation in the weather, nutrition and farm management from year to year might be responsible for increased weaning weight (Bharathidhasan et al., 2009). The significant differences in body weight among lambs born in different periods was attributed to differences in management, selection of rams and environmental conditions, such as the ambient temperature, humidity and rainfall (Thiruvenkadan et al., 2011). The seasonal changes in the climate were reflected as differences in body weights during different periods of the year. Year of birth has been found to have a significant influence on birth weight in cattle (Magnus and Brink, 1971). The high variation in birth weight due to year of birth can be explained by variations in amount of annual rainfall which in turn influenced pasture production and availability of feed for the dam. Kids, prior to weaning, depend mainly on dam's milk as food, the production of which is directly related to the availability of feeds to does (Peart, 1982; Mukundan and Bhat 1983; Groot et al 1993). Seasonal influence on birth weight operates through its effect on the dam's uterine environment mostly in late gestation (Eltawil et al 1970). Season of birth plays an important role in growth performance indirectly through its influence on the dam's nutrition and hence amount of milk available to the unweaned lamb. In the post-weaning period its influence is related to its effect on the quality and quantity of pasture available to the weaned kids. Large differences in rainfall lead to marked differences between years quality and quantity of forage available (Khombe, 1985) hence supplementation would remove the year effect. Differences between years are normal phenomenon and are normally caused by fluctuations in environmental conditions that are difficult to control. The month within a year in which a lamb was born is very important. According to Mukandan and Rajagopalan, (1971) birth weights are affected by feeding conditions. The significant effect of season of lambing on the 9th month may be due to those lambs born in first season pas through a period with a favourable climate when grasses of good quality were available. .Lams born in hot rainy season spent the first months of their life in a hot rainy season which was uncomfortable for them and in which the parasitic challenge was high (Thiruvenkadan et al., 2011). Pasture availability follows a seasonal pattern, Nagpal (1984) reported that the year had a significant effect on birth weight which also agreed with the findings of (Khan and Sohani, 1983). The year effect encompasses factors which include feeding, management, climate, temperature, disease control and management ability of the person responsible for data collection. Year of birth has been found to have a significant influence on birth weight in cattle (Magnus and Brink, 1971). Das et al., (1995) reported that year of birth had a significant influence on weight gain up to 6 months of age. Environmental conditions such as weather, kind and quality of feed, details of management naturally varied somewhat from season to season and may have had influenced the prenatal development of the pigs. The analysis of variance when the birth weight of pigs were grouped according to year in which they were furrowed, the effects of year was highly significant. Thiruvenkadan et al., (2011) suggested that the lower birth weight of lambs in second season was due to the effect of ambient temperature, since the gestation period of the ewes would occur during hot period of the year. It is well established that as the environmental temperature increases, the cow will direct a greater portion of her blood flow to her extremities for cooling. Therefore there is less blood flow to the core of the cow, which results in a decrease in the amount of nutrients being carried to the foetus through the maternal blood, resulting in decreased birth weights when environmental temperatures are increased during gestation. In contrast, cold temperatures will result in increased birth weights, as blood flow is directed to the core of the body. The decreased feed intake , depressed thyroid activity and hence in metabolic rate of pregnant does during hot summer months affected litter weight and mean kit weight at birth negatively (Abdel-Azeem et al., 2007). The effect of season and year of birth on birth weight of Sirohi breed of goat of either sex , reared in hot and humid climate of eastern India was reported by Sandip and Jana (2010). Variation in supply and composition of feeds and fodder affects weight of kids at different life stages (Sundaram et al., 2012). Birth year causes vacillations over body weight in different ages by the effect of climate condition(rate of rainfall, humidity and temperature), environmental and management conditions. \climate and environmental changes have effect on the quality and quantity of pasture forages, which also affect the provision of food and other requirements for animals (Mohammadi et al., 2010). Assan (2011) suggested that the below average of birth weight between 1991 to 1992 was due to prevailing drought in Zimbabwe which translated into low forage availability to animals on range. When the following season had improved the birth weight also improved. Because of the normal rainfall. This observation indicates that the large differences in rainfall can lead to marked differences between years in the quality and quantity of forage available, and this translate into differences in calf birth weights. Thorpe et al., also reported that high variation in birth weight due to year of birth could be explained by variation in the amount of rainfall which in turn influence pasture production and availability of fed. Differences in nutrition (especially during pregnancy) and management in various years are reasons for the effect of birth year on body weight in different ages (Shhroudi et al., 2001; Ahmadi et al., 2004). This influence on birth weight operates through its effect on the dam's uterine environment mostly in late gestation. (Eltwil et al., 1970). Apart from the year's effect mainly caused by climatic conditions and its influence on the availability of pasture (Carles and Riley, 1984) and milk production of the dam (Shelby et al., 1955). Environmental factors including management, disease control and administrative ability of persons responsible come into play. Yaqoob et al., (2009) reported that the effects of fodder availability and prolificacy on birth weight was significant in Dera Din Panah goats. The same author concluded that goat productivity was affected by the variation in fodder due to sporadic rains in the area and suggested a change in cropping practices such as growing more fodder during rainy season by introducing new fodder varieties and then conserve it for scarcity period. Thiruvenkadan et al., (2009) reported that the effects of birth month on planning kidding season would improve production efficiency. A significant variation in birth weights in kids during different fodder availability was also observed by Nahardeka et al., (2000) and Wenzhong et al., (2005). Banerjee and Jana, (2010) cited that kids born in the summer months may be heavier at birth because dams may have access to proper nutrition in form of grazing during the spring season just prior to the onset of summer. During monsoon months the animals are usually stressed due to high humidity in the region and also due to higher parasitic load, the pasture grasses have high crude fibre content and lower protein content. After cessation of monsoon the climate improves and there is plenty of grazing. The variation in birth weight of kids in different years reflected variation in level of management (Caro Petrovi, 2012).

