Sjournals
Scientific Journals
Scientific Journal of Animal Science (2013) 2(7) 199-214
ISSN 2322-1704

Contents lists available at Sjournals
Scientific Journal of Animal Science
Journal homepage: www.Sjournals.com

Review article

Genetic parameters and environmental factors influencing weaning weight in livestock production

N. Assan*
Zimbabwe Open University, Faculty of Science and Technology, Department of Agriculture Management, Box 3550, Bulawayo, Zimbabwe.

*Corresponding author; *Zimbabwe Open University, Faculty of Science and Technology, Department of Agriculture Management, Box 3550, Bulawayo, Zimbabwe*.

A R T I C L E I N F O

Article history,
Received 20 July 2013
Accepted 27 July 2013
Available online 30 July 2013

Keywords,
Genetic parameters
Environmental factors
Weaning weight
Animal production

A B S T R A C T

This is a review paper that focuses on genetic parameters and various environmental factors affecting weaning weight in animal production. Animal production is affected by both genetic and non-genetic factor, and level of weaning weight performance depends on their interaction. The estimates of direct heritability of weaning weight vary from medium to high which makes it a suitable selection candidate trait, however cognisance should be taken of the antagonism of genes controlling direct and maternal effects. The variation in genetic parameter estimates may be due to a variety of factors which include breed differences, management, data preparation and methods of estimation. Estimates of genetic parameters for weaning weight is partly model dependent and ignoring of maternal genetic effect in the model leads to overestimation of direct heritability. Whilst genetics is a major influence on weaning weight, there are also a large number of environmental, nutritional and management factors that impinge on weaning weight of an individual. Estimation of reliable estimates of genetic parameters for weaning weight need to take into account the adjustment of performance data for environmental factors hence this will increase the accuracy of selection of breeding animals. An understanding of environmental factors which affect weaning weight will direct changes in the breeding and management programs to minimise influences which reduce production efficiency.

Most environmental factors are significant source of variation for weaning weight and play an important role in expression of genetic potential. Management system is one of the many factors which could affect weaning weight in livestock since in a farm situation young ones will be subjected to the same season, parity, climatic conditions in terms of availability of feed, medication and vaccination. The review paper therefore, concludes that a number of environmental factors affect weaning weight can directly obscure recognition of genetic potential of individuals.

1. Introduction

Appropriate knowledge on variance components and genetic parameters for production traits such as weaning weight in animal production is paramount (Franke et al 2001; Intaratham et al., 2008; Vergara et al., 2009). Weaning weight of an animal is determined not only by its genetic potential but also by the maternal environment (Ribeiro et al., 2001; Atil et al., 2005; Hwange et al., 2008) hence accurate estimates for maternal genetic effects and their contribution with direct effects are essential (Speidel et al., 2007; Canas et al., 2008). Different estimates of direct and maternal heritability for weaning weight, which are low to high have been reported in literature for different animals species by Meyer, (1993) in cattle, Assan and Makuza, (2005) in sheep, Gholizadeh et al., (2010) in goats and Fernandez et al.,(2008) in pigs.

Weaning weight is the most important economic trait determining economic returns from any animal production enterprise and provide a good example of a trait subject to both genetic and environmental variation (Assan and Makuza, 2005). Weaning weight would reflect mothering ability of dam as well as the inherent growth potential of individuals animal. In addition to knowledge on genetic parameters, environmental factors influencing weaning weight in livestock is of interest to farmers as well as the animal breeders, because weaning weight is of great economic importance in livestock production. Both genetic parameters and information on environmental factors affecting weaning weight may be of value in general livestock management decision making and animal selection. Production traits such as weaning weight are affected by various non-genetic factors like sex, year, type of birth, dam age and management (Kumar et al., 2007; Paul et al., 1990). The review paper looks at the genetics and influences of environmental factors which might obscure recognition of genetic potential of individuals for weaning weight performance in animal production.

2. Genetic parameters for weaning weight

2.1. Cattle

Different models and methods have been used in estimating direct and maternal genetic parameters for weaning weight data in cattle (Meyer, 2001; De Mattos et al., 2000; Maiwashe et al., 2002; Beffa, 2005; Choi et al., 2000; Bosso et al., 2009; Palacios-Espinosa et al., 2010) and previously the ranking of models was mostly done by log likelihood ratio test (Dobson, 1990). Mohhiuddin et al., (1993) weighting various published estimates by the number of records used in each analysis obtained average values for weaning weight of 0.22 for direct genetic effect, 0.13 for maternal genetic effect and -0.15 for the genetic correlation between these parameters. Koots et al., (1994a) weighting various published estimates by the inverse of their sampling variance obtained mean heritabilities of the direct effect of 0.24 for weaning weight. The heritability estimates reported by several authors in cattle ranged from 0.80 to 0.25 depending on the model used and breed studied (Mattos et al., 2000; Guitierrez et al., 2007; Vostryt et al., 2007; Dezfuli et al., 2009). It was observed that estimates of direct heritability depended much on the model used with a range of zero to 0.68. The range of direct heritability estimates of 0.8 to 0.25 which were depended on the model used and breed of calves were reported in literature (Mercadante et al., 1997; Dodenhoff et al., 1999; DeMattos et al., 2000;Gutierrez et al., 2007; Vostry et al 2007; Dezfuli et al., 2009;). Low direct heritability estimates for weaning weight were reported by some authors for various breeds (Waldron et al., 1993; Lee et al., 1997). Goyache et al (2003) working with beef cattle reported high direct heritability of weaning weight of 0.67 which coincide with the direct heritability reported by Assan (2010) fitting different animal models in Tuli cattle. In this study the inclusion of additive maternal and/or maternal permanent environmental effects to the models reduced the direct heritabilities for weaning weight. The same result was observed in previous reports which compared models by Dodenhoff et al., (1999) and Vostry et al., (2007). Depending on the model used maternal heritability ranged from 0.09 to 0.26 for weaning weigh (Assan 2010). Lower maternal heritability for weaning weight was reported by Atil et al. (2005).

Low and positive estimate of direct-maternal correlation for weaning weight were reported by Assan (2010). The same result was also reported by Dodenhoff et al., (1999) for Angus cattle. The positive direct-maternal genetic correlation may suggest that relationship between the genetic structure of the calve and genetic structure of the dam has a certain effect on the calve weaning weight. Elsewhere negative direct-maternal genetic correlation has been reported in cattle for weaning weight (Atil et al., 2005). Meyer (1992) compared results from different studies of direct-maternal genetic correlation for weaning weight in beef cattle and argued that less than sufficient environment may impose a negative correlation. Koch (1972). suggested that excess milk production by her daughters, also resulting in a negative dam-offspring correlation. He suggested that high weaning weight impede milking potential of the developing animal, which may not be the case with the livestock indigenous to the harsh tropical environment hence the low and positive direct-maternal correlation in indigenous Tuli calves(Assan, 2011). Meyer (1997) suggested that inflated estimates of direct-maternal correlations for weaning weight might be caused to some extent by unaccounted sources of variation in the model used. A negative genetic covariance between direct and maternal genetic effects has been observed in cattle (Norris et al., 2004; Iwaisaki et al., 2005). However, other studies found covariance between direct and maternal genetic effects to be positive for weaning weight (Plasse et al., 2002; Assan 2011). The reason for the positive relationship in previous studies on growth traits could not conclusively be explained by authors (Dodenhoof et al., 1999).

Foulley and Lefort (1978) suggested that the estimation of maternal effects and their respective genetic parameters is inherently problematic and, due to the confusion of direct and maternal effect, subject to large sampling errors. Meyer (1994) attributed them also to a large extent, to sampling co-variation. Whilst Shi et al., (1993) thought there could also be a covariance between direct and maternal environments. Robinson (1996b) showed a dramatic increase in likelihood along with a substantial reduction in estimate of covariance of direct and maternal when additional effects such as sire* herd effect or regression on maternal phenotypic where included in the model of analysis. An investigation conducted by Dodenhoff et al., (1999) on several breeds of beef cattle indicates that dependences between direct and maternal genetic effects are determined by breed. Swalve (1993) suggested that the negative covariance between direct and maternal genetic effects may be the result of management system. Gutierrez et al., (1997) reported antagonism between direct and maternal genetic effects for weaning weight for Zebu cattle and suggested that this antagonistic relationship should be compensated by improving managerial practices and using supplemental feeding when necessary. In contrary, Maniatis and Pollot (2003) reported that estimation of the correlation between direct and maternal genetic effects is dependent on key pedigree relationships where a high proportion of both dams and maternal grand dams with their own records are essential. Meyer (1997) found that large, negative estimates of direct and maternal genetic covariance are associated with overestimating of additive direct and maternal variance.

