INFLUENCE OF GENOTYPE AND FEED RESTRICTION ON POST-WEANING GROWTH PERFORMANCE OF DOMESTIC RABBIT

BY

MALLAM, Iliya
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DEPARTMENT OF ANIMAL SCIENCE
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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE
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ZARIA

AUGUST, 2016

DECLARATION

I hereby declare that the work in the dissertation entitled "**INFLUENCE OF GENOTYPE AND FEED RESTRICTION ON POST-WEANING GROWTH PERFORMANCE OF DOMESTIC RABBIT**" has been performed by me in the Department of Animal Science under the supervision of Prof. B.I. Nwagu and Dr. M. Kabir. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another Degree or Diploma at any University.

Mallam Iliya	______________	_____________
(Student Name)	Signature	Date

CERTIFICATION

This dissertation titled "**INFLUENCE OF GENOTYPE AND FEED RESTRICTION ON POST-WEANING GROWTH PERFORMANCE OF DOMESTIC RABBIT**" by **MALLAM ILIYA** meets the regulations governing the award of the Degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to scientific knowledge and literary presentation.

______________________________ ___________________
Prof. B.I. Nwagu Date
Chairman Supervisory Committee,
National Animal Production Research Institute,
Ahmadu Bello University, Zaria

______________________________ ___________________
Dr. M. Kabir Date
Member, supervisory committee
Animal Science Department
Ahmadu Bello University, Zaria

______________________________ ___________________
Prof. S. Duru Date
Head of Department
Animal Science Department
Ahmadu Bello University, Zaria

______________________________ ___________________
Prof. Bala Kabir Date
Dean, Postgraduate School
Ahmadu Bello University, Zaria

DEDICATION

This Dissertation is dedicated to the Most High God; the Author of all knowledge and wisdom, and whose strength, guidance, provisions, love and grace saw me through the period of this study. It is also dedicated to my late father Mr. Mallam Kigbu and my beloved brother Mr. Samuel Mallam.

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ABSTRACT

Data on 102 progeny of New Zealand White (NZ), Chinchilla (CH) and Dutch (DU) breeds of rabbits and their crossbreds obtained from birth to 14 weeks were used for this study. Genotype and feeding regime were the factors of interest. The genotypes were New Zealand White x New Zealand White (NZxNZ), Chinchilla×Chinchilla (CHxCH), Dutch×Dutch (DU×DU), New Zealand White x Chinchilla (NZxCH), New Zealand White x Dutch (NZxDU) and Chinchilla×Dutch (CHxDU).The feeding regime consists of *ad libitum* feeding (A), 14 hours feed restriction/day (B), 10 hours feed restriction/day (C) and 6 hours feed restriction/day (D). The experiment was conducted at the National Agricultural Extension Research and Liaison Services (NAERLS) Skill Acquisition Farm, Ahmadu Bello University, Zaria-Nigeria. The traits studied at pre-weaning were litter size at birth (LSB), litter weight at birth (LWB), litter size at week 2 (LSW2), litter body weight at week 2 (LBW2), litter size at week 4 (LSW4), litter body weight at week 4 (LBW4), litter size at week 6 (LSW6) and litter body weight at week 6 (LBW6). Traits studied after weaning were body weight (BW), body length (BL), chest girth (CG), head-to-shoulder(HS), shoulder-to-tail drop (ST), length of hind leg (LHL), ear length (EL) and height at withers (HTW). Data collected were subjected to Analysis of variance and correlation procedure in SAS and a fixed effect model was used for the analysis with significant means separated using Duncan Multiple Range Test. There were significant (P<0.05) differences among the genotypes for LWB, LBW2, LBW4, LBW6 and post-weaning growth performance at the different ages. Chinchilla x Chinchilla was superior over other genotypes for most of the post-weaning growth traits studied at different ages (480.00 g, 650.00g, 941.30 g, 1206.00 g and 1401.75g mean body weights at week 6, 8, 10, 12 and 14 respectively). This was followed by CHxDU (476.30 g, 601.30 g, 751.00 g, 910.00 g and 1086.25 g for the same parameters. The coefficients of correlation were from low to high (0.00-0.99) and were positively and negatively correlated in all the genotypes except for CHxDU which were all positive. The results indicated that CHxCH and CHxDU genotypes could be most suitable for optimum genetic improvement. The mean body weights obtained were 772.67±38.72 g, 688.62±32.16 g, 730.75±35.24 g and 705.37±33.45 g for feeding regime A, B, C and D respectively which were not significantly different (P>0.05). It can be concluded that CHxCH genotype performed better in most of the post-weaning growth traits and rabbit farmers can use any of the feeding regimes especially during scarcity of feed and forages for rabbit feeding. The CHxCH is recommended for higher litter size and body weight at weaning while any of the feeding regimes can be adopted.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Variations exist in the growth performance of different breeds of rabbit. These variations are attributed to genetic and environmental factors. Environmental variations result from managerial, climatic and nutritional factors. Ibe and Nwakalor (1987) indicated that body size and conformation traits are highly heritable traits. This suggests that differences are expected among different genotypes. Several genetic factors such as breed, litter size, weaning age and sex as well as non-genetic factors such as diseases, season, temperature, housing and feeding have been noted to influence post-weaning growth performance of rabbits (Afifi and Emara, 1988). The productivity of an animal is therefore, largely determined by the interaction between genotype and environment (Chineke and Owosangba, 1999). Post-weaning growth is important in the economics of rabbit production, since it influences the rate of attainment of market weight. Kabir *et al.* (2012) reported that New Zealand White rabbit were superior for litter size at birth and at weaning, but Chinchilla breed is the best for individual weight at birth and at weaning as well as milk yield and mothering ability. Body weight and body measurements are good indicators of growth performance in domestic animals including rabbits. Body weight and body measurements are used to characterize rabbit breeds, contrast variation in size and shape (Shahin and Hassan, 2000) and estimate carcass and body weight (Oliveira *et al.*, 2005). Rabbits need less space and feed due to small body size, shorter generation interval, high prolificacy, faster growth and high feed conversion efficiency which are characteristics that makes it a suitable meat producer (Orheruata *et al.*, 2006 and Kabir *et al.,* 2011). These qualities make rabbit production a panacea to animal protein deficiency in developing countries (Obike *et al.*, 2010).

Rabbits are conventionally fed *ad libitum* (concentrate and forage) to enhance their growth and reproductive performance (Bawa *et al.,* 2007). The recent phenomenal rise in the cost of feeds and feeding stuffs in most parts of the humid tropics have forced farmers to now engage in indiscriminate feed restriction programmes, aimed majorly at reducing cost of production and consequently increasing profitability (Boisot *et al*., 2003). Reports from the temperate regions have indicated that feed restriction reduces post-weaning digestive disorders and improves feed efficiency (Boisot *et al.,* 2003; Gidenne *et al.*, 2003 and Boisot *et al.,* 2004). Boisot *et al.* (2003) reported that a feeding level of 60% was more efficient in reducing the negative impact of epizootic rabbit enteropathy syndrome conditions. Gidenne *et al. (*2003) indicated that mortality and morbidity were significantly reduced during feed restriction (a feeding level of 80% and 70%, respectively). Biobaku and Adegoke (1999) as cited by Yakubu *et al.* (2007) observed no significant difference in mean daily body weight gain among rabbits fed *ad libitum* and those fed for 8 and 16 hours, respectively. Therefore, unguided practices could further deteriorate this situation. Some researchers have advocated that growth traits of chicken are affected by feed restriction (Ibe and Nwachukwu, 1988).

1.2 Justification

There is dearth of information on the effect of feed restriction on growth traits of rabbit in literatures except perhaps on body weight gain. Information on the effect of feed restriction on growth traits is particularly important in the tropics as animal productivity is generally low in this area compared to the temperate regions. A study to investigate whether or not feed restriction could influence growth traits of rabbits is then necessary. Forages, on the other hand, are scarce and lignified during dry seasons leading to fluctuations in body weight of forage fed animals including rabbits and can influence their growth rates at such times. Therefore, selection of genotypes that can thrive well under limited feeding conditions is thus necessary for sustainable production.

Restricted feeding induces compensatory growth by realimination and increases feed efficiency (Tumova *et al.*, 2003 and Dalle Zotte, *et al.*, 2005) and body fat can be reduced (Washburn, 1990). Early feed restriction helps to address problems associated with early life fast growth rate such as increased body fat deposition, high incidence of metabolic disorders and high mortality (Urdaneta-Rincon and Leeson, 2002; Gidenne *et al.*, 2003; Hassanabadi and Nassiri, 2006). Reports on the effect of feed restriction on the performance of chickens abound in literature (Cable and Waldroup, 1990; McGovery *et al.*, 1999), similar investigations with rabbits especially in the tropics are not so available.

This study was therefore designed to determine the optimum combination of genotypes and feed regimes that will enhance optimum growth performance of rabbits in tropical environment.

1.3 Objectives

The objectives of this study were to determine the:

1. Influence of Genotype on growth performance of domestic rabbit

2. Effect of feed restriction on post-weaning growth performance of domestic rabbit

3. Relationship between the measured traits

1.4 Hypothesis

Null hypothesis: Genotype and feed restriction do not have effect on post-weaning growth performance of the domestic rabbit breeds.

H_o: $\overline{x}_{1=} \overline{x}_{2=} \overline{x}_{3\ldots}\overline{x}_n$

Alternative hypothesis: Genotype and feed restriction have effect on post-weaning growth performance of the domestic rabbit breeds.

$\mathbf{H}_{a}$: $\overline{x}_1 \neq \overline{x}_2 \neq \overline{x}_{3\ldots}\overline{x}_n$

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin and Domestication of Rabbit

Domestic rabbit (*Oryctolagus cuniculus*) is a descendant of wild rabbits of Europe and North Africa. This animal (rabbit) is thought to have been discovered by Phoenicians when they reached the shores of Spain about 1000BC (Lebas *et al.*, 1998). During the time of Romans, rabbit was emblematic of Spain. It appears that the Romans spread the rabbit throughout the Roman Empire as a game animal. In their natural habitat, rabbits are gregarious and prolific. They are also completely herbivorous (eat only plants) and mostly forage in the twilight or in the dark. The average life span of a rabbit is 5-10 years (potential life span of 15 years is possible). Rabbits are ideal for small livestock projects in peri-urban or rural areas, especially in developing countries such as Nigeria with a significant proportion of citizenry living below poverty datum line (World Bank, 2003). Rabbits are quite clean and relatively odourless. The raising of rabbit can be anything from a profitable hobby to a full-time living rabbits fit well into a balanced farming system. Rabbits production complement well with vegetable growing. Excess and waste from vegetable gardens and kitchen goes to feeding of rabbits, whereas their manure is used to fertilize gardens thus forming a profitable cycle and aiding the balance of nature. The reasons for raising rabbits are manifold. Rabbits are important source of food, particularly in Europe and Asia. Rabbits produce white meat that is high in protein, low in fat, highly palatable, low in cholesterol and can substitute poultry in most recipes. In the United State, rabbits are raised mainly for non-food purposes. High quality rabbit skins are used in fur garments (clothing, hats), to cover bicycles seats, etc. and their use could spark a village industry/crafts projects. Another significant use of rabbits is in cosmetic, medical and pharmaceutical research laboratories.

2.2 Anatomy of Rabbits

2.2.1 Musculoskeletal system

The rabbit skeleton is light, making up only 7-8% of body weight (Anna and Lance, 2000). The front limbs are short and fine, in contrast to the long and powerful hind limbs. The plantar surface of the hind limb from the tarsus distally is in contact with the ground at rest. The spine is naturally curved. Body conformation varies greatly depending on the breed, from 1kg to 10kg, and from the squat or cobby shape of the dwarf breeds to the light and lean Belgian hare. Skull morphology can lead to disease, especially dental problems, in some breeds. For example some dwarf breeds have a mandibular prognathism which causes incissor malocclusion, and breeds with a foreshortened skull seem predisposed to nasolacrimal duct and dental problems (Anna and Lance, 2000).

Great care must be taken when handling rabbits. Osteoporosis is often present due to lack of exercise and low calcium intake, and a kick from the powerful hind legs can result in lumbar vertebral fractures (usually L6/L7). The forelimb has five digits and the hind limb four. The vertebral formula of the rabbit is C7-T12-L7-S4-C16. Thirteen thoracic vertebrae are seen in some animals.

2.2.2 Dentition and oral cavity.

The upper lip of the rabbit is cleft. The dental formula is 2/1, 0/0, 3/2, and 3/3. The incisors are used for grazing, and food is then passed to the back of the mouth for grinding. Incisors have enamel layer only on the anterior surface, which wears more slowly than the posterior surface, thereby maintaining a chisel shape for cutting herbage. The vestigial second pair of upper incisors is located directly behind the first pair and is known as peg teeth (Janusz and Josef, 1982). All teeth are opening rooted, long-crowned and grow continuously. The cheek teeth are wider apart on the maxilla than on the mandible, and the lower teeth grow faster than the upper.

The oral commissure is small, and the oral cavity long and curved. Cheek folds across the diastema make visualization of the cheek teeth difficult in the conscious animal. The tongue is large and has a mobile rostral portion and relatively fixed thicker caudal portion (torus). There are four pairs of salivary glands: parotid, submaxillary, sublingual and zygomatic (Janusz and Josef, 1982).

2.2.3 Skin

Female rabbits possess a large fold of skin under the chin known as the dewlap, from which they pull hair to line the nest before kindling. The toes and metatarsal areas are completely covered with hair, and there are no footpads. Scent glands are located on the underside of the chin, either side of the perineum (inguinal glands) and at the anus (anal glands). The inguinal glands are large and pouch-like and often contain a yellow/brown oily deposit.

Hair coat depends on breed (Anna and Lance, 2000). The normal coat consists of a short soft undercoat protected by longer guard hairs. The only hairless areas are the tip of the nose, part of the scrotum and the inguinal folds. In the Rex breed the guard hairs are shortened so do not protrude above the level of the undercoat. Satin breeds have an altered hair fibre structure that gives the coat a characteristic sheen. Angora rabbits have very long undercoat and guard hairs that are harvested for spinning into wool, and needs regular grooming to prevent matting (Lasley, 1978)

The guard hairs are the first to emerge in new-born kits, followed by the undercoat. By a few days this soft baby coat is well-developed, and it persists until about five or six weeks of age. An intermediate or pre-adult coat then replaces this, followed by the adult coat by about six to eight months of age. Thereafter most rabbits moult approximately twice a year, (spring and autumn) but this can vary. Moulting starts at the head and proceeds caudally. Pregnant or pseudo-pregnant does undergo a loosening of the hairs on the belly, thighs and chest, which are then easily plucked to line the nest and expose Niles. Tactile vibrissae are present on the muzzle, which are used to help locate food and when underground. Doe rabbits possess four to five pairs of Niles on the ventrum while niles are absent in the male.

2.2.4 Eyes and ears

The large eyes are located laterally (prey species) and rabbits have a blind spot in the area beneath the mouth, so food is detected by the sensitive lips and vibrissae. The lens is large and almost spherical, and the ciliary body is poorly developed, so accommodation is limited. The retina is merangiotic, with the optic disc lying above the midline of the eye and retinal vessels spreading horizontally out from it. The optic disc has a natural depression or cup. A third eyelid is present and the Harderian gland is located just behind it. This gland has two lobes, the upper being white and the lower larger and pink in colour. The gland is larger in males, especially during the breeding season. The naso-lacrimal duct has a single *lacrimal punctum* in the medial aspect of the lower eyelid. From here there is a short (approximately 2mm) canaliculus causing medially and ventrally into a funnel-shaped lacrimal sac, supported medially by the lacrimal bone.

The duct then enters the maxilla through a semicircular foramen in the lacrimal bone. The duct has two sharp bends as it courses towards the nose, proximally in the maxillary bone and at the base of the incisor teeth. The duct narrows at these points, and this, plus the fact that the epithelium of the duct is undulating, and the opening into the nasal meatus is very small, mean that the naso-lacrimal duct is very prone to blockage in the rabbit.

The ears are highly vascular and are involved in heat regulation. They possess large arterio-venous shunts. Ear size varies between breed, and those that hang down are referred to as lops.

2.2.5 Anatomy of the rabbit digestive tract

The alimentary canal, which develops rapidly in the young rabbit, is nearly mature in an animal weighing 2.5kg, when it has reached only 60 to 70 percent of adult weight (Lebas *et al.*, 1997; Carabano and Piqupper, 1998). In rabbits weighing between 2.5 to 4.5kg the total length of the alimentary canal is 4.5 to 5m. After a short esophagus there is a simple stomach which stores about 90 to 100 g of a rather pasty mixture of feedstuffs (Carabano and Piqupper, 1998). The adjoining small intestine is about 3 m long and 0.8 – 1.0 cm in diameter. The small intestine ends at the base of the cecum (Lebas *et al.*, 1997). The cecum is the second digesta storage area, is 40-45cm long, contains 100-120g of a uniform pasty mixture and is the major site for microbial growth and fermentation. This strategy allows them to effectively utilize a forage based diet (Church and Kellems, 1998, Gidenne and Fortune-Lamothe, 2002). Very near the end of the small intestine, at the entrance to the cecum, begins the exit to the colon which is 1.5m long, creased and dented for about 50cm in the proximal colon but smooth at the distal colon (Lebas *et al*., 1997).

