PERFORMANCE OF NEWZEALAND WHITE, CALIFORNIAN AND CHINCHILLA RABBITS AND THEIR CROSSES IN A WARM TROPICAL ENVIRONMENT

BY

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DECLARATION

I hereby declare that this thesis has been prepared by me and that it is a record of my own research work. It has not been presented in any previous work for a higher degree.

---------H.K. Yahaya--------- Date:--10/8/93--

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CERTIFICATION

This thesis "Crossbreeding Experiment with Newzealand White, Chinchilla and Californian Rabbits" by Hajiya Hauwa'u Kulu Yahaya (Mrs) meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To

My husband Yahaya Abubakar

AND

Children

Rukayyat, Abubakar, Amina, Saratu, Khadijat, Ramat and

Mohammed Bashir.

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ABSTRACT

Mating within Newzealand White (NN), Californian (CC) and Chinchilla (CH) rabbits and between all possible crosses were carried out. A total number of 259 kittens obtained from 65 does and 32 sires were analysed to evaluate various performance traits. Results obtained indicate that sirebreed had no significant (P>0.05) effect on GESTL (gestation length), WTs (kitten body weight at 8weeks of age), NOSURV (number of Kittens survived to 8 weeks) and PMORTOT (total percent mortality %) . However, CC and NN had higher (P<0.05) Lsize (litter size) (5.35+0.5 and 5.37+0.4) and higher (P<0.05) MBWT (44.14+3g and 48.49+3g. NN was observed to produce kittens with higher (P<0.05) LBWT (Litter birthweight) (242.29+19g), higher (P<0.05) Noweaned (Number of kittens weaned at 4 weeks) 2.45+0.3 and had lower (P<0.05) MWD% (Percent mortality at weaning %) (42.63+7). NN and CH had heaviest (P<0.05) kitten body weight at WT2, (Kitten body weight at 2 weeks), WWT4 , (Kitten body weight at 4 weeks) (146.70+4.3g and 149.89±5.7g), (258.64+7.1 and 258.82+9.3) and WT$, (Kitten body weight at 6 weeks) (394.72+1.7g and 420.25+13.5g). Dam breed had no significant (P>0.05) effect on GESTL, MBWT, WT2, WWT_4, MWD% and PMORTOT %. All the dams were observed to have similar GESTL (30.72+0.8, 31.24+0.7days and 31.33+0.7 days). NN and CH had higher (P<0.05) Lsize (6.17+0.5 and 5.03+0.4), LBWT (239.62+21g and 220.85+18g),

Noweaned (2.65+0.4 and 2.17+0.3) and Nosurv (2.40+0.3 and 2.10+0.3). At 6 and 8 weeks of age, CC and CH had kittens with heavier (P<0.05) body weights (392.86+14.9g and 401.35+10.3g) and (524.54+19.6g and 546.59+13.Og). Season had no significant (P>0.05) effect on GESTL, Lsize, LBMT, MBWT, Noweaned and MWD %. However, kittens kindled between June and September gave higher (P<0.05) body weights at all sampling periods, Nosurv and lower (P<0.05) PMORTOT %.

Pure breeding had no significant (P>0.05) effect on GESTL, kitten body weights at WT_2, and WWT4, NN x NN had highest (P<0.05) LBWT (213.33+14g) while NN x NN and CC x CC had higher (P<0.05) MBWT (53.79+4g and 52.14+3g) with NN x NN and CH x CH having higher (P<0.05) Lsize (4.08+0.4 and 4.64+0,4). At WTe, and WTs CC x CC and CH x CH had heavier (P<0.05) kitten body weights (414.77+24.85g and 434.48+21.65g) and (578.57+33.78g and 580.00+29.26g), while NNxNN and CHxCH had higher (P<0.05) Noweaned (3.17+0.5 and 2.82+0.5) and Nosurv (2.67+0.4) and 2.64+0.4) with CC x CC having the highest (P<0,05) MMD % (46.25+10) and PMORTOT % (47.50+10).

Crossbreeding had a significant (P<0.05) effect on all parameters considered. GESTL ranged from 29.25+0.8 days 32.57+0.9 days with CC x NN, and CH x CC having the highest (P<0.05). NN x CH, CC x NN and CC x CH produced highest (P<0.05) LBWT (238.00.+ 22g, 241.25+25g and 232.69+20g) while NN x CC and NN x CH had heaviest MBWT (49.58 + 3g and

46.35+3g). CC x NN, CC x CH and CH x NN had highest (P<0.05) Lsize (6.25+0.6, 5.46+0.4 and 6.13+0.6). At WT_2, CH x CC had kittens with heaviest (P<0.05) body weight (190.00+13g), at WWT-t, NN x CH and CH x CC (247.73+9g and 295.00+18g), at WTe, CH x CC (500.00+31g) and at WTa, NN x CH (513.64+16g). CC x NN had highest (P<0.05) Noweaned (2.75+0.6 while NN x CH, CC x NN and CH x NN had highest (P<0.05) NOSURV (2.20+0.5, 2.25+0.6 and 1.88+0.6). However, CC x NN had lowest (P<0.05) MWD % and PMORTOT % (45.83+12 and 48.33+12).

Crossbred rabbits had higher LBWT and Lsize than the purebreds except for CH x CC (157.14+24g and 3.78+0.5). However, purebreds had higher MBWT, higher kitten body weights at WT_2, WWT4, WT_6, WT8, Noweaned, NOSURV, lower MWD % and PMORTOT % than their crosses.

CHAPTER ONE

INTRODUCTION

Among man's requirements are food, shelter, clothing, recreation, transportation and aid in carrying out heavy work. These requirements have been met largely by both the plants and animals which man has domesticated through out the ages (Snyder and David, 1957). The domestic rabbit breeds are decendants of the European wild rabbits Oryctolagus cuninculus found in the mediterranean countries. The rabbits have six incissor or chisel teeth hence are classified as members of the order Lagomorpha with family Leporidae and a major genera Oryctolagus (Fox, 1974).

Beginning in the late 19th century and picking up speed in the 20th century, hutch rearing led to a rabbit population explosion. This was made possible by the selection, protection, and multiplication of breeds and mutants unadapted to the wild (Lebas et al. 1986). The early breeders took great advantage of large variations in body size and coat colour characterististics to establish a variety of new valuable breeds by selection for both meat, fur, fancy and as laboratory animals (Fox, 1974). The economic importance of each breed depends on the purpose of its usage and that is, either for meat and/or wool or hobby (Arrington and Kelly, (1976). Rabbits are grouped on the basis of adult size (mature live body weight) in to three

breeds, viz: heavy breeds, average breeds and light breeds (Arrington and Kelly, 1970, Lebas et al., 1986). The heavy breeds which include the Flemish Giant; Bouscat Giant White and French Lop exceed 5.0 kg with sexual maturity at eight to ten months of age. The average breed or medium breed where the Newzealand White and Californian White belong varies from 3.5 kg to 4.5 kg and attain sexual maturity between five and six months of age and the light breed or small breeds where the Dutch and Small Chinchilla belong have an adult weight of 2.50 to 3 kg with sexual maturity at about four to five months of age. An alternative method of grouping rabbits is based on purpose such as for meat production where breeds such as Newzealand White, Standard Chinchilla, Satin and Californian White rabbits are used. The second group is for hobby or fancy where breeds such as Florida White, Havanna Tan and many others are used while the third group is for research or as laboratory animal where Dutch and Newzealand White rabbits are used (Arrington and Kelly, 1976). Rabbits were distributed to various parts of the world by early sailing vessels whose masters wished to have readily available source of meat on their voyage (Aduku and Olukosi, 1990). This may likely be the means of early introduction of the domestic rabbit to Nigeria. In 1971, the Dutch and Newzealand White breeds of rabbits were brought in to Nigeria by the help of the British Government (Balogun and Balogun, 1980) with the aim of multiplying the animals and

distributing them to interested individuals and organisations. The domestic rabbits have been seen by most Nigerian populace as pets and it is only in recent times that their importance as source of meat is being promoted by some agricultural establishments such as National Agricultural Extension (NAERLS), ABU, Zaria and of more recent Directorate of Food, Roads and Rural Infrastructure (DFFRI).

In the past two decades the world population has increased greatly and especially that of the developing countries in which approximately two-thirds of the world's population live and continue to increase (F.A.O., 1978). Nigeria has moderate population increase, faces economic depression and continues to experience protein deficiency (Okon, 1988). It has been estimated by F.A.O. that the annual increase in meat consumption is from five to seven percent (Aduku and Olukosi, 1990). Olayide et al. (1972) put the total daily intake of protein by the average Nigerian at 53.83 grams of which only 8.32 grams was from animal sources. Mayer (1976) observed that while in some of the developed nations at least 60 grams of animal proteins were consumed per capital per day, only 5.5 grams was consumed in Nigeria. It has been estimated that about 65 grams of protein will be needed per person per day between 1985 - 1990 out of which 26 - 32.5 grams will be from animal sources (Okon, 1988) while Awogbade (1986) put the minimum target of protein intake in Nigeria for 1992 at 60 grams per caput per day. The

estimated protein needs of Nigeria is 35 grams of animal protein per caput per day. The present supply of less than 10 grams per day leaves much to be desired (Denenu, 1989). Under the present economic situation, there is the need to increase meat production to match the population growth using animals with least or low cost of production and to maximize bioeconomic returns. Meat increase will therefore come from short production cycle animals amongst which is the rabbit (Umaru, 1987, Okon, 1988) since the ruminants such as cattle, sheep and goats have a relatively slow production cycle (Cheeke et al. 1982). Growth rate in rabbit is similar to broiler chicken (Khalil et al., 1986, Rao et al., 1977, Chen, 1978) and of all major livestock species in the world, rabbits ranked 5th behind swine in total number (Lukefahr 1985). Rabbits have a great potential for meat production due to their ability to efficiently utilize fibrous cellulose-based feed stuff not suitable for human consumption as compared with poultry and pigs that require food sources which are in serious competition with man. Their ability at converting forage to meat is more efficient than that by ruminant animals. Rabbits can produce about five times as much meat as beef from a given amount of alfalfa (Cheeke et al., 1982). They also incorporate more protein in their body (21.0%) than do broiler chickens and their feed protein utilization is also more efficient. The rabbit meat is all white, fine grained, delicately flavoured and is extremely

low in fat, cholesterol, and sodium levels (136 miligram % and 393 ppm respectively) but with higher proportions of essential polyunsaturated linolenic and lenoic fatty acids hence low in caloric contents and may play an important role in the prevention of vascular disease (Rao et al., 1979, Cheeke et al., 1982, Lukefahr et al., 1989, and Aduku and Olukosi, 1990). Although it should be possible to count on certain progress by means of pure breeding combined with strict selection, the wide spectrum of rabbit types in the world suggests a great possibility of increasing optimal combinations of germ plasm resources to increase production (Masoero, 1982). It seem important to test whether better slaughter charateristics and consequently a more economic production which are both quicker and more effective could be achieved by systematic crossbreeding. Mach et al. (1984) has reported that cross-bred rabbits were the heaviest and have the heaviest carcasses. The results of work done by Lukefahr (1985) indicated that litter growth, disease resistance and slaughter weight of terminal crosses could be improved by using a large sire breed on a pure breed or cross-bred females having Newzealand White dams. Increased rabbit production could therefore bridge the supply-demand protein gap and it is by far the most appropriate type of production system for subsistence meat since it can be produced on forage alone, requires only a fraction of the farmer's land for the production of feed. The amount of capital required

for the equipment and for the animals is low compared with other domestic animals. Despite the rabbit's high heritability for growth and carcass traits as compared to other types of livestock production, there has been little commercial development of hybrids, use of well designed crossbreeding schemes or other techniques that are routine in other type of livestock enterprises - hence the aim of this experiment.

Objectives

1. To examine the effect of sirebreed, dambreed and season on the reproductive performance of Newzealand White, Californian White and Chinchilla rabbits.
2. To evaluate the growth performance of Newzealand White, Californian White and Chinchilla breeds of rabbits under tropical conditions using the intensive management system.
3. To examine differences in preweaning performance traits among purebred and crossbred rabbits.

CHAPTER TWO

LITERATURE REVIEW

2.1 Effect of sire breed on reprductive performance

Breed differences have been reported for reproductive traits, though this have not been extensivelly studied (Lukefahr et al. 1983a). It has been reported that littersize and weight at 56 days and litter gain tended to be lower in Newzealand White compared with Californian White-Sired litters while mortality was higher in progeny of Newzealand White-sires (Lukefahr et al. 1983c). It was also reported that percentage early survival and litter birth weight were strongly influenced ($P<0.01$) and fertility percentage tended ($P<0.08$) to be influenced by sirebreed, with number weaned, late survival, litter weaning weight not being affected to a statistically significant extent (Lukefahr et al. 1983a). However, important sire breed effects on preweaning litter survival (Rouvier (1973) and for individual weight traits Carregal (1980) have been reported. Sinkovics and Szeremy (1980) attributed high pre-weaning mortality to malnutrition.