2.2. Sheep

Direct heritability estimates in the range of 0.07 to 0.18 have been reported in literature (Abboud, 1989; Notter, 1998) and in a summary, Wiener (1994) from 12 studies reported direct heritability range of 0.08 to 0.68 for weaning weight. Direct heritability estimates of preweaning growth and of weaning weight in lambs ranged from 0 (Butcher et al., 1964) to 0.84 (Botkin, 1955). Reason for higher estimates of heritability may be differences in statistical methods used, or differences in methods (e.g. paternal half sibs versus regression of offspring on parent) and sampling error. Comparable estimates of direct heritability estimates for weaning weight were also observed by Babaret al., (1998) and Maria et al., (1993, 1993) for sheep. Literature estimates for direct heritability are variable and range from low to high. Both extensive and intensive management system heritability estimates are within the ranges reported above for sheep by Olivier et al., (1994). The maternal heritability estimates were lower than direct heritability estimates (0.09 vs 0.38) for weaning weight in sheep (Assan et al., 2011). The maternal heritability estimates reported for weaning weight ranged from 0.6 to 0.14 (Larsqard et al., 1998; Khaldi et al., 1989; Snyman, 1996). Assan et al., (2005) reported total heritability estimates of 0.69 for weaning weight in Sabi sheep, which were higher than the range of estimates by other researchers (Burfening and Kress, 1993; Van Wyk et. al., 1993a; Tosh and Kemp, 1994; Snyman, 1996) which were 0.18 to 0.22 weaning weight. Understanding of the relationship between direct and maternal effects will facilitate formulation of optimum breeding programmes and improvement of selection efficiency (Robison, 1981). The size of maternal effects and their relationships among themselves and with direct genetic effects, however are less clear (Hagger, 1998). The results in literature dealing with the genetic correlations between direct and maternal effects for weaning weight in sheep vary (Neser et al., 2001). Strong negative covariances were reported in literature (Burfening and Kress, 1993; Maria et al., 1993). The correlations estimates reported are mostly negative in contrast to the positive estimates reported by Assan et al., 2005). Genetic correlations of direct and maternal effects of -0.74 to 0.01 were reported by other authors (Burfening and Kress, 1993; Mousa et al., 1999; Tosh and Kemp, 1994) while the results of Oku et al. (1999) reported estimates ranging from -0.99 to 0.99. The high positive direct- maternal additive genetic correlation could probably be the result of a small size of the data set used in different studies. However, it cannot be ruled out that the high positive direct-maternal additive genetic correlation is an indication of a possibility to improve maternal effect while selecting for weaning weight. Yazidi et al. (1997) observed positive direct- maternal correlations for weaning weight of approximately 0.50 for weaning weight. Nasholm and Danell (1996) concluded that selection for increased growth traits in sheep will also improve the maternal ability in the case of positive correlation between direct and maternal genetic effects. Higher estimates of permanent environmental effects have been reported and have been associated with permanent environment maternal effects of the uterus and the multiple births in small ruminants (Synman, 1996). The influences of environment factors in different locality have a bearing on the estimation of genetic factors (Meyer, 1992). Breeders may have used genetic parameters borrowed from other populations which have a different environment and management system, this may give false results (Assan et al., 2011). The nature of the genetic correlation between direct and maternal genetic effects and its size are far from being known. For sheep a recent estimate of this parameter to about weaning was -0.99 (Maria et al., 1993) contrast with another estimate for daily weight gain to 3 week of age of 0.12 (Nasholm and Danell, 1996). In related studies reason for large negative estimates obtained could not be conclusively be explained (Hagger, 1998). Robinson (1996a) found that seemingly unrelated effects, such as additional sire variance or sire- mating season effects, led to large negative estimates of direct and maternal correlation. It seems both positive and negative correlation between direct and maternal effects are possible (Tosh and Kemp, 1994; Robinson 1996b; Nasholm and Danell, 19960). The genetic correlation of direct and maternal effects estimated by Tosh and Kemp (1994) for Hampshire, Polled Dorset and Romanov lambs was negative and ranged from -0.13 to -0.56 while Maria et al., (1993) reported higher negative estimates which they attributed to small number and structure of the data. Cundiff (1972) argued that the negative covariance between direct and maternal genetic effects, explained from an evolutionary point of view, prevents species from becoming increasingly larger. The findings of Nasholm and Danell (1994) were not in agreement with this assumption, but also several authors mentioned that possible existence of a negative environmental covariance between dam and offspring could result in a biased estimation of genetic correlation between direct and maternal effects (Meyer, 1992). A review by Robison (1981) indicated that covariance between direct and maternal effects for growth traits were generally negative in beef and swine. A few estimates of this relationship are available foe sheep (Burfening and Kress, 1993). While Chang and Rae (1972), Eikje (1975) and Jonmundsson (1981) found the relationship to be negative, Hanrahan (1976) found it to be positive.

2.3. Pigs

A survey of published estimates of heritability for weaning weight in pigs reveals a range from zero to 0.24 within an average value of 0.08 (Ward et al., 1964). This figure was in close agreement with the estimate suggested by Craft (1953) in his review, however different from the same author, Craft (1958) in other assessment of 0.17. Litter weaning at 21d heritability estimate ranged from 0.15 to 0.22 (Fernandez et al., 2008). Cockerham (1952) reported estimates of 0.03 for weaning weight in pigs, however suggested that the amount of data surveyed and its critical evaluation was paramount to any estimates. Nugent (2003) reported a heritability estimate range of 19 to 0.27 in Landrace, Yorkshire, Duroc and Humpshire purebreds of pigs for weaning weight. The estimate of heritability at weaning of crosses of Nigerian indigenous and exotic breeds of pigs was 0.36 (Okoro et al., 2013). Litter weight at 21 d of age was also low, 0.10 (Peskovico et al., 1999). Different parities had effect on the estimation of heritability, for first and second parity the heritability estimates were 0.05 and 0.07, respectively. Maternal effects of most litter traits, such as litter weaning weight were from 0.20 to 0.50 lower than their direct counterparts. Lundgren et al., (2010) concluded that heritability estimates for weaning to service interval were 0.08 and 0.03 in the Landrace sows population, as well as in Chansomboon et al., (2009) investigation in Landrace and Large White population weaning to the first service interval heritability estimated was low, 0.024. Weaning weight heritability estimates for direct genetic effect were greater than those of maternal genetic effect, suggesting that the direct genetic effect was clearly expressed at the age at weaning (Tomiyama et al., 2009). Heritability of litter size at weaning was generally low (Pandey and Singh, 2010). Low estimates of heritability of litter size at weaning was also reported by Milojic and Petroic in Landrace. Khalkho (2004) recorded low to medium heritability value of litter size at weaning in Tamworth, Desi and their crosses. In contrary, to low heritability estimates, Craft (1985) suggested that the better nutrition of the suckling pig following the advent of balanced creep feeds may be responsible for higher heritability of weaning weight at 56 days. This would come about because creep fed pigs should have more opportunity to express their genetic potential for growth during the pre weaning period.

3. Environmental factors

3.1. Birth status and parity influencing weaning weight

Weaning weight of single born kids were higher than twins born kids, however the effect was non significant (Barathidhasan et al., 2006). Buvanendran et al. (1992) reported similar findings that lambs born and reared as singles were heavier at weaning than those born and reared as twins in Dorper sheep in Zimbabwe. 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 fetal development. Their weaning weight and average daily gain also follow the same trend (Dickson-Urdaneta et al., 2004; Selaive-Villarroel et al., 2008). Litter weight at weaning was controlled by the number of kits survived at weaning (Risam et al., 2006). Competence between twins to feed from their dam’s milk causes them to receive less milk than singles. Therefore, it is a good reason that singles are heavier than twins, when weaning (Dixit et al., 2001); Rashidi et al., 2008). But, Shahroudi et al., (2001) reported that birth type had no significant effect on body weight in Kurdish sheep. Elsewhere weaning weight were higher in second parity than the first parity in goats (Nelsen and Kress, 1981). Weaning weight increased with calving number till fourth calving as consequences in nursing ability between developing and adult dams. Results from other studies showed that weaning weight variation was more prominent in young ewes (Notter et al., 2005). The trend of effect of parity and birth type was not clear on weaning weight for intensive and extensive management systems in goats (Adenaike and Bemji, 2011). The author suggested that this was probably due to variation in size of kids’ dams. Since dam with big body size is expected to consume more feed which would transient to more available milk for its kids irrespective of its parity. The same observation was made by Gatenby (20020 and Akusu (2003) among other factors parity and type of birth had a significant effects on weaning weight of kids. The weaning weight and average pre-weaning daily gain had increased in second parity than the first parity (Bharathidhasan et al., 2009). In contrary, parity did not affect both weaning weight and daily average gain in lambs probably because lambs had access to concentrate for the most part of the pre-weaning period (Bermejo et al., 2010).