2.2.6 Respiratory system

Rabbits are nose-breathers (mouth breathing is a very poor prognostic sign). The nose moves up and down in a normal rabbit (twitching) 20-120 times a minute, but this will stop when the rabbit is very relaxed or anaesthetized (Johansson and Rendel, 1978). The glottis is small and visually obscured by the back of the tongue. Reflex laryngospasm is common in the rabbit, which can complicate endotracheal incubation. The thoracic cavity is small, and breathing is mainly diaphragmatic. The lungs have three lobes, and the cranial lung lobes are small (left smaller than right). Large amounts of intra thoracic fat are often present. The thymus remains large in the adult rabbit and lies ventral to the heart, extending in to the thoracic inlet (Lasley, 1978).

2.2.7 The liver

The liver is the largest gland in the body of the rabbit. Its anterior surface is convex and is contact with the posterior surface of the diaphragm, and the posterior surface is concave fitting against the stomach. The liver is divided into 5 lobes by a series of fissures (Thakur *et al.*, 1988). The right and left central lobes lie on either side of the median vertical fold of the peritoneum which attaches the liver to the diaphragm. The liver is richly supplied with blood vessels. Its large size makes it possible to contain as much as fifth of the blood and to act as blood reservoir. Thus, the liver is called “busiest port on the whole river of life’’ (Thakur *et al.*, 1988). This close relation of the liver through the circulatory system to all other parts of the body is due to the fact that the liver cells are involved in the most complicated catabolic and anabolic reactions, which occur in the rabbit’s body. The liver probably originated as an ordinary digestive gland but in modern vertebrates it is the main metabolic “factory’’ of the animal (Thakur *et al.,* 1988).

2.2.8 Cardiovascular and urinary systems

The heart is relatively small and lies cranially in the thoracic cavity. The right atrioventricular valve has only two cusps. The rabbit aorta has neurogenic rhythmic contractions. According to Thakur *et al*. (1988) the heart is a hollow conical muscular organ lying ventrally in the anterior part of the mediastinal cavity of the thorax. Its base is directed forward and apex backwards and slightly to the left. The heart of the rabbits has only four chambers-the right and left auricles and right and left ventricles. Veins of the heart differ from arteries in that some are provided with semi-lunar valves which prevent backward flow of blood in them.

Rabbit kidneys are unipapillate. Urine is the major route of excretion for calcium. Serum calcium levels in rabbits are not maintained within a narrow range, but are dependent largely on dietary intake, with excess excreted via the kidney. Rabbit urine is often thick and creamy due to the presence of calcium carbonate crystals. It can also vary in colour from pale creamy yellow through to dark red (often mistaken for haematuria by owners), due to the presence of porphyrin pigments thought to be derived from the diet.

2.3 Reproduction

According to Wu *et al*. (1987) the reproductive tract of the female rabbits is unusual compared to dog or cat. The uterus is biconuate and each uterine horn possesses a cervix, no uterine body and the two separate uterine horns and two cervices open into vagina .The vagina is large and flaccid. The reproductive rate of rabbits is notorious. The common rabbit breeds from February to October; its gestation period is 28-32 days and there are five to eight young in a litter. Domestic rabbits produce 5-7 litters of one to nine young per litter after a pregnancy of about one month. The babies are born blind and deaf (altricial). In most regions its numbers are kept down by its many predators, such as the fox, the badger, and birds of prey.

2.3.1 Reproductive physiology of rabbits

The reproductive cycle begins when the ovum of the female rabbit is fertilized by the spermatozoa of the male and end at parturition (Payne, 1990). The onset of reproductive cycle marks the attainment of puberty. Depending on the level of feeding and breeds differences, this is about 4-5 months in light breeds (Fielding, 1991). At puberty reproductive organs are fully developed.

Reproductive organs are not unconditionally necessary for the individual life, but they have essential role in the reproduction and genesis of species (Tohman and Massanyi, 1997; Massanyi *et al*., 2000). Reproductive efficiency and increased production can only be achieved by understanding the histology and morphometric characteristics of these very important and sensitive organs of reproduction (Murray and Meacham, 1993; Etches, 1996; Massanyi *et al*., 2000). They are dynamic organs in an animal as they reflect very sensitively various changes in the environment. Many times they are the only organs which at low toxicity show structural and functional changes (Massanyi *et al.,* 1999; Lukae *et al*., 2000).

2.3.2 Physiology of male reproductive system

The organ of reproduction in rabbits buck consists of two testicles which weighed over 6grams in some breeds (Herbert *et al*., 2005). After birth the testes develop less quickly than the rest of the body. From the age of five weeks they begin to grow very rapidly. Accessory glands undergo a similar development, but at a more even rate and are less precocious. The testicles are housed in the scrotum. The male sex cells are formed in the tiny seminiferous tubule. The seminiferous tubules are basically two ended loops with two ends opening into the rete testis. Each tubule is extensively convoluted and an appreciable proportion is branched so that they have three openings into the rete testis. The sperm from each testicle then passes through very small tubes into an epididymis. Each epididymal tube leads to longer tubes, the vas deferens. The two vas deferens ducts converge from the left and right sides of the body to connect with the urethra canal at its upper end, very near to where the urinary bladder opens into the urethra. The urethra is a large canal that leads through the penile organ to the outside of the body. Amann (2006) recommended that in sub chronic toxicity studies, exposure to a test compound should continue for at least 6 cycles of the epithelium before animals are sacrificed and fertility tested. In rabbit, this would require 64 days while in rat, it would require 77 days. Morton, (2006) reported that in sacrificed animals, a decreased weight of the testes indicates wide spread or diffuse loss of seminiferous epithelial cells. Reduced weights of accessory sex organs usually indicate reduced androgen stimulation. A decrease in the average minimum tubular diameter of 30 to 50 nearly round cross sections of seminiferous tubules may be used to quantitate the loss of seminiferous epithelium in degenerative and toxic lesions (Morton, 2006).

2.4 Gestation Period

Gestation in the rabbit lasts for about 28-32 days if properly managed and the doe can produce four to five litters per year (Rajadevan *et al.,* 1986). After mating, ova is transported to the middle of the oviduct within few hours of ovulation while the young embryos reach the uterine horn about 3 days after ovulation in the late morula stage (Paulfler, 1985). The author reported that follicles mature in 18 days it remains for about 7 days and then regresses within about 9 days unless ovulation occurs. Release of ova is stimulated by mating or hormonal injection (Sandford, 1986). Gestation length in rabbits is affected by several factors, some of those factors belong to the genetic, the environmental conditions (feeding, management, weather conditions, diseases, physiological efficiency of the doe and many others (Tawfeek, 1995). The average length of the gestation period in the New Zealand White rabbits ranged from 30.1 to 32.1 days under Egyptian condition. The gestation of the rabbit is determined by the number of embryos that survive and the stage of pregnancy. If embryos are lost by the fourth day of gestation, the doe returns to the normal estrus but if 1-4 embryos survive beyond day 4, then pregnancy is terminated with prolonged estrus by 6 days. If there are four (4) embryos in each uterine horn by 10 day or beyond, pregnancy continues. The female rabbit does not appear to show any improvement in efficiency of metabolism during gestation (Rajadevan *et al.,* 1986) and reducing maternal food intake during gestation significantly depressed pup weight and the total hepatic glycogen content of the pups (Hafez *et al.*, 1967).

2.5 Lactation

Early growth and survival in rabbits are dependent in part on the intrinsic ability of the dam to provide an adequate maternal environment (Yahaya,1993).The early stage of rabbit's life when it should feed on the milk from the doe only is very important and will affect its future growth, development and ability to thrive. The milk production in the rabbit reaches its peak by the 21st day of lactation (Sandford, 1986). Growth of the young up to 22 days depends on the milk consumed. Therefore maternal influence is greatest at this point (Peinado *et al.*, 1988). Litter size and weight at 21 days give very good evaluation of the doe's maternal ability as the young depend solely on dam's milk at that age (Ferraz and Eler, 1994). Breed variation in milk has been reported (Venge, 1963) and the New Zealand White females has been reported to produce less milk in their first lactation than subsequent lactations. This has been advanced as the reason for the low weaning weights observed in the litter of first parity does (Lukefahr, 1982).

2.6 Litter Size and Body Weight of Rabbit

Litter size and body weight of rabbit is the most important economic character in rabbit production (Abou-Khadiga, 2004 and Notal *et al.*, 2005). Litter size at birth in rabbits contributes to the expression of the reproductive capacity of the doe, depends on ovulation rate under *ad libitum* feeding conditions. Litter size is controlled by genetic, as well as, different non-genetic factors (environmental temperature, feeding systems, managerial conditions, etc), (Ismael, 1992). Litter size at birth ranged from 5.2 to 10.9 kits/doe (Yamani *et al.*, 1994). The live body weight of any animal is an important variable that determines the market value of that animal. The exact time at which the animal is ready for slaughter can be accessed on the basis of its body weight and general development (Kabir *et al.,* 2006). Diversity of rabbit breeds offer opportunity to increase the efficiency of commercial meat production through crossing (Piles *et al.,* 2004).Weaning mortality percentage of kit rabbits is vital, importance in commercial rabbit farming, where it plays a major role in determining the net financial income of the farms (Rashwan and Marai, 2000). With the increase of Litter size and decrease of mortality, income becomes more elevated (Szendro *et al*., 1996). Litter weight at weaning is controlled by the number of kits survived at weaning (Risam *et al.,* 2005). Ayyat *et al.* (1996) reported that addition of probiotic lacto-sacc to the normal protein diet (18.4%) of New Zealand White does rabbits, increased litter size and weight, pre-weaning litter survival rate doe milk yield. In offspring's, post-weaning growth showed positive response with normal protein (16.3%) diet supplemented with 0.1% Lacto-sacc. According to Ozimba and Lukefahr (1991) litter size was anticipated to an important source of explained variation within breed type, which otherwise would have existed, in part as among - litter residual variation. Hassanien and Baiomy (2011) reported that breed had significant effect on litter weight at birth, at 14 day and at 28 days (at weaning)

2.6.1 Morphometric Traits

Body measurements and live weights taken on live animals have been used extensively for a variety of reasons both in experimental work and in selection practices (Lawrence and Fowler, 2002; Cam *et al*., 2010). Body conformation and size as important traits in meat animals had been largely estimated quantitatively by scale weight, generally described by visual appraisal, giving rise to objective scores and such description as blocky, range or compact. Yakubu and Ayoade (2009) reported that heart girth alone explained about 83 %

of the variation in body weight in rabbits. The combinations of heart girth and body length, thigh circumference and body length accounted for about 84 % and 73 % of the variability in rabbit's body weight, respectively. Similar findings have been reported by other workers (Wu *et al*., 2008; Teguia *et al*., 2008). However, Ibe (1989) observed that the use of body measurements to predict body weight should be treated with caution due to multicollinearity, which has been shown to be associated with unstable regression estimates.

Different parts of the animal body develop in different manners and such morphological changes determine, at a given time, the shape, conformation and body proportion (Olutogun *et al*., 2003). Estimates of body conformation and carcass traits are vital aspects in the field of meat production in farm animals (Osario *et al.*, 2002). Linear traits have been used to evaluate breed performance, characterize breeds and predict live body weight (Ibe and Ezekwe, 1994). Moreover, it is very vital to measure animal size and shape quantitatively in estimating genetic parameters in animal breeding programs (Chineke, 2000). Linear body measurements reflect primarily the length of the long bone (Ibe and Ezekwe, 1994). Linear body measurements when taken sequentially over a period of time can be used to predict animal live weight and carcass composition (Tiamiayu *et al*., 2004).

2.7 Growth Traits in Rabbits.

2.7.1 Pre – weaning performance of rabbit

Studies in pre-weaning growth performance is important since in breeding all stages of growth are inter-related and cannot be viewed as isolated traits. Osinowo *et al*. (1993) noted that pre-weaning performance traits such as weight gain till weaning, weaning rate and weaning weight influenced herd productivity. McNitt and Moody (1988) and Lukefahr *et al.* (1990), identified pre-weaning variables as major factors affecting post-weaning performance of rabbits. This means that improvement of economic traits at pre-weaning stage, could lead to better weaning and post-weaning performance of rabbits. McNitt and Lukefahr (1993) suggested that heavy weaning weight is important as it could lead to attainment of market weight at an early age. Therefore, consideration of pre-weaning performance of the domestic rabbits in the humid tropics is important for their genetic improvement for better future performances particularly for the commercial meat type rabbit. Information on pre-weaning differences in terms of growth trails of rabbits rarer in the tropics mostly in Nigeria is scant in literature. Research interest has majorly been on pre-weaning litter traits. Therefore, evaluating the relationship between weaning, litter size, pre-weaning and post-weaning body weight of the domestic rabbit such a study will lend tips towards developing efficient breeding programmes for breeding heavier and early maturing rabbits, more so in Nigeria where little effort towards a planned breeding programme for genetic improvement of the domestic rabbit has been made. According to Obike and Ibe (2010) in the result of an experiment conducted, between Chinchilla x Chinchilla and New Zealand White, Chinchilla showed superior genotype in the pre-weaning growth performance compared to the New Zealand White. This corroborates the result of Chineke (2000) who reported superior performance of New Zealand White x New Zealand White over others, including Chinchilla x Chinchilla in body weight and all linear body parameters studied. Prayaga and Eady (2002) reported significantly better individual weight performance of Zealand white and Flemish Giant pure bred over Californian crossbreds. However, the observed superiority of purebreds over crossbreds in the study is contrary to the observations of Odubote and Somade (1992) and Chineke (2002) that pre-weaning growth characteristics of crossbred's rabbits were significantly higher than those of purebreds. These authors attributed the higher performance of crossbreds to heterosis, indicative of preponderance of non-additive genes for these growth traits. The observed superiority of purebreds over crossbreds according to Obike and Ibe (2010) may be due to low number of genotypes used in their study. On the other hand, it could suggest a preponderance of additive genes for the pre-weaning growth traits since no selection had been carried out in the population from which the experimental animals were taken. With this observation made, the genetic relationship among these populations in terms of these growth traits could be studied.

Lukefahr, (1987) observed that growth parameters are highly heritable traits, suggesting that differences among different genotype are expected and selection based on individual performance could successfully improve these traits. Dutch is a small breed (Fielding, 1991) compared to Chinchilla and New Zealand White. Thus, breed might have accounted for differences in body weight and linear body traits observed among the purebred genotypes CH x CH, NZ xNZ and DU x DU.

The New Zealand White rabbit has been noted for as a dam breed based on its outstanding maternal genetic merits for litter size, milking and general maternal ability (Lebas *et al.*, 1997; McNitt *et al.*, 2000). Okorie, (1983) earlier reported that Chinchilla breed of rabbit is characterized by fast growth rate and good mothering ability and is therefore used extensively for breed.The implication of this is that Chinchilla and New Zealand White breeds of rabbits have high milk yielding capacity for maintenance of their kits and the genetic potential to transmit desirable genes for fast growth rate. This is important in making fast genetic progress when considering growth traits. Obike and Ibe (2010), concluded in their study, that the performance of Chinchilla is better compared to the other genotype in terms of pre-weaning growth traits, followed by New Zealand White. Therefore the two genotypes could be considered as choice genotype for improvement of rabbits in the study region.

The young rabbits has extremely high growth rate which starts prior to birth and continues exponentially until the animal is about ten weeks old (Lang, 1981). The weight of the foetus increases from 1g at day 16 of gestation to birth weight of 60g, after 31 days of pregnancy (Prudhon and Selme, 1973). After birth, the young rabbit approximately doubles its weight every week until it reaches 0.45kg at three weeks of age and thereafter, the rabbit begins to eat solid food. Growth rate of the kit is 10-20g/day when milk is the sole feed and increases to 30-50g/day between three and eight weeks of age (Rao *et al*., 1977).

Omole (1982) reported that the growth of the young rabbit is significantly affected by the protein level and further explained that 18% crude protein diet was better than 22 or 26 % in supporting growth. Hafez *et al.* (1967) reported that males have higher growth competence before birth than female rabbits. Also, pre-weaning mortality percentage (PWM %) of kit rabbits is of vital importance in commercial rabbit farming, where it plays a major role in determining the net financial income of the farms (Rashwan and Marai, 2000). With the increase of litter size and decrease of mortality income becomes more elevated (Szendrô *et al.*, 1996).