2.1.1 Reproductive performance as affected by doe genetic composition

In rabbit, early growth and survival are dependent in part on the intrinsic ability of the dam to provide an adequate maternal environment. One major post-natal trait is milk production. Lebas (1969) reported a strong influence of

milk yield of the doe on preweaning growth rate of the litter while Venge (1963) observe differences in milk production among dam breeds devergent in adult body weight.

Cowie (1969) have reported Newzealand White does to surpass Dutch does in total milk production over a period of six weeks while Lukefahr et al. (1983) detected significant variation (P<0.01) among 225 doe records for litter size at 21 days, body weight at kindling, feed intake and efficiency in Newzealand White, California, Californian x Newzealand, and Newzealand White x Californian doe genetic groups. Straight breed Newzealand White was superior (P<0.01) to Californian does for milk production (3.97 versus (vs) 3.06 kg). Bartelli and Altomonle (1968) cited by Lukerfahr et al. (1983) similarly reported Newzealand White does to exceed Californian does in milking ability in their experiment using 21 day weight as a reflection of milk production.

Patridge et al.(1981) demonstrated breed superiority of Newzealand White does for number born and reared per litter. Lukerfahr et al. (1983) observed that Newzealand White does were heavier than Californian White does at first breeding at 154 days and produced heavier litters at birth and weaning (all P<0.01) and more efficient in converting feed to milk.

2.1.1.2 Gestation length:

Gestation always depend upon well functioning corpra lutea. The implantation of the embryo is carried out by tufts located on a disc-shaped zone on the placental membrane. This zone and the adjacent uterine mucosa start to unite intimately 6 - 7 days after fertilization and lose their superficial cell layers. Eight to nine days after insemination and fertilization, the embryoes are evenly spaced within the pregnant uterus. The bubble-like convexities of the embryoes with their placental membranes feel like a closely spaced row of fat pearls. Beginning at the 14th day, one can feel the uterus with its embryonal enlargement by palpation of the abdomen.

Peter et al. (1968) observed that gestation period or time from mating of the does to kindling of the litter averages 31 days and about 98% of normal litters will be kindled between the 30th and 33rd days but a small percentage may be kindled as early as the 29th or as late as the 35th day. Similarly Dim et al. (1989) observed that duration of pregnancy from day of mating varied between 30th and 33rd days with an average of 31 - 32 days. Duration of pregnancy from double mating was shorter than that from single or control mating ($P<0.001$).

Pickard (1930), Rosahn et al. (1934, 1935), Dudley (1952) and Venge (1963) reported that gestation length varied significantly with breed group. In a study with pure bred and

cross-bred litters produced by Bouscat, Giza White, White Flander and Baladi Red rabbit, the mean duration of pregnancy varied with breed group from 31.5 - 32.6 days. Differences in duration of pregnancy due to breed group effects were significant ($P<0.05$) and accounted for 2.33 of the total variance. The average duration of pregnancy was 31.9 days but reported relatively higher mean pregnancy duration for Giza White and Bouscat litters (31.5 and 31.6 days respectively) (Afifi et al., 1985). However, El-Ekishin et al. (1951) and El-Tawil et al. (1971) observed that mean pregnancy duration ranged from 30.6 - 30.8 days for the first breed and from 31.0 - 31.4 days for the second breed. On the contrary, Stalinski (1959) and Shawer (1963) found non-significant breed group differences in this trait. Similar findings were reported by Cuevas (1975) who found no difference in gestation length for Burgundy Fawn (31.67 days) Chinchilla 31.79 days and Newzealand White (32.03 days). Lee et al. (1989), however reported similar but significant breed differences in gestation length for does of Newzealand White, (31.2 days) and Califronian White (31.8 days) respectively.

2.2 Litter size

Litter size in rabbits is one of the most important factor contributing to productivity of does. The larger the number of young, the doe kindles and weans, the greater the likelihood of profitability (Afifi and Emara, 1987). Gregory (1932) indicated that litter size depends on the number of

eggs produced after mating and this number depends on the body size of the breed. On the other hand, Sandford and Woodgate (1974) observed that litter size is largely controlled by two different sets of factors, namely; genetic and non-genetic. The non-genetic factors: nutrition, age of doe, season, maternal environment, parity, and diseases all have their effects.

2.2.1 Breed differences with litter size

There is some variation in the size of litter produced by the different breed of rabbits, smaller breeds producing smaller litters while the large breeds have larger litters. Rao et al. (1977) in his work with Newzealand White rabbit observed that a littersize of seven occured more frequently than any other size. Litter size of 8.0 and 8.7 can be obtained among Newzealand White and Flemish Giant, a greater value of 9.1 among Newzealand White X Dutch progeny (Scholaut 1981) while Lukerfahr et al. (1983) reported a littersize of 8.91±0.54, 8.04±0.53, 10.60±0.63, 8.13±0.80 for Newzealand White, Californian, Californian x Newzealand White and Newzealand White X Californian doe genetic groups respectively. Similarly, Gugushvil (1983) obtained average littersize of 7.6, 8.0, 8.0 and 6.6 for Grey Giant (GG), Soviet Chinchilla (SC), Newzealand White (NZW) and Californian White (CW) rabbits, and 8.2, 9.0, 8.0 and 8.0 for CW X NZW, NZW X CW, SC X GG and GG X SC matings respectively. Garcial et al. (1980) in Lebas et al. (1986) obtained 7.04

and 7.23 live births per litter for Newzealand White and Californian breeds. However, in a study with Egyptian and exotic breeds and their crosses, a mean litter size of 6.43 versus 5.87 young in crossbred groups and parental pure breeds at birth and at weaning 4.29 versus 3.98 youngs respectively was observed. (Afifi and Emara, 1987).

With the work done with pure breeding and commercial crossisng of broiler types rabbits using Newzealand White, Californian White, Burgundy fawn, Big Marten, Argente de Champague, Giant Chinchilla, Czesh White and Morovian Giant rabbits average litter size of 6.6 for pure-bred litters versus 7.5, 8.4, and 8.4 for 2-3, and 4-breed crossbreds, respectively at birth and 5.2, 6./0, 6.9, 6.6 respectively at weaning (Mach and Safarova, 1989). Stawinski and Arias (1989) using Californian, Chinchilla and Californian X Chinchilla crossbred females mated to Newzealand White males reported average number of live young at birth as 8.93, 10.08, and 9.93 for Californian White, Chinchilla and Californian White X Chinchilla crossbred rabbits. In Newzealand White and Californian rabbits litter size at birth averaged 7.05 and 5.59 respectively and 6.70 and 5.52 at weaning (El-Maghwary et al. 1990). On the other hand, Zimmermann et al. (1990) reported an average litter size of 8.60±3.1, number of live born young per litter 7.64±3.5, and number weaned per litter 6.11±3.4 in Newzealand White rabbit. Zoccarato et al. (1990) obtained 8.47 and 8.32 average litter size at birth and 6.78

and 7.31 litter size at weaning. The work was with local breeds of grey rabbits using Newzealand White as a control. Bhasis et al. (1989 and 1990) reported average litter size of 6.06, 6.37, 6.03 and 6.27 respectively at birth and 4.57, 4.56, 4.51 and 4.39 at weaning using Newzealand White, Flemish Giant, Soviet Chinchilla and Grey Giant rabbits.

2.2.1.2 Doe's birth littersize

Littersize may be regarded as a measure of fertility. It has been observed in mice that females from large litters produced littersizes lower than average (Falconer, 1960). Babile and Matheron (1980) reported a difference of 1.07 and 0.73 for the total and live-born rabbits between maternal groups from litters of 5 and 11 animals while differences of 1.03, 1.01, and 1.55, respectively between groups for total number born, number born-alive and number weaned animals (Bibile et al., 1984). With the work done with Newzealand White and Californian rabbits, Zsolt et al. (1989) observed that size of the litter in which the doe was born and reared does not have the same effect in all populations on later production. The reproductive performance of does originating from large litters is lower than that of females from small litters of 2-9 kittens and does from litters of 10 - 11 kittens performed above average although the differences were not significant ($P>0.05$).

2.2.1.3 Effect of nutrition

The plane of nutrition affects reproduction and consequently the litter-size of rabbits. Inadequate nutrition during the dry season will result in a low release of pituitory gonadotropins and this may influence the response of target organ to either gonadotrophins or gonadal hormones (Marshall and Hammond, 1952). Increasing the plane of nutrition 4 days before and one day after mating results in considerable improvement in fertility (Broek and Lampo, 1978). Omole (1982) reported that litter size at birth increased with increasing levels of protein in the gestation diet and that still births could be largely reduced by high protein diet.

2.2.1.4 Effect of temperature

The rabbit has a normal rectal temperture of about 38°C and a critical rectal temperature of 41.7°C. Owen et al. (1977) found that rabbits exposed to temperatures of 43.3°C with relative humidities of 30 to 40% for one hour experienced 2.5°C increament in body temperature. However, the rabbit can undoubtedly acclimatise to temperatures of up to 31°C. Rabbits are susceptible to heat stress as a result of few functional sweat glands occuring only on the claws (Cheeke et al., 1987). Owen (1976) reported that in the tropical regions, fertility of the male rabbit is impaired and embryo mortality in the female is increased during periods of high ambient temperature. However, a total birth

of 7.8 and 7.0 and of 6.6 and 6.2 live births for Calfornian and Newzealand White breeds respectively, were reported in Cuba, which has a wet tropical climate (Ponce de Leon, 1977). Similarly Elamin (1978) reported average figures from the Sudan for the Californian and Newzealand White breeds as 7.10 and 7.49 for litterszie and 6.67 and 6.94 for live births per litter, respectively. On the other hand, Paez et al. (1980) gave the breeding parameters of Newzealand White and Californian breeds raised in Mexico, a tropical zone tempered by an altitude of 1800 metres as 8.5 and 8.0, and 8.0 and 8.72 for littersize and live births per litter. Although it has been observed that environmental temperature was related to litter-size, with the largest litters being born during the periods of lower temperature. These workers attributed this effect to the does requiring a greater proportion of the available energy for maintenance of body heat in the cooler periods. This led to a reduction in either ovulation rate or in the size of the litter which could be supported in utero (McNitt and Lukefahr, 1983). Trammell et al. (1989) observed that higher temperature influenced the metabolic and hormonal states of does and had a carryover effect that greatly reduced reproductive capability. Only two of nine does in the experimental group (at 32.2°C and 50% relative humidity) kindled with a mean littersize of 3.0 while eight of nine of control does (16.8°C and 53% relative humidity) kindled with a mean litter size of 5.9.

2.2.1.5 **Effect of season**

Seasonal variation in litter size was investigated by Sittman et al. (1964) and observed that total littersize at birth and number born alive per litter exhibit a seasonal trend. Monthly average littersize was shown as ranging between 6.49 and 8.07. The total littersize decreased from a high in the month of February to a low in the month of September. Their data indicated total littersize exhibiting an inverse relationship to the monthly maximum temperature.

Effect of parity

Rollins et al. (1963) on analysing the breeding record of 1472 litters of randomly bred Newzealand White rabbits observed that the sequence indicate greatest numbers born alive in second litter, fewer in the fourth and fifth litters and smallest in the first litters. Similarly, Broek and Lampo (1975) observed highest litter-size at the second and third litters after analysing data on 1228 Dendermonde breed litters. However, Lukefahr et al. (1981) observed that parity of the doe does not influence the littersize at birth or at 21-days of age but El-Maghawry et al. (1990) observed that parity significantly affected litter size at birth in Newzealand White rabbits.

2.2.1.7 **Effect of frequency of mating in a day**

Dim et al. (1989) reported that litter size is controlled partly by the doe and partly by the buck and that double mating within one hour interval produced the greatest

number of kits per litter. The authors also indicated very highly significant difference ($P<0.001$) between double and single or control mating.

2.2.3 Litter birth weight

The birth weight of rabbits varies, but it is in the interest of the rabbit breeder to strive towards as high birth weight as possible (Standford, 1979. The rabits birth weight as the product of prenatal growth period is affected by its genotype and its dam that furnishes the prenatal environment (Afifi *et al*., 1987). Standford (1979) stated that the size of the dam as well as littersize has the greatest influence on birth weight.

Mean kit weight was reported to range from 49.0 to 58.8 (Afifi *et al*., 1973, Afifi *et al*., 1982) and from 53.4 to 66.1g (Lukefahr *et al*., 1984) while Szendro and Barna (1984) gave a range of 53.0 to 67.6g. However, Afifi *et al*. (1985) revealed that mean birth weight averaged from 43.8 to 58.8g for rabbits raised in Egypt.