3.2. Year and seasonal effects on weaning weight

It is well established that year of weaning causes variation on weight and performance of livestock due to climatic variations. 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). Dams maintained in good body condition throughout the year may perform at or near their production potential which would explain the lack of seasonal effect on weaning weight of progeny from different dams. Weaning weight at south west monsoon showed the highest value over weaning weights of other seasons. Paul et al., (1990) observed that the body weight at 3 months was significantly affected by season. The variation in weaning weight due to season were attributed to feed intake accompanied by physiological stress caused by excessive heat in hot seasons and also inadequate environmental conditions. In this connection Ghaly (1988) reported a decrease of 40% of milk yield of the does under high ambient temperature. Variation in the weather, nutrition and farm management from year to year might be responsible for the increased variation in weaning weight (Bharathidhasan et al., (2009). Das et al., (1995) reported that year of birth had a significant influence on weight gain up to weaning (6 months of age) were more goats are weaned. It may be suffice to say that this phenomenon is expected because birth weight is highly correlated with weaning weight. Yaqoob et al., (2009) reported that the effects of fodder availability and prolificacy on weaning 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. The effects of birth month on planning kidding season would improve production efficiency. Variation in supply and composition of feeds and fodder affects weight of kids at different life stages (Sundaram et al., (2012). The year effects main effect will show on amount of milk the dams will produce for the young ones. This has a direct influence on weaning weight due to the changes in the dam's environment and differences in feeding.

Month of kindling effects were highly significant on litter size at birth and litter size at weaning (Abdel-Azeem et al., 2007). The rise in ambient temperature during May and June caused a decrease litter weight at birth and weaning in rabbits (Garcia et al., 2000; Zaky 2001; Zerrouki et al., 2005). The depression in litter size born during May- June was attributed to effects of the high ambient temperature that results in decrease in each of feed consumption by the does (Sallam et al., 1999), ovulation rate, fertilization rate and prenatal survival, and the embryonic mortality (Cifre et al., 1994). The hot climatic conditions (temperature and relative humidity), especially in open or semi open rabbitries, decrease milk production of the dam, that result in low amount of milk suckled by each kit and depression of the mean kit weight at weaning (Abdel-Azeem et al., 2007).

In beef cattle month of calving and age at weaning as a quadratic covariate did not influence weaning weight (Goyache et al., (2003). Calves born in the first part of the year were heavier at weaning than those born in the last months of the year. This was attributed to the fact that calves born at the last months of the year were sold slightly older in the spring market after a little grazing period in which nursing ability of the cow increases, hence reaching higher weaning weights. In sheep, season of year affected weaning weight with the lowest weights being for lambs born in winter. This effect occurred despite no obvious difference in flock management and nutrition (Bermejo et al., 2010). Thus external environment or climate during early growth may have influenced overall pre-weaning growth rate, as it had been observed in hair sheep in tropical areas (Rastogi, 2001).

3.3. Age of dam and weaning weight performance

The performance of progeny improved in kids in the third and fourth year of dams which was attributed to adaptability of dams to the region with time and also with the fluctuations in rainfall in the region during the years (Banerjee and Jana, 2010; Verma et al., (1991). The same was attributed to the genotypic environmental interactions amongst the different animals within the same breed. Weaning weight would reflect mothering ability of dam as well as the inherent growth potential, thereafter growth potential would predominate. Age of dam was found to have a non-significant effect on live weight at 72 weeks of age, only showing that the mothering ability of does had carried over effect up to 48 weeks of age. Wilson (1987) found that the effect of age of dam was significant on birth weight and growth rate at pre-weaning and that young ewes tend to produce smaller progenies at birth. It is generally known that mothering ability, especially milk production, increases with parity. Older ewes are larger in body and tend to be better milkers (Stobart et al 1986). The effect of parity of dam on kids is thus imparted as maternal influence whose direct influence is limited to the nursing period. In cattle maximum weaning weight appeared to be observed at 8 years of age of the dam. Previously eight years was reported as the age of maximum production by Sawyer et al., (1948) and Rollins and Gilbert (1954). Burgess et al., (1954), Nelms and Borgart (1956). Mc-Cormick et al., (1956) found maximum production was reached between 6 and 10 years, and Marlowe and Gaines (1958) reported 7 years as the age of maximum production. Weaning weights were lowest among calves from 2 year old cows and showed the largest change between ages of 2 and 3 years. The mean weaning weight increased at a diminishing rate from 2 to 6 years of age and showed a uniform decline between the ages of 9 and 12 years (Brown (1958). The lack of decline in production among older cows was probably the result of selection in the herd. The few cows remained beyond the age of 12 years would have survived many years of culling and represent the very best producers of their age group. Milk production of the sow is potentially a limiting resource in growth of piglets causing competition among piglets because the voluntary feed intake of piglets keeps increasing, whereas milk production of the sow reaches a rather constant level after 8 to 10d (Harrel et al., 1993). This may have a serious effect on sows with a larger litter size.

3.4. Management influencing weaning weight

Management system will affect weaning weight since progeny will be subjected to the same season, parity and climate (Adenaike and Bemji, 2011). Management group and age at weaning as a linear covariate influenced weaning weight in beef cattle (Goyache et al., 2003). Comparing rotationally grazed lambs and set-stocked managed lamb, the later had heavier weaning weight at 4, 6 and 18 weeks (Geenty, 1980). Under a traditional management production system the growth ability of calves was affected by lesser nursing ability of the mother in the last months of the lactating period within the dry season that can not be balanced by the calf by increasing the grass intake (Wright and Russel, 1987) hence influencing the weight at weaning. The significant effect of other environmental factors on weaning weight have been found in sheep of temperate breeds with the degree of effect varying with management (Eltavil et al., 1970; Sidwell et al., 1964; De Baca et al., 1956). There was a significant effect of year of birth on birth weight due to improvement in management and feeding of the ewes during pregnancy, but no significant difference in weaning weight between years was detected (Combellas et al., 1980).

The great advantage of extensive over intensive production is that it gives the goats some opportunity to supplement the diet provided for them under zero grazing and thus some chance of using selective grazing habits to overcome any dietary deficiency (Devendra and Burns, 1983). Under extensive management system animals are allowed to roam about while in intensive management system animals are confined or kept under cultivated pasture at a high stocking density or zero grazing with concentrate supplement. The overall weaning weight under intensive management system was significantly higher than that of extensive management system (Adenaik and Bemji, 2011). This may be probably due to the feed supplementation to dams and kids raised under intensive management system. The other possible reason is that confined animals may consume more milk than their counterparts in extensive system. The young ones have limited access to dams milk in extensive management system because there are only fed when they have started making noise. The quantity of milk fed to young ones may be the contributing factor in variation in weaning weight in intensive system versus extensive management systems. The quantity of milk from the dam is a primary factor which contributes to growth in offspring, however this depends on parity, type of birth and level of nutrition given to the mothers.

3.5. Sex of animal and weaning weight

Average weaning weight of female kids at 3 months was 2.28% higher than male kids (Bharathidhasan et al., 2009). Thiruvenkadan et al., (2009) reported that sex, the period of birth and type of birth of kids were the major factors affecting growth rate in Tellichery goats. Similar findings were reported for male body weight at 3 months age which were higher than females body weight (Das et al., 1995). In cattle males were heavier at weaning and grew faster than females (Nelsen and Kress, 1981). Also Josefina et al., (1980), Gonzalez et al., (1972) and Reveron et al., (1978) observed that male lambs being heavier at weaning in comparison with females. Sex, season, parity and type of birth for both intensive and extensive management systems had a significant effects on weaning weight (Adenaike and Bemji, 2011). Gatenby (20020 and Akusu (2003) among other factors sex had a significant effects on weaning weight of kids. The difference in weaning weight between males and females were 1.5, 2.4 and 2.3 kg for indigenous Sabi, Mutton Merino and Dorper sheep (Assan and Makuza, 2005).

The differences in sexual chromosomes, probably in the position of genes related to growth, physiological characteristics, differences in endocrinal system (type and measure of hormone secretion especially sexual hormones) leads to difference in animal growth (Mohammadi et al., 2010). In relation to endocrinal system, estrogen hormone has a limited effect on the growth of long bones in females. That could be one of the reason in which females have smaller body and lighter weight against males (Shhroudi et al., 2001 Rashidi et al., 2008). Differences in body weight between males and females with the advanced age might be due to the increasing differences in the endocrine system between males and females (Swenson and Reece, 1993) These sex differences are consistent with results from other investigations (Mandal et al., 2003; Mokhtari et al., 2008).