2.6. Fetal development and the resultant birth weight

Placental weight is a primary factor determining size of birth in many animal species (Heasman et al., 1999). Kelly (1992) and many workers working with sheep concluded that numerous factors influence placental growth and development and having investigated the role of maternal nutrition as a regulator of placental and foetal size. The major restriction in foetal growth in rapidly growing dams occurs irrespective of high concentration of essential nutrients in the maternal circulation and suggests that the small size or altered metabolic and transport capacity of placenta is the primary constraint to foetal growth hence the low birth weight. Restricting maternal nutrition to decrease birth weights is not a sound management practice. Extreme reductions in feed, such as feeding less than 70% of the cow's nutrient requirements will result in decreased birth weights. However it often times results in an increase in calving difficulties because the cows are weak and undernourished. Slightly restricting the nutrient requirements of the cow will result in decreases in energy reserves (body fat) of the cow before limiting the nutrient flow to the foetus. In partitioning of nutrients, the cow puts her pregnancy at the top of the list, right below keeping herself alive, therefore her body will work overtime to metabolize stored nutrients to allow the foetus to grow. This is why restricting feed, unless in an extreme case, has little impact on birth weight. In sheep[placental weight peaks at approximately mid gestation, with structural remodelling occurring over the second half of pregnancy to meet the increasing nutritional demands of the growing foetus. In general the right horn of the uterus in beef cows is larger, in addition a greater percentage of the ovulations, that result in pregnancy come from the right ovary. Some research suggests that calves are conceived in the right horn gestation are have great birth weights due to the larger uterine horn. While it is well understood that the dam and sire of a calf play a role in the genetically predicted birth weight of a calf, other factors do come into play. It is important to keep the other factors in mind that impact the birth weights of your calves to help ensure a successful and prosperous calving season.