In an experiment using Bauscat, Giza White, White Flender and Baladi Red breeds in a diallel crossing programme, Afifi *et al*. (1987) reported an overall mean birth weight of 55.8 grams and a standard devaition of $\pm$ 12.8 grams. Other literature cited revealed average birth weight of 58.52 ± 1.06 and 57.13 ± 1.11g (Ledur and Garregal, 1989) while Lui *et al*. (1989) in a study with Californian, Dutch and Newzealand White rabbits reported that for rabbits sired

by males of the three breeds, birth weight averaged 56.98, 56.15 and 57.3g. A litter birth weights in grammes of 497±31, 412±29, 575±36, and 471±45 have been reported on 280 litters of straight bred rabbits from four doe genetic groups Newzealand White, Californian White, Californian X Newzealand White and Newzealand White X Californian (NN, CC, CN, NC) respectively (Lukefahr et al. 1983) while El-Maghawry et al. (1990) in a study with Newzealand White and Californian rabbits obtained 425.90 and 403.91 grams average litter weight at birth and birth weight of 62.52 and 63.03 g in the two breeds, respectively.

Lukefahr (1982) reported estimates of repeatability of 0.09 for litter birth weight while Lampo and Van de Broek (1975) in Lukefahr (1983) obtained 0.12. Similarly Lukerfahr et al. (1983) obtained repeatability of 0.33 litter birth weight.

2.2.3.1 Effect of doe weight and littersize on birth weight

It has been reported that a doe weighing about 3 kg will on average produce young weighing about 35 g while a doe weighing about 5 kg may have young weighing as much as 60 g. Good birth weight along with medium littersize tends to decrease the mortality of rabbit production (Lang 1981). It has been observed that the young from a small litter is supposed to weigh twice as much as the young from a larger litter, all things being equal (Standford, 1979).

2.2.3.2 **Effect of Nutrition and Age**:

The availability of the nutrients to the developing litter during the latter half of pregnancy influences the birth weight of the offspring (Hammond, 1937, Standford, 1979), while Lerner and Donald (1966) observed that the competition between litter mates in the uterus before birth causes a reduction in birth weight. On the contrary, Lebas (1975) found that the restriction of feed intake of does during pregnancy had no noticeable effect on birth weight. This was supported by Omole (1982) who reported that birth is not influenced by protein intake during gestation. However, Lukerfahr et al. (1983) reported that quardratic regression effect of age of dam at kindling significantly influenced litter birth weight. The curve increased but at a decreasing rate as age of dam increased. In a study of inheritance of age at first breeding, litter size and weight in rabbits using 171 daughters of 20 New Zealand White sire, Lahiri and Mahajan (1982) reported 0.37±0.01 kg litter birth weight at the average mating age of 166.90±2.03 days.

2.2.4 **Weaning age and weaning weight**:

Weaning weight of any animal is a result of several factors interacting with one another, some of which are genetic and other environmental. Under most commercial breeding programmes, the young are weaned at eight weeks and at that time should weigh approximately 1.8 kg each, smaller litters (under five young) can be weaned at an earlier age and the doe rebred (Hagen, 1974). Lebas (1969) in David

(1978) demonstrated that weaning weight depends on the milk production of the does and to a lesser extent, on the ability of the kittens to make fast and efficient gains. Lebas (1971) suggested that rabbits could be weaned at 21 days considering the fact that milk production of the doe decline during the fourth week after paturition. At this time the weight of the litter is no longer related to milk yield as the young are consuming approximately 90% of their intake in the form of plant protein (Hagen, 1974), Fahmy et al. (1978) reported that litter weight at weaning when considered individually could be one of the best estimates of productivity since it is a function of all preweaning effects.

In a study on litters from 18 does mated with Californian, Dutch and Newzealand White (CC, DD and NN) male rabbits, Lui et al. (1989) obtained 498.47, 530.94 and 523.14g ($P<0.01$) body weight at 28 days and, 1805.58, 1469.68 and 1753.89g ($P<0.01$) body weight at 70-day respectively. Stawinski and Arias (1989) reported 1051.29, 1009.10 and 1069.88g body weight at weaning (42 days) for Californian (CC) and Chinchilla does mated to bucks of the same breed and Californian crossed Chinchilla does mated to NN White bucks. On the other hand, Ledur and Carregal (1989) in a study with 458 purebred (NN or CC) and crossbred (NN X CC or CC X NN) rabbits reported 296.31±6.65 and 308.74±7.06g body weight at 21 days, at 28 days (weaning) 475.33±10.94 and 504±11.62g body weights and at 70 days 1715.92±29.23g and 1691±31.05g

body weight. Zoccarato and Pangan (1990) obtained 589.9 and 543.6g (P<0.01) average body weight at 28 days and 2763.6, 2665.0g at 90 days in a study with Grey and NN rabbits while El-Maghawry et al. (1990) reported 652.14 and 589.28g for NN and CC rabbits body weight at 28 days. Zimmermann and Dempfle (1990) in a study with NN rabbits obtained body weight at 8-12 weeks of 1766±308 and 2770±316g, respectively for males and 1702±285 and 2718±324g for females.

2.2.4.1 Effect of season of the year and age of doe

In a study with randomly bred Newzealand White rabbits, Casady et al. (1962) observed that there were significant season and age of doe effect on individual weaning weight. Individual weaning weight of a doe's first litter were lower (1.7kg) than litters two through five (1.8kg) and (1.8kg) for litters six through ten. These observations were based on breeding records collected in Southern Californian which showed that March and Appril produced maximum weaned weight (1.8kg) while the months of July through October produced the lowest (1.6kg) weaned weight for a doe's first litter. Lahiri and Mahajan (1982) in a study of inheritance of age at first breeding using Newzealand White rabbits reported 3.93±0.08 kg litter weight at weaning (6 weeks).

CHAPTER THREE

MATERIALS AND METHODS

Location and Climate:

The data utilised for this study originated from the National Animal Production Research Institute (NAPRI), Shika-Zaria, Nigeria. Located between latitude 11° and 12°N, at an altitude of 640m above sea level and within the Guinea Savannah ecological zone of Nigeria.

The average annual rainfall is 1100 mm, most of which falls during the months of May to October. Peak rainfall is recorded during the wet season (June to September) with the average relative humidity and daily temperature of 72% and 25°C respectively. The dry season commences with a period of dry cool weather called Harmattan lasting from about mid-October to January. This is followed by hot dry weather conditions from February to May. At this period, daily temperatures range from 21°C to 36°C while mean relative humidity is 21%.

3.1 Feeding and Management:

All the experimental animals were fed on the same diet with groundnut cake used as the major protein source and clean water supplied daily. The composition of the ration used is as follows:

Maize	36.6%
Rice bran	30.0%
Groundnut cake	30.0%
Bone meal	2.80%

Vitamin premix	0.3%
Salt	0.3%

Proximate analysis of the feed is as follows:

Dry matter	94.68%
Oil	6.74%
Crude fibre	9.84%
Crude protein	21.02%
Ash	9.60%

All the animals were fed once daily using small earthern pots as feeders and wateres. Dried Delicus lab-lab was served once in a while.

The animals were housed individually, in wire cages with each cage measuring 140 cm x 112 cm x 48 cm high. Dead animals were removed immediately when noticed, while sick ones were isolated and treated. Each doe was weighed before mating. A nestbox measuring 41cm x 31cm x 21cm made from 12mm ply-wood or earthen nest pot of diameter 31cm x 10cm deep was provided for each doe from the 27th day of pregnancy.

3.1.1 Mating Procedures

Three doe genetic groups in a nested design were used in this study. Litters from the three sire breeds were represented in each doe genetic group. The three breeds used were Newzealand White, Californian and Chinchilla. The system of mating used permitted the production of litters representing the three pure breeds and their single crosses in all possible combinations in each parity.

Table 1: Mating Plan

Sire Breed*	Dam Breed	Offspring
NN	NN	NN x NN
NN	CC	NN x CC
NN	CH	NN x CH
CC	CC	CC x CC
CC	NN	CC x NN
CC	CH	CC x CH
CH	CH	CH x CH
CH	CC	CH x CC
CH	NN	CH x NN

*Sire breed abbreviations of NN, CC, CH are codes for straight breed Newzealand White, Californian White and Chinchilla bucks respectively. Dam genetic group abbreviations of Newzealand White, Californian White, and Chinchilla are NN, CC, and CH respectively.

A total number of sixty five (65) does consisting of twenty two (22) Newzealand White (NN), eighteen (18) Californian White (CC), and twenty five (25) Chinchilla pure bred (CH) were involved. 32 sires consisting of 11 NN, 10 CC and 11 CH were used at all times to minimize inbreeding. Three sire breeds of NN, CC and CH purebreds produced a total of 259 kittens from one hundred and nine matings. The animals used are of the same parity. The breed of each doe's first mating was chosen at random, with buck for her second and third matings coming from the remaining two sire breeds but with a restriction to avoid fullsib and halfsib matings. The specific buck used for mating was always one of the appropriate breeds with the greatest time interval of two days since the previous mating. Does were taken to the buck's cage for mating. Mating was done in the morning

between 7.00 a.m. and 9 a.m, and diagnosis of pregnancy through abdominal palpation followed after ten or fourteen days later. Does diagnosed to be open were immediately returned to the appropriate buck for remating.

Date of mating and of kindling of each doe was recorded. Kindling litter size and litter birth weight of each doe was recorded. Litter birth weight and subsequent weekly body weights were taken using a mechanical scale of twenty five grammes gradation and with a sensitivity of fifty grammes. Each nestbox or nest pot was checked daily and the dead kitten(s) removed. The kittens from each doe were weighed collectively in the first week. In the second week each kitten was ear tagged and then weighed individually until eight weeks. The kittens were weaned at twenty eight (28) days and were separated from their dams and transfered to empty cakes in groups where they had free access to feed and clean water daily. Number weaned and number survived per doe was also recorded. In this study fostering of kittens between litters was not practiced.

Performance data collected from the does were pregancy duration, litter-size, birth weight, mean kitten birth weight number weaned, number survived, percentage kitten mortality at weaning and total percent mortality. Litter traits included litter body weight at two, four, six and at eight weeks of age.

3.1.2 Screening

The first part of the screening was a general editing of records. Each record was checked to determine if entry mistakes could be identified. After coding, the data were transfered from the database (DBASE) into the SAS soft-ware for statistical analysis.

3.1.2.1 Statistical analysis:

All the performance traits, that is gestation length, littersize, litter birth weight, number weaned, mean kitten birth and survived per doe, weaning weight and bi-weekly body weight of kittens were subjected to basic statistics to get the means ± standard error of means (SEM), and coefficient of variation (CV).

Effects of sire breed, dam breed and season on performance traits: GESTL, Littersize, litter birth weight, mean kitten birth weight, kitten body weights at 2, 4, 6 and 8 weeks of age, percentage mortality at weaning and total percentage mortality were analysed by the least aquares procedure according to Harvey (1960) using SAS (1967). Tests of significance at 0.5% was carried out using Duncan Multiple Range Test (Steel and Torrie, 1980). The following model was used:

$$Y_{ijkl} = SB_i + DB_j + S_k + e_{ijkl}$$

Where

Y_{ikjl} = the observation on the l^{th} kitten born in the k^{th} season belonging to the j^{th} dam breed and i^{th} sirebreed.

U = the overall mean

SB_i = fixed effect of the i^{th} Sirebreed (i = 1, 3)

DB_j = fixed effect of the j^{th} dambreed (i = 1, 3).

S_k = fixed effect of the k^{th} season (k = 1, 3)

e_{ijkl} = random error associated wih each record with expectation 0 and variance.

The effects of purebreeding and crossbreeding on the above mentioned performance traits were evaluated using the following model.

$Y_{ij} = u + B_i + e_{ij}$

Y_{ij} = The observation on the j^{th} kitten belonging to the i^{th} breeding.

SB_i = fixed effect of the i^{th} breeding (i = 1, 3).

e_{ij} = random error associated with each record with expectation 0 variance.

Phenotypic correlations:

Phenotypic correlations between Gestation length, litter birth weight, mean kitten birth weight, number weaned and survived and kitten body weights at fixed ages were computed using the PEARSON CORRELATION module according to SYSTAT (Wilkinson, 1998) procedures while tests of significance at 1 and 5% levels were carried out using BONFERRONL probabilities.

CHAPTER FOUR

RESULTS

4.0 Results:

The effects of sire breed, dam breed and season on gestation length, litter size, litter birth weight and mean kitten birth weight are shown in tables 4.1 and 4.2.

The least square analysis of variance (table 4.1) revealed that sire breed has no significant ($P>0.05$) effect on gestation length but had a significant effect on litter size, birth weight and mean kitten birth weight. In the case of dambred effect, a significant ($P<0.05$) effect was observed for litter size and litter birth weight. However, a non-significant ($P>0.05$) difference was observed on gestation length and mean kitten birth weight. Season had no significant ($P>0.05$) effect on GESTL, Lsize, LBWT and MBWT.

The least squares mean (table 4.2) show that all the sire breeds have similar gestation length. Considering litter birth weight, Newzealand White and Californian breeds were at par with each other but were statistically higher than that of Chinchilla (242.29±19g and 229.31±21g versus 186.95±22g). Newzealand White produced the heaviest (48.49±3.0g versus 44.14±3.0g and 34.26±3.0g) mean kitten birth weight.