3.6. Early weaning versus late weaning in nutrient utilization

Weaning weight was largely dependent on the age at weaning that in turn dependent on month of birth of the calf (Goyache et al., 2003). Utilization of dietary nitrogen indicated higher nitrogen intake by early weaned lambs due to the higher dry matter intake which led in turn to higher nitrogen retention due to well developed rumination and fermentation in comparison with the later weaned lambs (Abou-Ward et al., 2008). Favourable reasons for early weaning include reduction of carcass fat and removal of competition by ewes under conditions of feed shortage (Geenty, 1980). Age at weaning affected average daily gain and feed conversion efficiency in favour of early weaning in sheep in spite of higher dry matter intake in comparison with late weaned sheep (Alhadrami et al., (2000). The lower body weight for pups weaned at two weeks of age could be attributed to stress accompanying early separation of pups from does as well as the level of efficiency of early weaned grasscutter to digest and utilize the dry matter content of feeds (Henry et al., 2012). Studies have shown that fibre levels in the diet of grasscutters is associated with digestibility of dry matter, protein and fat which could lead to reduction in growth rate (Vanzyl et al., 1999). Xicatto et al., (2000) and Tumova et al., (2006) opine that digestive tract development does not affect feed consumption of early weaned rabbits. Changes in management practices such as early weaning have been investigated as a possible means of intensifying lamb production (Ruttle and Everett, 1969). Lambs can be successfully weaned as early as 3-5 weeks of age (Jagusch et al., 1970; Rattray et al., 1976). This has been associated with a reduction in fat levels immediately following weaning due to fat mobilization (Fennessy et al., 1972) and increased requirement of energy for protein deposition in lambs consuming pasture alone (Rattray and Jagusch, 1977). Early weaning may be defined as the withdrawal of milk supply before the time when weaning would normally occur. Gallois et al., (2003; 2004) demonstrated that feed consumption was higher for early weaned rabbits in comparison to those weaned at 35 days of age, although weaning age differed between both studies. The success of early weaning is depended partly upon the speed with which the rumen develop in both lambs and calves and partly upon the level of milk production of the dams (Wardrop, 1960). Fonteh et al., (2005) observed that early weaned kits overcome weaning stress and also developed the capacity to handle efficiently solid and fibrous feed than the late weaned kits. Rumen function develops rapidly after birth until at about 8 weeks of age, the grazing lambs can digest herbage with efficiency of an adult (Abou Ward et al., 2008). The rumen microorganisms of 3 week old lambs can digest as wide a variety of carbohydrates and proteins as can those found in adult sheep (Walker and Walker, 1961). Pigs that were weaned at an older age had more value than pigs weaned at a younger age due to the lower mortality and increased growth rate in nursery and finished period. The early weaning management practice is to increase efficiency of production and no useful end is achieved by early weaning in situation where young ones can be satisfactorily fattened by suckling the dam, unless the milk is rarely produced or required for commercial purposes. Geenty (1980) recommended that the conventional lamb weaning age be reduced to about 9 weeks. Using coincident pregnancy, lambs were weaned in the beginning of spring where they derive the benefit from spring pasture with high quality (Saghi et al., 2007).

3.7. Genotype and weaning weight

The sire breed*dam breed interaction was an important source of variation for weaning weight in goats (Browning et al., 2007). Differences in weaning weight due to breed were reported by Bodisco et al., (1973) and Gonzalez (1972). 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. The genotype of both the mother and the fetus 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). In general crossbred litter showed higher litter weight at weaning than those of purebred litter (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. Olivier et al. (1987) found that the between sire variance terms were significant for weaning weight in their study on Grootfontein Merino flock and similarly found variation between sires for type traits. Sire effect had non significant effect on weaning weight in the exotic sheep breeds while highly significant in the indigenous Sabi sheep (Assan and Makuza, 2005). This could have been due to the ram exchange program were new rams were occasionally introduced into the flock from surrounding farmers. This resulted into high phenotypic and genetic variability in the indigenous Sabi flock could be exploited for genetic gain in weaning weight through mass selection. The non significant effect of sire in the exotic sheep breeds could have been a result of inbreeding depression due to continued use of same rams in the flocks for a long time due to unavailability of rams of the exotic sheep breeds under the ram exchange program. The importance of the random effect of sires within breeds on weaning weight suggest that selection of rams should be given a priority in any sheep production system making it useful in the improvement of overall economic efficiency. The significance of sire effect could also suggest that there is a possibility of high generic variance weaning weight in sheep.

4. Conclusion

The review conclude that in order to improve breeding value and selection for weaning weight must be based on genotypic rather than environmental superiority. Thus variation due to definable environmental effects must be removed by use of suitable adjustment factors. It is necessary that all known sources of variation influencing weaning weight should be included in the model of analysis, otherwise the results may not be reliable. Both direct and maternal genetic effects seem to be very important for weaning weight. A negative correlation between direct and maternal genetic effects could be an indication of genetic antagonism between genes and it may therefore be important to consider the both direct and maternal genetic effect in selection for weaning weight to improve selection response. In order to design optimal breeding programs targeting weaning weight breed specific genetic parameters need to be considered to enhance selection response.

The significant influences of environmental factors on weaning weight can be explained in part by differences in years, male and female endocrine system, competition for milk between twins, maternal effects and maternal ability of dam in different ages. In pigs the antagonistic relationship between litter size and piglets weaning weight was confirmed, subsequently it may be reasonably to conclude that inclusion of birth weight as a selection criteria is recommended.

References

Abboud, S. Y. 1989. Genetic and phenotypic parameters associated with growth of purebred and crossbred lambs. Dissertation Abst. International. B. Sci. and Eng. 50, 38.

Abdel-Azeem, A.S., Abdel-Azim, A.M., Darwish, A.A., Omar, E.M., 2007. Litter traits in four purebreds of rabbits and their crosses under prevailing environmental conditions of Egypt. The 5th Inter. Con. On Rabbit Prod. In Hot Climate, Hurghada, Egypt, 39-51.

Abegaz, S., van Wyk, J.B., Olivier, J.J., 2005. Model comparisons and genetic and environmental parameters estimates of growth and kleiber ratio in Horro sheep. S. Afr. J. Anim. Sci. 35,30-40.

Abou Ward, G.A., Tawila, M.A., Sawsan, M., Gad, A.A., Abedo, El-Naggar, S., 2008. Effect of weaning age on lamb's performance. World J. Agric. Sci. 4(5),569- 573.

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

Ahamadi, M., Roshanfekr, H., Khashoei, E.A., Mohamadi, Y., 2004. The study of genetic and phenotypic parameters and some growth traits Kermanshah Sanjabi sheep. J. Agric. Sci. Nat. Resour. 11,91- 98.

Akusu, M.O., 2003. Reproduction of goats for maximum animal production in Nigeria. University of Ibadan, Ibadan.

Alhadrami, G., Nigm, A., Aboul_Ela, M., 2000. The effects of early weaning and crossing with Chios on fattening performance of local lambs in the United Arab Emirates. Arab-Gulf J. Sci. Res. 18,10- 14.

Arrowsmith, S. P., Ward, H.K., 1983. Indigenous Sheep Selection Programme and Productivity of Indigenous Sheep and Goats. Annual Report 1980/81, Division of Livestock and Pastures, Department of Research and Specialist Services, Harare, pp. 92-95.

Assan, N., 2011. Fitting different random effects in genetic parameter estimation using animal models for weaning weight in indigenous Tuli cattle of Zimbabwe. J. Anim. Sci. Adv. 1(2),111- 118.

Assan, N., Mabuku, O., Musasira, M., 2011. Estimation of covariance components and genetic parameters for weaning weight in Matebele goat, Sabi, Dorper and Mutton Merino sheep. J. Anim, Sci. Adv. 1(1),38-46.

Assan, N., Makuza, S., Mhlanga, F., Mabuku, O., 2002. Genetic evaluation and selection response of birth weight and weaning weight in indigenous Sabi sheep. Asian-Aust. J, Anim. Sci.. 15(12),1690- 1694).

Assan, N., Makuza, S.M., 2005. The effect of non genetic factors on birth weight and weaning weight in three sheep breeds of Zimbabwe. Asia-Aust. J. Anim. Sci. 18(2),151-157.

Atil, H., Khattab, A.S., Badawy, L., 2005. Genetic parameter of birth and weaning weights for Friesian calves by using an animal model. Arch. Tierz., Dummerstorf, 48(3),261- 269.

Babar, I. R., Tahir M., Ahmad, M.K., 1989. Heritability estimates of weaning weight in Awassi sheep in Pakistan. Pakistan Vet. J. 9,183-85.