2.7. The relationship between birth weight and calving problems

Calving difficulties account for a tremendous amount of economic loss in the beef cattle industry. The highest correlated factor contributing to calving difficulties is the size and or body weight of the calf. Of all cases of calving difficult, 60-90% of them can be attributed to the birth weight of the calf. While it is well understood that genetic selection for birth weight is critical for a successful calving season, there are several factors, aside from genetic influence, that impact the birth weight of a calf. Birth weight has long been regarded as a major contributing factor associated with calving difficulty. Basically, the higher the BW EPD, the greater the calving difficulty is expected from the use of such sires. Also, the birth weight is an important breed characteristic in cattle. The birth weight is not only the easiest and the most reliable measurement of the prenatal period, but also a substantial factor that affects post-natal growth and development (Akbulut et al., 2001). A substantial and positive relationship was determined between the birth weight and the first calving age (Kaygisiz et al., 1995; Bakir et al., 2004; Heinrichs et al., 2005). This relationship can be interpreted as Heifers that have a higher birth weight on calving at an earlier age (Pietersma et al., 2007). Additionally, calving difficulties and death risk are closely related to the birth weight in cattle farming. The rate of death and calving difficulty has increased in both calves that have a very low and high birth weight (Johanson and Berger, 2003).

3. Genetic parameters

3.1. Cattle

Literature estimates for direct heritability for birth weight in cattle are variable and range from low to high. In most cases the direct additive genetic variance is higher than maternal additive genetic variance. The corresponding direct heritability and maternal heritability of birth follow the same trend (Assan, 2012). This shows that birth weight is much more influenced by the genetics of the calf than the dam, however both effects remain very important. Findings of larger direct additive genetic variance in cattle have been reported in literature by DeMattos et al., (2000) and Choi et al., (2000). Direct heritability estimates for birth weight in different univariate and bivariate analysis for Charolais and Hereford calves born at first and later parities ranged from 0.44 to 0.51 (Eriksson, et al 2004). In a related study higher estimates of direct heritability were observed by Phocas and Laloe, (2004) working with Charolais and Maine-Anjou breeds, and Limousin and Blonde d'Aquitaine breeds of 0.30 and 0.40, respectively. Other comparable results for direct effects have also been found in study of native Korean cattle by Lee et al., (2000), in study of Austrian beef cattle by Meyer et al (1993) and in study of Japanese Black cattle by Aziz et al (2005). The heritability estimates of birth weight are in conformity with those reported in literature for Boran (Bos Indicus) cattle in Ethiopia (0.24) (Haile- Mariam. and Philipson, 1995), and those reported for Nelore (Bos indicus) cattle in Brazil (0.22) (Eler et al., 1995) and 0.25 reported by Shin, et al. (1990). However the estimate of direct heritability reported above are slightly below the weighted mean estimate (0.31) for several different beef breeds (Koots et al., 1994). There are also less than the direct heritability (0.33) reported for Bos Taurus and Bos Taurus* Bos indicus crosses of (Meyer, 1992a) and for Brahman cattle (0.33) in Venezuela (Plasse et al 2002a). Elsewhere lower heritability estimates were obtained by Ferraz et al (2000) for birth weight of Santa Gertrudis, which were lower than the average value of 0.31 summarized of 167 number of research studies by Koots et al (1994)

Maternal heritabilities estimated for birth weight in different univariate and bivariate analysis for Charolais and Hereford calves born at first and later parities ranged from 0.06 to 0.15 (Eriksson, et al 2004) and were comparable to those reported by Phocas and Laloe, (2004) working with Charolais and Maine-Anjou breeds, and Limousin and Blonde d'Aquitaine breeds observed reported maternal effects on birth weight of 0.10. Assan (2012) reported maternal heritability for birth weight of 0.14 in Tuli cattle which coincides with reports by Intaratham et al., (2008) in a Northeastern Thai indigenous cattle and Meyer, (1992). The weighted mean from different beef breeds ranged from 0.12 to 0.55 reported by Kriese, et al., (1991). Lower maternal heritability of 0.08 and 0.07 were reported by Plasse et al (2002a;

2002b), 0.09 obtained by Haile- Mariam and Philipson (1995) and 0.11 reported by MacNeil (2003). Generally the maternal heritability is less than literature estimates of Meyer (1992b) which was 0.17 for mean estimate for Bos tauras and Zebu crosses. Based on a suggested appropriate model, Dezfuli and Mashayekhi, (2009) estimated maternal heritability for birth weight to be 0.08. From an analysis of Boran cattle birth weight, Wasike et al. (2009) reported maternal heritability of 0.10 for birth weight. Gutierrez et al. (2007) and Albuquerque (2001) also reported direct and maternal heritability for birth weight of Zebu cattle of 0.28 and 0.01, respectively. But, Kriese et al (1991), working with Santa Getrudis cattle, obtained estimates of direct and maternal heritability to be 0.38 and 0.26. Low to moderate maternal heritabilities range of (0.11- 0.24) were estimated for birth weight in Najdi calves by Dezfuli and Mashayekhi, (2009) using different models.