2.7.2 Post-weaning growth

The potential growth of an animal, its pattern of development and to some extent, its ultimate carcass composition in terms of the proportions of muscle, bone and fat are genetically predetermined (Lebas, 1969). Growth rate and development in rabbit is breed dependent (Lukefahr *et al*., 1980), where some rabbits reach 2kg at eight weeks of age (Chen *et al.*, 1978) while others achieve much poorer growth (Lang, 1981). Rao *et al.* (1977*)* reported an average daily gain of 39.1g from four to six weeks and 36.3g from six to eight weeks. Average daily gain increased to a maximum between 40 and 55 days of age and then declined gradually with advancing age. Body weight at weaning of doe rabbits is one of the important traits that influence rabbit production. There are many factors that have influence on body weight as breed, feeding and management (Yamani *et al*., 1991 and Maertens, 1992), disease, temperature and season of year (Cheeke *et al.*, 1982;Yamani *et al.*, 1991 and Tawfeek, 1996). Feed intake during rearing period seems to be an important factor influencing body development (Rommers *et al*., 1999). Feed consumption varies depending on size of rabbits, temperature, rate of growth and genetic characteristics. From 10 week of age onwards, body growth was increased by gradually increasing feed intake to stimulate sexual development and puberty.

2.8 Attributes and Importance of Rabbits:

Small body size**:** There are number of advantages of small animals in developing countries. They require small amounts of feed and use inexpensive, easily constructed housing. The small body size provides a small carcass that can be consumed by a family in one meal, eliminating the need for meat storage and refrigeration, especially in Nigeria where there is erratic, insufficient and rampant power failure. Thakur *et al*. (1988) stated that rabbit meat is stored on the live animal until needed. Hence, Rabbits are 'biological refrigerators'. Many households in Northern Guinea Savanna zone of Nigeria kept an average of 10.6 rabbits due to their small body size and the dominant mixed breeds kept are in the following order New Zealand White, Chinchilla, Dutch and Simonaire (Jokthan *et al.*, 1996)

Rapid growth: In American and European rabbit production, market weight of fryers (i.e 2kg) is reached in 8 and 9 weeks of age, but the growth rate is usually lower in developing countries; 1.8kg at 12 weeks for Nigeria (Omole, 1982). Rabbits reach market or consumable size much faster than larger livestock. Iyeghe- Erakpotobor *et al.* (2005) reported that the slow growth rate of rabbits under tropical conditions has made it impossible to produce fryers by 9 weeks as obtained under temperate conditions. Hence, fryers rabbits are sold between 20-25 weeks old in most tropical countries. However, nutritional studies are connected during the weaners' phase (4-10 weeks) when growth is higher in rabbits and do not take into consideration the slow growth rate of rabbits between the ages of 12-25 weeks in the tropics. This period according to the authors, coincide with the growing, pubertal and adult phases of rabbit's growth.

Short generation interval and high reproductive potential: The reproductive capacity of rabbit is legendary. However, Togun *et al.* (2009) had implicated factors like genetic, nutrition and environment as determinants of growth, development and efficient functioning of the reproductive organs of the rabbit. Rabbits are induced ovulators, and will breed within 24 hours of parturition. Thus, it is theoretically possible to produce about 10 litters per year (Cheeke, 1986). This intensive type of production could not be obtained in developing countries, but it is quite feasible to produce four to six litters per year or about 25 offspring per doe per year. It had been suggesting with good feeding and early rebreeding, 9 or more litters a year are possible

(NRC, 1998).With only three does and a buck, a breeding program can be set up so that a slaughtered rabbit is available for consumption by the family at least once per week. The potential for year-round production is another advantage of rabbits.

Utilization of non-competitive feeds: Like ruminants, rabbits can be raised successfully on grain-free diets, based on forage and by-products. Acceptable growth performance can be obtained using greens such as weeds, tree leaves, tropical legumes and grass forage, vegetable tops, waste fruits and vegetables with supplements of tables' scraps and by-products such as rice bran and maize offal (Aduku and Olukosi, 1990).

Potential for genetic improvement: There is a high degree of diversity in the rabbit genetic resource pool and thus, the productive performance of rabbits is a function of the breed or strain (Cheeke, 1986; Ayorinde, 1997). Mature body weight ranges from <1kg to >10kg, while there is much variability in traits such as maternal ability, fecundity, resistance to heat stress. Thus, it is possible, by selection, to make rapid improvement in animal performance. The maternal effect of doe size, body weight, age, gestation gain and parity on some economically important traits has been reported (Khalil and Mansour, 1987).

The rabbit plays a role as an alternative food source, particularly for people in developing countries. It is claimed that there are far traditional/social taboos concerning the eating of rabbit meat (Mamattah, 1978). According to Elemele *et al.* (1980) stated that dry rabbit manure contains 18.8% crude protein, 9.0% moisture, 13.5% crude fibre and 19.2MJ gross energy per kg. In the same study, 100g of rabbit manure per kg of diet can be fed to broiler chicks and there will be no decline in growth rate as compared to performances when placed on standard diet. Rabbit manure has also been experimentally fed to rabbits (Swick *et al.,* 1978) and could be fed to ruminants as well. Rabbit and other animals' manures can be used to produce methane gas as household sources of alternative energy (SIC Waten and Stahl, 1982, Jacobs, 1986; Trujillo *et al.*, 1991). Rabbit as a laboratory animal are very important in Research Institutes. The current number of rabbits used for research is about 6000 annually World over (Anonymous, 2006). The fur is used as raw material for production of wool, rug and pillows. Rabbits are used as pets in homes and their feaces serves as biologically enhanced fertilizer. More recently, they have been used as source of meat. When feeding and management are of a high standard, the rabbit is one of the most efficient animals in the world at converting food to meat (Fielding, 1991).

2.9 Breeds of Rabbit

A breed is a group of animals from known lineage of similar animals, with an agreed set of physical and behavioural attributes which (preferably) breed 'true' and have common origin i.e reliably replicate these characteristics in their progeny. The late Hilton Briggs, the quintessential authority on breeds and author of the book, “Modern Breeds of Livestock,” defined a breed as: “a group of animals that, as a result of breeding and selection, have certain distinguishable characteristics.” Rabbit breeds are distinctively identified phenotypically by the body size, shape and the coat color (Lebas *et al*., 1997). The concept of breed was first used in animal breeding in the sixteenth century. Microsoft Encarta (2011) defined breed as a population or a group of population which can be distinguished from other populations of the same species on the basis of different allele frequencies, chromosome changes or genetically determined phenotypic characteristics. Breeds are stock of animals or plants within a species having a distinctive appearance and typically having been developed by deliberate selection. Rabbits are generally classified according to size, weight and type of pelt. Small rabbits weigh about 1.4 to 1.8kg at maturity, Medium breeds weigh about 4.1 to 5.4kg and large breeds weight 6.4 to 7.3kg.There are many breed of rabbits these are distinguished by varying characteristics such as size, shape, stature and colour.

2.9.1 The Chinchilla

This is an exotic breed with a gray surface fur but underneath it is blue. The belly is white in colour. It weighs about 4.1kg at maturity in temperate climate. This breed is blue-grey in color with a white belly; there is a thick fold of skin around the front of the chest which is very obvious when the rabbit is in good condition and sitting in a resting position and erect ears. The weight range for the mature Chinchilla is 3-4.5kg at maturity. The Chinchilla rabbit falls under both the medium and small class breeds; the Chinchilla Giganta, also called Grand Chinchilla. The advantage of the small breed is that they usually develop very quickly and make excellent mothers. They eat less than the medium and large breeds and could be crossed or used as purebred in developing countries to produce light, meaty carcass of 1 to 1.2 Kg.

2. 9.2 The New Zealand White

This is a heavy breeds weighing 4.1 to 4.5kg at maturity. This breed has a white fur covering every part of the body with shiny eyes. It is a commercial meat rabbit breed in Nigeria (Szendro *et al.*, 1988). It attains maturity at about 5-6 months of age. This rabbit was originally developed in 1916 by W.S Preshaw in America for the purpose of optimal meat production and fur trade. The New Zealand Red strain was first developed in California with a system of selecting similar breed to that used in France on the Burgundy Fawn Strain (Lebas, 1983). They have a well- rounded body and small bone structure, resulting in a larger portion of their weight being meat. They have pink eyes and a great disposition and usually weigh 3-5kg when mature. New Zealand rabbits are available in recognized colors (New Zealand white rabbit, New Zealand red rabbit, and New Zealand black rabbit). Although cross breeding can result in many different combinations of the three basic pigmentations. This breed is used most widely throughout the world for meat production.

2.9.3 Dutch breed

Dutch rabbit easily identifiable by its characteristic color pattern was once the most popular of all rabbit breeds. However, after dwarf rabbits were developed, the popularity of the Dutch rabbit dwindled. Nevertheless, the Dutch rabbit remains one of the top ten most popular breeds worldwide. Although the name suggests that the Dutch rabbit is from the Netherlands, it was actually developed in England. During the 1830s rabbits were imported to England from Ostend in the Netherlands every week for the meat market. The Dutch is a small breed with a mature live weight of 2.5-3.5kg. It has a wide white band of fur around its body at the shoulders as well as a white stripe down the middle of its face, compact, well-rounded body; rounded head; short, stocky, well-furred ears; and short, glossy "fly back" fur (Microsoft Encarta, 2011).

2.10. Rabbit Production and Management

In 1994, World’s production of rabbit meat was estimated to be 1.5million tons per annum, this would mean per caput annual consumption of 280g per person per year. The six major world’s rabbit producing countries are Italy, Russia, Ukraine, France, China, and Spain (Akinmutimi and Onwukwe, 2002). In Africa, the leading rabbit producing countries are

Morocco and Nigeria and these are reported to produce 20000 to 99000 tons of meat per year (Moreki, 2004). For over three decades now, the contribution of smallholder rabbit units to food security in developing countries has been clearly recognized (Lukefahr and Cheeke, 1991). Rabbit production in Nigeria is largely traditional, non-commercially oriented, family consumption targeted and small holder type comprising 2-7 does and 3 bucks (Taiwo *et al.,* 1999). About 3.4-5.2% of the Nigeria population may be keeping rabbits with women and chilDr.en being mostly involved (Egbunike, 1997). Rabbit keeping is both intensive and semi intensive, though some scattered free range backyard rabbit keeping has been recorded (Isaac *et al.,* 2010).Backyard rabbit rearing in Nigeria provides additional income and supplies additional protein for poor rural and urban households with low investment and labour inputs.

Housing constitutes an important factor in rabbit production (Mailafia *et al.,* 2006). The main purpose of housing is to protect the rabbits against adverse climatic conditions, predators, ectoparasites and endoparasites (Hoy, 2008). Poor housing, which is common to the lesser developed countries, is a limiting factor affecting growth of rabbits (McNitt *et al.,* 2000). The house floor, walls, equipment should cause no pain, suffering or injuries to the rabbits. Additionally, housed rabbits should be provided with feed and water according to their nutritional needs. Rabbit houses should also be kept clean and well ventilated to avoid accumulation of toxic gases such as ammonia (Hoy, 2008). The sun and wind direction, security, drainage and proximity to the farmer’s house should be some of the factors to consider while selecting a construction site for a rabbit hutch. Rabbits, like any other animal need to be protected from adverse weather conditions and predators. The major consideration in construction of rabbit house is ventilation as well as protection from

Dr.aught and rain splash. Many types of housing for rabbit production are in use today. These include suspended wire cage inside a shed or building and that of individual weather proof rabbit hutches raised above ground level (Anonymous, 2006). The size of the hutches depends on the breeds of rabbit and objectives for rearing the animals. Common cage sizes are 30×30 inches, 30×36 inches and 30 40 inches. These sizes can house a doe and her litter for dwarf, medium and giant size rabbits respectively (Fielding, 1991; Sheldon and Williams, 2000; Anonymous, 2006). Housing must keep the rabbit dry without drafts and must provide an environment with temperature of at least 40^oF and not more than 90^oF (Fielding, 1991). The domestic rabbits are primarily herbivorous and consume most types of grains, forages and hay. Diets, whether home grown or commercially prepared consist of ingredients from plant sources. Since rabbits can utilize a certain amount of forage, they have a place in food production by making use of some non-competitive feeds (Herbert, 2001; Nworgu *et al*., 2001; Biobaku and Dosumo, 2003; Herbert *et al*., 2005; Omoikhoje *et al*., 2006).

Forage can contribute up to 50% of rabbit diets (Sanni *et al*., 2005), although there is improvement in performance of rabbit fed concentrate and forage compared to feeding forage or pellets alone (Taiwo *et al*., 2004).

2.11. Rabbit Production Systems

At least 82% of the world's rabbit meat is produced in the developed countries where they are produced under intensive system attaining slaughter live weight of 2kg in 12-13 weeks (Lukefahr and Cheeke, 1990) and more recently in 11weeks (Maertens *et al*., 2006). The production system is characterized by feeding on commercial feeds compounded to meet the recommended nutrient requirements of rabbit thus high growth rates and minimized labor requirements by use of automated feeding and drinking facilities (Walsingham, 1972). Rabbits produce 8.7 liters each of 6.4 live kits per year (Ayyat and Marai, 1998) which would translate to 40-50 fryers (assuming a post weaning mortality of 10%) under intensive feeding system compared to 20-35 marketable fryers per doe per annum (Lebas *et al*., 1997; Lukefahr and Cheeke, 1991) under semi intensive feeding common in developing countries (Lukefahr and Goldman, 1985). In this less intensive production system, farmers practice more intensive rabbit breeding during favorable seasons, particularly when supply forage is abundant, while breeding less intensively during adverse seasons (Lukefahr and Cheeke, 1990). Such a system would translate to fewer marketable fryers per year.

Under extensive production rabbits will take longer to attain the slaughter weight for example Cheeke (1987) reported that 3.71 months was required to produce a 1.82 kg fryer rabbit and approximately 4 months for a 2 kg fryer rabbit. However, the author argued that the economic considerations may in some cases well justify the lowered productivity under extensive production systems due to substantially low capital requirements. Lukefahr (2007) also noted that cost of production in this production system is substantially low since it is characterized by low initial costs of establishment and low feeding costs as the rabbits are raised purely on forages that are locally available.

2.12. Nutrient Requirements of Rabbits

2.12.1 Crude protein

Protein is perhaps the most frequent nutrient lacking in the diets of rabbits primarily because the common energy source such as maize and other cereal grains and tuber crops are low in protein. Rabbits make its own particular proteins from the proteins and amino acids they obtain from their food (Fielding, 1991, Kellems and Church, 2006). This protein synthesis uses up energy. The ten essential amino acids which must be provided in the diet for rabbits to survive and grow are, lysine, methionine, arginine, phenylalanine histidine, valine, threonine, tryptophan, leucine, isoleucine, (Fielding, 1991). Essential amino acids need to be included in the ration for rabbits. Lysine and methionine are usually the amino acids that are found to be deficient in rabbit ration (Gillespie, 1998). While there is bacterial protein synthesis in the caecum, it is not enough to meet the essential amino acid requirements of rabbits.

For rabbits, the recommended crude protein level in the dry matter of the ration is over 18% for newly weaned rabbits, 16-18% for rabbits from 12-24 weeks, 15-17% for breeding does, and 12-14% for all other stock (Fielding, 1991). Several researchers have investigated the protein requirement of growing rabbits. In an experiment in which Martina and Damianan (1983) fed rabbits with decreasing crude protein levels of 18.08, 16.32, 14.22 and 12.50%, they found that crude protein could be reduced to 16.32% with lysine and methionine supplementation without affecting weight gain and feed efficiency. Different results were obtained when Carregal and Nikuma (1983) used diets with increasing crude protein levels, 14.3%, 17.2% and 21.4%, as they found no significant difference among groups of rabbits with regard to body weight, feed intake or feed conversion efficiency. According to Pond *et al.* (1995) dietary protein quality is particularly important for rapidly growing weaning rabbits, which may not have well developed caecal fermentation. Recent research has demonstrated that the amino acid requirements are age dependent and change during the reproduction cycle of the does. In early growth state (4-7 weeks of age), rabbits need a higher amino acids is more pronounced (Taboada *et al*., 1994)

Many research reports have shown that a reduction of the level of protein and essential amino acids in the diets, from an optimum level for growth in animals, is associated with a decreased growth rate and efficiency of feed utilization and concomitant increase in body fatness (Wahlstrom and Libal, 1974 and Russell *et al.*, 1983). Dietary protein level is one of the several non-genetic factors that influence the amount of body fat in animals (Marks, 1990 and Wang *et al.*, 1991). Forbes (1995) reported that if the amino acid content in the feed of animals differed widely from animal's requirement for amino acids, feed intake would be depressed and that if the deficient amino acid was supplemented, intake would be increased.

