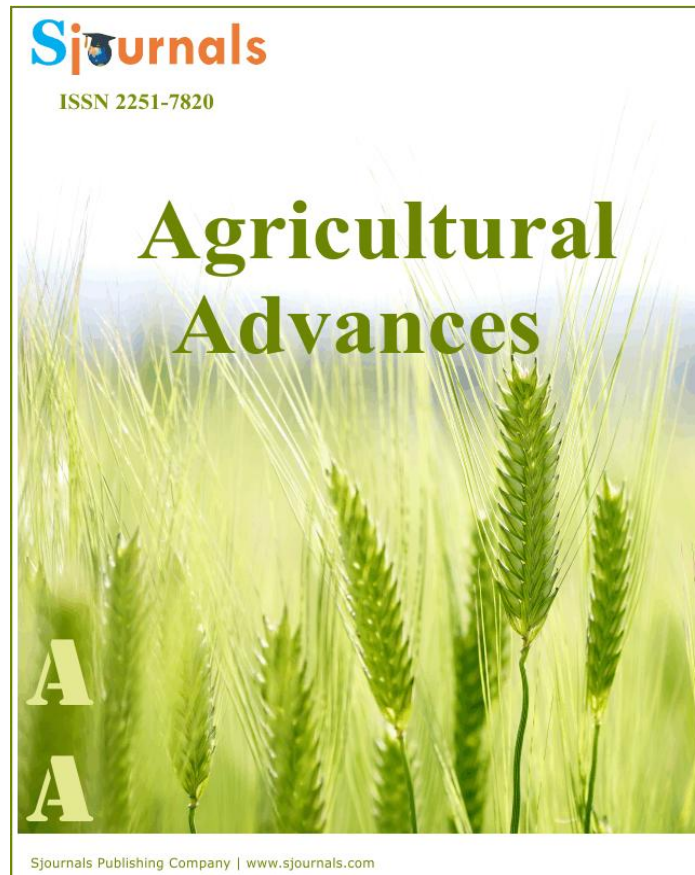


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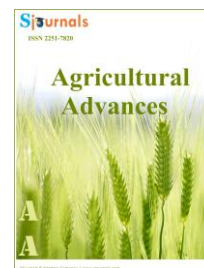
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Review article

Effect of genotype and some non-genetic factors on weaning weight in rabbits

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ABSTRACT

The rabbit meat producers have a strong desire to improve productivity in order to maximize on financial gains. There has been a deliberate move to target improved weaning weight, which is thought to be a critical component in influencing total meat yield and economic returns. However, it has been acknowledged that weaning weight is partly influenced by individual kit genetic potential at the same time its overwhelmed by various non genetic factors. In this respect, weaning weights a complex character which reflects the influence of many biological processes namely fertility, maternal instinct, growth and viability. For the purpose of increasing production, it is reasonably to suggest that the complex inter-relationship among known various non genetic factors that influence weaning weight and the degree of their interactive effects need to be ascertained and understood in different production systems. While, genotype is a major contributor to weaning weight, environmental, nutritional and management practices also play significant roles in influencing weaning weight. There are several known environmental factors that influence weaning weight and these include feeding practices, birth weight, parity order, sex of kits, management, etc. The rabbit producers' attention to the aforementioned factors is likely to improve weaning weight at enterprise level. It is important to note that selection for increased litter size have an adverse effect on average litter birth weight which subsequently reflects on weaning weight. The enhanced prolificacy in does has

resulted in an increase in within litter variation and a larger number of kits born light. From the farmer's performance point of view, genetic diversity utilization in crossbreeding has been the focus in improving weaning weight in commercial rabbit meat production. However, the complementary role played by nutritional status in optimization of performance in selected genotypes has been tremendous in the past two decades. Crossbreds have performed at levels consistent with different targeted rabbit meat market expectations. Generally, it is pronounced that improved nutritional regime and patterns for lactating does and their suckling kits had a positive effect on weaning weight. On the other hand, unbalanced parity structure and distribution in rabbit enterprise results in unreasonable variation in weaning weight, which impacts negatively on subsequent kits management after weaning. The purpose of this review is to discuss the influence of genotype and some non-genetic factors (litter size, birth weight, parity) on weaning weight in rabbits.