Banerjee, S., Jana, D., 2010. Factors affecting birth weight of Sirohi goat kids reared in hot and humid climate of west Bengal. World App. Sci. J. 9(12),1379-1382.
Beffa, L.M., 2005. Genotype*Environment interaction in Afrikaner cattle. PhD dissertation, University of the Free State, Bloemfontein, South Africa.
Bermejo, L.A., Mellado, M., Camacho, A., Mata, J., Arevalo, J.R., Nascimento, L., 2010. Factors influencing birth and weaning in Canarian hair lambs. J. Appl. Anim. Res. 37,29-31.
Bertrand, J.K., Benyshek, L.L., 1987. Variance and covariance estimates for maternally influenced beef growth traits J. Anim. Sci. 64, 728.
Bharathidhasan, A., Narayan, R., Gopu, P., Subramanian, A., Prabakaran, R., Rajendran, R., 2009. Effect of nongenetic factors on birth weight, weaning weight and preweaning gain of Babri goat. Tamilnadu J. Vet. Anim. Sci. 5(3),99-103.
Bodisco, V., Duque, C.M., Valle, S.A. 1973. Comportamiento productive de ovinos tropcalles an el period, 1968-1972. Agronomia Tropical. 23,517- 340.
Bosso, N.A., Van der Waaij, E.H., Agyemang, K., Van Arendok, J.A.M., 2009. Genetic parameters for growth traits in N'Dama cattle under tsetse challenge in Gambia. Liv. Res. Rural Dev. 21(3).
Botkin, M.P., 1955. Selection for efficiency of gain in lambs. J. Anim. Sci., 14, 1176.
Bowman, J. C., 1984. An introduction to animal breeding. Edward Arnold. London. UK.
Brown, C.J., 1958. Heritability of weight and certain body dimensions of beef calves at weaning. Ark Agri. Exp. Sta. Bul. 597.
Browning, Jr R., Donnelly, B., Payton, T., Byars, M., 2007. Preweaning body weights of meat goat kids produced in a three-breed dialled managed on southeastern pastures. Southern Section, American Society of Animal Science, Annual Meeting Mobile, Alabama, February 3-7, 2007.
Burfening, P. J., Kress, D.D., 1993. Direct and maternal effects on birth weight and weaning weight in sheep. Small Ruminant Res. 10,153-163.
Burfening, P.J., Kress, D.D., 1992. Early growth traits in sheep related to their subsequent most probable producing ability. Small Rumin. Res. 7,67-74.
Burgess, J.B., Nellie, L., Landblom, L., Stonaker, H.H., 1954. Weaning weights of Hereford calves as affected by inbreeding, sex and age. J. Anim. Sci. 13,843.
Butcher, R.L., Dunbar, R.S., Jr. Weish, J.A., 1964. Heritabilities of and correlations between lamb birth weight and 140-day weight. J. Anim. Sci. 23, 12-17.
Buvanendran, V., Makuza, S.M., Chironga, P., 1992. Phenotypic and genetic parameters of weaning traits in Dorper sheep in Zimbabwe. Small Rumin. Res. 7,369- 374.
Campbell, Q. P., 1971. Breding problems in Dorper sheep. PhD. Thesis. University of Orange Free State, Bloemfontein, SA.
Canas, A.J., Ramirez, T.J., Arboleda, A.O., 2008. Estimation of genetic parameters for weaning weight in white Orejinegro cattle in the Colombian Northwest. Revista MVZ Cordoba, 13(1), 1138- 1145.
Carriedo, J. A., Rio, A., San Primitivo, F., 1988. Heritability of body weight and preweaning growth of single born lambs and environmental factors affecting these. Anales de la Facultad de Veterinaria. 34,15-27.
Chang, T.S., Rae, A.L., 1972. The genetic basis of growth, reproduction and maternal environment in Romney ewes. II. Genetic covariations between hoggets characters, fertility and maternal environment of ewe. Aust. J. Agric. Res., 23, 149- 165.
Chansomboom, C., Elzo, M.A., Suwanasopee, T., Koonawootrittriron, S., 2009. Genetic and environmental factors affecting weaning to first service interval in a Landrace-Large White swine population in northern Thailand. Kasetsart J. Nat. Sci. 43,669-679.
Choi, S.B., Lee, J.W., Kim, N.S., Na, S.H., Keown, J.F., Van Vleck, L.D., 2000. Estimation of genetic parameters for direct, maternal and grand maternal genetic effects for birth weight, weaning weight and six month weights of Hanwoo (Korean Cattle). Asian-Aus. J. Anim. Sci. 2, 149- 154.
Cifre, J., Vicente, J.S., Baselga, M., Garcia-Ximenez, F., 1994. Ovulation rate in lines of rabbits selected on different criteria. In,Baselga, M. And Marai, I.F.M. (Eds). In,Proc. 1st Intern. Conf. Rabbit Prod. Hot Climate. 6-8 Sept, Cairo, Egypt. 247-251.
Cockerham, C.C., 1952. Genetic co-variation among characteristics of swine. PhD Thesis, Iowa State College, Ames, Iowa.
Craft, W.A., 1953. Results of swine breeding research. USDA. Circ. 916.

Craft, W.A., 1958. Fifty years of progress in swine breeding. J. Anim. Sci. 17,960.
Das, N., Sharma, A.K., Joshi, H.B., 1995. Body growth in Babari goats under intensive management system. Indian J. Anim. Sci. 65(30,348-351.
Das, S.M., Rege, J.E.O., Shibre, M., 1994. Phenotypic and genetic parameters of growth traits of Blended goats at Malya Tanzania.In, Proc. 3rd Biennual Conf. African Small Ruminant res.. Network, Kampala, Uganda, 5-9, December 1994, 85-87.
DeMattos, D.I., Misztal, D.I., Bertrand, J.K., 2000. Variance and covariance components for weaning weight for Hereford in three countries. J. Anim Sci. 78,33- 37.
Devendra, C., Burns, M., 1983. Goat production in the tropics. Common Wealth Agricultural Bureau, U.K. pp 80-131.
Devendra, C., McLeroy, 1982. Goat and sheep production in the tropics. Longman, London, UK.
Devendra, C., Owen, J.E., 1983. Quantitative and qualitative aspects of meat production from goats. World Animal Rev., 47, 19-49.
Dezfuli, B.T., Mahsyekhi, M.R., 2009. Genetic study of birth weight and weaning weight in Najdi calves. J. Anim. Vet. Adv. 8(20), 276-280.
Dickson-Urdaneta, L., Torres-Hernandez, G., Daubeterre, M., 2004. Crecimiento en ovinos West African bajop un sistema de pastoreo restringido en Venezuela. Rev Fac. Agr-Luz, 21,59-67.
Dixit, S.P., Dhillon, J.S., Singh, G., 2001. Genetic and non genetic parameters estimates for growth traits of Bharat Merino lambs. Small rumin. Res. 42,101-104.
Dobson, A.J., 1990. An introduction to generalized linear models. Chapman and Hall,, New York, USA.
Dodenhoff, J., Van Vleck, L.D., Gregory, K.E., 1999a. Estimation of direct, maternal and grandmaternal genetic effects for weaning weight in several breeds of cattle. J. Anim. Sci. 77,840- 845.
Dodenhoff, J., Van Vleck, L.D., Kachman, S.D., Koch, R.M., 1999b. Parameter estimates for direct, maternal and grandmaternal genetic effects for birth weight and weaning weight in Hereford cattle. J. Anim. Sci. 76, 2521-2527.
Donkin, D. J. 1973. Sheep breeds in Rhodesia In. Sheep handbook. Sheep Producers Association, Harare, pp 2.1-2.8.
Eikje, E.D., 1975. Studies on sheep production records. VII Genetic, phenotypic and environment parameters for productivity traits of ewes. Acta Agric, Scand. 25,242-252.
Fernandez, A., Rodriganez, J., Zuzuarregui, J., Rodriguez, M.C., Silio, L., 2008. Genetic parameters for litter size and weight at different parities in Iberian pigs. Spanish J. Agric. Res. 6,1-10.
Ferraz, J.B.S., Eler, J.P., Ribeiro, P.M.T., 2000. Genetic study of Santa Getrudis cattle in Brazil. Liv. Res. Rural Dev. 12 (20), 130- 137.
Fonteh, F.A., Niba, A.T., Kubdi, A.C., Tchoumboue, J., Awa-Nduku, J., 2003. Influence of weaning age on the growth performance and survival of weaned guinea pigs. Liv. Res. Rur. Dev. 17(12).
Franke, D.E., Habet, O., Tawah, L.C., Williams, A.R., De Rouen, S.M., 2001. Direct and maternal effects on birth and weaning traits in multibreed cattle data and predicted performance of crosses. J. Anim. Sci., 79; 1713- 1722.
Gallois, M., Gidenne, T., Fortun-Lamonte, L., 2003. Digestive development in the young rabbit, Impact of weaning at 21d. In; Proc. 3rd meeting of Workgroup 3rd and 4th COST Action 848, pp15 Prague, Czech Public.
Garcia, M.L., Lavara, R., Viudes de Castro, M.P., Vicente, J.S., 2000. Litter size components from two selected lines of rabbits. In, Proc. 7th Worl. Rabbit Congr., 4- 7 July, Valencia, Spain A,133-137.
Gatenby, R.M., 2002. Sheep. Mcmillan Publishers Limited, Oxford. Pp 71- 94.
Geenty, K.G., 1980. Influence of weaning age, management and slaughter age on export lamb carcass production and slipe wool weights. N.Z. J. Agric. Res. 23,433-440.
Ghaly, K.A.A., 1988. Effect of environmental conditions on reproductive performance of rabbits MSc. Thesis, Faculty Agriculture, Minia University, Egypt.
Gonzalez, J., 1972. Relaciones entre los pesos al nacer;al destete y de la madre en ovinos de cruce . Agronomla Tropical. 22,605-612.
Goyache, F., Fernandez, I., Royo, L.T., Alvarez, I., Pablo, J., 2003. Factors affecting actual weaning weight, preweaning average daily gain and relative growth rate in Austuriana de los Valles beef cattle breed. Arch. Tierz Dummerstorf 46,235-244.
Gray, H. Q., F. W. C. Neser, G. J. Erasmus and J. B. Van Wyk. 1999. Genetic trends in South African nucleus breeding scheme. S. Afr. J. Anim. Sci. 29,48-53.