In the case of effect of dambreed, Newzealand White, Californian and Chinchilla had similar gestation length, (30.72±0.8 days 31.24±0.7 days and 31.33±0.7 days). Newzealand White and Chinchilla had higher litter size

(6.17±0.5 and 5.03±0.4 versus 4.29±0.5) and litter birth weight (239.62±21g and 222.85±18g versus 198.07±20g). However, these values were higher than those obtained for Californian dambreed. All the dambreeds have similar mean kitten birth weight. Season had no effect statistically on all the above parameters.

The least square analysis of variance (table 4.3) revealed that sire breed had a significant effect ($P<0.05$) on kitten body weight at 2, 4 (weaning) and 6 weeks and non-significant at 8 weeks of age. In the case of effect of dambreed, a non-significant ($P>0.05$) effect was noticed at 2 and 4 weeks but a significant ($P<0.05$) effect was observed at 6 and 8 weeks of age. However, season of kindling had a significant ($P<0.05$) effect on all body weight at different ages.

The least squares means (table 4.4) shows that kittens produced by Newzealand White and Chinchilla sires had higher body weights at 2 weeks (146.70±4.3g) and 149.89±5.7g versus 141.69±5.1g), at 4 weeks of age (weaning) (258.64±7.1g and 258.82±9.3g versus 240.50±8.5g) and at 6 weeks of age (394.72±10.7g and 420.25±13.5g versus 349.47±12.1g) respectively when compared to kittens produced by Californian sires. At 8 weeks of age, kittens of all sire-breeds were within the same body weight range. Considering dambreed effect, it was observed that all dams produced kittens with similar body weight (141.23±4.8g, 149.33±5.8g and 147.72±8.1g) at 2 and 4 weeks of age (239.76±8.1g,

265.02±9.8g and 253.19±7.3g). However, at 6 weeks (392.86±14.9g and 401.35±10.3g versus 370.23±11.7g) and at 8 weeks (524.54±19.6g, 546.59±13.0g versus 505.68±14.9g) kittens of Californian and Chinchilla had similar body weight but were higher than those of Newzealand White dams. It was also observed that kittens produced between February and May had lower body weight than those kindled between June and September (213.99±5.4g versus 291.32±9.0g, 317.54±8.1g versus 458.76±12.7g, 428.90±10.3g versus 458.76±12.7g and 428.90±10.3g versus 622.32±16.4g) at 2, 4, 6 and 8 weeks of age throughout the experimental period.

Data on analysis of variance and least squares means of sire breed, dambreed and season as it affects number weaned, number survived, percentage mortality at weaning and total percentage mortality are shown on tables 4.5 and 4.6, respectively. Sire breed had a significant ($P<0.05$) effect on number weaned and percentage mortality at weaning but has no significant ($P>0.05$) effect on number that survived and total percentage mortality. Dambreed had a significant ($P<0.05$) effect on number weaned and number that survived but has a non-significant ($P>0.05$) effect on percentage mortality at weaning and on total percentage mortality. Season had no significant ($P>0.05$) effect on number weaned, number that survived, percentage mortality at weaning and on total percentage mortality.

Least squares means (table 4.6) revealed that number of kittens weaned by Newzealand White sires was (2.45±0.3 versus

1.85±0.3 and 1.96±0.4) higher than those weaned by Californian and Chinchilla. It also revealed a non statistical difference between number of kittens that survived in Newzealand White, Californian and Chinchilla (2.18±0.3, 1.72±0.3 and 1.90±0.3) and total percentage mortality (48.54±7, 54.08±7 and 54.73±8). Californian and Chinchilla sires exhibits similar percentage mortality at weaning (52.47±7 and 59.53±8) but were higher than that obtained for Newzealand White sire (42.63±7). In the case of the effect of dambreed, Californian was observed to have a lower number of kittens weaned (1.48±0.3 versus 2.65±0.4 and 2.17±0.3) and survived (1.30±0.2 versus 2.40±0.3 and 2.10±0.3) as compared to Newzealand White and Chinchilla dams which are at par. However, there were no (P>0.05) statistical difference in percentage mortality at weaning and total percent mortality for all dambreeds but Californian dams produced the highest percentage mortality at weaning (57.41±7 versus 40.95±8 and 56.27±7 and (58.82±7 versus 43.29±8 and 55.24±7) when compared with Newzealand White and Chinchilla. There were also no statistical (P>0.05) difference in number of kittens weaned and percentage mortality at weaning with regards to seasonal variation but kittens produced between June and September had a higher 2.11±0.3 versus 1.76±0.2) survival rate and lower total percentage mortality (48.42±8 versus 56.48±5) than those kindled in February to May.

The least square analysis of variance and least squares

means for pure-breeding as it affects gestation length, litter birth weight, mean kitten birth weight and litter size are shown on tables 4.7 and 4.8 respectively. Results on least square analysis of variance indicate a non-significant ($P>0.05$) effect on gestation length in all pure-breds used (table 4.7) but there was a significant ($P<0.05$) effect on all other traits mentioned above. It was observed (table 4.8) that pure- bred Newzealand White had the highest litter birth weight with Californian pure-bred producing the lowest (213.33±14g versus 190.91±15g versus 156.78±13). Mean kitten birth weights of Newzealand White and Californian were at par (53.79±4g and 52.14±3.0g) but were higher than that of Chinchilla pure breds (42.52±4.0g). With regards to litter size, Newzealand White and Chinchilla pure breds produced similar number of kittens (4.08±0.4 and 4.64±0.4) but were higher than that obtained for Californian (3.31±0.2).

Tables 4.9 and 4.10 show the least squares analysis of variance and least squares means of kitten body weight at 2, 4, 6 and 8 weeks of age for pure-bred rabbits used. There were no significant ($P>0.05$) effect between kitten body weight at 2 and 4 weeks (table 4.9) but there was a significant ($P<0.05$) effect of pure breed at 6 and 8 weeks of age. It was observed (table 4.10) that all the kittens had statistically the same body weight at 2 weeks (150.39±7.7g, 163.64±10.2g and 155.33±8.7g), and at 4 weeks (248.29±12.6g, 296.82±16.6g and 261.23±14.2g) of age. At 6 and 8 weeks of age, body weight of Californian and Chinchilla pure-bred

kittens were at par (414.74±24.85g and 434.48±21.65g) and (578.57±33.78g and 580.00±29.26g) with each other but were higher than those of Newzealand White (378.82±20g and 508.59.27.37g).

The least squares analysis of variance (table 4.11) and least squares means (table 4.12) show the effect of pure-breeding (straight breeding) on number weaned, number survived, percentage mortality at weaning and total percentage mortality. Data on (table 4.11) revealed that there was a significant ($P<0.05$) effect among breed on number weaned, number survived, percentage mortality at weaning and total percent mortality.

Least squares means (table 4.12) revealed that number of kittens weaned (3.17±0.5 and 2.82±0.5 versus 1.38±0.4) and number surviving (2.67±0.4 and 2.64±0.4 versus 1.31±0.4) were at par for Newzealand White and Chinchilla but were higher than those of Californian pure-bred, respectively. It was also shown that Newzealand White and Chinchilla had a lower percentage mortality at weaning (21.11±12 and 38.85±12 versus 46.25±10) and total percentage mortality (27.78±11 and 33.85±12 versus 47.50±10) than Californian purebred.

Tables 4.13 and 4.14 show the least squares analysis of variance and least squares means of effect of cross-breeding on gestation length, litter birth weight, mean kitten birth weight and litter size.

Results on least square analysis of variance (table 4.13) revealed that crossbreeding had a significant ($P<0.05$)

effect on all the above mention traits. Data on least squares means indicates that NN x CH, CC x NN, CC x CH and CH x CC had higher gestation length (31.90±0.7 days, 32.38±0.8 days, 30.92±0.6 days, 32.57±0.9 days versus 29.81±0.7 days and 29.25±0.8 days) than NN x CC and CH x NN respectively. It was observed that NN x CH, CC x NN and CC x CH had the highest litter birth weight (238.00±22g, 241.25±25g and 232.69±20g) and were at par with each other, this was followed by NN x CC (224.09±21g) and CH x NN (211.25±25g) with CH x CC obtaining the lowest (157.14±27g) litter birth weight. Considering mean kitten birth weight, NN x CC and NN x CH had statistically the same but higher values (49.58±3g and 46.35±3g) when compared to CC x NN and CC x CH, (42.64±4g and 43.24±3g which were also at par with each other, with CH x NN (35.08±4g) and CH x CC (33.21±4g) having the least mean kitten birth weight. In the case of litter size, CC x NN, CC x CH and CH x NN produced almost equal number of kittens per litter (6.25±0.6, 5.46±0.4 and 6.13±0.6) but were higher when compared to those of NN x CC and NN x CH (4.73±0.5 and 5.10±0.5 versus 3.71±0.6) with CH x CC having the least number of kittens per litter.

Least square analysis of variance and least squares means of effect of crossbreeding on kitten body eight at 2 weeks, 4 weeks, 6 weeks and 8 weeks of age are presented on tables 4.15 and 4.16, respectively.

Least square analysis of variance (table 4.15) revealed that crossbreeding had a significant ($P<0.05$) effect on all

kitten body weights. It was observed (table 4.16) that CH x CC produced the heaviest kittens at 2 weeks (190.00±13) when compared to NN x CH and NN x CC, CC x NN, and CH x NN (140.20±6g versus 116.03±6g, 109.83±5g and 110.00±7g), respectively. At 4 weeks (weaning) of age kitten body weight of NN x CH and CH x CC were similar (247.73±9g and 295.00±18g) statistically but were heavier when compared to kitten body weight of NN x CC, CC x CH and CH x NN (198.81±9g, 189.77±9g and 189.06±10g versus 173.18±9g) which were also at par with each other, with CC x NN producing kittens with least body weight. At 6 weeks, CH x CC had the heaviest kitten (500.00±31g). This was followed by kittens from NN x CH (367.05±13g) which in turn was heavier when compared to CC x CH and CH x NN kittens (290.00±14g and 305.00±16g) that were also at par with each other, and NN x CC and CC x NN kittens having the least body weight (267.50±17g and 242.25±14g). At 8 weeks of age, kittens of NN x CH and CH x CC performed best (513.64±16g and 500.00±43g) when compared to those of CH x NN which also performed better than kittens of NN x CC, CC x NN and CC x CH (410.00±19 versus 370.38±21g, 364.44±17g and 398.75±17g), respectively.

The effect of crossbreeding on number of kittens weaned, number that survived, percentage mortality at weaning and total percentage mortality is shown on table 4.17 and 4.18.

Data on least square analysis of variance (table 4.17) show that crossbreeding exhibits a significant ($P<0.05$)

effect on number weaned, number survivied, percentage mortality at weaning and on total percentage mortality. The least square means (table 4.18) revealed that CC x NN performed best with regards to number of kittens weaned when compared to NN x CH and NN x CC (2.75±0.6 versus 2.20±0.6 and 2.00±0.5). This was followed by CH x NN and CC x CH which were also having similar value for number weaned but were higher than that of CH x CC (1.88±0.6 and 1.46±0.3 versus 0.71±0.7) respectively. In case of number of kittens that survived, NN x CH, CC x NN and CH x NN though were at par had highest survival rate of kittens when compared to CC x CH and NN x CC which in turn had higher rate than CH x CC (2.20±0.5, 2.25±0.6 and 1.88±0.6 versus 1.31±0.5 and 1.45±0.5 versus 0.57±0.7) respectively. When percentage mortality at weaning and total percentage mortality was considered, CC x CH and CH x CC were at par with each other (74.36±9 and 89.29±13) and (71.60±9 and 80.00±12) respectively when compared to NN x CC, NN x CH and CH x NN (54.41±10, 58.17±7 and 68.63±12) and (66.10±10 , 58.17±10 and 68.63±12) respectively with CC x NN having the least (45.83±12 and 48.33±12) percentage mortality at weaning and total percentage mortality respectively.

Table 4.21 shows the least squares means for performance of pure-bred and crossbred rabbits with regards to gestation length, litter birth weight, mean kitten birth weight and litter size. It was observed that the crossbreds had higher litter birth weight (224.09±19g, 238.00±20g, 241.25±22g, 232.69±18g, 157.14±24g and 211.25±22g) for NN x CC, NN x CH,

CC x NN, CC x CH, CH x CC and CH x NN than their counterpart purebreds (213.33±18g, 156.79±17g and 190.91±19g) for NN x NN, CC x CC and CH x CH respectively. Crossbreds also had higher litter size (4.73±0.5, 5.10±0.3, 6.25±0.5, 5.46±0.4, 3.71±0.6 and 6.13±0.5) for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN than the pure-breds (4.08±0.4, 3.31±0.4 and 4.64±0.5) for NN x NN, CC x CC and CH x CH respectively. However, the crossbreds had lower mean kitten birth weights (49.58±3g, 46.35±3g, 42.64±4g, 43.24±3g, 33.21±4g and 35.02±4g) when compared with the pure-breds (53.79±3g, 52.14±3g and 42.64±4g) for NN x NN, CC x CC and CH x CH respectively.