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1. Introduction

The influence of genotype and non-genetic factors on weaning weight in rabbits have been extensively studied (El-Kholya, 2011; Attalah, 2005; Poigner et al., 2000; El-Maghawry et al., 1993). Weaning weight in rabbits is a complex character which reflects the influence of many biological processes namely fertility, maternal instinct, growth and viability (Lukefahr et al., 1990). The primary determinants of weaning weight are classified into direct genetic potential of the individual kit and the level of non-genetic factors and their interaction. Weaning weight vary with genotype, feeding, birth weight, litter size, parity order, management system, etc. (Al-Saef et al., 2008; Chineke, 2005; Reddy et al., 2003; Bhasin et al., 1996; McReynolds, 1974). Litter size has far reaching influence on body weight at various stages of growth from weaning up to marketing (Gupta et al., 2002). Kits from larger litters generally experience lower weight at weaning as compared with their counterparts in smaller litters (Poigner et al., 2000). The economic return of a rabbit meat production enterprise greatly dependent on weaning weight, as heavier kits are likely to attain a heavier market weight (Rashwan et al., 1997). This implies that improved market weight translates to higher total rabbit meat marketed and higher the economic margin (Zeferino et al., 2013). If weight at weaning is high, then it is anticipated that post weaning growth rate and final market weight would be high (Das et al., 2007). In this respect, improved weaning weight ultimately decides quantum of meat produced at finisher phase (Gerencser, 2011). It would be reasonably to suggest that weaning weight is one of the major productivity indicators in rabbit meat production. The judging of viability and calculation of economic returns from rabbit enterprise will greatly depend on average litter weaning weight. The purpose of this review is to discuss the influence of genotype and some non-genetic factors (litter size, birth weight, parity) on weaning weight in rabbits.

2. Genotype and genetic improvement

Various studies have demonstrated that genotype/breed had an influence on weaning weight in rabbits (Olowofese et al., 2012; Youssef et al., 2008; Attalah, 2005; Patial et al., 1991). It is certainly true that genotype has an impact on average growth rate and weaning weight, however this effect is more pronounced when rabbits are fed high plane of nutrition. This implies that different genotypes can exhibit dramatically different genetic expression of weaning weight fed a comparable diet. Pasupathi et al. (2014) observed that breed had an influence on weaning weight in rabbits. Genetic groups of Chinchilla vs Giant Flemish registered the highest mean litter weaning weight (Olowofese et al., 2012). In a similar study, Chinchilla and crossbred does produced kits with heavier weaning weights than New Zealand White and California breeds. Hyla crossbred had significantly improved

weaning weight compared to Hyla purebreds due to high hybrid vigor in the crosses (Akinsole et al., 2014). This implies that heterotic effect on weaning weight can be taken advantage of for high productivity in rabbit meat production. The high level of genetic diversity and population structures in both exotic and indigenous rabbit breeds can be exploited in crossbreeding schemes resulting in increased performance in rabbit meat production. This might mean crosses of exotic and low performing indigenous rabbit breeds in the tropics would register improved weaning weight due to heterotic effect or genetic distance. Higher weaning weights of kits were reported in California than New Zealand White by Ferraz et al. (1999), however, this was in contrary with report from Lukefahr et al. (1983) who observed improved weaning weight in New Zealand White compared to California. Hamilton et al. (1997) working with the same rabbit breeds cited the influence of smaller litter and/or less milk production in California rabbit as the major cause of light weaning weight than the New Zealand White. An average litter weight at weaning of 1277g was registered by Youssef et al. (2008) and Attalah (2005) working with local rabbits of Black Balada and Red Balada, respectively. Their observations were comparably lower than those reported by Abou-Khadiga et al. (2009) for synthetic V line and Khalil (1993) for Danish White rabbits. The variation in weaning weight in these rabbit genetic groups was ascribed to differences in litter size. Seasonal effect was also mentioned as partly influencing litter weight and size at weaning in the study. Average body weight at weaning of more than 466g were reported by Sahel et al. (2005) in Balade Black and their crosses. In similar studies Abdou et al. (2006) reported higher average body weight working with New Zealand White, California Bauscat, Flander and Balade Black. This was in agreement with reports by Szendro et al. (1998) and Tag-El-Din et al. (1990) who also reported higher weaning weights in different breeds and their crosses. Improved weaning weights were reported for Chinchilla does as compared to New Zealand White and California, which was capable of being traced to superior maternal and/or high milk yield of Chinchilla rabbit breed (Iyeghe-Erakpotobor, 2011). Maternal line genotype had an influence on litter weight at weaning with California does surpassing New Zealand White does for both average (671.11 vs 646.58g) and total (3073.7 vs 2841.1g) weaning weight (Ferraz et al., 1991). The Flemish Giant rabbit kits were heavier for growth rates than the New Zealand White at weaning. On the other hand, the breeding of Flemish Giant and New Zealand White as purebreds registered lower growth rates than their crosses (Lukefahr et al., 1980). New Zealand White dams crossed with Flemish Giant males registered high weaning weights (Patial et al., 1991). Akinsola (2012) registered higher average weaning weight than the values observed in similar Hyla rabbits by Hamouda et al. (1990) in Tunisia, Yamani (1994) in Egypt and Crystosome et al. (2011) in Benin. This implies that different lines of the same rabbit hybrid may feature differently in different environments. Pure breeding of New Zealand White and California dams recorded low weaning weights than their crosses (Iyeghe-Erakpotobor, 2011). This was in disagreement with observation made by Lukefahr et al. (1984) who reported that kits weaned at 21 days from New Zealand White and California breeds their weight were proportionate.