2.12.2 Energy

Although energy is not a nutrient, but Rabbit requires 10% energy, hence this can be met by the microbial protein and energy of the cecotrophs, it is a property of carbohyrates, fats and proteins when they are oxidized during metabolism. The energy needed by rabbits for organic synthesis is usually supplied by carbohyDr.ates and a lesser extent by fats. When there is an excess of protein, a process of diminution will take place and energy will be supplied. Rabbits adjust their feed intake as a function of their dietary energy concentration (Partridge, 1989). According to partridge (1989), this regulation of intake to achieve constant daily intake is only possible at a dietary digestible energy concentration above 2250kcal/kg. Several factors influence the energy requirements of rabbits (Kellems and Church, 2006). These include productive function (growth, lactation, maintenance, etc), sex, age, body size and environment (Temperature, humidity, air-movement). As temperatures decrease, the rabbit requires more energy to maintain normal body temperature (Gillespie, 1998). And to compensate for this increase energy, either the intake level of fed must be increased or the energy content of the ration must be increased.

Average maintenance requirement determined in growing rabbits is about 100kcal DE/Kg $^{0.75}$ (Maertens, 1992). Fed on energy-concentrated foods, rabbits can satisfy their requirements, but this is not possible on forages alone because forages are usually dilute source of energy (Fielding, 1991); hence when fed only on forages they cannot obtain as much energy as those fed on concentrated foods such as maize grains or cereal grains. Rabbits according to Cheeke, (1986) require a diet of 2200kcal DE/Kg DM.

Products of microbial degradation of dietary fibre which contributes to the energy demand of the host animal are the volatile fatty acids (VFAS). In rabbits, about 10-20% of maintenance energy expenditure comes from VFA (Hoover and Heitman, 1972). Despite the apparently poorer utilization of fibre by rabbits than by horses or ruminants, VFAS absorbs 30% of the maintenance energy requirement. Pond *et al.* (1995) reported that digestible energy levels in typical rabbits diets are quite low, being in the range of 2400-2800kcal/kg weight diet. They further indicated that higher energy levels impair animal performance and result in reduced energy intake.

Rabbits are efficient users of starch in cereal grains and preter barley to corn (Gillespie, 1998) when given a choice of cereal grains. Diets that are based on corn have produced poorer growth rates as compared to barley or oat-based diets (Gillespie, 1998).About 3% fat is recommended in rabbit diets, dietary fat is well utilized by rabbits and improved diet palatability and increases energy level without causing carbohyDr.ate overload of the hindgut (Pond *et al*., 1995). The rabbit, for instance the breeding doe, adjusts its feed intake according to the energy concentration of the feed as well as the protein and other dietary components present to around 220-240kcal of digestible energy (DE) per kg metabolic weight.

2.12.3 Crude fibre

According to Maertens (1988), although fibre is not considered real nutrients in rabbits because of its low digestibility (average dietary digestibility is less than 20%), it is considered a nutrient to maintain the gut motility. Cell-wall constituents from feedstuff have low lignin content or young plants having a considerable higher digestibility than highly liquefied sources, 40-70% versus 5-20% respectively. It is not clear what the minimum fiber intake for prevention of diarrhea in rabbits should be. Research report from Blas *et al.* (1994) and Gidenne and Sehl, (2000) examined the effect of low fibre diets to rabbits, and observed that a sharp increase in fibre level from 9-19% in the diet doubled the risk of digestive trouble.

The population of cellulolytic bacterial decreased in the caecum and the microbial ecology system in the caecum become unbalanced which may cause death from diarrhea. Feeding of rabbits with a diet low in fibre and high in energy or a finely ground concentrate diet can result in high mortality due to intestinal disorders such as enterotoxemia (Lukefahr and Cheeke, 1991). The significant role of dietary lignin (ADL) on the rate of passage and its protective effect against diarrhea has been demonstrated by the French INRA (Institute national de la Recherche Agiono Mique) team.

Quite similar effects were observed by the same team of researchers with various cellulose (ADF-ADL) levels. They clearly indicated that the recommendations in terms of dietary safety cannot be expressed as a single fibre fraction. Furthermore, recommendations of dietary fibre are age dependent. Young rabbits require higher minimum levels that fattening or breeding does, probably because of their lower daily intake to reduce enteritis. An excess of dietary fibre is also not desirable because digestible energy (DE) content decreases and a too high protein-to-energy ratio is commonly the result. Such a situation is favourable for the proteolytic flora that produces ammonia with an increasing risk of digestive disorders (De Blas, 1981; Lebas, 1989).

Besides dietary fibre, starch also plays a key role in the nutrition-enteritis interaction. Young rabbits have an immature pancreatic enzyme system that can lead to significant amount of starch reaching the caecum when using high starch diets, especially dietary starch with higher resistance (corn) against hyDr.olysis could lead to starch overload. The risk of destabilization of the caecal flora is higher if the increased ileal starch flow is not accompanied with a similar increase of fibre intake (Gidenne *et al.*, 1998). Rabbits use crude fibre less efficiently due to a faster rate of passage of digesta and smaller holding capacity, compared to grazing ruminants. Rabbits are therefore more selective in their diets than ruminants (Jarvis, 1976). Optimal fiber balance also includes a dietary recommendation for particle size. A sufficient amount of large-size particles is required for optimal performance and to reduce the risk of digestive disorders. According to De Blas *et al.* (1999) a minimum proportion of 25% of large particles (>0.315mm) is required. Chemical composition and form of fibre not only affected its susceptibility to digestion but can also influence feeding habits.

2.12.4 Minerals and vitamins

Pond *et al.* (1995) stated that the major mineral elements of concern in rabbit diet formulation are calcium and phosphorus (Ca and P), and that the other minerals are usually provided in adequate amounts by the ingredients used plus the addition of trace mineral salt. Studies on the calcium and phosphorus requirements of growing rabbits have shown that they need these minerals much less than lactating does. The amounts excreted through the milk are significant. However, excess of calcium (>40g/kg) or phosphorus {>19g/kg) induce significant alternation of fertility and prolificacy or higher proportions of still births. The lack of response to low-dietary phosphorus levels has been confirmed with fatteners (Lebas *et al*., 1998). The Ca:P ratio does not seem to be critical for rabbits (Lebas *et al.,* 1998) and is usually 2:1, however, rabbits can tolerate much higher ratios coer sulphate which is often used as a non-nutritive feed additive aids. Fielding (1991) stated that rabbit are born with high level of mineral in their livers, sufficient for their pre-weaning growth. Rabbits require water-soluble (B group and C) as well as fat-soluble vitamins (A, D, E and K). According to Lukefahr and Cheeke (1991) the major vitamins needed in rabbit diets are vitamins A, D and E and that protein and carbohyDr.ate dietary sources, fed in good variety, may largely meet the mineral and vitamin requirements.

Microorganisms in the digestive flora synthesize sizeable amounts of water soluble vitamins which are utilized by the rabbits through caecotrophy. Vitamin K and the B vitamins are not required in the diet, since they are synthesized through coprophagy and fermentation in the caecum or hindgut; likewise vitamin C (Lukefahr and Cheeke, 1991). Under practical conditions, the B-Complex vitamins are not dietary essential for rabbits; however, under stress situations and at high performance levels deficiencies can occur

(Ismael, 1992). Gillespie (1998) has indicated that the use of iodized salt at the rate of 0.5% of the diet will supply the needed sodium, chlorine and iodine for rabbits. The vitamin A requirement of rabbits has not been adequately determined and a level of 10,000IU/Kg of diet is adequate while levels in excess of 40,000 IU/Kg diet may adversely affect reproduction (Pond *et al*., 1995). They further stated that vitamin A-deficient rabbits exhibit poor growth, leg deformities, increased susceptibility and a high incidence of enteritis. Vitamin C supplementation is recommended for rabbits under stress (Verde and Piqupper, 1986)

2.12.5 Water as a nutrient for rabbits

Water is normally considered a nutrient, although its properties and functions are quite different from other nutrients found in feeds. Water is the major component of the rabbit's body, making up 70% of the lean body mass (Maertens, 1992), this indicated that rabbits will die more rapidly from water deprivation than from food deprivation. Restricted Dr.inking water or limited drinking time leads to reduced feed intake that is directly proportional to the amount of water being consumed (Szendro *et al.,* 1988). They further reported that water and feed consumption varies with changes in environmental temperature and humidity. An excessive temperature rise will reduce feed intake and increase water consumption. According to Pond *et al.* (1995) water plays an essential role in a number of functions vital to an animal such as digestion, nutrient transportation, waste excretion and temperature regulation. One of the most important properties of water in nutrition is its remarkable ability to dissolve substances. It is said that this property is due to its dielectric constant, which in turn is due to its hyrogen bonding (Lassister and Hardy, 1982).

2.13. Rabbit Diseases

The highest cause of reduction in production and mortality in rabbits is disease occurrence. Rabbit health combined with feeding, determines the body condition score and breeding performance of both the buck and the doe. Rabbits are mostly susceptible to conditions associated with nutritional deficiencies and ingestion of contaminated feed, mainly 20 with mycotoxins such as aflatoxins (Szilagyi *et al*., 1994). Aflatoxins are often found in low-cost rabbit feed constituents such as maize-milling wastes and when consumed, these toxins cause destruction of the body tissues of rabbits by oxidizing proteins causing immune-suppression (Kumar *et al*., 2008). Aflatoxicoses may also cause gastrointestinal problems, internal bleeding, hemorrhages or bruising, stomach ulcers, mouth sores, kidney or liver damage (Szilagyi *et al*., 1994; Aziz *et al*., 1995). All of these conditions are often encountered in rabbit farms. The main infectious agents causing rabbit digestive disorders are bacterial (Licois, 2004), which may present as diarrhea with associated mortality reach 12% during the fattening period.

Coccidiosis is one of the most important infectious causes of digestive disorders in commercial rabbit production. This is caused by a protozoan parasite of the genus *Eimeria* which are reportedly always present in rabbit farms and virtually impossible to eradicate. In a study investigating the incidence and prevalence of coccidian infection among rabbits in Egypt El-Shahawi *et al*. (2012) identified eight species of *Eimeria. Eimeria intestinalis* and *Eimeria coecicola* were generally the most predominant species. These authors reported an overall prevalence of 70%. Higher incidences of coccidiosis are associated with contaminated hutch bedding and floor materials that come into contact with feed and water, and are ingested by the rabbits (Dal Bosco *et al.*, 2002). Although coccidiosis occurs in all ages of rabbits, weaners are more susceptible and the infected rabbits exhibit diarrhea, anorexia and rough hair coat.

2.14. Feed Restriction

From long time, Maertens (1992) recommended to restrict feeding for young doe rabbits for longer reproductive life, lower replacement level of does and to prevent extreme fattening of breeding doe rabbits. Elhakeam (1992) found that post-weaning duration of food restriction did not affect final body weight of Californian rabbits at 18 weeks of age (rabbits at 5 weeks old were divided into 4 groups, 1st group was given *ad libitum* (controls); 2nd , 3rd and 4th groups were allowed access for 6 hours/day for 2,3 and 4 weeks respectively, before being allowed *ad libitum* access again), but at 14weeks differences among groups were significant. Post-weaning duration of feed restricted groups 3 and 4 had low body weights. In the 2 groups the significant reduction in feed consumption and the non-significant difference in total gain compared with controls resulted in an improvement in feed conversion.

Tawfeek (1996) found that live body weight of New Zealand White rabbits, daily weight gain and feed intake at 10 and 12 weeks of age were lower ($P<0.05$ or 0.01) while feed conversion efficiency was better in the restricted fed rabbits (80% of the *ad libitum* diet, from 5-12 weeks of age) than in the *ad libitum* one. In addition, live body weight at 40 weeks of age was lower ($P<0.05$) with the restricted diet. Mao *et al*. (1999 and 2001) and Almeida, *et al.* (2001) mentioned that the restricted groups (50% of *ad libitum* intake from day 22 to 28) lost more body weight than the *ad libitum* group. On the opposite trend

Emeash and Saleh (1995) found that feed restriction (50% of feed intake) increase body weight.

Rommers *et al.* (2001a) stated that restrictive feeding can be used to control body growth and prevent excusive fat deposition in doe rabbits. He added that restrictive fed does mated at 17.5 week of age had similar body weight and similar body composition as *ad libitum* fed does mated at 14.5 week of age. Also, Rommers *et al.* (2001b) found that restrictive feeding during rearing period in NZ rabbit does increased uniformity in body weight at 1st insemination, which decreases the number of too small does at 14.5 wk of age and number of too heavy does at 17.5 wk of age. He added that restrictively fed 17 does inseminated at 17.5 week of age had an increase in feed intake during first gestation and first lactation compared to *ad libitum* fed does.

During the growing period between 10 to 17 weeks of age, the body weight of one day fasting showed close similarity to that of the *ad libitum* group (Eiben *et al.*, (2001). At 17 weeks of age and at first mating, body weight of growing rabbits decreased significantly as affected by two day fasting a week group compared with *ad libitum* group. Chiericato *et al*. (2001) mentioned that feed restriction negatively influenced (P<0.01) body gain (1.07 *vs* 33.10 g/day) and feed intake (80 *vs* 178 g/day) in restricted fed female rabbits (fed 80 g/day, about 50% *ad libitum* intake) during prepuberty (from 95 to 117 days of age). Fekete *et al.* (2001) found that final live weight of female New Zealand White rabbits (618 weeks of age) was 84.7% (3.14±0.24 kg) in 70% restricted group (RS) compared to the *ad libitum* group (3.71±0.31 kg) and the average daily gain proved to be lower (25.5±5.6 *vs*. 32.4±3.2 g). The daily water consumption in group RS was higher (335 ml, that is 3.5 ml/g dry matter intake) than in *ad libitum* animals (265 ml, that is 1.9 ml/g DM).

Moderate feed restriction (74% of *ad libitum* intake) reduced feed consumed from 13 week of age to end of the first pregnancy with no significant impact on efficiency of piglet production (Klindt *et al*., 2001). Gyovai *et al.* (2003) observed that rabbit's fed on restricted diet regimen (85-90%) of the *ad libitum*, from weaning at 21 days of age to 15.5 or 18.5 weeks of age) had significant the lower body weight. At 15 weeks of age, the highest difference was found between the group of fed restricted (2.75 kg) and that of fed *ad libitum* (3.81 kg). Abou-Sekken (2005) studied the effect of four feed restrictions systems (control group with *ad libitum* feeding (C); restricted feeding 130g daily feed per head until 17 weeks of age, then 140 g/day until first mating (130R); two days fasting/week (one day at the beginning of the week and other day on the last day of it) (2D); 12 hours daily access to the diet (12H) and 6 hours daily access to the diet (6H)) during rearing period (10-17or 20 weeks of age) on reproductive performance in NZ doe rabbits under desert conditions, feed supply returned to *ad libitum* for 4 days at 17-22 week of age to flushing the 4 treated groups before the first mating. He found that the best feed conversion was in 12 hours group (3.48 kg FI/kg gain). However, comparing of doe bodyweight, the control and 12 hours groups showed low body weight increase followed by 2 day group, while groups 130 Restricted and 6 hours were almost similar.

2.14.1 Effect of feed restriction on body development:

The period after weaning is characterized by a rapid development of the caecum until 5 to 6 weeks of age as a consequence of the transition from milk to solid food. Feed restriction should not be applied in this phase, because the caecum plays a major role in the digestion of the rabbit and feed restriction can even favor conditions for pathogenic agents (Maertens and Peeters, 1988). Muscle (protein) tissue shows a high development rate until 10 to 12 weeks of age (Cantier *et al.*, 1969 and Deltoro and Lopez, 1985). By restricting feed intake from 5 to 6 weeks of age onwards, protein and fat deposition will be hindered. By gradually increasing feed intake after 10 weeks of age, sexual development will be stimulated that starts around 10 to 12 weeks of age. By increasing feed intake from 10 to 12 weeks of age onwards, does will be able to compensate for the loss in protein development. Restrictive feeding regime was compared to *ad libitum* feeding and the effect on body development, feed intake capacity and 21 subsequent reproductive performances was studied in young does that were inseminated at 14.5 or 17.5 wk of age (Rommers *et al.*, 2001b).

The results of the different experiments (Rommers *et al.*, 2001a, 2001b) showed that body composition at first insemination could be manipulated by rearing strategies. Rommers *et al.*, (2001a) found a higher gap in body fat, which was lower by 123 g in restricted females inseminated at 17.5 weeks than in does fed *ad libitum* and inseminated at 14.5 weeks. A higher fat content can have negative effects during gestation and lactation. To prevent over fattening, feed intake can be restricted during rearing.