Table 4.22 shows the least squares means for kitten body weight at 2, 4, 6 and 8 weeks of age for pure-breds and their crosses. When kitten body weights were considered it was observed that the kitten from pure bred rabbits had higher body weights than their crosses at all ages. At 2 weeks of age body weight of kitten were (150.39±6g, 163.64±8g and 155.33±7g) for NN x NN, CC x CC and CH x CH versus (116.03±7g, 140.20±8g, 109.83±7g, 120.37±7g, 190.00±17g and 110.00±9g) for NN x CC, NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively. At 4 weeks (weaning) kitten body weights were (248.29±10g, 296.82±13g and 261.23±11g) for NN x NN, CC x CC and CH x CH (versus 198.81±13g, 247.73±13g, 173.18±13g, 189.77±13g, 295.00±27g and 189.06±15g) for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively. At 6 weeks of age body weight

of kittens were (378.82±16g, 414.77±20g and 434.48±17g) for NN x NN, CC x CC and CH x CH (versus 267.50±25g, 367.05±20g, 242.25±21g, 290.00±20g, 500.00±46g and 305.00±24g) for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively. At 8 weeks of age kitten body weights were (508.59±21g, 578.57±26g and 580.00±23g) for NN x NN, CC x CC and CH x CH (versus 370.34±33g, 513.64±26g, 364.44±28g, 393.75±27g, 500.00±69g and 410.00±31g) for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively.

Table 4.23 shows the least squares means for number weaned, number survived, percentage mortality at weaning and total percentage mortality between pure-breds and their crossbreds.

It was observed that number of kittens weaned (3.17±0.5, 1.38±0.4 and 2.82±0.5) for NN x NN, CC x CC and CH x CH (versus (2.00±0.5, 2.20±0.5, 2.75±0.6, 1.46±0.5, 0.71±0.7 and 1.88±0.6) for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively and number of kittens that survived (2.67±0.5, 1.31±0.4 and 2.64±0.5) for NN x NN, CC x CC and CH x CH) except for CC x NN (2.25±0.6) (versus 1.45±0.3, 2.20±0.5, 1.31±0.4, 0.57±0.6 and 1.88±0.6) for NN x CC, NN x CH, CC x CH, CH x CC and CH x NN respectively were higher in pure breds than in their counterpart crosses. It was also observed that the pure breds had lower percentage mortality at weaning (21.11±11, 38.85±11 and 46.25±9) for NN x NN, CH x CH and CC x CC versus (54.41±11, 58.17±12, 45.83±13, 74.36±10, 89.29±14, 68.63±13) respectively, when compared

with their crosses. However, the pure breds also had lower total percentage mortality (27.78±10, 33.85±11 and 47.50±8) for NN x NN, CH x CH and CC x CC versus (66.10±11, 58.17±11, 48.33±13, 76.60±10, 80.00±13 and 68.63±13) respectively than their crosses.

Phenotypic correlations between gestation length, litter size, litter birth weight, number weaned and number survived are shown in table 4.19. It was observed that there was a non ($P>0.05$) significant co-efficient of correlation between litter size and gestation length (0.11) but a high ($P<0.01$) positive correlation between litter birth weight and gestation length (0.149) and a very high ($P<0.001$) correlation between litter birth weight and litter size (0.781) was noticed. A non-significant ($P>0.05$) correlation was shown between mean birth weight and gestation length (0.029) but a very highly ($P<0.001$) negative and very high positive ($P<0.001$) correlations existed with litter size (-0.423) and litter birth weight (0.208) respectively. It also revealed highly ($P<0.01$) significant correlation between number weaned and gestation length (0.216) and very high ($P<0.001$) correlation between number weaned and litter size (0.462) and between number weaned and litter birth weight (0.362) respectively. In the case of number survived, it had very highly significant ($P<0.001$) correlation with litter size (0.473) and litter birth weight (0.406) but a non-significant ($P>0.05$) correlation with gestation length (0.081) and mean kitten birth weight (0.025). There was also

a very high (P<0.001) between number weaned and number survived (0.893).

Table 4.20 shows the phenotypic correlations between kitten body weight at 2, 4, 6 and 8 weeks of age. It was observed that they were all high and positively significant (P<0.001) ranging from 0.575 - 0.900.

Table 4.01: Basic Population Statistics

NN x NN

	N	Mean	Std. Dev.	C.V.
GESTL	12	32.00	2.35	7.34
L size	12	4.08	1.52	37.25
LBWT	12	213.33	63.15	29.74
MBWT	12	53.79	11.04	20.52
WT_2	38	150.39	52.16	34.68
WWT_4	38	248.29	82.70	33.31
WT_6	34	378.82	131.50	34.71
WT_8	32	508.59	170.22	33.47
NO WEANED	12	3.17	1.64	51.86
NOSURV	12	2.67	1.44	53.83
MWD	12	21.11	30.02	142.20
PMORTOT	12	27.78	27.64	99.49

Table 4.02: Basic Population Statistics

NN x CC

	N	Mean	Std. Dev.	C.V.
GESTL	11	29.82	2.36	7.90
L size	11	4.73	1.52	32.29
LBWT	11	224.09	63.15	28.24
MBWT	11	49.58	11.06	22.30
WT_2	29	116.03	35.69	30.76
WWT_4	21	198.81	57.81	29.08
WT_6	14	267.50	33.09	12.37
WT_8	13	370.38	64.27	17.35
NO WEANED	11	2.00	1.18	59.16
NOSURV	11	1.45	1.21	83.43
MWD	11	54.41	34.40	59.54
PMORTOT	11	66.10	31.46	47.59

Table 4.03: **Basic Population Statistics**

NN x CH

	N	Mean	Std. Dev.	C.V.
GESTL	10	31.90	2.34	7.33
L size	10	5.10	1.52	29.74
LBWT	10	238.00	61.97	26.04
MBWT	10	46.35	12.24	26.41
WT_2	25	140.20	37.26	26.58
WWT_4	22	247.73	36.93	14.91
WT_6	22	367.05	68.31	18.61
WT_8	22	513.64	82.28	16.02
NO WEANED	10	2.20	2.15	97.72
NOSURV	10	2.20	2.15	97.72
MWD	10	58.17	38.11	65.51
PMORTOT	10	58.17	38.11	68.51

Table 4.04: Basic Population Statistics

CC x CC

	N	Mean	Std. Dev.	C.V.
GESTL	16	32.31	2.36	7.30
L size	16	3.31	1.52	45.92
LBWT	16	156.79	67.6	43.11
MBWT	16	52.14	11.4	21.86
WT_2	22	163.64	49.24	30.09
WWT_4	22	296.82	85.41	28.78
WT_6	22	414.77	124.32	29.97
WT_8	21	578.57	144.54	24.98
NO WEANED	16	1.38	1.63	118.39
NOSURV	16	1.31	1.58	120.37
MWD	16	46.25	49.92	107.93
PMORTOT	16	47.50	50.00	105.26

Table 4.05: Basic Population Statistics

CC x NN

	N	Mean	Std. Dev.	C.V.
GESTL	8	32.38	2.35	7.35
L size	8	6.25	1.53	24.45
LBWT	8	241.25	63.25	26.22
MBWT	8	42.64	11.07	25.95
WT_2	30	109.83	23.80	21.67
WWT_4	22	173.18	31.98	18.47
WT_6	20	242.25	51.59	21.30
WT_8	18	364.44	73.00	20.03
NO WEANED	8	2.75	2.12	77.13
NOSURV	8	2.25	1.98	88.09
MWD	8	45.83	29.21	63.72
PMORTOT	8	48.33	25.32	52.39

Table 4.06: Basic Population Statistics

CC x CH

	N	Mean	Std. Dev.	C.V.
GESTL	13	30.92	2.35	7.59
L size	13	5.46	1.52	27.77
LBWT	13	232.69	63.32	27.21
MBWT	13	43.24	11.05	25.55
WT_2	27	120.37	19.66	16.33
WWT_4	22	189.77	28.26	14.89
WT_6	21	290.00	58.76	20.26
WT_8	20	393.75	57.28	14.55
NOWEANED	13	1.46	1.98	135.74
NOSURV	13	1.31	1.75	133.86
MWD	13	74.36	34.94	46.98
PMORTOT	13	76.60	32.25	42.11

Table 4.07: Basic Population Statistics

CH x CH

	N	Mean	Std. Dev.	C.V.
GESTL	11	31.64	2.36	7.45
L size	11	4.64	1.53	32.91
LBWT	11	190.91	63.28	33.15
MBWT	11	42.52	11.59	27.25
WT_2	30	155.33	39.83	25.64
WWT_4	30	261.23	64.03	24.51
WT_6	29	434.48	88.49	20.37
WT_8	28	580.00	143.17	24.68
NO WEANED	11	2.82	1.40	49.72
NOSURV	11	2.64	1.29	48.79
MWD	11	38.85	34.83	89.64
PMORTOT	11	33.85	28.99	85.63

Table 4.08: Basic Population Statistics

CH x CC

	N	Mean	Std. Dev.	C.V.
GESTL	7	32.51	2.36	7.24
L size	7	3.71	1.51	40.71
LBWT	7	157.14	63.34	40.30
MBWT	7	33.21	11.01	33.35
WT_2	5	190.00	57.55	30.29
WWT_4	5	295.00	51.23	17.37
WT_6	4	500.00	91.29	18.26
WT_8	3	500.00	86.60	17.32
NO WEANED	7	0.71	1.25	175.50
NOSURV	7	0.57	0.98	170.78
MWD	7	89.29	28.35	31.75
PMORTOT	7	80.00	36.06	45.07

Table 4.09: Basic Population Statistics

CH x NN

	N	Mean	Std. Dev.	C.V.
GESTL	8	29.25	2.35	8.03
L size	8	6.13	1.53	24.93
LBWT	8	211.25	63.25	29.94
MBWT	8	33.21	11.07	31.60
WT_2	20	110.00	20.13	18.3
WWT_4	16	189.06	44.69	23.64
WT_6	15	305.00	80.84	26.50
WT_8	15	410.00	88.03	21.47
NO WEANED	8	1.88	1.89	100.54
NOSURV	8	1.88	1.89	100.54
MWD	8	68.63	32.92	47.97
PMORTOT	8	68.63	32.92	47.97

Table 4.1: Least square analysis of variance of effect of sire breed, dambreed and season on gestation length (GESTL), litter size (Lsize), litter birth weight (LBWT) and mean kitten birth weight (MBWT)

Source	DF	GESTL	Lsize	LBWT	MBWT
Sire breed	2	$3.10^{N.S}$	3.42*	10587*	679.04*
Dambreed	2	$1.44^{N.S}$	11.28*	5444*	$11.93^{N.S}$
Season	1	$0.54^{N.S}$	$0.54^{N.S}$	$160^{N.S}$ S	$18.80^{N.S}$
Error	51	6.73	2.70	5096.17	105.24

N.S = Non significant

* = P<0.05.

Table 4.2: Least square means (L.S.M)±S.E for gestation length (GESTL), litter size (Lsize), litter birth weight (LBWT) and mean kitten birth weight

Effect	GESTL(day)	Lsize	LBWT(g)	MBWT(g)
Sire breed				
NN	30.68 ±0.7	5.37^{a} ±0.4	242.29^{a} ±19	48.49^{a} ±3
CC	31.54 ±0.8	5.35^{a} ±0.5	$229.31^{a,b}$ ±21	44.14^{a} ±3
CH	31.03 ±0.8	4.78^{b} ±0.5	186.95^{b} ±22	34.26^{b} ±3
Dam breed				
NN	30.72 ±0.8	6.17^{a} ±0.5	239.62^{a} ±21	42.61 ±3
CC	31.24 ±0.7	4.29^{b} ±0.5	198.07^{b} ±20	42.99 ±3
CH	31.33 ±0.7	$5.33^{a,b}$ ±0.4	$220.85^{a,b}$ ±18	41.30 ±3
Season				
February-May	30.97 ±0.4	5.30 ±0.2	217.24 ±11	41.52 ±2
June-September	31.23 ±0.9	5.03 ±0.5	221.79 ±23	43.03 ±3

Means followed by the same superscript with column for each effect are not statistically different from each other at * = P<0.05.

Table 4.3: Least square analysis of variance for kitten body weight at 2(WT_2), 4(WWT_4), 6(WT_6) and 8(WT_8) weeks of age across sire breed, dam breed and season

Source	DF	WT_2	WWT_4	WT_6	WT_8
Sire breed	2	1088.29*	6858.89*	65368.54*	3838.62NS
Dam breed	2	1354NS	17946.36NS	17224.46*	27729*
Season	1	56307.55*	213231.86*	670474.12*	1207607.75*
Error	220	1567.21	3821.92	7430.42	11571

N.S. = Non-significant (P>0.05)
* = P<0.05.

Table 4.4: Least square means (L.S.M.) ± S.E. for kitten body weight at 2(WT_2), 4(WWT_4), 6(WT_6) and 8(WT_8) weeks of age across sire breed, dam breed and season.