Guiterrez, J.P., Canon, J., Goyache, F., 1997. Estimation of direct and maternal genetic parameters for preweaning traits in the Austriana de los Valles beef cattle breed through animal and sire models. J. Anim. Breed, Genet., 114, 261- 266.
Gutierrez, J.P., Goyache, F., Fernandez, I., 2007 Genetic relationships among calving ease, calving interval, birth weight and weaning weight in the Asturiana de los valles beef cattle breed. J. Anim. Sci. 85(1), 69- 75.
Hagger, C., 1998. Litter, permanent environmental, ram-flock and genetic effects on early weight gain of lambs. J. Anim. Sci., 76, 452-457.
Haile- Mariam, M., Philipson, J., 1995. Estimates of genetic and environmental trends of growth traits in Boran cattle. Blackwell Wissenschafts-Verlag, Berlin pp 43- 55.
Hanrahan, J.P., 1976. Maternal effects and selection response with an application to sheep data. Anim. Prod. 22, 359-369.
Harrel, R.J., Thomas, M.J., Boyd, R.D., 1993. Limitations of sow milk yield on baby pig growth. Pages 156-164 in Proc. 1993 Cornell Nutr. Conf. Feed manufacturers, dept. Anim. Sci. Div. Nutr. Sci., new York State College Agric. Life Sci., Cornell Univ. Ithaca.
Henry, A.J., Ibe, S.N., Asuquo, B.O., 2012. Effect of weaning age on growth and slaughter characteristics of grasscutter (Thrynomois swinderians) raised under intensive management in the humid tropics. J. Agric. Sci. 4(12),232-242.
Hwang, J.M., Choi, J.G., Kim, H.C., 2008. Genetic relationship of gestation length with birth and weaning weight in Hanwoo (Bos Taurus coreanae). Asian-Austra. J. Anim. Sci. 21(5); 633- 639.
Intaratham, W., Koonawootrittriron, S., Sopannarath, P., Graser, H.U., Tumwasorn, S.,2008. Genetic parameters and annual trends for birth and weaning weights of a Northeastern Thai indigenous cattle line. Asian-Austr J Anim Sci 21,478-483.
Iwaisaki, H., Tsuruta, S., Misztal, I., Bertrand, J.K., 2005. Genetic parameters estimated with multitrait and linear spline random regression models using Gelbvieh early growth data. J. Anim. Sci. 83,757-763.
Johnson, Z.B., Nugent III R.A., 2003. Heritability of body length and measure of body density and teir relationship[p to backfat thickness and loin muscle area in swine. J. Anim. Sci. 81,1943-1949.
Johnston, D.J., Benysheck, L.L., Bertrand, J.K., Johnson, M.H., Weissa, G.M., 1992. Estimates of genetic parameters for growth and carcass traits in Charlois cattle. Can. J. Anim. Sci. 72,493- 499.
Jonmundsson, J.V., 1981. Genetic correlation between direct and maternal effects for weaning weight of lambs. J. Agric. Res. Iceland. 13,41- 47.
Khaldi, G., Boichard, D., 1989. Effects directs et maternels sur les caracteres de croissance en race ovine Barbarine. Intra-Ariana (Tunisie) 62,3-20.
Kirkman, M. N., Singh, H., Singh, V., Choudhary, R.P., 1988. Genetic studies on growth in pure and crossbred sheep. Indian Vet. Med. J. 12,32-39.
Koch, R.M., Cundiff, L.V., Grgory, K.E., Dickerson, G.E., 1973. Genetic and phenotypic relations associated with preweaning and post weaning growth of Hereford bulls and heifers. J. Anim. Sci. 36,235- 239.
Koch, RM., Cundiff, L.V., Gregory, K.E., 1994. Cumulative selection and genetic change for weaning or yearling weight or for yearling weight plus muscle score in Hereford cattle. J. Anim. Sci. 78,1414-1421.
Koots, K.R., Gibson, J.P., Smith, C., Wilton, J.W., 1994a. Analyses of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. Anim. Breed. Abstr. 62,825-853.
Koots, K.R., Gibson, J.P., Smith, C., Wilton, J.W., 1994b. Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. Anim. Breed. Abstr. 62,309-338.
Kumar, A., Singh, U., Tomar, A.K.S., 2007. Early growth parameters of Kutchi goat under organized farm. Indian Vet. J. 83,105-106.
Lasqard, A. G., Olensen, I., 1998. Genetic parameters for direct and maternal effects on weights and ultrasonic muscle and fat depth of lambs. Livest. Prod. Sci.
Lee, C., Pollak, E.J., 1997. Relationship between sire*year interactions and direct-maternal genetic correlation for weaning weight of Simmental cattle, J. Anim. Sci., 75, 68- 75.
Lee, J.W., Choi, S.B., Jung, Y.H., Keown, J.F., Van Vleck, L.D., 2000. Parameter estimates for direct and maternal genetic effects on yearling weight, 18-month and slaughter weights of Korean native cattle. J. Anim. Sci. 78,1414- 1421.

Lundgren, H., Canario, L., Grandinson, K., Lundeheim, N., Zumbach, B., Vangen, O., Rydhmer, L., 2010. Genetic analysis of reproductive performance in Landrace sows and its correlation to piglet growth. Liv. Sci. 128,173-178.

Maiwashe, A.N., Bradfield, M.J., Theron, H.E., Van Wyk, J.B., 2002. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. Livest. Prod. Sci. 75,293- 300.

Mandal, A., Pant, K.P., Nandy, P.K., Rout, P.K., Roy, R., 2003.Genetic analysis of growth traits in Muzaffarnagari sheep. Trop. Anim. Health Prod. 35,271- 284.

Maniatis, N., Pollot, G.E., 2003. The impact of data structure on genetic covariance components of early growth in sheep, estimated using an animal model with maternal effects. J. Anim. Sci. 81,101,108.

Maria, G. A., Boldman, K.G., Vann Vleck, L.D., 1993. Estimates of variances due to direct and maternal effects for growth traits of Roman sheep. J. Anim. Sci. 71,845-849.

Mason, I. L., Maule, J.P., 1960. The Indigenous Livestock of Eastern and Southern Africa. C.A.B., Farnham Royal, England.

Mavrogenis, A., Constantinou, A., 1990. Relationships between pre-weaning growth, post weaning growth and mature body size in Chois sheep. ANIM. Prod., 30, 271-276.

McCormick, W.C., Southwell, B.L., Warwick, E.J., 1956. Factors affecting performance in herds of purebred and grade polled Hereford cattle. Ga. Agr. Exp. Sta. Tech. Bul. N.s. 5.

Mercadante, M.E.Z., Lobo, R.B., 1997. Estimates of covariance components and genetic parameters for growth traits due to direct and maternal effects in Nelore heifers. Rev. Bras. Zootec. 26, 1124-1133.

Meyer, K., 1992a. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. Livest. Prod. Sci. 31,179-204.

Meyer, K., 1992b. Bias and sampling covariances of estimates of variance due to maternal effects. Genetique, Selection, Evolution. 24,487-509.

Meyer, K., 1993. Covariance matrices for growth traits of Australian Polled Hereford cattle. Anim. Prod. 57, 37- 45.