The rearing of more productive rabbit breeds and their crosses could be an appropriate approach to improve the productivity and financial return in rabbit production. Productive traits such as weaning weight are determined by many genes, but are also overwhelmed by various environmental factors. This implies that weaning weight is subject to the outcome of contribution of genes and its environment. The genetic influence on weaning weight in terms of variation is of interest in sustainable genetic improvement, firstly because genetic variation can be exploited in selection response and secondly utilization of genetic variation in crossbreeding schemes where positive outcome depends on genetic distance and/or diversity. Both within population selection and crossbreeding have significantly contributed to the improvement of weaning weight in rabbit production. Through selection and crossbreeding producers, have managed to increase weaning capacity for slaughter, in addition to better carcass and meat quality properties. Hybrid vigor in crossbreeding is significant where the population crossed differ genetically. After decades of within rabbit breeds selection, the focus is now on breeding of specialized paternal and maternal genotypes in order to maximize production. It is assumed that the crosses of the best paternal and maternal genotypes when crossed will capitalize on expression of hybrid vigor. The idea is based on the fact that rabbit breeding should focus on creating the ideal crosses from the best paternal and maternal crosses to maximize meat production. The selection strategy for specialized maternal genotypes is based on litter size at birth and at weaning. However, it should be noted that the influence of genotype on weaning weight is partly caused by variation in milk production of different genetic groups. There is considerable variation between rabbit breeds in weaning weight, which can be exploited in order to maximize production through hybrid vigor. This has been ascribed to genetic influence on growth and development where on average smaller breeds will mature faster than larger breeds. In addition, lines within breeds may also vary in their weight at weaning. There is

a positive phenotypic and genetic correlation of weaning weight and subsequent growth traits has been reported in literature (Elamin et al., 2011). It is important to note that weaning weight is moderately heritable hence it is usually used for selection of does for breeding. Lebas et al. (1997) reported that the average weaning weight per kit was 887g and 55 to 65 kits could be weaned per doe per year in semi intensive systems. Doe nutrition was critical in influencing weaning weights and final market weight due to the positive correlation of all stages of growth. In this regard, productivity will depend on the achievable growth potential of kits which later determines the profitability of the rabbit enterprise. The present discussion alludes to the interactive effects of genotype and some non-genetic factors influencing weaning weight, hence the need to give attention to these for maximum production.

3. Birth weight and litter size

Birth weight and litter size are negatively correlated, as a result the improvement in one has an adverse effect on the other. This implies that number of kits born influence individual weight at birth, in turn the weaning weight. In addition, both traits have a profound effect on future growth of kits. Birth weight is one of the principal sources which influence weaning weight and a key factor of weaning capacity in rabbits. Di Meo et al. (2004) cited an average kit birth weight of about 60 to 70g with a range from 35-40 to 80-90g. Palos et al. (1996) observed a profound dual functional coaction of birth weight and litter size on average daily gain which in turn reflected on weaning weight. The litter size relates mutually to the weight at birth of kits which normally range from 40 to 70g (Poigner et al., 2000). Positive phenotypic and genetic correlation has been reported between litter size at birth and litter weight at weaning (Sorhue et al., 2014). An attempt to select for increased litter size resulted in low weaning weight (Rochambeau, 1998). There is a negative association of litter weight at weaning and litter size in rabbits (Rollins et al., 1963; Rao et al., 1977).