Effect	WT_2	WWT_4	WT_6	WT_8
Sire breed				
NN	146.70[a]	258.64[a]	394.72[a]	535.92
	±4.3	±7.1	±10.7	±13.7
CC	141.69[a b]	240.50[b]	349.47[b]	494.12
	±5.1	±8.5	±12.1	±15.7
CH	149.89[a]	258.82[a]	420.25[a]	546.78
	±5.7	±9.3	±13.5	±17.4
Dam breed				
NN	141.23	239.76	370.23[b]	505.68[b]
	±4.8	±8.1	±11.7	±14.9
CC	149.33	265.02	392.86[a]	524.54[a]
	±5.8	±9.8	±14.9	±19.6
CH	147.72	253.19	401.35[a]	546.59[a]
	±4.5	±7.3	±10.3	±13.0
Season				
Feb.-May	126.97[a]	213.99[a]	317.54[a]	428.90[a]
	±3.2	±5.4	±8.1	±10.3
June-Sept.	165.21[b]	291.32[b]	458.76[b]	622.32[b]
	±5.5	±9.0	±12.7	±16.4

Means followed by the same superscript within column for each effect are not statistically different from each other at:
* = P<0.05.

Table 4.5: Least square analysis of variance for number weaned (NOWEANED), number survived (NOSURV), percent mortality at weaning (MWD%) and total percent mortality (Pmortot) across sire breed, dam breed and season

Source	DF	NoWeaned	NoSurv	MWD%	Pmortot%
Sire breed	2	4.81*	1.83NS	2809.05*	361.94NS
Dam breed	2	10.45*	10.02*	2423.02NS	1900.00NS
Season	1	0.16NS	4.29*	753.96NS	2172.66*
Error	90	3.06	2.66	1538.67	1469.86

N.S. = Non-significant
* = P<0.05.

Table 4.6: Least square means (L.S.M.) ± S.E. for number weaned (NOWEANED), number survived (NOSURV), percent mortality at weaning (MWD%) and total percent mortality (Pmortot) across sire breed, dam breed and season

Effect	NOWEANED	NOSURV	MWD%	PMORTOT%
Sire breed				
NN	2.45[a] ±0.3	2.18 ±0.3	42.63[b] ±7	48.54 ±7
CC	1.85[a b] ±0.3	1.72 ±0.3	52.47[a] ±7	54.08 ±7
CH	1.96[a b] ±0.4	1.90 ±0.3	59.53[a] ±8	54.73 ±8
Dam breed				
NN	2.65[a] ±0.4	2.40[a] ±0.3	40.95 ±8	43.29 ±8
CC	1.48[b] ±0.3	1.30[b] ±0.3	57.41 ±7	58.82 ±7
CH	2.17[a] ±0.3	2.10[a] ±0.3	56.27 ±7	55.24 ±7
Season				
Feb.-May	2.05 ±0.2	1.76[a] ±0.2	54.78 ±5	56.48[a] ±5
June-Sept.	2.15 ±0.4	2.11[b] ±0.3	48.31 ±8	48.42 ±8

Means followed by the same superscript within column for each effect are not statistically different from each other at:
* = P<0.05.

Table 4.7: Least square analysis of variance of effect of pure breeding on gestation length (GESTL), litter birth weight (LBWT), mean kitten birth weight (MBWT) and litter size (Lsize)

Effect	DF	GESTL	LBWT	MBWT	Lsize
Pure breeding	2	1.50$^{N.S.}$	10579.68*	399.68^{S}	5.93*
Error	36	5.78	2389	148.26	1.80

$^{N.S.}$ = Non-significant

* = P<0.05.

Table 4.8: Least square means (L.S.M) ± S.E. for gestation length (GESTL), litter birth weight (LBWT), mean kitten birth weight (MBWT) and litter size (Lsize) of pure bred rabbits

Source	Breeds		
	NN X NN	CC X CC	CH X CH
Gestl (day)	32.00 ±0.7	32.31 ±0.6	31.64 ±0.7
LBWT (g)	213.33^{a} ±14	156.78^{c} ±13	190.91^{b} ±15
MBWT (g)	53.79^{a} ±4	52.14^{a} ±3	42.52^{b} ±4
Lsize	4.08^{a} ±0.4	3.31^{b} ±0.3	4.64^{a} ±0.4

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.9: Least square analysis of variance of effect of pure breeding at 2(WT_2), 4(WWT_4), 6(WT_6) and 8(WT_8) weeks of age

Effect	DF	WT_2	WWT_4	WT_6	WT_8
Pure breeding	2	1221.61$^{N.S}$	16641.97$^{N.S}$	25112.39	48521.43*
Error	87	2270.98	6035.91	13591.39	23968.91

$^{N.S}$. = Non-significant

* = P<0.05.

Table 4.10: Least square means (L.S.M.) ± S.E. of kitten body weight at 2(WT_2), 4(WWT_4), 6(WT_6) and 8(WT_8) weeks of age for pure bred rabbits

Breeds

Source	NN x NN	CC x CC	CH x CH
WT_2	150.39 ±7.7	163.64 ±10.2	155.33 ±8.7
WWT_4	248.29 ±12.6	296.81 ±16.6	261.23 ±14.2
WT_6	378.82^{b} ±20	414.77^{a} ±24.85	434.48^{a} ±21.65
WT_8	508.59^{b} ±27.37	578.57^{a} ±33.78	580.00^{a} ±29.26

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.11: Least square analysis of variance of effect of pure breeding on number weaned (Noweaned), number survived (Nosurv), percent mortality at weaning (MWD%) and total percent mortality (Pmortot)

Source	DF	Noweaned	Nosurv	MWD%	Pmortot%
Pure bred	2	12.81*	8.47*	2211.80*	2440.19*
Error	36	2.47	2.13	1650.47	1508

* = P<0.05.

Table 4.12: Least square means (L.S.M.) ± S.E. of number weaned (Noweaned), number survived (Nosurv), percent mortality at weaning (NWD%) and total percent mortality (Pmortot)

Breeds

Source	NN x NN	CC x CC	CH x CH
Noweaned	3.17[a] ±0.5	1.38[b] ±0.4	2.82[a] ±0.5
Nosurv	2.67[a] ±0.4	1.31[b] ±0.4	2.64[a] ±0.4
MWD%	21.11[a] ±12	46.25[b c] ±10	38.85[a b] ±12
Pmortot %	27.78[a] ±11	47.50[b] ±10	33.85[a] ±12

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.13: Least square analysis of variance of effect of cross breeding on gestation length (GESTL), litter birth weight (LBWT), mean kitten birth (MBWT) and litter size (Lsize)

Source	DF	GESTL	LBWT	MBWT	LSIZE
Pure bred	5	16.05*	7071.32*	351.53*	6.89*
Error	51	5.34	5069.60	104.67	2.69

* = P<0.05.

Table 4.14: Least square means (L.S.M.) ± S.E. of effect of cross breeding on gestation length (GESTL), litter birth weight (LBWT), mean kitten birth weight (MBWT) and litter size (Lsize)

Cross breeding

Source	NN x CC	NN x CH	CC x NN	CC x CH	CH x CC	CH x NN
GESTL(days)	29.81^{bc} ±0.7	31.90^{ab} ±0.7	32.38^{a} ±0.8	30.92^{bc} ±0.6	32.57^{a} ±0.9	29.25^{bc} ±0.8
LBWT	224.09^{ab} ±21	238.00^{a} ±22	241.25^{a} ±25	232.69^{a} ±20	157.14^{b} ±27	211.25^{ab} ±25
MBWT	49.58^{a} ±3	46.35^{a} ±3	42.64^{ab} ±4	43.24^{ab} ±3	33.21^{b} ±4	35.08^{b} ±4
Lsize	4.73^{ab} ±0.5	5.10^{ab} ±0.5	6.25^{a} ±0.6	5.46^{a} ±0.4	3.71^{b} ±0.6	6.13^{a} ±0.6

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.15: Least square analysis of variance of effect of cross breeding on kitten body weight at 2(WT_2), 4(WWT_4), 6(WT_6) and 8(WT_8) weeks of age

Source	DF	WT_2	WWT_4	WT_6	WT_8
Cross breeding	5	7964*	22579.69*	67985.95*	62985.05*
Error	130	895.49	1707.78	3870.49	5507.89

* = P<0.05.

Table 4.16: Least square means (L.S.M.) ± S.E. of effect of cross breeding on kitten body weight at 2(WT2), 4(WWT4), 6(WT6) and 8(WT8) weeks of age

Cross breeding

Source	NN x CC	NN x CH	CC x NN	CC x CH	CH x CC	CH x NN
WT2 (g)	116.03^{c} ±6	140.20^{b} ±6	109.83^{c} ±5	120.37^{c} ±6	190.00^{a} ±13	110.00^{c} ±7
WWT4 (g)	198.81^{b} ±9	247.73^{a} ±9	173.18^{c} ±9	189.77^{b} ±9	295.00^{a} ±18	189.06^{b} ±10
WT6 (g)	267.5^{d} ±17	367.05^{b} ±13	242.25^{d} ±14	290.00^{c} ±14	500.00^{a} ±31	305.00^{c} ±16
WT8 (g)	370.38^{c} ±21	513.64^{a} ±16	364.44^{c} ±17	393.75^{c} ±17	500.00^{a} ±43	410.00^{b} ±19

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.17: Least square analysis of variance of effect of cross breeding on number weaned (Noweaned), number survived (Nosurv), percent mortality at weaning (MWD%) and total percent mortality of weaning (Pmortot%)

Source	DF	Noweaned	Nosurv	MWD %	Pmortot %
Cross breeding	5	3.79*	3.26*	2001.15*	1194.67*
Error	51	3.00	2.9	1109.6	1084.8

* = P<0.05.

Table 4.18: Least square means (L.S.M.) ± S.E. of effect of cross breeding on number weaned (Noweaned), number survived (Nosurv) percent mortality at weaning (MWD %) and total percent mortality (Pmortot %).

	Crosses					
Source	NN X CC	NN x CH	CC x NN	CC x CH	CH x CC	CH x NN
Noweaned	2.00^{a,b} ±0.5	2.20^{a,b} ±0.6	2.75^{a} ±0.6	1.46^{b} ±0.5	0.71^{c} ±0.7	1.88^{b} ±0.6
Nosurv	1.45^{b} ±0.5	2.20^{a} ±0.5	2.25^{a} ±0.6	1.31^{b} ±0.5	0.47^{c} ±0.7	1.88^{a} ±0.6
MWD %	54.41^{a,b} ±10	58.17^{a,b} ±11	45.83^{b} ±12	74.36^{a} ±9	89.29^{a} ±13	68.63^{a,b} ±12
Pmortot %	66.10^{a,b} ±10	58.17^{a,b} ±10	4833^{b,c} ±12	76.60^{a} ±9	80.00^{a} ±12	68.63^{a,b} ±12

Means followed by the same superscript on the same row are not statistically different from each other at * = $P<0.05$.

Table 4.19: Phenotypic correlations between gestation length, littersize, litter birth, weight, mean kitten birth weight, number weaned and number survived

	GESTL	Lsize	LBWT	MBWT	NOWEANED	NOSURV
GESTL	1.000					
LSIZE	0.11^{NS}	1.000				
LBWT	0.149*	0.781***	1.000			
MBWT	0.029^{NS}	-0.423***	0.208***	1.000		
NOWEANED	0.216***	0.462***	0.362***	-0.030^{NS}	1.000	
NOSURV	0.081^{NS}	0.473***	0.406***	0.025^{NS}	0.893***	1.000

NS = Non-significant (P>0.05)
* = P<0.05
** = P<0.01
*** = P<0.001.

Tabel 4.20: Phenotypic correlations between kitten body weight at 2, 4, 6 and 8 weeks of age

	WT_2	WWT_4	WT_6	WT_8
WT_2	1.000			
WWT_4	0.719***	1.000		
WT_6	0.673***	0.821***	1.000	
WT_8	0.575***	0.728***	0.900***	1.000

NS = Non-significant (P>0.05)
* = P<0.05
** = P<0.01
*** = P<0.001.