Meyer, K., 2001. Estimate of direct and maternal covariance functions for growth of Australian beef calves from birth to weaning. Geneti. Sel. Evol. 33,1-28.

Meyer, K., Carrick, M.J., Donelly, B.J.P., 1993 Genetic parameters for growth traits of Australian beef cattle from a multibreed selection experiment. J. Anim. Sci. 71,2614-2622.

Minyard, J.A., Dinkel, C.A., 1965. Weaning weight of beef calves as affected by age and sex of calf and age of dam. J. Anim. Sci. 24,1067-1071.

Mohammadi, K., Beygi Nassiri, M.T., Fayazi, J., Roshanfekr, H., 2010. Effects of environmental factors on preweaning growth traits in Zandi lambs. J. Anim. Vet. Adv. 9(5),903- 906.

Mohiuddin, G., 1997. Estimates of some performance traits in beef cattle. Anim. Breed. Abstr. 61.

Mokhtari, M.S., Rashidi, A., Mohammadi, Y., 2008. Estimation of genetic parameters for post weaning traits of Kermani sheep. Small. Rumin. Res. 80,22-27.

Mousa, E., Van Vleck L.D., Leymaster, K.A., 1999. Genetic parameters for growth traits for a composite terminal sire breed of sheep. J. Anim. Sci. 77,1659-1665.

Nasholm, A., Danell, O., 1996. Genetic relationships of lamb weight, maternal ability and mature ewe weight in Swedish fine wool sheep. J. Anim. Sci., 74, 329- 339.

Ncube, S., 2005. The role of proanthocynidins and related flavonoids in the utilization of sorghum grain varieties as feed for ruminant in semi arid areas of Zimbabwe. PhD. Thesis, Univesrsity of Zimbabwe, Mt Pleasant, Harare, Zimbabwe.

Nelms, G.E., Bogart, R., 1956. The effect of birth weight, age of dam and time of birth on suckling gains of beef calves. J. Anim. Sci. 15,662.

Nelsen, T.C., Kress, D,D., 1981. Additive and multiplicative correction factors for sex and age of dam in beef cattle weaning weight. J. Anim. Sci. 53,1217-1224.

Nelsen, T.C., Kress, D.D., 1981. Additive and multiplicative correction factors for sex and age of dam in beef cattle weaninh weight. J. Anim. Sci. 53,1217-1224.

Neser, F. W. C., Erasmus, G.J, Van Wyk, J.B., 2001. Genetic parameter estimates for pre-weaning traits in Dorper sheep. Small Rum. Res. 40,197-202.

Norris, D., Banga, C., Benyi, K., Sithole, B.C., 2004. Estimation of genetic parameters and variance components for growth traits in Nguni cattle in Limpopo Province, South Africa. Trop. Anim. Health Prod. 36,801-806.

Notter, D. R., 1998. Genetic parameters for growth traits in Suffolk and Polypay sheep. Liv. Prod. Sci. 55,205-213.

Okoro, V.M.O., Ogundu, U.E., Okoli, I.C., Opara, M.N., Okoro, C.L., Nwachukwu, E.N., Ibe, S.N., 2013. Estimates of genetic parameters for growth traits in pig crosses of Nigerian indigenous and exotic breeds at birth, weaning and maturity. Wayamba J. Anim. Sci.578,660-667.

Okut, H., Bromley, C.M., Van Vleck, L.D., Snoder, G.D., 1999. Genotypic expression with different ages. 1. Prolificacy traits of sheep. J. Anim. Sci. 77,2357-2365.

Olivier, J.J., Erasmus, G.J., Van Wyk, J.B., Konstintatinov, K.V., 1994. Direct and maternal variance components for clean fleece weight, body weight and mean fiber diameter in the Grootfontein merino stud. S. Afr. J. Anim. Sci. 24, 122-124.

Palacios-Espinosa, A., Luis, E.V.J., Guerra-Iglesias, D., 2010 Direct and maternal effects for weaning weight in Zebu beef cattle population in Cuba. Revista Mexicana De Ciencias Pecuarias, 1(1), 1- 11.

Pandey, A., Singh, S.K., 2010. Estimates of heritability along with standard error of growth traits and reproductive traits in Landrace, Desi and their cross-brads and data pooled over all genetic group pigs. Int. J. Genomics and Proteomics 1(1),9- 11.

Paul, S., Sahu, B.B., Singh, D., Rawat, P.S., 1990. Effect of season of birth, weaning age and concentrate supplementation on growth and chevon production. Indian J. Anim. Prod. Managmt. 6(4),182-186.

Peskovicova, D., Heteny, L., Huba, J., 1999. Genetic parameters of reproductive traits in White Meaty pigs. J. Farm Anim. Sci. 32,15- 21.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteijn, P., Bestidas, J., Bastardo, J., 2002. Covariance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. J Anim Breed. Gen 119 (3),141- 153.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteijn, P., Bestidas, J., Bastardo, J., 2002b. Covariance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. J. Anim. Breed. and Gen. 119 (3),141- 153. Robinson, D.L., 1996b. Models which might explain negative genetic correlations between direct and maternal genetic effects. Livest. Prod. Sc, i4. 5, 111-122.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteinjn, R., Bastidas, P., Bastardo, J., 2002a. (Co)variance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. J. Anim. Breed. Genet., 119,141- 153.

Rashidi, A., Mokhtari, M.S., Jahanshashi, A.S., Abadi, M.R.M., 2008. Genetic parameter estimates of preweaning growth traits in Kermani sheep. Small Rumin. Res. 74,165- 171.

Rastogi, R.K., 2001. Production performance of Barbados black belly sheep in Tobago, west indies. Small Rumin. Res. 41,171-175.

Ribeiro, M.N., Pimenta, E.C., Martins, G.A., 2001. Hertability of maternal and direct effects of growth traits in Nellore herds at Paraiba State, Brazil, Revista Brasileira De Zootecna-Brazilian J. Anim Sci. 30(4), 1224- 1227.

Risam, K.S., Das, G.K., Bhasin, V., 2005. Rabbit for meat and wool production in India, A Review. Indian J. Anim. Sci. 75,365- 382.

Robinson, D.L., 1996b Models which might explain negative correlations between direct and maternal genetic effects. Liv. Prod. Sci., 45, 111- 122.

Robinson, D.L., 1996b. Models which might explain negative genetic correlations between direct and maternal genetic effects. Livest. Prod. Sci 45, 111-122.

Robinson, D.L., 1996b. Models which might explain negative genetic correlations between direct and maternal genetic effects. Livest. Prod. Sci. 4(5),111-122.

Robison, O.W., 1981. The influence of maternal effects on the efficiency of selection. A Review. Livest. Prod. Sci., 8, 121-137.

Robnison, D.L., 1996a Estimation and interpretation of direct and maternal genetic parameters for weights of Australian Angus cattle. Liv. Prod. Sci. 45, 1-11.

Rollins, W.C., Guibert, H.R., 1954. Factors affecting growth of beef calves during the suckling period. J. Anim. Sci. 13,517.

Roy, R., Prakash, B., Khan, B.U., 1989. Genetic and non-genetic sources of variation for growth in Jamunapari kids. Indian J. Anim.Sci. 59,874-877.

Ruttle, J.L., 1967. Influence of sex and type of birth on performance of early weaned lambs. J. Anim. Sci. 32(5),974-976.

Ruttle, J.L., Everett, T.E., 1969. The influence of age, body weight and diethylstilbestrol on feedlot performance of early weaned farm lambs. NMSU Agr. Exp. Sta. Bull. 551.

Saghi, D.A., Khadivi, H., Navidzadeh, M., Nikbakhti, M., 2007. Study on influence of environmental effect on birth weight, weaning weight and daily growth of Baluchi sheep. Pakistan J. Anim. Nutr. 6(5),436- 437.

Sallam, M.T., Toson, M.A., Uohana, B.A., 1999. Effect of crossing Egyptian local Baladi with New Zealand White Rabbits on preweaning litter performance. Egypt Poultry Sci. J. 19,71,83.

Sawyer, W.A., Ralph, B., Olaufa, M.M., 1948. Weaning weight of calves as related to age of dam, sex and color. J. Anim. Sci. 7,514.

Selaive-Villarroel, A.B., Maciel, M.B., de Oliveira, N,M., 2008. Effects of weaning age and weight on lamb growth rate of Morada Nova breed raised in a tropical extensive production system. Ciencia Rural 38(3),784-788.

Seleem, T.S.T., 2005. Some reproductive, productive and physiological aspect of purebred and crossbred Flander and New Zealand white rabbits under Egyptian environmental conditions. In, Proc. 14th Intern. Conf. Rabbit Prod. Hot Clim., 24- 27. Feb. Sharm El-Sheikh, Egypt, 161- 168.