It is generally concluded that the covariance and correlation between additive and maternal genetic effects were negative (Meyer, 1993; Arthur et al. 1994; Pang et al 1994). The results in literature dealing with the genetic correlation between direct and maternal effects for birth weight vary (Meyer, 1992a). A negative correlation between direct and maternal genetic effects could be an indication of genetic antagonism between genes (Ferraz et al., 2000) and it may therefore be important to consider the both direct and maternal genetic effect in selection for weaning weight. The weak negative genetic correlation (-0.31) between direct and maternal genetic effects for birth weight were comparable to those reported by Ferraz, et al., (2000) of –0.39 and –0.37 obtained by Plasse et al., (2002a). A similar estimate of -0.36 for Brahman cattle was obtained by Pico, (2004). This is also similar to weighted mean obtained for several beef breeds by Koots et al. (1994), but higher than estimates of –0.55 for Boran (Haile- Mariam, and Philipson 1995) and of -0.50 reported by Diop, (1970) in Gobra cattle in Senegale. It is however less than the estimates of –0.17 obtained for Gobra cattle by Diop and Van Vleck (1998) and –0.14 reported in Boran cattle by Wasike, et al. (2009). The genetic correlation between direct-maternal effects was negative , low and could indicate a genetic antagonistic between genes and should be considered in selection criteria. This agrees with results reported by Kriese et al. (1991) in Santa Getrudis cattle and other Brahman crosses in USA and Eler et al., (1994) in Nelore cattle in Brazil. The low negative covariance (-0.06) estimate was associated with a moderate estimates of direct and low maternal heritability and, an increase in the total heritability. The total heritability for birth weight was 0.67 in Tuli cattle (2012) and this is higher than the estimates of 0.28 and 0.30 obtained by Plasse et al (2002a; 2002b) in Brahman cattle. Lower estimates of 0.10, 0.17 and 0.08 were found by the following authors, Eler et al. (1995) for Nelore, Haile- Mariam and Philipson (1995) for Boran and Diop and Van Vleck (1998) for Gobra, respectively.

3.2. Sheep

Assan (2012) working with two exotic sheep breeds in Zimbabwe reported estimates of heritability for direct genetic effects, maternal genetic effects, and the genetic covariance between direct and maternal effects as a proportion of the total variance for birth weight as 0.23, 0.16, 0.85 and 0.26, 0.46, -0.25 for Dorper and Mutton Merino sheep, respectively. Fitting the direct and maternal genetic covariance resulted to negative estimates of direct-maternal genetic correlation for birth weight (Ghafouri-Kesbi and Eskandarinasab, 2008). Chaudhry and Shah (1985) reported that heritability of birth weight was 0.14 in Lohi and 0.10 in Kachhi breeds of sheep. Maui and Rodricks (1987) studied production data of Merino-Nilagiri crossbred sheep and reported heritability of birth weight as 0.10 .,t 0.07. Sarti et al. (2001) reported the heritability estimation as low as 0.20, calculated on the basis of analyzing 393 weight records, collected from birth till weaning. Bromley et al., (2000) reported the heritability estimate of birth weight as 0.09 in Columbia, Polypay, Rambouillet and Targhee breeds of sheep.