2.14.2 Effect of feed restriction on puberty characteristics

The increase in the availability of feeds and previous consumption of nutrients before the estrus flushing improves the appearance and the reproductive performance in does (Theau Clement and Boiti, 1998;RoDr.iguez DE Lara, 2002). Flushing following a restricted feeding period in nulliparous does improved reproduction performance (Van Den Broeck and Lampo, 1977). Manchisi *et al.* (1988) when comparing two levels of feeding (*ad libitum vs* restricted, 80% of *ad libitum)* it was observed that 90 % of nulliparous females on restricted feeding accepted the male, 90% ovulation rate of nulliparous, 15.0±9.97;Number of transferable embryos. Gosalvez *et al.* (1994) observed that nulliparous does under flushing, followed by a period of restriction, showed improved receptivity.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

The study was conducted at the National Agricultural Extension Research and Liaison Services (NAERLS) Skill Acquisition Farm, Ahmadu Bello University, Zaria, Kaduna State, Nigeria. Zaria is located within the Northern Guinea Savannah Zone of Nigeria between latitude 11^0 $33^,$ N and longitude 12^0 33’E. The Annual rainfall of Zaria ranges from 1102mm to 1904m per annum which last from May to Mid-October. The mean temperature fluctuates from 31^0C maximum during the Dry season to 18^0C minimum during the wet season. The relative humidity during the Dry and wet season was 21% and 72% respectively (Meteorological Unit of Institute for Agricultural Research/Ahmadu Bello University, Zaria, 2009).

3.2 Experimental Animals

3.2.1 Source

The stocks of rabbit used were purchased from Alhaji Abdullahi Jumo Farm Zaria, Kaduna State. The rabbits used were 18 does and 6 bucks of age six months and above. They were kept in individual cages in well ventilated pens. Feed and clean drinking water were provided *ad libitum* throughout the two weeks of acclimatization and adaptation. The pens were disinfected with Izal 5 days before the arrival of the rabbits to avoid infection prior to mating.

3.2.2 Mating plan

Table 3.1: Mating scheme and number of kittens per mating group

MG	NBs	NDs	P	NKs
NZ×NZ	1	3	1	18
CH×CH	1	3	1	18
DU×DU	1	3	1	20
NZ×CH	1	3	1	19
NZ×DU	1	3	1	13
CH×DU	1	3	1	14
Total				102

MG= Mating group NZ=New Zealand White, CH=Chinchilla, DU=Dutch, NBs=Number of bucks, NDs=Number of does, P=Parity, NKs=Number of kittens.

Pregnancy diagnosis was carried out on the 14th day after mating by abdominal palpation as described by Fielding (1991). Those that were not pregnant were rebred immediately. Prior to the kindling, does were supplied earthen nesting pots with some clean straw to help the does in preparing a warm and comfortable nest for receiving their litter. Kits were handled with nylon disposable hand gloves so as to avoid rejection by their dams. After kindling, litter size at birth and litter weight at birth were counted and weighed, respectively and thereafter examined every morning to get rid of the dead kits. Also, body weight and litter size at week 2, 4, and 6 were recorded. Kits were weaned at week 6 after which feed were restricted till the 14th week.

3.2.3 Management and feeding regimes

The weaned rabbits were fed concentrate ration (16% crude protein and 2504Kcals/kg metabolizable energy) and forage legume as shown in Table 3.2. Forage legume (*Digitaria smutssi*) was chopped and mixed with the formulated feed before feeding. The four feeding regimes were designed and administered to the different genotypes. Group A was fed *ad libitum (*free choice) while groups B, C and D were restricted for 14, 10 and 6 hours/day, respectively. Water was given *ad libitum* to all experimental rabbits. The rabbits were housed in individual row cages made of metal and wire-gauze of $60\times44\times50cm^3$. Routine management operations such as regular cleaning and disinfection of pens, cages, feeders, waterers and treatment of sick rabbits were carried out throughout the research period. Following the removal of nesting boxes after weaning, eight (8) kits from each of the 6 different genotypes were randomly selected and assigned to each of the four feeding regimes. A total of 48 rabbits from the weaned rabbits of the 6 different genotypes were used.

There was no mortality in the restricted groups (14 hours/day feed restriction, 10hours/day feed restriction and 6 hours/day feed restriction) while three (3) rabbits died in the *Ad libitum* group and the mortality record was transformed into logarithms as reported in Table 4.7.

3.3 Traits Measured

The traits measured were body weights (BW) and linear body measurements (LBMs) namely body length (BL), chest girth (CG), head-to-shoulder (HS), shoulder-to-tail (ST), length of hind limb (LHL), ear length (EL) and height at withers (HTW). Body weight was taken in grams using a weighing scale (Dimensions: 56 x 47 x 37cm, Model Number: KFC, Manufacturer: Yongkang Huaying Weighing Apparatus Company limited, China) and height at withers with a ruler in centimeters. Measurements were done on a bi-weekly basis for 5 weeks (6, 8, 10, 12 and 14 weeks).

All the traits, with the exception of body weight and height at withers were measured using measuring tape in centimeters as described below.

The anatomical reference points were in accordance with the standard zoometrical procedures (Gueye *et al.*, 1998; Teguia *et al.*, 2008).

Body length (BL): Distance from the points of shoulder to points of hip or first thoracic vertebrae to base of tail or hip bone (cm).

Chest girth (CG): This refers to the body circumference and was measured just behind the fore-legs using a measuring tape (cm).

Head to shoulder (HS): Is the distance from nose to the point of the shoulder (cm)

Shoulder-to-tail-Drop (ST): This is the distance from the point of the shoulder to the pin bone otherwise called (Coccygeal vertebrae) and was measured using a measuring tape (cm)

Length of Hind Limb (LHL): Hind limb is a posterior limb of an animal. The term hind leg is often instead used. This is the distance from the base of the hind leg to the tip or feet of the hind leg (cm)

Ear length (EL): Measured from the ear base to the zygomatic arch of the ear (cm)

Height at withers (HTW): Vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones to the fore feet. This was taken using a graduated measuring ruler in centimeters (cm)..

3.4 Experimental Design and Data Analysis

A fixed effect model was used for the analysis in which Genotype and feeding regime were factors of interest.

The statistical model considered was:

$Y_{ijk} = \mu + G_i + F_j + (GF)_{ij} + e_{ijk}$

Where:

Y_{ijk}= Single observation on the kth progeny of the ith genotype placed on the jth feed regime.

μ=Overall mean

G_i=Fixed effect of the ith genotype, i= (1, 2, 3…6)

F_j=Fixed effect of the jth feed regime, j= (1, 2, 3 and 4)

$(GF)_{ij}$= Effect of interaction between genotype and feed regime

e_{ijk}=Random error=NiiD(0, σ^2), independently and identically normally distributed with zero mean and constant variance.

Data collected were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (2004) Significant means were separated using Duncan Multiple Range Test (Duncan, 1955) modelled in SAS (2004) statistical package. The relationships amongst the measured traits were determined using correlation and analysis procedure of SAS (SAS, 2004)

Table 3.2 Composition of weaner's rabbit diet

Ingredients	Composition
Maize (%**)**	15.90
Maize Offal(%)	49.70
Brewers dried grain(BDG) (%)	6.50
Groundnut cake(%)	7.00
Soybean cake(%)	9.00
Rice offal(%)	9.00
Limestone(%)	2.20
Salt(%)	0.25
Vit Premix(%)	0.25
Lysine(%)	0.10
Dl- Methionine(%)	0.10
Total	100
Calculated Analysis	
Energy (MEKcal/kg)	2504.00
Crude protein(%)	16.00
Crude fibre	11.03

CHAPTER FOUR

4.0 RESULTS

4.1 Pre-weaning Performance

The least square means (± SE) for litter traits of different genotypes from birth to 6 weeks of age is shown in Table 4.1. The results showed that genotype had significant ($P>0.05$) effect on the litter traits at birth to six weeks of age (pre-weaning performance) except on litter size at birth (LSB), litter size at week 2(LSW2), litter size at week 4(LSW4) and litter size at week 6 (LSW6). New Zealand White×Chinchilla gave the highest value for LWB (553.33±56.96 g), while the Chinchilla×Dutch gave the least value (223.33±12.02 g). New Zealand White x New Zealand White and Chinchilla x Dutch gave higher values for LBW2 (730.00±62.45 and 730.00±85.44 g), respectively while DUxDU gave the least value for LBW2 (413.33±36.67 g).

4.2 The least square means of growth traits for the different genotypes of rabbits from 6 to 14 weeks of age.

Genotype affected ($P<0.05$) growth traits from 6 to 14 weeks of age.The least square means of growth traits for the different genotypes of rabbits at 6 weeks of age is presented in Table 4.2. At 6 weeks of age, Chinchilla×Chinchilla had the highest body weight (480.00±12.31g), body length (20.83±0.41cm), length of hind leg (18.82±0.40cm), ear length (8.30±0.16cm) and shoulder-to-tail (28.00±0.47cm). New Zealand White×Dutch had the highest value for height at withers (8.53±0.19cm). Dutch × Dutch gave higher value for chest girth (13.85±0.29cm); CH×DU had the highest value for head-to-shoulder (12.65±0.19cm).New Zealand White × New Zealand White had the lowest values for body weight (322.50±12.21g), chest girth (11.75 ±0.21cm) and ear length (6.75±0.14cm) while CH ×CH had the lowest value for height at wither (6.73±0.13cm); NZ×CH had the least value for body length (18.23±0.40cm).

The least square means of growth traits for the different genotypes of rabbits at 8 weeks is presented in Table 4.3. The Chinchilla × Chinchilla had higher value for body weight (650.00±17.03g), head-to-shoulder (13.33±0.20cm), length of hind leg (20.33±0.26cm), ear length (9.25±0.08cm) and shoulder-to-tail (31.25±0.71cm) at 8 weeks of age while New Zealand White×Dutch had the highest mean body length (23.24±0.46cm), followed by CH×CH (22.90±0.46cm). New Zealand White×Dutch had the highest value for chest girth (15.80±0.17cm) followed by CH×DU (15.35±0.14cm).Height at wither (8.45±0.10cm) for Chinchilla×Dutch was higher compare to other genotypes and the Dutch×Dutch had the lowest body weight (470.00±16.98g) followed by NZ×NZ (475.00±17.00g). New Zealand White × New Zealand White had the lowest value for chest girth (13.63±0.14cm), head-to-shoulder (10.78±0.14cm) ear length (7.70±0.05cm) and shoulder-to-tail (27.23±0.66 cm).

Table 4.1 Least square means (± SE) for litter traits of different genotypes from birth to 6 weeks of age.

	Traits							
Genotype	LSB	LWB(g)	LSW2	LBW2(g)	LSW4	LBW4(g)	LSW6	LBW6(g)
CH×CH	6.00±0.15	266.67±33.33^{b}	4.33±0.88	463.33±85.70^{ab}	4.00±1.15	1286.67±446.67^{a}	4.00±1.15	2026.67±612.89^{a}
NZ×NZ	6.00±0.58	246.67±29.06^{b}	5.33±0.88	730.00±62.45^{a}	4.67±1.20	810.00±162.58^{c}	3.67±0.33	1210.00±122.88^{b}
DU× DU	6.67±0.33	293.33±31.79^{b}	3.67±0.88	413.33±36.67^{b}	3.00±0.58	846.00±163.98^{b}	3.00±0.58	1036.67±191.95^{c}
NZ× CH	6.33±0.33	553.33±56.96^{a}	4.67±1.20	646.67±92.62^{ab}	4.00±0.58	1175.00±175.38^{a}	3.67±0.67	1560.00±202.97^{a}
NZ× DU	4.33±0.67	240.00±20.82^{b}	4.00±0.58	646.67±100.89^{ab}	3.67±0.88	833.33±218.58^{c}	3.67±0.88	1643.33±413.37^{a}
CH×DU	4.67±0.88	223.33±12.02^{b}	4.33±0.67	730.00±85.44^{a}	4.33±0.67	1460.00±176.16^{a}	3.33±0.33	1610.00±170.88^{a}

^{abc}Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ=New Zealand White, DU=Dutch, LSB= Litter size at birth, LWB=litter weight at birth, LSW2=Litter size at week 2, LBW2=Litter body weight at week2, LSW4=Litter size at week 4, LBW4=Litter body weight at week4, LSW6=Litter body weight at week 6, LBW6=Litter body weight at week 6.

Table 4.2 Least square means of growth traits for the different genotypes of rabbits at 6 weeks of age

	GROWTH TRAIT							
GENOTYPE	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	HTW	EL	ST
NZxNZ	322.50±12.21^{c}	18.65±.0.31^{bc}	11.75±0.21^{b}	8.33±0.15^{c}	16.80±0.37^{bc}	7.35±0.16^{c}	6.75±0.14^{d}	22.45±0.44^{c}
CHxCH	480.00±12.31^{a}	20.83±0.41^{a}	13.53±0.26a	12.48±0.18^{a}	18.82±0.40^{a}	6.73±0.13^{d}	8.30±0.16^{a}	28.00±0.47^{a}
DUxDU	351.30±11.20^{c}	19.55±0.37^{b}	13.85±0.29^{a}	8.13±0.15^{b}	17.58±0.39^{b}	7.93±0.18^{b}	7.30±0.14^{c}	25.38±0.43^{b}
NZxCH	420.00±12.22^{b}	18.23±0.40^{c}	13.75±0.25^{a}	10.48±0.17^{c}	16.93±0.37^{bc}	7.45±0.14^{bc}	7.13±0.13^{cd}	24.75±0.43^{b}
NZxDU	445.00±12.18^{ab}	19.08±0.41^{bc}	13.25±0.23^{a}	7.85±0.14^{c}	16.18±0.29^{c}	8.53±0.19^{a}	7.05±0.13^{cd}	22.43±0.42^{c}
CHxDU	476.30±12.25^{a}	18.58±0.40^{bc}	13.75±0.21^{a}	12.65±0.19^{a}	16.50±0.36^{bc}	7.73±0.16^{bc}	7.88±0.15^{b}	25.53±0.44^{b}

^{abc} Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ= New Zealand White, DU= Dutch, BW=Body weight, BL= Body length, CG= chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail-drop.

Table 4.3 Least square means (± SE) of growth traits for the different genotypes of rabbits at 8 weeks of age

GENOTYPE	GROWTH TRAIT							
	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	HTW(cm)	EL(cm)	ST(cm)
NZxNZ	475.00±17.00^{d}	21.98±0.45^{ab}	13.63±0.14^{d}	10.78±0.14^{c}	18.10±0.24^{c}	7.38±0.05^{b}	7.70±0.05^{d}	27.23±0.66^{bc}
CHxCH	650.00±17.03^{a}	22.90±0.46^{ab}	13.90±0.15^{cd}	13.33±0.20^{a}	20.33±0.26^{a}	8.18±0.07^{ab}	9.25±0.08^{a}	31.25±0.71^{a}
DUxDU	470.00±16.98^{d}	21.53±0.43^{bc}	13.80±0.15^{d}	11.30±0.18^{c}	19.75±0.25^{ab}	8.43±0.09^{a}	8.18±0.07^{c}	27.88±0.61^{bc}
NZxCH	585.00±17.13^{bc}	22.00±0.45^{ab}	14.30±0.16^{c}	11.98±0.19^{b}	19.50±0.25^{b}	8.43±0.09^{a}	8.00±0.07^{c}	28.48±0.70^{b}
NZxDU	537.50±17.02^{c}	23.24±0.46^{a}	15.80±0.17^{a}	10.90±0.17^{c}	19.90±0.26^{ab}	8.20±0.06^{ab}	8.15±0.07^{c}	27.35±0.69^{bc}
CHxDU	601.30±17.14^{b}	20.48±0.39^{c}	15.35±0.14^{b}	13.28±0.20^{a}	17.53±0.24^{c}	8.45±0.10^{a}	8.40±0.08^{b}	29.33±0.81^{b}

^{abc} Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ= New Zealand White, DU= Dutch, BW=Body weight, BL= Body length, CG= chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail-drop.

The least square means of growth traits for the different genotypes of rabbits at 10 weeks is shown in Table 4.4. At 10 weeks of age, Chinchilla ×Chinchilla had higher mean body weight (941.30±19.17g), length of hind leg (22.33±0.40cm), height at wither (10.58±0.06cm), ear length (9.73±0.10cm) and shoulder-to-tail (33.58±0.58cm) while the New Zealand White × New Zealand White had the least values for chest girth, head-to-shoulder and ear length (14.60±0.08cm, 11.63±0.40cm and 8.03±0.04cm) respectively. The Dutch×Dutch had the least mean body weight (552.50±18.68g) and body length (22.38±0.21cm) and it had the second lowest mean value for ear length (8.53±0.06cm) and shoulder-to-tail (29.35±0.49cm). New Zealand White × Chinchilla had the second lowest mean value for chest girth (14.75±0.06cm) while NZ×DU had the highest head-to-shoulder length (18.80±0.59cm) and second to the highest length of hind leg (21.05±0.39cm) and CH×DU had the highest body length (22.40±0.20cm).