Shahroudi E.F., Shiri, A., Tawakolyan, J., Mesgaran, M.D., 2001. Estimation of maternal effects on growth traits of Kurdish lqam in North of Khorasan. Pjoohesh Sazandegi 50,62- 65.

Shi, M.J., Laloe, D., Menissier, F., Remand, G., 1993. Estimation of genetic parameters for preweaning performance in the French Limousin cattle breed. Genet. Sel. Evo., 25, 177-189.

Shi, M.J., Laloe, D., Menissier, F., Renand, G., 1993. Estimation of genetic parameters of preweaning performance in the French Limousin cattle breed. Genet. Sel. Evol. Les Ulis 25,177-189.

Singh, S.K., Sood, S.B., Khan, B.U., 1993. Recent Advances in Goat Production. Proceedings of the V International Conference on Goats, held in New Delhi, India, 2-8 March 1992. International Goat Association, New Delhi, India/International Development Research Centre, Ottawa, Canada/Food and Agriculture Organization of the United Nations, Rome, Italy/Indo-Swiss Development and Fodder Production Project, Ajmer, Rajasthan, India. pp. 675-678.

Singh, V. K., D. Gopal, D., Mehta, S.C.,Sharma, P.R., 1998. Selection in Marwari sheep. 1 Performance of selection line. Indian J. Small Ruminants. 4,1-4.

Speidel SE, Enns Rm, Garrick DJ (2007). Weaning weight inheritance in environments classified by maternal body weight change. J. Anim. Sci. 85(3), 610-617.

Splan, R.K., Cundiff, L.V., Dikeman, M.E., Van Vleck, L.D., 2002. Estimates of parameters between direct and maternal genetic effects for weaning weight and direct genetic effects for carcass traits in crossbred cattle. J. Anim. Sci., 80, 3107-3111.

Stobart, R.H., Bassett, J.W., Cartwright, T.C., Blackwell, R.L., 1986. An analysis of body weights and maturing patterns in Western Range ewes. J. Anim. Sci. 63(3),729-740.

Sundaram, M.S., Muthuramalingam, T., Rajkumar, J.S.I., Nishanth, B., Sivakumar, T., 2012. Growth performance of Tellicherru goats in an organized farm. Intern. J. Dairy Sci. Res. 1(3),9-11.

Swalve, H., 1993. Estimation of direct and maternal covariance components for growth traits in Australian Simmental beef cattle J. Anim. Bred. Genet., 110, 241- 252.

Swenson, M.J., Reece, W.O., 1993. Dukes' physiology of domestic animals. 11th edition, Cornell University Press, Ithaca, New York.

Synam, M. A., Olivier, J.J., Olivier, W.J., 1996. Variance components and genetic parameters for body weight and fleece traits of Merino sheep in an arid environment S. Afr. J. Anim. Sci. 26,11-14.

Szwaczkowski, T., Wojtowski, J., Stanislawska, E., Gut, A., 2006, Estimates of maternal genetic and permanent environmental effects in sheep. Archiv fur Tierzucht., 49, 186-192.

Tawonezvi, H. P. R., 1982. Selection of beef females. Zimb. Agric. J. 79,65-71.

Tilki, M, Inal, S., Tekin, M.E., Colak, M., 2003. The estimation of phenotypic and genetic and genetic parameters for calf birth weight and gestation length of Brown Swiss cows reared at the Bahri Dagdas International Agricultural Research Institute. Turk J. Vet. Anim. Sci., 27, 1343-1348.

Tomiyama, M., Oikawa, T., Arakene, T., Kanetani, T., Mori, H., 2008. Analysis of environmental effects in production and reproduction traits of purebred Berkshire in Japan. Res. J. Anim. Sci. 2,157-163.

Tomiyama, M., Oikawa, T., Hoque, M.A., Kanetani, T., Mori, H., 2009. Influence of early post weaning traits on genetic improvement of meat productivity in purebred Berkshire J. Anim. Sci. 87,1613-1619.

Tosh, J. J., Kemp, R.A., 1994. Estimation of variance components for lamb weight in three sheep populations. J. Anim. Sci. 72,1184-1190.

Tosh, J.J., Kemp, R.A., 1994. Estimation of variance components for lamb weights in three sheep populations. J. Anim. Sci., 72, 1184- 1190.

Tsenkov, I., Laleva, S., 1989. The variability of birth weight in thrace fine wool lambs of the stara Zagora breed type. Genetikai Selektsiya. 22,429-434.

Tumova, E., Zita, L., Marounek, M., Skrivanova, V., Berladyn, A., 2006. The effect of weaning age on performance, nutrient digestibility and lipase activity in broiler rabbits. In, proc. 3rd rabbit Congr. of the Americas, Maringa, Brasil.

Van Wyk, J. B., Erasmus, G.J., Konstantinov, K.V., 1993b. Relationship between early growth in the Elsenburg Dormer sheep stud. S. Afr. J. Anim. Sci. 23,81-84.

Vanzyl, A., Meyer, A.J., Merwe, V.M., 1999. The influence of fibre in the diet on growth rates and digestibility of nutrients in the greater cane rat Thrynomis swinderians). Comparative Biochemistry and Physiology, Part A, Molecular and Intergrative Physiology. 123 (2),129- 135.

Vergara, O.D., Ceron-Munoz, M.F., Arboleda, E.M., 2009. Direct genetic, maternal genetic and heterozygosity effects on weaning weight in a Colombian multibreed beef cattle population. J. Anim. Sci. 87(2), 516- 521.

Verma, R.R.P., Singh, B.K., Singh, M.P., Singh, N. 1991. Factors affecting reproductive performance in Black BBengal goats. Indian Vet. J. 68,235-39.

Vostry, L., Pribyl, J., Vesela, Z., 2007. Selection of a suitable data set and model for estimation of gentic parameters of the weaning weight in beef. Archiv Fur Tierzucht-Archives of Animal Breeding. 50(6), 562- 574.

Waldron, D.F., Clarke, J.N., Rae, A.L., Kirton, A.H., Bennet, G.L., 1992. Genetic and phenotypic parameters estimates for selection to improve lamb carcass traits., New Zealand J. Agric. Res. 35, 287- 298.

Waldron, D.F., Morris, C.A., Baker, R.L., Johnson, D.L., 1993. Maternal effects for growth traits in beef cattle. Livest. Prod. Sci. 34, 57- 70.

Walker, D.M., walker, G.J., 1961. The development of the digestive system of the young animal. The development of rumen function in the young lambs. J. Agric. Sci. 55,271-258.

Ward, H. K., Richardson. F.D., Denny, R.P., Dye, P.J., 1979. Matopos Research Station, A perspective, Rhod. Agric. J. 76 (1), 5- 18.

Ward, H.K., 1959. Some observation on the Indigenous ewes. Rhodesia Agricultural Journal 56,218-223.

Ward, H.K., 1978. Indigenous cattle research-A Review. Rhod. Agric. J. 75,45- 53.

Ward, H.K., Rempel, W.E., Enfield, F.D., 1964. Genetic relationship of weaning weight with post weaning growth rate in swine. J. Anim. Sci. 23, 651-655.

Wardrop, I.D., 1960. The total growth of the visceral organs of lamb. II-the effect of diet on growth rate with particular reference to the parts of the alimentary tract. J. Agric. Sci. 55,127- 132.

Wasike, C.B., Indetie, D., Ojango, J.M.K., Kahi, A.K., 2009. Direct and maternal covariance components and genetic parameters for growth and reproductive traits in the Boran cattle in Kenya. Trop. Anim. Health Prod. 41(5), 741- 748.

Wiener, G., 1994. Animal Breeding. Macmillan, London, UK.

Willham, R.L., 1972. Role of maternal effects in animal breeding, III. Biometrical aspects of maternal effects in animals. J. Anim. Sci. 35,1288- 1293

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

Xiccato, G., Trocino, A., Sartori, A., Queaque, P.I., 2000. Early weaning of rabbits, effect of age and diet on weaning and post weaning performance. In, Proc. 7th Worl. Rabbit Congr. (483- 490), Valencia, Spain.

Yaqoob, M., Shahzad, F., Aslam, M., Younas, M., Bilal, G., 2009. Production performance of Dera Din Panah goat under desert range conditions in Pakistan. Trop. Anim. Health Prod.41,141-149.

Yazidi, M.H., Engstrom, G., Nasholm, A., Jorjani, H., Liljedahl, L.E., 1997. Genetic parameters for lamb weight at different ages and wool production in Baluchi sheep. Anim. Sci. 65,247-255.

Zaky, H.I., 2001. Effects of genetic and non genetic factors on litter traits in crosses of two rabbit strains under desert conditions. Egyptian Poultry Sci. J. 21,627- 640.