Barazandeh et al., (2011) in goat demonstrated that animal models which ignore maternal effects might result in overestimation of direct heritability Moderate direct heritability estimates for sheep were reported by Campbell, (1971) (0.26); Murayi and Wilson,(1991) (0.24); Mehta and Bhatqava, (1992) (0.22). Using a sire model for birth weight Burfening and Carpio(1993), Van Wyk et al., (1993) and Nicoll et al., (1989) reported heritability estimates range of 0.10 to 0.20. However higher direct heritability estimates for BWT in sheep were reported by Maria et al.,(1993) (0.48); Boujenme and Kerfal (1990) (0.34) and Alkassi et al.,(1990) (0.44). (Maria et al., (1993) and Snynam et al.,(1996) reported lower direct heritability than in the present study of 0.04 and 0.11, respectively. On the other hand Bowman (1984) and Wiener (1994) cited approximate value ranges of direct heritability estimates of birth weight of 0.08 to 0.72 from several authors working with different breeds of sheep such as Shropshire, Southdown, Corriedale, Targhee, Columbia and Ramboillet. It is interesting to note that direct heritability on sheep on range agreed very well with those studied under intensive system. It can be concluded that direct heritability may vary according to method of analysis, type of breed and management system. Moderate heritability estimates recorded for birth weight (0.47) (Assan,2012) was lower than most of the estimates in the literature (Al-Shorepy, et al., 2002; Portolana et al., 2002 and Kosum, et al., 2004), though similar to 0.43 reported by Hongping (2007) and lower than 0.68 reported by Mourad and Anous (1998) for Boer goats and Common African and Alpine goats, respectively. Stobart (1983) made genetic analysis of Columbia, Rambouillet and Targhee sheep and reported that heritability of birth weight was 0.06 + 0.01. Sheikh et al. (1986) made genetic evaluation of a flock of Kashmir Merino sheep and reported that heritability of birth weight was 0.03 to 0.02.

Maternal heritability estimates were 0.16 and 0.46 for Dorper and Mutton Merino sheep, respectively (Assan, 2012). However it was noted that maternal heritability was higher than direct heritability in Mutton Merino sheep which indicates that maternal effects play an important role and need to be included in the analysis of birth weight in this population. Elsewhere Burfening and Kress (1992) observed maternal heritability estimates range of 0.30 to 0.65 for birth weight in different breeds. However the above estimates were higher than those reported by Khaldi and Biochard (1989) of 0.02. The higher estimates of maternal heritability were probably due to high common environmental effects as a proportion of the total phenotypic variance which constituted more. The reported estimates of additive maternal effects suggest that maternal effects might be important for birth weight in small ruminants. The advantage of inclusion of maternal effects in pre-weaning weight animal models avoids upwards biased estimates of direct heritability Van Wyk et al., (1993) and Waldron et al., (1992) which may result in overestimation of total genetic response. Genetic correlation between direct and maternal effects was large and positive (0.85) for Dorper which may be biologically impossible (Assan, 2012). Elsewhere positive genetic correlation of direct and maternal effects have been reported by Synam et al., (1996) and Olivier et al., (1994) for birth weight in sheep. Yazidi et al., (1997) observed positive direct and maternal genetic effects of 0.18 for birth weight in sheep. The positive genetic correlation may imply that selection for increased birth weight may be possible, however caution should be taken to to minimize difficult birth in the populations. The positivity of the correlation between direct and maternal effects has been previously attributed to the structure of the data (Lee and Pollack,1997). The negative and small genetic correlation of direct and maternal effects have also been reported in literature (Van Wyk et al., 1993; Burfening and Kress, 1992; Olivier et al., 1994). The estimate of negative correlation between direct and maternal effects of the above authors fall within the range of -0.18 to -0.74 reported by several authors working with different breeds of sheep (Burfening and Kress, 1992;Yazidi et al., 1997; Tosh and Kemp, 1994). Common environmental maternal effects variance contributed 13% and 25% of the total phenotypic variance for birth weight in Dorper and Mutton Merino sheep, respectively (Assan, 2012). This may be attributed to the uterine environmental and the ability of the ewes to provide adequate milk when the multiple birth which are common in both breeds.