The mean of growth traits for the different genotypes of rabbits at 8 weeks is presented in Table 4.5. Chinchilla× Chinchilla had the highest body weight (1206.00±23.03g), body length (27.80±0.25cm), head-to-shoulder length (15.98±0.15cm), length of hind leg (25.03±0.28cm), height at wither (11.15±0.09cm), ear length (11.03±0.09cm), shoulder-to-tail drop (40.48±0.50cm) but second highest for chest girth (17.88±0.22cm) at 12 weeks of age. New Zealand White × New Zealand White had the least values for head-to-shoulder length (12.73±0.11cm), length of hind leg (20.60±0.20cm), height at wither (8.68±0.06cm) and ear length (8.58±0.06cm) while Dutch×Dutch had the least body weight (725.00±22.50g), body length (23.18±0.18cm), chest girth (15.65±0.20cm) but it was the second lowest for head-to shoulder length (12.83±0.11cm), height at wither (9.18±0.07cm), ear length (8.70±0.07cm) and shoulder-to-tail Drop (31.78±0.39). New Zealand White ×Chinchilla had the second lowest for chest girth (15.78±0.20cm) and shoulder-to-tail Drop (31.78±0.40cm). New Zealand White×Dutch had the highest chest girth (19.05±0.27cm), followed by Chinchilla× Chinchilla (17.88±0.22cm) but was the second highest in term of body length (26.38±0.24cm), head-to-shoulder length (13.95±0.12cm), length of hind leg (22.25±0.25cm) and height at wither was (10.18±0.11cm).

The least square means of growth traits for the different genotypes of rabbits at 8 is reported in Tables 4.5. At 14 weeks of age, Chinchilla × Chinchilla was found to have higher mean body weight (1401.75±27.70g), body length (28.63±0.34cm), head-to-shoulder length (16.20±0.13cm), length of hind leg (25.55±0.21cm), height at wither (11.40±0.21cm), ear length (11.35±0.13cm), shoulder-to-tail Drop (42.13±0.50cm) except for chest girth (17.68±0.19cm).Chinchilla × Dutch had the second highest in terms of body weight (1086.25±27g) and chest girth (17.85±0.18cm). The least mean body weight (870.00±26.32g) and chest girth (16.28±0.17cm) were found in Dutch × Dutch.

4.3: Effect of feed restriction on growth traits and mortality rate of rabbit

The effect of feed restriction on growth traits and mortality rate of rabbit is presented in Table 4.7.The results obtained show that there were no significant (P>0.05) difference among the feeding regime in all the growth traits measured (BW, BL, CG, HS, LHL, EL, ST and HTW). The body weight obtained were 772.67±38.72g, 688.62±32.16g, 730.75±35.24g and 705.37±33.45g for feeding regime A, B, C and D respectively. The BL, CG, HS, LHL, EL, ST and HTW ranged between 23.02-23.66cm, 15.59-15.72 cm, 12.48-12.99 cm, 20.31-20.62 cm, 8.61-8.78 cm, 31.19-31.74 cm and 8.80-9.06 cm respectively. There were no significant differences (P>0.05) in observed mortality rates.

Table 4.4. Least square means (± SE**)** of growth traits for the different genotypes of rabbits at 10 weeks of age

GENOTYPE	GROWTH TRAIT							
	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	HTW(cm)	EL(cm)	ST(cm)
NZ×NZ	565.00±18.88^{d}	23.45±0.21^{b}	14.60±0.08^{d}	11.63±0.40^{c}	20.10±0.22^{c}	8.88±0.02^{bc}	8.03±0.04^{d}	29.43±0.50^{c}
CH×CH	941.30±19.17^{a}	24.23±0.23^{a}	16.68±0.09^{ab}	14.13±0.48^{b}	22.33±0.40^{a}	10.58±0.06^{a}	9.73±0.10^{a}	33.58±0.53^{a}
DU×DU	552.50±18.68^{d}	22.38±0.21^{c}	15.45±0.06^{c}	12.65±0.55^{bc}	20.90±0.25^{b}	8.93±0.04^{bc}	8.53±0.06^{c}	29.35±0.49^{c}
NZ×CH	703.80±18.90^{bc}	23.98±0.22^{ab}	14.75±0.06^{d}	12.78±0.56^{bc}	20.68±0.24^{bc}	8.98±0.05^{bc}	8.63±0.05bc	31.61±0.52^{b}
NZ×DU	670.00±18.78^{c}	24.43±0.24^{a}	16.42±0.07^{a}	18.80±0.59^{a}	21.05±0.39^{b}	8.88±0.03^{bc}	8.73±0.09^{bc}	30.65±0.50^{bc}
CH×DU	751.30±19.00^{b}	22.40±0.20^{c}	16.70±0.09^{b}	13.53±0.46^{b}	19.20±0.23^{d}	9.00±0.05^{b}	8.83±0.09^{b}	31.95±0.53^{b}

^{abc} Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ= New Zealand White, DU= Dutch, BW=Body weight, BL= Body length, CG= chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop.

Table 4.5. Least square means (± SE) of growth traits for the different genotypes of rabbits at 12 weeks of age

GENOTYPE	GROWTH TRAIT							
	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	HTW(cm)	EL(cm)	ST(cm)
NZxNZ	738.00±22.52^{c}	25.73±0.20^{c}	16.53±0.23^{c}	12.73±0.11^{d}	20.60±0.20^{d}	8.68±0.06^{f}	8.58±0.06^{d}	32.33±0.43^{d}
CHxCH	1206.00±23.03^{a}	27.80±.025^{a}	17.88±0.22^{b}	15.98±0.15^{a}	25.03±0.28^{a}	11.15±0.09^{a}	11.03±0.09^{a}	40.48±0.50^{a}
DUxDU	725.00±22.50^{c}	23.18±0.18^{d}	15.65±0.20^{d}	12.83±0.11^{d}	21.40±0.25^{bcd}	9.18±0.07^{d}	8.70±0.07^{d}	31.78±0.39^{e}
NZxCH	884.00±22.70^{b}	25.33±0.22^{c}	15.78±0.20^{d}	13.60±0.11^{c}	21.60±0.26^{bc}	9.55±0.10^{c}	9.15±0.09^{c}	31.78±0.40^{e}
NZxDU	890.00±22.75^{b}	26.38±0.24^{b}	19.05±0.27^{a}	13.95±0.12^{b}	22.25±0.25^{b}	10.18±0.11^{b}	9.65±0.09^{b}	34.03±0.41^{b}
CHxDU	910.00±22.91^{b}	23.43±0.19^{d}	17.12±0.21^{c}	13.83±0.11^{bc}	21.30±0.23^{cd}	9.33±0.09^{c}	9.33±0.07^{c}	33.35±0.40^{c}

^{abc} Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ= New Zealand White, DU= Dutch, BW=Body weight, BL= Body length, CG= chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop.

Table 4.6. Least square means (± SE) of growth traits for the different genotypes of rabbits at 14 weeks of age

GENOTYPE	GROWTH TRAIT							
	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	HTW(cm)	EL(cm)	ST(cm)
NZxNZ	942.50±26.84^{c}	27.15±0.32^{bc}	17.73±0.19^{b}	13.63±0.09^{c}	22.50±0.31^{c}	9.93±0.11^{d}	9.25±0.11^{c}	36.00±0.44^{c}
CHxCH	1401.75±27.70^{a}	28.63±0.34^{a}	17.68±0.19^{b}	16.20±0.13^{a}	25.55±0.21^{a}	11.40±0.21^{a}	11.35±0.13^{a}	42.13±0.50^{a}
DUxDU	870.00±26.32^{c}	25.98±0.32^{d}	16.28±0.17^{c}	13.75±0.13^{c}	23.03±0.30^{bc}	9.38±0.10^{e}	9.05±0.12^{c}	34.10±0.34^{e}
NZxCH	1031.25±27.59^{b}	26.93±0.28^{c}	19.79±0.20^{c}	14.43±0.11^{b}	23.53±0.29^{c}	10.55±0.11^{b}	9.95±0.14^{b}	38.30±0.37^{b}
NZxDU	1048.75±27.60^{b}	27.90±0.32^{ab}	19.79±0.20^{a}	14.43±0.12^{b}	23.53±0.30^{b}	10.55±0.15^{b}	9.95±0.12^{b}	38.30±0.37^{b}
CHxDU	1086.25±27.70^{b}	25.70±0.33^{d}	17.85±0.18^{b}	13.98±0.10^{c}	22.88±0.29^{bc}	10.18±0.13^{c}	9.65±0.14^{b}	35.60±0.35^{d}

^{abc} Means within the same column having the same letter are not significantly(P>0.05) different. CH =Chinchilla, NZ= New Zealand White, DU= Dutch, BW=Body weight, BL= Body length, CG= chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop.

Table 4.7: Effect of feed restriction on growth traits and mortality rate of rabbit

F.R.	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	EL(cm)	ST(cm)	HTW(cm)	MORT
A	772.67±38.72	23.61±0.46	15.59±0.25	12.48±0.29	20.54±0.37	8.78±0.16	31.74±0.69	9.06±0.19	0.48
B	688.62±32.16	23.02±0.39	15.59±0.25	12.81±0.30	20.31±0.30	8.61±0.12	30.61±0.62	8.97±0.15	0.00
C	730.75±35.24	23.31±0.38	15.72±0.22	12.99±0.34	20.62±0.33	8.75±0.16	31.19±0.62	8.99±0.14	0.00
D	705.37±33.45	23.66±0.38	15.66±0.29	12.96±0.32	20.41±0.31	8.77±0.13	31.23±0.64	8.80±0.19	0.00

F.R. = Feeding regime, A=*Ad libitum* feeding, B=14 hours/day feed restriction, C=10 hours/day feed restriction, D=6 hours/ day feed restriction, BW=Body weight, BL=Body length, CG=Chest girth, HS= Head-to-shoulder, LHL=Length of hind leg, EL=Ear length, ST=Shoulder-tail Drop, HTW=Height at wither, MORT=Mortality

4.4 Effect of interaction between the genotypes and the feeding regime.

The interaction between the genotypes and the feeding regime are given in Table 4.8. The results obtained show significant ($P<0.05$) difference between the genotypes and feeding regime in all the growth traits measured. New Zealand White × New Zealand White had the highest body weight (667.00±104.86g) for the feeding regime D followed by feeding regime C (595.00±100.23g), feeding regime A(592.00±111.40 g) and the least was observed in feeding regime B (580.00±96.55g) respectively. In the Chinchilla × Chinchilla genotype, the feeding regime A had the highest body weight (1049.00±121.01g) followed by feeding regimes C (966.00±104.28g), B (889.20±98.24 g) and D (839.20±102.80 g) while in Dutch× Dutch genotype, the mean body weight for feeding regime A (637.00.00±117.30g) was higher followed by feeding regime B (606.00±95.01g), feeding regime D (578.00±100.56 g) and the least was observed in feeding regime C (554.00±100.01 g). Similarly, the feeding regime A had the highest body weight (784.00.00±119.44g) and the second highest body weight was observed in feeding regime D (735.00±100.42g) while the third was in feeding regime C (701.00±102.14g) and the least was observed in feeding regime B (679.00±96.89 g) for New Zealand White ×Chinchilla genotype. In the interaction between the genotype and feeding regime for New Zealand White ×Dutch, the feeding regime C had the highest body weight (818.00±103.97 g) followed by feeding regime A(782.00±110.50g) then the feeding regime B (638.00±97.57g) while the least was observed in feeding regime D (635.00±100.30 g). In the results obtained between genotype x feeding regime for Chinchilla ×Dutch show that the feeding regime A had the highest body weight (792.00±101.11g) followed by feeding regime D (778.00±100.33 g), feeding regime C (750.00±103.45g) and the least was observed in feeding regime B (739.50±97.08 g).

Table 4.8 Interaction between genotypes and the feeding regimes

		GENOTYPES					
F.R.	**TRAITS**	**NZxNZ**	**CHxCH**	**DUxDU**	**NZxCH**	**NZxDU**	**CHxDU**
A	BW(g)	592.00±111.40^{b}	1049.00±121.01^{a}	637.00±117.30^{b}	784.00±119.44^{b}	782.00±110.50^{b}	792.00±101.11^{b}
	BL(cm)	22.40±2.02^{b}	26.14±1.39^{a}	22.90±3.03^{ab}	23.54±1.45.00^{a}	24.14±2.34^{ab}	22.54±1.26^{b}
	CG(cm)	14.24±0.92^{c}	16.36±1.09^{ab}	14.80±1.03^{bc}	15.00±1.07^{bc}	16.92±1.10^{a}	16.2±1.12^{ab}
	HS(cm)	10.84±0.78^{d}	14.76±0.89^{a}	11.08±0.70^{cd}	12.78±0.67^{bc}	12.06±0.81^{bcd}	13.36±0.72^{ab}
	LHL(cm)	18.28±1.20^{c}	23.0±1.35^{a}	21.48±1.24^{ab}	19.94±1.33^{bc}	21.141±1.09^{ab}	19.42±1.00^{bc}
	EL(cm)	7.72±0.41^{c}	10.26±0.53^{a}	8.60±0.27^{bc}	8.52±0.32^{bc}	8.84±0.37^{b}	8.7±0.39b
	ST(cm)	28.58±2.07^{b}	35.92±2.10^{a}	31.18±2.09^{ab}	31.90±2.09^{ab}	31.10±2.08^{ab}	31.74±2.12^{ab}
	HTW (cm)	7.72±0.50^{b}	9.98±0.71^{a}	9.02±0.55^{a}	8.90±0.54^{a}	9.66±0.69^{a}	9.06±0.53^{a}
B	BW(g)	580.00±96.55^{b}	889.20±98.24^{a}	606.00±95.01^{b}	679.00±96.89^{ab}	638.00±97.57^{b}	739.5±97.08^{ab}
	BL(cm)	22.84±1.21^{a}	24.20±1.31^{a}	22.20±1.42^{a}	23.12±1.34^{a}	23.86±1.55^{a}	21.88±1.60^{a}
	CG(cm)	14.66±0.55^{b}	16.20±0.35^{ab}	15.12±0.43^{ab}	15.02±0.57^{ab}	16.56±0.80^{a}	15.96±0.69^{ab}
	HS(cm)	11.48±0.59^{b}	14.36±1.02^{a}	11.74±0.86^{b}	12.72±0.93^{ab}	13.34±1.10^{ab}	13.20±1.01^{ab}
	LHL(cm)	19.52±0.89^{b}	22.16±1.15^{a}	20.62±1.13^{ab}	20.46±1.11^{ab}	19.76±0.99^{b}	19.32±0.97^{b}
	EL(cm)	8.18±0.33^{b}	9.76±0.35^{a}	8.18±0.36^{b}	8.44±0.25^{b}	8.38±0.25^{b}	8.74±0.29^{b}
	ST(cm)	28.94±2.06^{b}	34.86±2.19^{a}	29.58±1.64^{b}	30.48±2.12^{b}	29.36±1.18^{b}	30.44±1.55^{b}
	HTW(cm)	8.52±0.52^{a}	9.50±0.72^{a}	8.78±0.65^{a}	9.02±0.68^{a}	9.28±0.47^{a}	8.74±0.66^{a}

Table 4.8 (Continues)

C	BW(g)	595.00±100.23^{bc}	966.00±104.28^{a}	554.00±100.01^{c}	701.00±102.14bc	818.00±103.97^{ab}	750.50±103.45^{abc}
	BL(cm)	23.50±1.09^{ab}	24.98±1.11^{a}	21.34±1.05^{b}	23.02±1.06^{ab}	25.12±1.14^{a}	21.88±1.03^{a}
	CG(cm)	14.92±0.66^{b}	16.14±0.78^{ab}	14.96±0.76^{b}	15.14±0.79^{b}	17.12±0.99^{a}	15.96±0.77^{ab}
	HS(cm)	11.54±1.02c	14.54±1.05^{a}	11.74±1.03^{bc}	12.4±1.04^{abc}	14.16±1.07^{ab}	13.20±1.08^{ab}
	LHL(cm)	20.18±0.98^{b}	22.74±0.99^{a}	19.48±0.96^{b}	20.10±0.98^{b}	21.7±0.98^{ab}	19.32±0.85^{b}
	EL(cm)	8.52±0.41^{b}	10.18±0.55^{a}	7.92±0.39^{b}	8.52±0.42^{b}	8.88±0.52^{b}	8.74±0.50^{b}
	ST(cm)	29.80±1.80^{b}	35.80±2.01^{a}	27.80±1.75^{b}	31.01±1.91^{b}	31.90±1.96^{b}	30.44±1.95^{b}
	HTW(cm)	8.58±0.44^{bc}	9.72±0.46^{a}	8.24±0.35^{c}	9.06±0.37^{abc}	9.32±0.43^{ab}	8.74±0.40^{a}
D	BW(g)	667.00±104.86^{ab}	839.20±102.80^{a}	578.00±100.56^{b}	735.00±100.42^{ab}	635.00±100.30^{ab}	778.0±100.33^{ab}
	BL(cm)	24.82±1.20^{a}	24.18±1.18^{a}	23.64±1.18^{a}	23.48±1.19^{a}	23.69±1.21^{a}	22.16±1.26^{a}
	CG(cm)	15.56±0.98^{a}	15.02±0.93^{a}	15.14±0.94^{a}	14.98±0.85^{a}	17.07±1.00^{a}	16.20±1.01^{a}
	HS(cm)	11.80±0.72^{a}	14.02±0.88^{a}	12.36±0.74^{a}	12.72±0.65^{a}	13.18±0.86^{a}	13.68±0.93^{a}
	LHL(cm)	20.50±1.30^{a}	21.74±1.27^{a}	20.54±1.25a	20.32±1.21^{a}	19.72±1.01^{a}	19.66±1.10^{a}
	EL(cm)	8.14±0.40^{b}	9.52±0.47^{a}	8.68±0.46^{ab}	8.56±0.37^{ab}	8.72±0.44^{ab}	9.02±0.32^{ab}
	ST(cm)	30.62±2.20^{a}	33.76±2.22^{a}	30.22±2.29^{a}	31.42±2.08^{a}	29.84±1.95^{a}	31.54±30a
	HTW(cm)	8.94±0.61^{a}	8.22±0.50^{a}	9.02±0.62^{a}	8.78±0.54^{a}	8.80±0.62^{a}	9.06±0.65^{a}

NZ= New Zealand White, CH=Chinchilla, DU= Dutch, F.R. =Feeding regimes, A= *ad libitum* feeding, B= 14hours restriction, C=10 hours restriction, D= 6 hours restriction, BW=Body weight, BL= Body length, CG= Chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop.