Table 4.21: Least square means (L.S.M.) ± S.E. for comparison between pure breeding and cross breeding on gestation length (GESTL), litter birth weight (LBWT), mean kitten birth weight (MBWT) and litter size (Lsize)

	NN x NN	NN x CC	NN x CH	CC x CC	CC x NN	CC x CH	CH x CH	CH x CC	CH x NN
GESTL (days)	32.00 ±0.7	29.82 ±0.7	31.90 ±0.7	32.31 ±0.6	32.38 ±0.8	30.92 ±0.7	31.64 ±0.7	32.57 ±0.9	29.25 ±0.8
LBWT (g)	213.33 ±18	224.09 ±19	238.00 ±20	156.79 ±17	241.25 ±22	232.69 ±18	190.91 ±19	157.14 ±24	211.25 ±22
MBWT (g)	53.79 ±3	49.58 ±3	46.35 ±3	52.14 ±3	42.64 ±4	43.24 ±3	42.52 ±3	33.21 ±4	35.02 ±4
Lsize	4.08 ±0.4	4.73 ±0.5	5.10 ±0.5	3.31 ±0.4	6.25 ±0.5	5.46 ±0.4	4.64 ±0.5	3.71 ±0.6	6.13 ±0.5

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.22: Least square means (L.S.M.) ± S.E. for comparison between pure breeding on kitten body weight at 2(WT2), 4(WWT4), 6(WT6) and 8(WT8) weeks of age

Source	NN x NN	NN x CC	NN x CH	CC x CC	CC x NN	CC x CH	CH x CH	CH x CC	CH x NN
WT_2 (g)	150.39 ±6	116.03 ±7	140.20 ±8	163.64 ±8	109.83 ±7	120.37 ±7	155.33 ±7	190.00 ±17	110.00 ±9
WWT_4 (g)	248.29 ±10	198.81 ±13	247.73 ±13	296.82 ±13	173.18 ±13	189.77 ±13	261.23 ±11	295.00 ±27	189.06 ±15
WT_6 (g)	378.82 ±16	267.50 ±25	367.05 ±20	414.77 ±20	242.25 ±21	290.00 ±20	434.48 ±17	500.00 ±46	305.00 ±24
WT_8 (g)	508.59 ±21	370.34 ±33	513.64 ±26	578.57 ±26	364.44 ±28	393.75 ±27	580.00 ±23	500.00 ±69	410.00 ±31

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

Table 4.23: Least square means (L.S.M.) ± S.E. for comparison between pure breeding and cross breeding on number weaned (Noweaned), number survived (Nosurv), percent mortality at weaning (MWD %) and total percent mortality (Pmortot %)

Source	NN x NN	NN x CC	NN x CH	CC x CC	CC x NN	CC x CH	CH x CH	CH x CC	CH x NN
Noweaned	3.17 ±0.5	2.00 ±0.5	2.20 ±0.5	1.38 ±0.4	2.75 ±0.6	1.46 ±0.5	2.82 ±0.5	0.71 ±0.7	1.88 ±0.6
Nosurv	2.67 ±0.5	1.45 ±0.5	2.20 ±0.5	1.31 ±0.4	2.25 ±0.6	1.31 ±0.4	2.64 ±0.5	0.57 ±0.6	1.88 ±0.6
MWD %	21.11 ±11	54.41 ±11	58.17 ±12	46.25 ±9	45.83 ±13	74.36 ±10	38.85 ±11	89.29 ±14	68.63 ±13
Pmortot %	27.78 ±10	66.10 ±11	58.17 ±11	47.50 ±9	48.33 ±13	76.60 ±10	33.85 ±11	80.00 ±13	68.63 ±13

Means followed by the same superscript on the same row are not statistically different from each other at * = P<0.05.

CHAPTER FIVE

DISCUSSION

5.1 Reproductive traits:

5.1.1 Gestation length, Lsize, LBWT and MBWT:

(a) Sire effect:

The non significant (P>0.05) effect of sire breed on gestation length could be attributed to the fact that this trait is not a function of the sire but that of the dam. The significant (P<0.05) effect of sire breed on litter size, litter birth weight and mean kitten birth weight could possibly be as a result of varying quantity of spermatozoa produced (fertility) to fertilize the ova and also due to difference in mature body weight of the sire. This agrees with the findings of Rouvier (1973); Caregal (1980) and Lukefahr et al (1983) who found that fertility percentage was significantly influenced by sire breed. Newzealand White sire breed was observed to have kitten with higher litter birth weight and mean kitten birth weight than other two breed considered. This could be attributed to the larger body size of the animal. Similar report was given by Lui et al (1989) who found that for rabbits sired by males of Californian, Dutch and Newzealand White, birth weight average 56.98g, 56.15g and 57.39g and a litter birth weight of 497±31g, 412±29g, 575±36g and 471±5g for Newzealand White, Californian, California x Newzealand and Newzealand White x California.

b) Dam breed effect:

The significant (P<.05) effect observed due to dam breed on litter size and litter birth weith could be as result of differences in mature body weights and genetic make up of the does. The non significance difference in gestation length among doe breed is contrary to the findings of Lee et al (1989) who reported significant breed differences in gestation length for does of Newzealand White and Californian 31.2 days) and 31.8 days) respectively. Afifi et al (1987) reported that rabbit birth weight as a product of prenatal growth period is affected by its genotype and its dam that furnishes the prenatal environment. It was observed that Newzealand White and Chinchilla does had higher littersize, litterbirth weight than Californian does. This could be related to larger body size of both Newzealand White and Chinchilla does, higher milk production rate, and better maternal ability than a Californian does. This confirms the report by Afifi et al (1978) who found that heavier does gave larger and heavier litter at birth and the existence of maternal breed effect in favour of the Newzealand White group possibly due to increased milk production of Newzealand White group possibly due to increased milk production of Newzealand White over Californian does (Lukefahr et al 1983a and b). The higher litter size observed for Newzealand does could be as aresult of differences in fertility levels. This agrees with the finding of Rouvier (1973) who observed fertility

levels of 63.5 and 62.9% for Newzealand White and Californian does respectively.

c) Seasonal effect:

There was no seasonal influence on gestation length, littersize, litterbirth weight and meankitten birth weight. This is in contrast to the findings of Sittman et al (1964) who observed that total littersize at birth and number born alive per litter exhibited a seasonal trend.

d) Effect of purebreeding:

For purebreds, gestation length varies between 31.64 days - 32.31 days which falls within the range reported by Dim et al (1989) that duration of pregnancy from day of mating to kindling varied between 30th and 33rd day with an average of 31 - 32 days. A non significant result obtained on gestation length in this study is also similar to the findings of Cuevas (1975) who reported no difference in gestation length for Burgundy Fawn (31.67 days), Chinchilla (31.79 days) and Newzealand White (32.03 days) does. The Newzealand White (4.08±0.4) and Chinchilla (4.64±0.4) were observed to have larger littersize than Californian (3.31±0.3). However, this result was observed to be lower but follow the same trend as those reported by Gugushvil (1983) who obtained 8.0, 8.0 and 6.6 for Soveit Chinchilla, Newzealand White and Californian and Bhasis et al (1989) and (1990) who reported 6.06, 6.37, 6.03 and 6.27 average littersize at birth, respectively using Newzealand White, Flemish Giant, Soviet Chinchilla and Grey Giant rabbits. The

lower littersize produced by Californian could be attributed toits smaller body size. The litterbirth weight of Newzealand White (213.33±14) out weighed that of Chinchilla (190.91±15g) and Californian (156.78±13g). This result though lower, follow the same trend with those reported by Lukefahr et al (1983) who obtained 575±36g for Newzealand White and 412±29g for Californian and El-Maghawry et al (1990) who obtained 425.90g and 403.96g in a study with Newzealand White and Californian rabbits respectively. The mean kitten birth weight ranges from 42.52±4 - 53.79±4 with Newzealand White having the highest. This result is similar with the findings of Afifi et al (1973) and Afifi et al (1982) who reported that mean kitten birth weight ranged from 49.09 - 58.8g and Afifi et al (985) who reported 43.8 - 58.8g average mean kitten weight at birth for rabbits raised in Egypt. The general lower littersize, litter birth weight and mean kitten body weight at birth could be attributed to lower mature body size of the rabbits used as compared to those used in the litterature and also may be due to low protein level in the diet. This however, could go with the finding of Broek and Lampo (1978) who observed that increasing the plane of nutrition 4 days before and one day after mating results in considerable improvement in fertility and Omole (1982) who reported that littersize at birth increased with increasing levels of protein in the gestation diet and still birth could be largely reduced by high protein diet.

e) Crossbreeding effect:

When crosses were considered gestation length was observed to vary between 29.25 ±0.8 days (CH x NN) to 32.57±0.9 days (CH x CC). This agrees with the findings of Peter et al (1968) who observed that gestation period averages 31 days and about 90% of normal litter will be kindled between the 30th and 33rd days but a small percentage may be kindled as early as the 29th or as late as the 35th day. The lower litter birth weight observed in CH x CC and NN x CC as compared to NN x CH, CC x NN, CC x CH and CH x NN, respectively could possibly be due to lower body size of the doe involved (that is Californian) at maturity and its lower feed intake and feed conversion efficiency than Newzealand White and Chichilla (Lukefahr et al., 1983). The lower mean kitten birth weight and higher litter size recorded for CC x NN, CC x CH and CH x NN (42.64±4g, 43.24±3g, 35.08±4g and 6.25±0.6, 5.46±0.4 and 6.13±0.6) respectively could be attributed to the fact that the higher the littersize, the lower the mean kitten birth weight and the larger and heavier the doe, the larger its littersize. This is in agreement with the findings of Standford (1979) who stated that the size of the dam as well as littersize has the greatest influence on birth weight.

5.1.2 Growth traits

5.1.3 Kitten body weights at 2, 4, 6 and 8 weeks of age

a) Sire effect:

The non significant effect of sire breed on kitten body

weight at 8 weeks of age could be associated with the fact that at this age, kittens depend entirely on plant proteins for growth and how well they can adapt to the external environment. This result agrees with that reported by Lukefahr et al., (1983a) who found that litter weight at 56 days were not significantly influenced by sire breed. The higher body weights of kittens of Newzealand White and Chinchilla sires at 2, 4 and 6 weeks of age (146.70±4.3g and 149.89±5.7g, 258.64±7.1g and 258.82±9.3g and 394.72±10.7g and 420.25±12.1g) respectively over those of Californian sires (141.69±5.1g, 240.50±8.5g and 349.47±12.1g) could be associated to higher mature body weights of Newzealand White and Chinchilla bucks. This also agrees with the findings of Lukefahr et al. (1983) who reported that early individual weight were significantly influenced by sire breed.

b) Dambreed effect:

Kittens produced by Newzealand White and Chinchilla does had higher body weights at 6 and 8 weeks of age as compared to those of Californian dams.

c) Seasonal effect:

The significant ($P<0.05$) lower body weights of kittens at all ages (WT_2, WWT_4 (weaning) WT_6 and WT_8) considered between February and May than those kindled between June and September could result from the fact that at this period (February and May), daily temperature was high ranging from 21-36°C with a low relative humidity of about 21% which in turn could lead to low feed intake and higher rate of

metabolism.

d) Pure breeding effect:

Kitten body weight at 2 and 4 (weaning) weeks of age were found to be statistically the same for all the breeds studied. Californian pure bred kittens had the highest body weight at 2 weeks. This could be possibly due to smaller litter size produced by this breed which in turn could result in a lower competition between littermates at birth and at early weeks of age for milk consumption. However, at 4 weeks (weaning) of age the non statistical differences between body weights could be related to the fact that kittens no longer depend on the does for food. This agrees with the findings of Hagen (1974) who stated that at 4 weeks of age, the weight of the litter is no longer related to milk yield as the young are consuming approximately 90% of the feed requirement in the form of plant protein. At 6 and 8 weeks of age pure bred Californian kittens were observed to have higher body weights than Newzealand White, this could be as a result of smaller data set observed for Californian than Newzealand White.

e) Crossbreeding effect:

At 2 weeks of age CH x CC produces the heaviest animals probably due to its lower litter size which in turn may reduce competition between litters for milk. However, at 4 weeks of age (weaning) body weight ranges from 173.18±9g for CC x NN to 295.00±18g for CH x CC. At this age, NN x CH and CH x CC performed better than other crosses considered in the study. The better performance made by NN x CH could be

attributed to larger body size of both the sire and the dam while that of CH x CC could be due to low data set. The same trend was followed at 6 weeks of age for NN x CH and CH x CC, but at 8 weeks of age, NN x CH produced the heaviest animals (513.64±16g). This is true since this crossing involved rabbits with larger mature body sizes, and higher litter feed intake and feed efficiency (Lukefahr, 1983).

5.1.4 Survivability

5.1.5 Number weaned, Number survived, percentage mortality at weaning and Total percentage mortality

a) Sire breed effect:

There is a significant ($P<0.05$) effect of sire breed on number weaned and percentage mortality at weaning. This could be due to difference in the mature body weight and genetic make of the sire. This agrees with the findings of Rouvier (1973), Carregal (1980) and Lukefahr et al (1983a) who found that percentage early survival, fertility percentage and individual weight were significantly influenced by sire breed. The non significant effect of sire breed on number that survived and total percentage mortality could be associated to the fact that these traits are not a function of the sire. Similar report was given by Lukefahr et al (1983a) who found that late survival was not being affected to a statistically significant extent by sire breed.

b) Dambreed effect:

The significant ($P<0.05$) effect of dam breed on number weaned and number that survived could be related to variation in litter size produced and mothering ability. However

number of kittens weaned and survived observed for Newzealand White and Chinchilla does than Californian does could be associated with larger body size of both Newzealand White and Chinchilla does, higher milk production rate and better maternal ability than Californian does. This confirms the report by Afifi et al (1978) who found that heavier does gave larger and heavier litters at birth and the existence of maternal breed effect in favour of Newzealand White group possibly due to increased milk production of Newzealand White over Californian does (Lukefahr et al., 1983a and b).

c) Seasonal effect:

The higher survival rate and lower total percentage mortality of kittens observed between June and September could have been influenced by lower daily temperature, and higher relative humidity which in turn could result in higher feed intake and lower rate of metabolism, thus the rabbits could be less prone to diseases.

d) Pure breeding effect:

Newzealand White and Chinchilla pure breeds had significantly ($P<0.05$) higher number of kittens weaned and survived. With regard to kitten percentage mortality at weaning, and total percentage mortality, Californian purebreds rank the highest. The lower litter birth weight and lower average milk production along with poor mothering ability could have been the possible causes of its lower number of kittens weaned and survived, higher percentage mortality at weaning and higher total percentage mortality.