Litter size has been described as one of the litter traits that influence productivity and the profit margin in rabbit production (Eady and Prayaga, 2000). It is an important performance trait in prolific species such as rabbits and pigs (Argente, 2006). Moreki (2007) working with the New Zealand White breed in France reported an average litter size of around 7 to 9 kits, however in literature litter size can range from 1 to 20 kits. Registered milk yield of does had a quadratic typical feature on rabbit growth, this was well pronounced in higher milk production order. Kits from large sized litter raised by poor lactational does registered low growth. Growth was considerably depressed as litter size at weaning increased from one to four kits. And thereafter depicted a constant negative linear tendency to a litter size of 11 kits (McNitt and Lukefahr, 1983). It would be reasonable to suggest that in unbalance litter sizes, it's appropriate to even out litter size through adoption of kits, so as to have manageable size of kits which the does can nurse. Generally, it has been pronounced that an increase in litter size is associated with a decline in quantity of milk share for each kit (Zerroukietal, 2012; Yuan et al., 2015). The litter size relates mutually to the weight at birth of kits which normally range from 40 to 70g (Poigner et al., 2000). The physiological complexity of litter size emanates from the fact that it is influenced by several biological processes expressed successively. The sequential reproductive processes which influence litter size at birth include ovulation rate, fertilization, embryo development and fetal survival.

Litter size can be targeted for selection in rabbit breeding in order to maximize weaning weight (Eady and Prayaga, 2000). A negative phenotypic correlation of number of young rabbits born in a litter and average birth weight of kits of -0.69 was reported by Argente et al. (1999) which in turn had a profound influence on weaning weight. In their study they concluded that breeders should be mindful that targeting increased litter may have an adverse effect on birth weights at the same time the resultant weaning weight. Further, suggested that the use of selection index method which account for birth weight might be essential in the development of breeding objectives to promote weaning weight. The larger the litter at birth, which can survive up to weaning, the greater the economic returns of a rabbit enterprise. It has been credible for rabbit meat producers to use litter size and weaning weight as criterion for measuring viability and productivity (Khalil et al., 1987). However, it is important to note that weaning weight apart from being influenced by litter size, maternal behavior also plays a crucial role in determining weights at weaning and the final market weight. Pasupathi et al. (2014) reported that weight at weaning notably decreased with large litter size. Weaning weight was notably different among large and small litter size. Litter size of two gave the maximum weaning weight, which was 717.04g, while a minimum of 510.23g was registered from a litter size of seven. In a similar study, litter size greatly influenced weaning weight, with kits in a litter size of 2 or 3 registering higher weaning weights than larger litters (Fayeye and Ayorinde, 2008).

The high weaning weight in small litter size was due to adequate milk supply or share from the dam. The number and individual littermate's body weight contributes to determination of dams' total milk production, where milk yield increase when litter size increases in rabbits (MacNitt and Lukefahr, 1990). The amount of milk ingested by individual kits is dependent on litter size and dams milk quantity (Zotte and Paci, 2013). Fortun-Lamothe (2006) observed that depressed milk yield in multiparous does was ascribed to insufficient energy body reserves due to extended suckling by larger litter size, which resulted in poor body condition. It has been demonstrated that kits born in large litter sizes have a compromised weight at weaning as compared to those born in small litter sizes (Poigner et al., 2000). This is explained by the fact that there is a lot of competition for milk in large litters. The weak litter mates tend to starve due to inability to compete for adequate milk share. It is a fact that the growth capacity of the kits is propelled by milk intake at this stage. Ayyat et al. (1995) observed that dams milk yield is positively associated with litter size. In this case, small litter size kits will consume more milk than those in large litter size hence registered improved weaning weight. There is greater competition for milk in larger litters to the extent that weak kits can continuously starve resulting in poor individual weight gain and weaning weight. It is predictably that this competition could be exacerbated by less teats number. It is also reasonably to suggest that increasing litter size has a negative effect on weight gain and weight at weaning. Maternal capabilities of older dams to milk greater contribute to improved weaning weights.

From maternal investment point of view can predict that kits weaning weight would be improved in smaller litter size than larger size. The appropriate litter size at the time of weaning suggest that 6 to 8 rabbits could be close to the upper limit that domestic rabbit doe is capable of nursing. Garreau et al. (2004) demonstrated that the average litter size of most maternal rabbit lines is around 10 kits, however with a low individual weaning weight. The large number of kits put high requirements for suckling or lactation on the dam. Lukefahr et al. (1983) observed a substantial positive correlation within breed between lactation and both litter size and weight at weaning. Garreau et al. (2004) found it valid to utilize dams from lines selected for improved litter size in order to improve milk yield. On the other hand, compromised feed intake in nulliparous does resulted in low milk yield, which led to the consequent inability to suffice suckling requirements of kits (Xiccato et al., 2004) resulting in poor growth. This can explain the comparable low average weaning weight in kits. The same author, reported an increase in milk yield as litter size increases. However, this could have applied to crossbreds which were selected for high feed intake. It is reasonably to suggest that the case might be different on unselected population, which might not efficiently adjust their voluntary feed intake to suffice energy requirement during lactation (Pascual et al., 2000).