4.5 Coefficients of correlation for growth traits for the six genotypes

The coefficients of correlation for growth traits of NZxNZ and CHxCH are presented in Table 4.9. The growth traits measured showed varying degrees of relationship. The phenotypic correlation were positive and negative, low to high ranging between -0.01 to 0.99 and were all significant at ($P<0.05$). For NZxNZ, a significant ($P<0.05$) correlation was observed between BW and CG (0.96), BW and HS (0.97), BW and LHL (0.89), BW and HTW (0.89), BL and ST (0.95) CG and HS (0.99), HG and HTW (0.97), HS and HTW (0.97). A significant correlation ($P<0.05$) was observed between BW and EL (0.59), BL and HG (0.49), BL and HS (0.47), BL and HTW (0.58), CG and LHL (0.87) HG and EL (0.44), CG and ST (0.59), HS and LHL (0.82), HS and EL (0.39), HS and ST (0.55), LHL and EL (0.81), LHL and ST (0.38) and LHL and HTW (0.67), ST and HTW (0.59). Other traits measured, although positive and negative but did not show significant ($P>0.05$) correlation. In the CHxCH genotype, a very highly significant ($P<0.001$) correlation was obtained between BW and BL (0.98), LHL and ST (0.98) while other correlated traits are significant ($P<0.05$) with the exception of BW and HS (-0.33), BW and HTW (0.28), BL and EL (0.31), BL and HG (0.36), CG and HS (-0.68), HS and LHL (-0.81), HS and HTW (-0.01), LHL and HTW (0.08). The highest correlation coefficients were obtained between HS and CG (0.99) while the least was between HS and HTW (-0.01).

Table 4.9: Coefficient of correlation for growth traits of NZxNZ and CHxCH

Genotype	Traits	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	EL(cm)	ST(cm)	HTW (cm)
NZxNZ	BW(g)	-							
	BL(cm)	0.24^{NS}	-						
	CG(cm)	0.96***	0.49*	-					
	HS(cm)	0.97***	0.47*	0.99***	-				
	LHL(cm)	0.89***	0.16^{NS}	0.87**	0.82**	-			
	EL(cm)	0.59*	-0.44^{NS}	0.44*	0.39*	0.81**	-		
	ST(cm)	0.36^{NS}	0.95***	0.59*	0.55*	0.38*	-0.18^{NS}	-	
	HTW(cm)	0.89***	0.58*	0.97***	0.97***	0.67*	0.18^{NS}	0.59*	-
CHxCH	BW(g)	-							
	BL(cm)	0.98***	-						
	CG(cm)	0.84**	0.79**	-					
	HS(cm)	-0.33N^{S}	-0.17^{NS}	-0.68^{NS}	-				
	LHL(cm)	0.80**	0.67**	0.86**	-0.81^{NS}	-			
	EL(cm)	0.37*	0.31^{NS}	0.81**	-0.82^{NS}	0.64*	-		
	ST(cm)	0.64**	0.47*	0.70**	-0.85^{NS}	0.98***	0.54*	-	
	HWT(cm)	0.28^{NS}	0.36^{NS}	0.40*	-0.01^{NS}	0.08^{NS}	0.37*	-0.37^{NS}	-

NZ=New Zealand White, CH=Chinchilla, BW=Body weight, BL=Body length, CG=Chest girth, HS=Head-to-shoulder, LHL=Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop, NS=Not significant (P>0.05), *=P<0.05, **=P<0.01, ***= P<0.001.

Table 4.9 represents the coefficient of correlation for growth traits of DUxDU and NZxCH. All the growth traits measured showed varying degrees of relationships. The genetic correlation were positive and negative, low to high ranging between -0.05 to 0.99. For DUxDU, a highly significant ($p<0.01$) correlation was obtained between CG and LHL (0.91), LHL and EL (0.95), LHL and ST (0.99), LHL and (0.91), EL and ST (0.99). A significant correlation ($P<0.05$, $P<0.01$) were observed between BW and HG (0.44), BW and LHL (0.65), BW and EL (0.73), BW and ST (0.66), BW and HTW (0.85) BL and HS (0.52), BL and LHL (0.84), BL and EL (0.66), BL and ST (0.77), BL and HTW (0.65), HG and EL (0.74), HG and ST (0.84), CG and HTW (0.85), EL and HTW (0.85), ST and HTW (0.87). Other traits measured, although positive and negative but did not show significant correlation ($P>0.05$). A highly significant ($p<0.01$) correlation were obtained between BW and BL (0.92), BL and HG (0.97), BL and ST (0.97), BL and HTW(0.96), HG and ST (0.99), CG and HTW (0.87), ST and HTW (0.90) while other correlated traits are significant ($P<0.05$) with the exception of BW and EL (0.21), CG and LHL (0.32), HS and LHL (0.29), HS and EL (0.00), LHL and EL (-0.29), EL and HTW (0.32) for NZxCH genotype while the highest correlation coefficient for the same genotype was obtained between CG and ST (0.99) and the lowest correlation coefficient was between HS and EL (0.00).

Table 4.10 Coefficient of correlation for growth traits of DUxDU and NZxCH

Genotype	Traits	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	EL(cm)	ST(cm)	HTW(cm)
DUxDU	BW(g)	-							
	BL(cm)	0.17^{NS}	-						
	CG(cm)	0.44*	0.95***	-					
	HS(cm)	-0.71^{NS}	0.52*	0.23^{NS}	-				
	LHL(cm)	0.65*	0.84**	0.91***	0.07^{NS}	-			
	EL(cm)	0.73**	0.66*	0.74**	-0.05^{NS}	0.95***	-		
	ST(cm)	0.66*	0.77**	0.84**	0.06^{NS}	0.99***	0.99***	-	
	HTW(cm)	0.85**	0.65*	0.85**	-0.29^{NS}	0.91***	0.85**	0.87**	-
NZxCH	BW(g)	-							
	BL(cm)	0.92***	-						
	CG(cm)	0.80**	0.97***	-					
	HS(cm)	0.89**	0.68*	0.55*	-				
	LHL(cm)	0.55*	0.51*	0.32^{NS}	0.29^{NS}	-			
	EL(cm)	0.21^{NS}	0.52*	0.73**	0.00^{NS}	-0.29^{NS}	-		
	ST(cm)	0.82**	0.97***	0.99***	0.52*	0.39*	0.69*	-	
	HWT(cm)	0.91***	0.96***	0.87**	0.63*	0.74**	0.32^{NS}	0.90***	-

DU= Dutch, NZ=New Zealand White, CH=Chinchilla, BW=Body weight, BL= Body length, CG= Chest girth, HS= Head-to-shoulder, LHL= Length of hind leg, HTW=Height at wither, EL= Ear length, ST=Shoulder-to-tail drop, NS=Not significant (P>0.05), *=P<0.05, **=P<0.01, ***= P<0.001.

Table 4.10 shows the coefficient of correlation for growth traits of NZXDU and CHxDU. Results obtained indicated that the growth traits measured showed varying degrees of relationships. The phenotypic correlation were positive and negative, low to high ranging between 0.12 to 0.99 and were significant (P<0.05). For New Zealand White x Dutch, a very highly significant (P<0.001) correlation were obtained between BW and BL (0.99), BW and HS (0.93), BW and LHL (0.99), BW and ST (0.98), BL and HS (0.92), BL and LHL (0.98), BL and ST (0.94), HS and LHL (0.89), HS and ST (0.88), LHL and ST (0.98). A significant (P<0.05) correlation were observed between other traits except for BW and HG (-0.52), BL and CG (-0.53), HG and HS (-0.79), CG and LHL (-0.43), CG and EL (0.33), CG and ST (-0.41), CG and HTW (-0.72), HS and EL (0.31), EL and HTW (0.23) where there were non-significant (P>0.05) difference. For Chinchilla x Dutch a very high (P<0.001) correlation were obtained between BL and ST (0.89), BL and HTW (0.88), HG and LHL(0.98), HG and EL(0.89), HG and ST (0.85), CG and HTW (0.89), LHL and ST (0.94), LHL and HTW (0.93), ST and HTW (0.92) while other correlated traits are significant (P<0.05) with the exception of BW and EL (0.23), BL and HS (0.12), BL and EL (0.32). The highest correlation coefficient was obtained between LHL and ST (0.94) while the lowest correlation coefficient was between BL and HS (0.12)

Table 4.11: Coefficient of correlation for growth traits of NZxDU and CHxDU

Genotype	Traits	BW(g)	BL(cm)	CG(cm)	HS(cm)	LHL(cm)	EL(cm)	ST(cm)	HTW(cm)
NZxDU	BW(g)	-							
	BL(cm)	0.99***	-						
	CG(cm)	-0.52^{NS}	-0.53^{NS}	-					
	HS(cm)	0.93***	0.92***	-0.79^{NS}	-				
	LHL(cm)	0.99***	0.98***	-0.43^{NS}	0.89***	-			
	EL(cm)	0.61*	0.54*	0.33^{NS}	0.31^{NS}	0.67*	-		
	ST(cm)	0.98***	0.94***	-0.41^{NS}	0.88***	0.98***	0.72**	-	
	HTW(cm)	0.66*	0.57*	-0.72^{NS}	0.81**	0.60*	0.23^{NS}	0.70**	-
CHxDU	BW(g)	-							
	BL(cm)	0.41*	-						
	CG(cm)	0.49*	0.61*	-					
	HS(cm)	0.48*	0.12^{NS}	0.82**	-				
	LHL(cm)	0.54*	0.74**	0.98***	0.75**	-			
	EL(cm)	0.23^{NS}	0.32^{NS}	0.89***	0.76**	0.81**	-		
	ST(cm)	0.58*	0.89***	0.85**	0.54*	0.94***	0.56*	-	
	HWT(cm)	0.40*	0.88***	0.89***	0.46*	0.93***	0.74**	0.92***	-

NZ=New Zealand White, DU= Dutch, CH=Chinchilla, BW=Body weight, BL=Body length, CG=Chest girth, HS= Head-to-shoulder, LHL=Length of hind leg, HTW=Height at wither, EL=Ear length, ST=Shoulder-to-tail drop, NS= Not significant ($P>0.05$), *=$P<0.05$, **=$P<0.01$, ***= $P<0.001$.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Pre-weaning Performance.

The results in this study showed that there was no significant difference among litter size at birth (LSB) for all the genotypes used. Onyiro *et al.* (2008) however stated significant ($P<0.05$) difference with the DUxDU producing higher LSB than New Zealand White x New Zealand White, Chinchilla x Chinchilla, New Zealand White x Chinchilla, New Zealand White x Dutch and Chinchilla x Dutch). These differences could be due to temperature and dam effect as reported by Yamani *et al*. (1994).

The value of LSB for NZxNZ (6.00±0.58g) observed was higher than the value for CHXCH (6.00±0.15g). Also Yahaya (1993) who reported higher LSB for Chinchilla does than for New Zealand White and Californian White does. The possible reason for this could be the source of the animals, breeds, nutrition, dams and sire effect and the season. Obike and Ibe, 2010 reported a significant ($P<0.05$) difference between the litter weight at birth and litter body weight at week 2 (LBW2) in all the genotypes. This corroborates the work of Hassanien and Baiomy (2011) who reported that breed had significant ($P<0.05$) effect on the litter weight at birth, at 14 days and 28 days.Litter weight at week 2 (LWB2) for NZxNZ (730.00±62.45g) was the highest among all the genotypes followed by CHxDU (730.00±62.44g). There was no significant ($P>0.05$) difference between the LSW4, LBW4, LSW6 and LBW6, although, numerically the LSW6 and LBW6 for CHXCH were higher than other genotypes. The higher LBW6 could be attributed to the higher LSW6. This is in agreement with the report of Risam *et al.* (2005) who stated that litter weight at weaning is controlled by the number of kits that survived at weaning. McNitt and Moody (1988) identified pre-weaning variables as major factors affecting post-weaning performance of rabbits.

5.2 Least square means (± SE) of growth traits for the different genotypes of rabbits from 6 to 14 weeks of age.

Genotype significantly ($P<0.05$) affected the mean growth traits of rabbits at 6, 8, 10, 12 and 14 weeks of age. The results show that CHxCH genotype was superior compared to the other genotypes in most of the growth traits measured at 6 weeks of age. The observed differences could be due to the fact that growth parameters are highly heritable traits suggesting that the differences among different genotypes are expected and selection based on individual or genotype performance could successfully improve these traits. This finding also agrees with the report of Lukefahr *et al.* (1980) who stated that the growth rate and development in rabbit is breed dependent. The findings is similar and agrees with the report of Obike and Ibe (2010) who reported that the mean body weight and some linear body measurements of CHxCH (546.00g) at 6 weeks was higher than those for NZxNZ (476.92g), DUxDU (390.00g), NZxCH (394.00), NZxDU (348.57g) and CHxDU (361.25). The mean values obtained in this study for BW at week 6 for NZxCH (420.00±12.31g), NZxDU (445.00±12.18g) and CHxDU (476.30±12.25g) were higher than the values reported by Obike and Ibe (2010) and this could be that the rabbits used in this study have high reproductive potentials and fast growth rate compared to the rabbits used by the authors. McNitt and Lukefahr (1993) suggested that heavy weaning weight is important and it could lead to attainment of market weight at an early age. The mean linear body measurements obtained was generally lower than the values reported by McNitt and

Lukefahr (1993). The reason could be due to variation in the genetic and environmental (climate, temperature, diseases, nutrition) factors which are known to affect the performance of rabbits.

At 8 weeks of age, there was significant ($P<0.05$) difference in body weight and linear body measurements among all the genotypes. This implies that genotype had influence on growth traits of rabbit at week 8.Chinchilla x Chinchilla showed superiority over other genotypes for five growth traits (BW, HS, LHL, EL and ST), followed by NZ x DU for two traits (BL and HG). This could be because Chinchilla is a hardy breed adapting easily to new environments and is characterized by fast growth rate, efficient feed conversion rate and it has a genetic potential for increased body weight gain (Okorie, 1983). The implication of the result is that the CHxCH proved the best in terms of having the highest preponderance of genes which additively impact on growth traits. This agreed with the findings of Kabir (2010) who reported that the CHxCH breed could possibly increase growth performance because of their higher general combining ability (GCA). The body weight (650.00±17.03g) for CHxCH at 8 weeks of age obtained is lower than the values reported by Obike and Ibe (2010) and Kabir (2010) and this could be due to environmental and genetic differences which affect rabbit's growth. For instance, the body weight for CHxCH reported by Obike and Ibe (2010) was 741.00g while the body weight reported for NZxNZ by Kabir (2010) was 770.61±14.84g but the BL (22.90cm) and EL (9.25cm) obtained for CHxCH was higher than the value reported by Kabir (2010). The value for ST, HTW for all the genotypes are within the range reported by Obike and Ibe (2010).Chinchilla x Chinchilla at 10 week of age still maintained superiority for most of the growth traits over other genotypes. This can be attributed to the greater heritable traits in growth parameters of CHxCH breed as reported by Lukefahr (1987). This could also be that CHxCH breed of rabbit have high milk yielding capacity for maintenance of their kits and the genetic potential of transmitting desirable genes for fast growth rate (Kabir *et al.*, 2012). Body weight at week 10 for NZxNZ (565.00 ±18.88g) and CHxCH (941.30±19.17g) were lower than the value reported by Kabir (2010). The variation could be as a result of non-genetic factors such as diseases, season, temperature, housing, feeding which have been noted to influence post-weaning growth performance of rabbits (Afifi and Emara, 1988). Another reason for this differences could be due to the fact that feed restriction influenced (P<0.01) body weight and LBMs of rabbits as reported by Chiericato *et al.*, (2001). But EL, BL, CG values were within the range reported by Chiericato *et al.*, (2001) at 10 weeks of age.