3.3. Genetic parameters for birth weight in pigs

Genetic analyses of birth weight and its variation within litter have been presented in several papers (Hogberg and Rydhmer, 2000; Hermesh et al., 2001; Damgaard et al., 2003; Huby et al., 2003). Birth weight direct heritability estimates are reported in the range from 0.02 to 0.11 (Kaufmann et al., 2000; Knol et al., 2002; Grandinson et al., 2002; Chimonyo et al., 2006; Su et al., 2006). Low to moderate heritabilities were found for litter weight at birth and within litter standard deviation in the birth of 0.19 (Begsma et al., 2008) which conform to reports by Okoro et al., (2013) who reported an estimate of 0.15. The differences in heritability from the previous studies may be attributed partly due to the fact that direct maternal effect model could not be fitted (Roeche, 1999), data and maternal genetic effects were estimated in a combined litter effect. However, Roeche and Kennedy (1993) managed to show that the direct genetic and litter effects model can be efficiently used to estimate direct effects independent of maternal genetic effect, which maternal genetic and environmental effects cannot be disentangled or not enough pedigree information is available. Singh et al., (2001) working with Landrace using full sib correlation method the estimate of heritability for body weight at birth (0.94) from dam component of variance was higher in magnitude than the sire component(0.38). This was attributed possible due to inclusion of maternal/non-additive genetic variance component which had considerable influence on the growth performance of piglet up to weaning. These results were fairly comparable with the reports by Sukh Deo et al., (1981). Differences in breed was not conspicuous in estimation of heritabilities, for litter at birth, 0.32 for Landrace, 0.32 for Yorkshires, 0.23 for Durocs and slightly lower, 0.09 for Hampshires, respectively (Kim et al., 1988). This scenario may be attributed to pig population under the same management. Estimates of heritability for age at birth of last litter were between 10 and 20% ranging from 0.11 for Yorkshire to 0.19 for Landrace and 0.19 for Duroc (Johnson and Nugent, 1999). Estimate for posterior means of heritability for birth weight was almost three times as high at 0.20 (Roeche et al., 2009). A low heritability of litter weight at birth of 0.14 was reported by Rasali and Penalba (1993) and average weight of pig per litter at birth was small (Rattanaronchart and Puprasert, 1986). Traits like average birth weight appeared to have moderate heritability, 0.33 for sows of lines selected for growth rate on restricted feeding and low for litter birth elsewhere, 0.08 (Roeche, 1999). Using a Bayesian posterior means for direct, maternal heritability and litter proportion of variance in individual birth weight were 0.09, 0.26 and 0.18, respectively

4. Final comment

The review concludes that there is a strong influence of various environmental factors on birth weight of animals. The significant influences of environmental factors on birth weight can be explained in part by differences in years, male and female endocrine system, limited uterine space and inadequate availability of nutrients during pregnancy and maternal effects and maternal ability of dam in different ages. The influence of different environmental variables on birth weight are not independent of each other but may overlap considerably. Sex influence seems inescapable in birth weight differences, it is real but comparatively unimportant among the other causes of differences in birth weight. Practical implications of studying birth weight is not only for livestock management decision making but also to minimize the adverse effects of factors that retard foetal development.

It has been evident from the discussion that environmental factors influence birth weight of animals as much as genetic factors, with better birth weight observed were indigenous animals are crossed with improved livestock type. This suggest that there is potential for improving tropical animal breeds by combining their great adaptability with the higher potential of improved genotype.

The direct heritability of birth weight is variable, ranging from low to high and is much dependent on statistical model used. Both negative and positive correlation of direct and maternal genetic effect are possible for birth weight. The negative genetic correlation for direct and maternal genetic effect shows that there is antagonism of genes as a result both direct and maternal genetic effects should be considered in selection in such a situation.

Birth weight has become a significant predictor of later health outcomes, lower birth weights than optimum are associated with reduced energy reserves, lowered thermoregulatory capacity and increased deaths of young ones. Birth weight should be given some consideration in preliminary selection criteria in livestock populations in view of the fact that there is comparatively high genetic variability of both direct and maternal effects in livestock species which can be exploited to improve weight traits by selection. However, to arrive at a valid conclusion for weight at birth, the association of birth with further live weights should be understood first. There is high genetic variability for birth weight in animals which may be exploited, if birth weight is to be considered for inclusion in selection index for genetic improvement of live weights as productive traits in animal production. In pigs the antagonistic relationship between litter size and piglets birth weight was confirmed, subsequently it may be reasonably to conclude that inclusion of birth weight as a selection criteria is recommended. Research has also acknowledged that the number of piglet born alive and the average piglet weight at birth have a negative correlation, therefore the weighting of both characters in selection index should be done with care as a result not to overemphasize weight at birth and unintentionally decrease litter size by selecting heavier baby pigs from smaller litter.

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