4. Dam parity order and nutrition

Sedki et al. (2002) observed that doe parity order had an influence on weaning weight in rabbits. In contrary, parity did not influence weaning weight, while litter size significantly influenced weight at weaning (Iyeghe-Erakpotobor, 2011). However, it was noted that weaning weight increased with increase in parity order. Kits born in third parity were heavier at weaning than those raised in the second and first parity orders. This can be explained by variation in maternal ability, where older does had better maternal instinct than first kindlers. Maternal capabilities of older dams to milk greater contribute to improved weaning weights. With respect to parity order, multiparous does registered higher average litter weight at birth, but produced less milk at than primiparous at 21st day of lactation (Pasuthi et al., 2014) hence influencing weaning weight. In New Zealand White, the low weaning weight in litter of first parity was ascribed to less milk in their first lactation as compared to consecutive lactations (Kalinowski and Rudolp, 1978). Sound dam body condition within parity enhance chances to achieve high milk yields and maximize the average weaning weight. The consecutive act of kit suckling in different parity will promote the enlargement of mammary glands, hence improving milk secretion and weaning weight. This implies that enlarged mammary glands in older dams are more productive in subsequent lactations than unsuckled or poorly suckled udder. In order to attain predictable weaning weights does' parity structure should be constant. Apart from parity or age, milk production in rabbits may be influenced by breed of the dam (Lukafahr et al., 1983), age of kits and litter size (Taranto et al., 2003), feeding (Chrastinova et al., 1997) and physiological status of the dam (Maertens et al., 2006).

Achievable growth potential and heavy weaning weight are dependent partly on the intrinsic maternal behavior of the doe to provide adequate milk (Yahaya, 1993). Lebas (1969) observed that in first litter weaning weight is less than those consecutive litters considering the lactation curve. A positive association of litter weight

at weaning with does milk yield has been reported by Lukefahr et al. (1981). It has been noted also that breed influence milk production. New Zealand White dams registered higher total milk production than the Dutch rabbit does over a period of six weeks (Cowie, 1969). Due to the fact that growing rabbit depends exclusively on does milk at weaning (21d), it is reasonable to assume that 21 days is at appropriate point to assess the doe's maternal ability (Ferraze et al., 1991). Does should produce as much milk as possible to maintain kits and achieve optimum litter weaning weight. On the same note, Szendro et al. (1993) working with New Zealand White and California rabbits deduced that selection of does based on teat number for milk production may be rapid and valid. This selection procedure has been effective in other multiparous species. McKay and Rahnefeld (1990) reported moderate heritability for teat number in pigs where both anterior and posterior teat number were improved and may be subject to significant maternal influence (Pumfrey et al., 1980). Milk producing phase is an energy intense period in dams. Energy mobilization for lactation causes a discord between dam nutritional requirement and its kits, mainly over the amount of milk each kit suckle. Body reserve mobilization during lactation in does starts at about 11 (Partridge et al., 1983) persists through maximum production day 18 or 19 to weaning (21d) thereafter milk production drop off rapidly (Sanchez et al., 1985). Around weaning (22d) the growing rabbits depend immensely on the milk consumed from the doe which implies that maternal instinct is greatest at this point (Peinado et al., 1988). However, there is competitive interplay among kit mates for milk share, which is likely to be intense with increased in litter size. During weaning stages, the energy demand for growing rabbits is high which implies that their survival and weight gain entirely depend on the doe's milk (Fortun-Lamothe and Gidenne, 2000). This makes dams milking capacity an important element in enhancing productivity (Iraqi et al., 2010). Kits from dams nursing large litters suffer more where the number of kits exceed the number of teats.