Genotypes of rabbits at 12 weeks of age had significant (P<0.05) effect on growth traits measured.The differences in body weight for all the genotypes (NZxNZ=738.00±22.52g, CHxCH=1206.00±23.03g,DUxDU=725.00±22.50g,NZxCH=884.00±22.70g,NZxDU=890.00±22.75g, CHxDU=910.00±22.91g) and linear body traits can be attributed to genotype or breed effects. The observed differences agreed with the report of Lukefahr *et al.*, (1980*)* who stated that growth rate and development in rabbit is breed dependent, where some rabbits reach 2000g at 8 weeks of age (Chen *et al.,*1978) while others achieve much poorer growth (Lang, 1981). In all the growth traits measured at week 12 for all the genotypes, CHxCH had higher values than other genotypes except for CG (19.05±0.27cm) in NZxDU which is higher than the value obtained in CHxCH (17.88±0.22cm). This could be because CHxCH had the ability to transmit favourable genes for improved growth rate compared to the other genotypes (NZxNZ, DUxDU, NZxCH, NZxDU and CHxDU). The body weight obtained at week 12 for CHxCH (1206.00±23.03g), NZxCH (884.00±22.75g) and CHxDU

(910.00±22.91g) are higher than the values reported by Onyiro *et al.*, (2008). These differences can be attributed to breed and environmental factors.

Genotypes had significant (P<0.05) effect on the mean growth traits of rabbits at 14 weeks of age.This implies that growth rate and development are breed dependent (Lukefahr *et al.*, 1980). The body weight of all the genotype ranged between (870.00±26.32g-1401.75±27.70g). The results obtained for CHxCH consistently showed superiority in terms of body weight (1401.75±27.70 g) and most of the linear body measurements measured at 14 week of age, which means CH breed had a genetic potential for increased body weight gain at all ages. Therefore, genetic improvement of these growth traits by individual selection method will be successful. Body weight of CHxCH (1401.75±27.70 g) was higher followed by CHxDU (1086.25±27.70g), NZxDU (1048.75±27.70g), NZxCH (1031.25±27.59g), NZxNZ (942.50±26.84g) while the least was obtained in DUxDU (870.00±26.32g).This variation in genotype for growth traits was also reported by Onyiro *et al.* (2008).

5.3 Effect of Feed Restriction on Growth Traits and Mortality Rates of Rabbit

Results obtained show that there were no significant differences (P>0.05) among the different feeding regime (A, B, C and D) for all the growth traits studied (BW, BL, CG, HS, LHL, EL, ST and HTW). The present result agreed with the findings of Tumova *et al*. (2004) who reported no significant differences among rabbits fed *ad libitum* and those on feed restriction. This also agrees with the report of Yakubu *et al.* (2007) who reported no significant difference in final body weight among rabbits fed *ad libitum(*1338.75g), those restricted for 8hrs/day (1248.75g) and skip-a-day feeding (1165.00g). Elhakeam (1992) found that post-weaning duration of food restriction did not affect final body weight of

Californian rabbits at 18 weeks of age. This could be attributed to the fact that rabbits generally have low maintenance requirement. Rabbits equally utilize feed more efficiently than other animal species through the practice of cecal fermentation and cecotrophy (Aduku and Olukosi, 1990). Additional nutrients resulting from this proper digestion could possibly compensate for the restrictions imposed. This finding indicates that rabbits could be raised on *ad libitum* feeding or subjected to any of the feeding regimes in this study without any adverse effect on their growth rate and attainment of market weight. This finding contradicts the report of Urdaneta-Rincon and Leeson (2002) who reported that rabbits fed *ad libitum* had higher body weight than the restricted counterparts. This could be due to individual difference, type of feed, breed and possibly the intensity of restriction.

No significant differences (P>0.05) were found in the mortality rate of rabbits among the feeding regime. The only mortality recorded was in rabbits fed *ad libitum*. The present finding is in consonance with the report of Osman (1991) and Gidenne *et al.* (2003) who reported that feed restriction did not affect mortality of rabbits. Also, Urdaneta-Rincon and Leeson (2002); Gidenne *et al*. (2003); Hassanabadi and Nassiri (2006) stated that early feed restriction helps to adDr.ess problems associated with early life fast growth rate such as high mortality and high incidence of metabolic disorders. The reason for zero mortality in the restricted groups could be due the fact that feed restriction reduces the negative impact of epizootic rabbit enteropathy synDr.ome conditions Boisot *et al*. (2003). The mortality recorded could also be that the rabbits take in more than what their system (digestive system) can handle resulting to metabolic disorders thereby leading to mortality of the *ad libitum* group. Gidenne *et al.* (2003) in their findings indicated that mortality and morbidity were significantly reduced during feed restriction (a feeding level of 80% and 70%, respectively).

5.4 Interaction between Genotype and Feeding Regime

Results obtained showed significant (P<0.05) difference across genotypes at different feeding regimes. NZxNZ rabbits restricted for 6 hours/day had a higher mean body weight (667.00±104.86g) compared to 592.00±111.40g, 580.00±96.55g and 595.00±100.23g for rabbits fed *ad libitum,* restricted for 14hrs/day and 10hrs/day respectively. This corroborates the work of Perrier and Ouyayoun (1996) and Gidenne (1993) who reported that improved digestibility of nutrients and feed efficiency in rabbits at restricted feed period which in turn increased the body weight. But no significant differences (P>0.05) were observed in BL, CG, HS, LHL, EL, ST and HTW. The values obtained however were lower than 1338.75g, 1248.75g and 1165.00g recorded by Yakubu *et al.* (2007). The differences could be attributed to breed difference, age at which the rabbits were restricted and the intensity or duration of restriction.

Significant (P<0.05) differences were observed in term of BW among feeding regime A, B, C and D in CHxCH genotype. The results obtained showed that the mean body weight in rabbits fed *ad libitum* (1049.00g±121.01) was higher than 966.00±104.28g, 889.20±98.24g and 839.20±102.80g for rabbits restricted for 10hrs/day, 14hrs/day and 6hrs/day respectively. This could be as result of reduced feed intake in the restricted groups which depressed growth during the period of restriction, but reduced growth can be later compensated for by realimentation (Szendro *et al*., 1989). Meanwhile, there were no significant difference (P>0.05) between the *ad libitum* group and restricted groups in terms of BL, CG, HS, LHL, EL, ST and HTW. Decrease in the body weight gain during feed restriction is a function of plane of nutrition, thereby resulting in inadequate intake of nutrients required to sustain rapid growth and development (Esonu *et al.*, 2002). This contradicts the report of Yakubu *et al*. (2007) who reported no significant difference (P>0.05) in the final body weight of rabbits fed *ad libitum* (454.94g) compared to rabbits fed 8 hours/day (356.36g) and skip-a-day feeding (331.48g).The variation in body weight in this current study from other authors can be attributed to breed differences, age in which the rabbits were restricted, intensity of restriction and other environmental factors. No significant (P>0.05) differences were observed in all the growth traits studied (BL, CG, HS, LHL, EL, ST and HTW) except in the BW in DUxDU cross. The higher mean body weight was obtained in rabbit fed *ad libitum* (637.00±117.30g), followed by feeding regime B=606.00±95.01g, feeding regime D=578.00±100.56g and feeding regime C=554.00±100.01g. This is because growth rate is slower during feed restriction period than when they have unrestricted access to feed.

Results of NZxCH showed that the rabbits fed *ad libitum* performed better in terms of mean body weight (784.00±119.44g) compare to the mean body weight of 735.00±100.42g, 701.00±102.14g and 679.00±96.89g for feeding regimes D, C and B respectively. This result is in agreement with report of Foubert *et al*. (2008) who reported that a restricted feeding (70% of the *ad libitum* level) resulted in a lower live weight (-8.8%) at the end of restriction period (32-53 days). Tumova *et al.* (2003) also reported that during the restriction period, weight gain in the restricted rabbits was about 60-70% lower than in the *ad libitum* fed rabbits. This is likely because of the reduced feed intake in the restricted groups which in turn affects the growth rate during the restricted period. But there were no significant difference (P>0.05) between the *ad libitum* group and those restricted for 14hrs/day, 10hrs/day and 6hrs/day in all the LBMs (BL, CG, HS, LHL, EL, ST and HTW) measured. In fact, numerically, the restricted groups had higher CG, LHL, EL and HTW in the NZxCH.

The result of the interaction between the NZxDU and the feeding regime showed that the feeding regime significantly ($P<0.05$) influenced the mean body weight but no significant difference in LBMs (BL, CG, HS, LHL, EL, ST and HTW). The rabbits subjected to 10hrs/day feed restriction (feeding regime C) performed better in terms of body weight (818.00±103.97g) followed by the feeding regimes A(782.00±110.50g), B(638.00±97.57g) and D(635.00±100.30g). The reason for this is because feed restriction improved feed efficiency (Dalle Zotte *et al.*, 2005) and increased the gastrointestinal tract length which explained the results obtained. This agrees the report of Gidenne (1993) who reported that rabbits restricted had higher body weight than the rabbits fed *ad libitum* due improved digestibility of nutrients and feed efficiency in restricted rabbits. These results were contrary to the report of Foubert *et al*. (2008) who reported that restricted feeding (70% of the *ad libitum* level) resulted in a lower live weight (-8.8%) at the end of restriction period (32-53 days). The variation could be attributed to individual differences and probably due to some environmental factors. There were no significant differences ($P>0.05$) between the mean body weight of rabbits fed *ad libitum* (792.00±101.11g) the mean body weight 778.00±100.33g, 750.50±103.45g and 739.50±97.08g for feeding regime D, C and B respectively. The result observed in feeding regime A contradicts the report of Tumova *et al.* (2003) who reported that during the restriction period, weight gain in the restricted rabbits were about 60-70% lower than in the *ad libitum* rabbits. The authors also observed that the non-restricted animals had higher body weight throughout the experimental period, but at 11 weeks of age, there was no difference in the daily weight gain between the restricted groups and the non-restricted rabbits. The reason for these differences could be due to amount of feed consumed per day and probably changes in some environmental factors like temperature and relative humidity. The implication of this is that mean body weight and other LBMs are not only influenced by feed restriction but by other environmental factors.

The results obtained across the genotype in the four feeding regime showed significant ($P<0.05$) difference among the genotypes. This results was at variance with the report of Onyiro *et al.,* (2008) who reported non-significant ($P>0.05$) interaction between feeding regime and genotypes. The reason for this variation could be due to the fact that the authors restricted feed based on the percent (%) inclusion of concentrate and forage while in this current study, the restriction was based on hours/day. In the feeding regimes A, B, C and D, the CHxCH had significantly ($P<0.05$) higher BW when compared to other genotypes. This is possibly because the CHxCH still maintained its superiority for mean body weight and some LBMs during the restriction period. Also, the CHxCH had the highest BW (995.00±104.28g) followed by NZxDU (818.00±103.97g) while the DUxDU had the least mean body weight (554.00±100.01g) in all the rabbits restricted for 10hrs/day in all the genotypes. The implication is that if two genotypes with different body weight are restricted for the same hours/day, the genotype with higher body weight before the restriction might still have higher body weight during and after the feed restriction. This means that the differences observed across the genotype is mainly due to difference in breed and their ability to thrive under feed restriction. CHxCH for instance had higher body weight than DUxDU before the restriction and still maintained it throughout the restriction period. Apart from the body weight, other growth traits measured in this study revealed that CHxCH had higher values except for few growth traits (CG, BL and HTW) in feeding regime A, B and C.

5.5 Coefficient of Phenotypic Correlation for Different Traits in Rabbits

Both positive and negative correlation coefficients were obtained in all the growth traits except for those in CHxDU whose correlation coefficients were all positive. Phenotypic correlation values between body weight and other linear parts ranged from low to high (0.00-0.99) in all the genotypes. The high coefficients of correlation suggest possible strong relationship between the traits, and the likelihood of pleotrophic effect of genes operating on them. Therefore, any attempt to select for one trait in a breeding program will automatically result to improvement on those other correlated traits. Previous studies have indicated positive and significant correlations between live weight and body dimensions in farm animals, body dimensions are good indicators and can be used to predict the body weight of rabbits. The positive phenotypic correlations obtained for CHxDU is inline with the findings of Chineke (2000) and Okoro *et al.,* (2010). The authors observed positive relationship between body weight and LBMs such as EL, BL, HS, LL, HG and TL in Chinchilla breed at week 3, 6 and 8 weeks of age. This simply means that as any one LBMs or BW is increasing a corresponding increase is expressed in the other the negatively correlated traits are the inverse. The positive correlation obtained for CHxDU is in concord with the report of Kabir (2010) who reported positive correlation between body weight and LBMs in CHxCH, NZx NZ, CAWxCAW and their crosses. The moderate to high correlation coefficient obtained corroborates the work of (Akano and Ibe 2005 and

Chineke, 2000) in various breeds of rabbits as cited by Kabir *et al*. (2012). The current study was in agreement with the findings of Tiamiyu *et al.* (2000). The values of the correlation coefficients also varied with different LBMs and body weight which affirms the fact that there is variation in the different LBMs and body weight of the rabbits.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS.

6.1 SUMMARY

The CHxCH had higher litter size and body weight at weaning than other genotypes while DUxDU had higher litter size at birth. Therefore, researchers and rabbit farmers in the Northern Guinea Savannah zone of Nigeria are advised based on this study to raise the Chinchilla breed than other genotypes used in this study or cross Dutch with Chinchilla since it has higher reproductive performance. The results of this study further indicated that the CHxCH genotype maintained its superiority over other genotypes for most of the traits measured or studied. For most of the growth traits measured after weaning indicated that CHxDU cross was the best combination. Generally, it was observed that the CH breed performed better than crosses with either NZ or DU.

The correlation coefficients ranged from low to high and there are various degrees of relationships for all the traits measured except for growth traits obtained in CHxDU were all positively correlated. This is in line with other literature reports.

From the results obtained for the effect of feed restriction, it was observed that feed restriction has no significant ($P>0.05$) effect in all the growth traits measured (BW, BL, CG, HS, LHL, EL, ST and HTW). In the interaction between feeding regimes and genotypes, there were significant difference ($P<0.05$) in terms of body weight for CHxCH, DUxDU and NZxDU. In fact, some restricted groups had higher value for some LBMs than *ad libitum* group within genotype. Although they were not significantly different.

6.2 CONCLUSION

1 The Chinchilla x Chinchilla offsprings at weaning had higher litter size (4.00±1.15) and weight (2026.67±612.89g) than other genotypes

2 The Chinchilla x Chinchilla offsprings maintained its superiority in terms of body weight and most of the linear body measurements studied from 6 to 14 weeks of age. The body weights obtained were 480.00±12.31g, 650.00±17.03 g, 941.30±19.17g, 1206.00±23.03g and 1401.75±27.70g at week 6, 8, 10, 12 and 14 respectively which is higher than other genotypes at those ages. This means that the breed is the best for selection and breeding/production purposes aimed at improving post-weaning growth traits of meat type rabbits in the Northern Guinea Savannah zone of Nigeria.

3 During scarcity of feed, rabbit farmers or raisers can adopt any of these feeding regimes (14hrs/day feed restriction, 10hrs/day feed restriction and 6hrs/day feed restriction) without any adverse effect on the performance of rabbits. The mean body weights of the rabbits feed *ad libitum*, restricted for 14hrs/day, 10hrs/day and those restricted for 6hrs/day were 772.67±38.72g , 688.62±32.16g, 730.75±35.24g and 705.37±33.45g respectively which were not significantly different ($P>0.05$). Therefore, any of these feeding regimes can be exploited in the feeding of rabbits, especially in periods of scarcity of commercial feed and forages for rabbit feeding. Also, the *ad libitum* feeding had mortality of 0.13±0.05 while no mortality was recorded in all the restricted groups (14hrs/day feed restriction, 10hrs/day feed restriction and 6hrs/day feed restriction).

6.3 RECOMMENDATIONS

1. Chinchilla x Chinchilla genotype is recommended for higher litter size and litter weight at weaning and for its superiority for most of the growth traits measured (BW, BL, HS, LHL, EL, ST and HTW) after weaning.
2. Farmers or rabbit raisers can adopt any of these feeding regime (14hrs/day feed restriction, 10hrs/day feed restriction or 6hrs/day feed restriction) without any adverse effect on the performance of rabbits.

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