Lukefahr et al (1983a) reported a similar but non statistical significant result, but observed large breed differences for number born and weaned per litter. The present result is also in corroboration with the findings of Sinkovics and Szeremy (1980) who reported that malnutrition accounts for an increase of losses and Lukefahr et al (1983b) who stated that percentage survival was higher in kittens reared by Newzealand White does than in those reared by Californian does.

e) Crossbreeding effect:

The lower number of kittens weaned and number that survived observed for CH x CC (0.71±0.7 and 57±0.7) respectively could be attributed to poor mothering ability associated with Californian does. The lowest percentage mortality at weaning and lowest total percentage mortality found in CC x NN (45.83±12 and 48.33±12), respectively could result from its moderate litter size, higher litter birth weight, mean kitten birth weight, number weaned and number that survived.

5.2 Comparison between purebred and crossbreds for reproductive and productive traits:

The higher litter birth weight and litter size observed for the crosses when compared with the purebreds may possibly be due to optimal combinations of germplasm, since it is a well known fact that crossbred animals tend to have higher litter birth weights and higher litter size than their counterpart purebreds. This result is similar to that

reported by Afifi and Emara (1987) who obtained higher value for litter size in crossbred groups than in parental purebreds at birth (6.43 versus 5.87) in a study with Egyptian and exotic breeds and their crosses. Similar findings was also reported by Gugushvil (1983) who obtained average litter size of 7.6, 8.0, 8.0 and 6.6 for Gray Giant (GG), Soviet Chinchilla (SC), Newzealand White (NZW) and Californian White (CW) rabbits and 8.2, 9.0, 8.0 and 8.0 for CW x NZW, NZW x CW, SC x GG and GG x SC matings respectively. The lower mean kitten birth weight and kitten body weights at 2, 4, 6 and 8 weeks of age observed in the crosses than in the pure breds could be attributed to higher competition between litter mates in the uterus for nutrient probably due to poor feed quality in the gestation diet. This could result in a carry over effect manifesting itself in the early stages of growth. The lower number weaned, number that survived and higher percentage mortality at weaning and higher total percentages mortality observed for the crosses than in the pure breds could be associated with natural and artificial (that is survival for the fitest) selection. Since the crossbreds were observed to have higher litter sizes, lower birth weight and lower kitten body weights at all sampling periods thus may be highly prone to diseases. Considering the source from where the experimental rabbits were obtained, though pure breeds with regards to their phenotypic appearance, they could be inbred rabbits. The present result agrees with the findings of Lasley (1978) who

stated that inbreeding is accompanied by a decline in traits closely related to physical fitness, such as fertility, mothering ability, viability, birth weight, mature body weight and greater death losses early in life.

5.3 Phenotypic Correlations:

There was a significant correlation ($P<0.05$) between gestation length and litter birth weight, and this is attributable to the fact that the longer the gestation, the more the foetus grows and at kindling, the birth weight also increase. This weight advantage at birth is carried over to later ages so that even at weaning, litters of high birth weight maintain this superiority of surviving up to weaning. This possibly explains the positive, significant correlation coefficient obtained for gestation length and number of kittens that are weaned. There were non-significant correlations between gestation length and litter size, mean kitten birth weight and number of kitten that survived to eight weeks of age, an indiction that any association observed between these variables was merely due to chance.

Litter size was positive and highly significantly ($P<0.001$) correlated with litter birth, number of kittens weaned and survived, but negatively correlated with mean kitten birth weight ($P<0.001$). This negative correlation conforms to expectation because the more the litter size, the lower the individual kitten birth weight, and it agrees with the report of Stanford (1979) that an increase in litter size resulted to a decrease in birth weight. Litter birth weight

was highly significantly correlated ($P<0.001$) with mean kitten birth weight, number of kittens weaned and survival to eight weeks of age. This follows the expected trend since the higher the litter birth weight, the faster the growth and the higher the chances of survival to later ages of the kittens. Mean kitten birth weight was negatively correlated with number of kittens weaned, and positively correlated with number of kittens that survived. However, both correlations were non-significant. This indicates that mean kitten birth weight cannot be used as a reliable parameter for the evaluation of survival of the kittens. Number of kittens weaned recorded the highest correlation coefficient with number of kittens that survived to eight weeks of age. This is expected because the more the number of kittens that reach weaning age with high body weights, the better their chances of surviving to later ages.

All the phenotypic correlations between kitten body weights at 2, 4, 6 and 8 weeks of age were positive and highly significant ($P<0.001$). It is observed in practise, that as kittens advance in age, they are growing and this leads to a resultant increase in body weight. This explains the positive correlation values obtained between body weights at different ages.

SUMMARY

Results obtained indicate that sire breed had a significant ($P<0.05$) effect on litter size, litter birth weight and mean kitten birth weight, kitten body weight at 2, 4 weeks (weaning) and at 6 weeks, Noweaned had and on percentage mortality at weaning. However, it had no significant ($P>0.05$) effect on gestation length, number survived, total percentage mortality and on kitten body weight at 8 weeks.

Chinchilla sires produced lower litter size (4.78 ± 0.5) than Californian and Newzealand White but Newzealand White had heaviest kits (48.49 ± 3g) at birth when compared with Californian and Chinchilla sires. However, Newzealand White and Californian sires produced heavier litters at birth than Chinchilla. Kittens from Newzealand White and Chinchilla sires had heavier body weights at 2 weeks, at 4 weeks and at 6 weeks of age respectively when compared to kittens produced by Californian sires. Newzealand White sires had higher number of kittens weaned than Californian and Chinchilla sires. However Newzealand White sire had lower percentage mortality at weaning than Californian and Chinchilla.

Dam breed effect on litter size, litter birth weight, kitten body weight at 6 and 8 weeks of age, number weaned and number survived was significant ($P<0.05$). However, it had a non significant ($P>0.05$) effect on mean kitten birth weight, kitten body weight at 2 and 4 weeks, percentage mortality at weaning and total percentage mortality.

Gestation length was 30.72±0.8 days and 31.33±0.7 days for Newzealand White, Chinchilla and 31.24±0.7 days for Californian dams. Newzealand White, had higher litter size and litter birth weight than Chinchilla and Californian dams. All the dam breeds had similar mean kitten birth weight and kitten body weight at 2 and 4 weeks of age. Californian and Chinchilla dams produced heavier kittens at 6 weeks and at 8 weeks of age than Newzealand dams. Season had no significant ($P>0.05$) effect on gestation length, litter size, litter birth weight, mean kitten birth weight, number weaned and percentage mortality at weaning. However, it had a significant ($P<0.05$) effect on all body weights at various ages and on numbers survived and on total percentage mortality.

Body weight of kittens kindled between June and September were higher than those kindled between February and May at 2 weeks, at 4 weeks, 6 weeks and at 8 weeks of age. A greater number of kittens kindled between June and September survived more than those kindled between February and May. A total percentage mortality of 48.42±8 and 56.48±5 were obtained for kittens kindled between June and September and between February and May.

A non significant ($P>0.01$) effect was observed for gestation length and kitten body weights at 2 and 4 weeks of age. Litter birth weights of 213.33±14g, 156.78±13g and 190.91±15g and mean kit birth weights of 53.79±4g, 52.14±3g and 42.52±4g respectively were obtained for Newzealand White,

Californian and Chinchilla pure breds, Litter sizes of 4.08±0.2 and 4.64±0.4 versus 3.31±0.3 were obtained for Newzealand White, Chinchilla and Californian. At 2 and 4 weeks of age all the purebred kittens had similar body weights.

At 6 weeks of age body weight of kittens of Chinchilla and Californian was 434.48±21.65g and 414.77±24.85g versus 378.82±20g and at 8 weeks was 580.00±29.26g and 578.57±33.78g versus 508.59±27.37g for Newzealand White kittens. Newzealand White and Chinchilla purebreds had higher number of kittens weaned and number of kittens that survived than Californian. However, Californian purebred kittens had higher percentage mortality at weaning and total percentage mortality than Newzealand White and Chinchilla purebred kittens.

Gestation length of 29.81±0.7, 31.90±0.7, 32.38±0.8, 30.92±0.6, 32.57±0.9 and 29.25±0.8 days and litter birth weight of 224.09±21, 238.00±22, 241.21±25, 232.69±20, 157.14±27 and 211.25±25 (in grammes) were obtained for NN x CC, NN x CH, CC x NN, CC x CH, CH x CC and CH x NN respectively.

Litter size ranged from 3.71±0.6-6.25±0.6 with CC x NN, CC x CH and CH x NN having the highest while mean kit birth weight ranged from 33.21±4g - 49.58±3g with NN x CC and NN x CH having the highest. Kitten body weight at 2 weeks ranged from 110.00±7g - 190.00±13g with CH x CC, having the highest weight and at 4 weeks it ranged from 189.06±10g to 295.00±18g

with NN x CH and CH x CC having the highest. At 6 weeks of age it ranged from 242.25±14g-500.00±31g with CH x CC having the highest while at 8 weeks of age it ranged from 370.38±21g-513.64±16g with NN x CH having the highest body weight. Number of kitten weaned varied from 0.71±0.7 to 2.75±0.6 with CC x NN having the highest while number survived ranged from 0.57±0.7 to 2.25±0.6 with CC x NN having the highest. Percentage mortality at weaning varied between 45.83±12 to 89.29±13 and between 48.33±12 to 80.00±12 for total percentage mortality with CH x CC having the highest.

In comparing the various performance traits between pure breeding and cross breeding, it was revealed that crossbred rabbits had higher LBWT and Lsize. However, the purebred rabbits produced higher MBWT, kitten body weights at WT_2, WWT_4, WT_6 and at WT_8. They also had higher number of kittens weaned and survived and had lower kitten mortality at weaning (MWD%) and lower total percentage mortality than the cross breeds.

Gestation length had a non significant ($P>0.05$) correlation with litter size, mean kitten birth weight and number of kittens that survived to eight weeks of age. However, it had a significant ($P<0.05$) correlation with litter birth weight and a very highly significant ($P<0.001$) correlation with number of kittens weaned. Litter size had a very highly positive and significant ($P<0.001$) correlation with litter birth weight, number weaned and survived, but had a very highly negative and significant ($P<0.001$) correlation

with mean kitten weight at birth. Litter birth weight had a very highly significant ($P<0.001$) correlation with mean kitten birth weight, number weaned and number that survived. Mean kitten birth weight had a negative but non significant ($P>0.05$) correlation with number weaned and a positive, non-significant ($P>0.05$) correlation with number that survived. Number of kitten weaned had a very highly significant ($P<0.001$) correlation with number survived.

Kitten body weights at 2, 4, 6 and 8 weeks of age were very highly significantly ($P<0.001$) correlated with each other.

CONCLUSION AND RECOMMENDATION

The result of the study with Newzealand White, Chinchilla and Claifornian rabbits and all their possible crosses made the author to draw the following:

Californian and Newzealand White sires produced higher litter size and had kits with higher mean birth weight. Newzealand White and sires gave higher litter birth weight, number of kittens that were weaned at 4 weeks of age and lower percentage mortality. However, kittens produced by Newzealand White and Chinchilla sires had higher body weight at 2, 4 and 6 weeks of age than that of Californian sires.

Newzealand White and Chinchilla dams were consistently better than Californian dams for litter size, litter birth weight, kitten body weights at 6 and 8 weeks of age. They also had higher number of kittens that were weaned and number of kittens that survived to 8 weeks of age.

Newzealand White and Chinchilla straight breds gave higher litter size, number of kittens that were weaned and survived. They also had lower kitten percentage mortality at weaning and total percentage mortality. Newzealand White straight breds produced kittens with higher litter birth weight. With regard to mean kitten birth weight, Newzealand White and Californian straight breds produced kits with heavier body weight at birth. Californian and Chinchilla straight bred kittens were heavier at 6 and 8 weeks of age than kittens from Newzealand White straight breds.

CC x NN, CC x CH and CH x NN produced higher litter size than all other crosses. NN x CH, CC x NN and CC x CH had higher litter birth weight while NN x CC and NN x CH produced heavier kittens at birth. NN x CH and CC x NN had higher number of kittens weaned at 4 weeks of age. However, kittens produced from NN x CH had heavier body weights at 2. 4. 6 and 8 weeks of age and lower weaning and total percentage mortality. Kittens from NN x CH, CC x NN and CH x NN survived better than the other crosses.

Based on the above, I therefore recommend the following:

(1) For breeding, Californian sires performed better than Newzealand and Chinchilla sires.

(2) Newzealand White and Chinchilla dams should be used as breeding does.

(3) For straight breeding Chinchilla dam and sire breeds is recommended.

(4) For cross breeding NN x CH is the best.

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