Maternal nutritional status exerts a great influence on does milking capacity. The attainment of steady flow of milk production and realization of its peak production will depend on doe's nutrition (Sandford, 1986). Adequate levels of dam's daily feed intake have been associated with improved milk production. Daily intake is an important performance trait which is highly heritable. Therefore, can deduce that appropriate nutrition of dams during nursing greatly influence milking capacity, which in turn can reflect in improved weaning weight. Daily intake and feed conversion efficiency will improve total milk production of does hence weaning weight. Apart from improved feed intake promoting high litter weaning weight, it also has a positive bearing on subsequent reproductive capacity in does. This implies that rabbit producers should supply dams with adequate energy and protein to support sufficient milk production for kits during suckling which will translate into improved weaning weight. It is important to note that dam's milk is mostly the exclusive source of nutrition of growing kits, therefore growth and development of kits rely upon milking capacity. Diet manipulation and improvement could be used to advance milk production in does. The feeding of does apart from enhancing milk production, it improves the doe's body condition in preparation for the next kindling with high chances of producing a large litter. Poor body condition of does has a negative effect on weaning weight, which is reflected in poor final slaughter and/or market weight.

In other multiparous species selection for teat number and quality in dams ensure excellent milking ability resulting in improved weaning weight. Suckling stimulates the udder milk secretion resulting in weight gain in kits which translate into weaning weight. In this regard, heavier kits at birth have greater chances to actively suckle the teats, survive, gain weight and be weaned at heavier weight. In terms of growth, the average daily gain of kits varies between 30-40g during suckling period in semi-intensive production systems (Lebas et al., 1997). It might be reasonable to suggest that selection for maternal attributes, which include the component of teat number and quality may result in does that can produce more milk hence improving weaning weight. This implies maternal instinct, more milk and ability to suckle of kits supported by reasonable teat number can sustain kits hence heavier litter weaning weights. Bautista et al. (2005) reported that heavy littermates had a clear advantage in suckling in large litters. On the same note, Blasco et al. (1993) reported that selection for maternal behavior is beneficial for productivity.

5. Implication

From a series of studies conducted to ascertain the influence of genetic and non-genetic effects on weaning weight in rabbits, can discreetly conclude that weaning weight vary with genotype, litter size, birth weight and parity. It has been acknowledged that weaning weight is a determinant of weaning capacity in rabbits as a consequence of its influence on subsequent growth potential and slaughter or final market weight. However, kits

suckling of enough milk of good quality tend to sustain improved weaning weight and subsequent market weights. This implies that adequate attention should be given to nutrient supply during lactation for maximum growth of kits and improved weaning weight. It appears that appropriate dietary provision will enhance the growth of kits which give a fair chance for improved weaning weights. On the other hand, due to intense competition among littermates for does milk, larger litters will likely have low weaning weight as compared to smaller litters. This is explained by the fact that weak kits from large sized litters have minimal or less chances of suckling than kits of small sized litters hence poor growth rates. The subsequent kit growth notably is affected by dam's milk production capacity and litter size at weaning for the reason that the relative allotment of milk from the dam per kit declines as the litter size increases. In this respect, plausible explanation for a decrease of weaning weight with increase in litter size is the intense competition for milk share among littermates in large litters, where weaklings may not access adequate milk to meet their growth requirement. Suboptimal nutrition impose restricted weight gain on kits that typically has a negative implication for subsequent weaning weight and market weight. The negative consequences of defective plane of nutrition is seen during lactation with resultant impairment of production and reproduction characters. Generally, it is pronounced that feeding strategy applied prior weaning is very crucial because the growth of the kits is immensely dependent on the amount of milk the dam produces for suckling. However, litter size influence the individual kits portion of milk intake, hence their ability to grow. Selection for large litters at birth may have adverse effect on overall productivity, possibly through risking on higher rate of pre-weaning mortality

One of the appropriate approaches to improving weaning weight in commercial rabbit meat production is to select does that have good maternal abilities/behavior/instinct, which has been positively associated with parity order. High parity order does, due to significantly developed udder glandular tissues, as a result of consecutive suckling produces more milk than low parity order does. Hence, targeting maternal behavior traits for selection is highly likely to contribute to improved kits growth rate as a result influencing undoubtedly the weight at weaning and final market weight. The differences in genotype weaning weight may be explained partly by genotype differences in maternal ability. It has been acknowledged that substantial variation among rabbit breeds/genotypes in maternal instinct or behavior exist, which in turn reflected in differences in weaning weight. This has simply been ascribed to variation in milk production capacity in different breeds. Success on proposition for utilization of pure breeding or crossbreeding schemes in rabbit production will depend on detailed information on the influence of genetic and non-genetic factors on weaning weight for both purebreds and crossbred raised in different production systems. Streamlined studies targeted at various systems are essential to assist in ascertaining the degree of influence of non-genetic factors and expected optimum range of weaning weight for increased productivity. Such information would be valuable for successful selection programs for optimum genetic performance in rabbits.

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