# GENETIC STUDIES ON THE PERFORMANCE OF CERTAIN BROILER RABBIT BREEDS

By

**K.ANITHA**
**B.V.Sc. & A.H**

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**OCTOBER, 2007**

# CERTIFICATE

I certify that **Ms. K. ANITHA** has satisfactorily prosecuted the course of research and that the thesis entitled **"GENETIC STUDIES ON THE PERFORMANCE OF CERTAIN BROILER RABBIT BREEDS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by her for a degree of any University.

Date: **(Dr. M. GNANA PRAKASH)**

Place: Hyderabad **Major Advisor**

# CERTIFICATE

This is to certify that the thesis entitled **“GENETIC STUDIES ON THE PERFORMANCE OF CERTAIN BROILER RABBIT BREEDS”** submitted in partial fulfillment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** of Sri Venkateswara Veterinary University**,** Tirupati**,** is a record of the bonafide research work carried out by **Ms. K. ANITHA** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged.

**(Dr. M. GNANA PRAKASH)**

**Chairman of the Advisory committee**

**Thesis approved by the Student Advisory Committee**

**Chairman:** **Dr. M.GNANA PRAKASH**

Senior Scientist and Head,

AICRP on pigs,

Tirupati.

**Member:** **Dr. B. RAMESH GUPTA**

Professor and University Head,

Department of Animal Genetics & Breeding,

College of Veterinary Science, Rajendranagar

**Member:** **Dr. A.RAJASHEKAR REDDY**

Professor

Department of Poultry Science

College of Veterinary Science, Rajendranagar

# DECLARATION

I, **Ms. K. ANITHA,** hereby declare that the thesis entitled **“GENETIC STUDIES ON THE PERFORMANCE OF CERTAIN BROILER RABBIT BREEDS”** submitted to Sri Venkateswara Veterinary University for the Degree of **MASTER OF VETERINARY SCIENCE** is a result of original research work done by me. It is further declared that the thesis or any part there of has not been published earlier in any manner.

Date: **(K.ANITHA)**

Place: Hyderabad

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**(K.ANITHA)**

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ADG | - Average Daily Gain |
| B | - Cross |
| BL | - APAU Black |
| BB | - Black Brown |
| BW | - Body Weight |
| CW | - Californian White |
| DP | - Dressing Percentage |
| FCE | - Feed Conversion Efficiency |
| FCR | - Feed Conversion Ratio |
| FG | - Flemish Giant |

| | |
|---|---|
| FN | - APAU Fawn |
| GG | - Grey Giant |
| GNC | - Ground Nut Cake |
| L | - Local |
| LSB | - Litter Size at Birth |
| LSW | - Litter Size at Weaning |
| LWB | - Litter Weight at Birth |
| LWW | - Litter Weight at Weaning |
| NZW | - New Zealand White |
| SC | - Soviet Chinchilla |
| WG | - White Giant |

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## ABSTRACT

The present study was conducted on New Zealand White (NZW), Grey Giant (GG), Soviet Chinchilla (SC), Flemish Giant (FG), Californian White (CW) purebreds and two synthetics - APAU Fawn (FN) and APAU Black (BL) bunnies born during November 2006 and July 2007 in the "Rabbit Production for Meat" scheme, Department of Animal Genetics and Breeding, College of Veterinary Science, Hyderabad. Bunnies were reared under cage and deep litter system.

The overall least-squares mean litter size at birth and weaning and litter weight at birth and weaning were 6.18 ± 0.28 and 3.75 ± 0.23 bunnies and 305.16 ± 13.75 and 1190.93 ± 56.92 g, respectively. Winter proved to be the favorable season of birth for litter traits.

The overall least-squares mean body weights were 50.00 ± 0.59, 104.52 ± 1.89, 175.10 ± 3.28, 239.50 ± 6.11 and 354.07 ± 9.19 g at birth, 1 2, 3 and 4 weeks age, respectively. In general, BL bunnies and those born in rainy season recorded significantly

higher pre-weaning body weights. Mean body weights from birth to 3 weeks of age declined as the LSB increased.

The overall mean body weights at 6, 8, 10, 12, 14 and 16 weeks of age were 551.89 ± 16.84, 684.30 ± 19.68, 856.37 ± 23.33, 1018.79 ± 28.83, 1207.18 ± 31.98 and 1352.84 ± 37.93 g, respectively. The FG rabbits have recorded significantly higher weights up to 8 weeks age. Post weaning body weights of bunnies born in winter were higher. The litter size classes 1-3 and 4-6 recorded higher body weights.

The overall least square mean ADGs during 5-6, 7-8, 9-10, 11-12, 13-14 and 15-16 weeks were 17.55 ± 1.04, 9.06 ± 0.73, 10.91 ± 0.80, 10.46 ± 0.94, 14.47 ± 0.90 and 10.98 ± 1.0 g, respectively. Genetic group, rearing system and season had significant influence.

The overall least-squares mean lactation milk yield was 1116.21± 98.28 g. Does kindled during February and those with a LWB of >250 g. recorded significantly higher milk yield. The mean daily milk yield ranged from 61.2 ± 2.1 to 73.3 ± 2.1.

The effect of genetic group and season of birth was significant on feed intake and feed efficiency but not on weight gain.

The overall least-squares means for pre-slaughter weight, dressed weight, dressing percentage, forecut, midcut, hindcut, head and feet, pelt, edible offals, inedible offals and length of caecum were 1451.14 ± 63.04 g, 695.33 ± 39.18 g, 46.69 ± 0.86, 245.73 ± 12.14 g, 174.41 ± 12.95 g, 275.19 ± 14.81 g, 193.79 ± 6.33 g, 141.11 ± 8.93 g, 57.44 ± 2.81g, 303.19 ± 11.47 g and 43.38 ± 0.85 cm, respectively. Length of caecum was significantly lower in CW rabbits. Most carcass traits studied were significantly higher in males and in those born in winter season. Rearing system had a significant influence on the length of caecum only.

The overall least-squares means for dry matter, total ash, protein, fat and cholesterol in rabbit meat were 24.3%, 1.3%, 20.3 g%, 4.1% and 0.1mg%, respectively.

Heritability estimates for litter traits were beyond the normal range. Heritability estimates of the pre and post weaning body weights, post weaning ADGs and carcass traits that could be computed varied from 0.11 ± 0.69 to 0.98 ± 1.94.

The genetic and phenotypic correlations ranged from -0.04 ± 1.75 to 0.98 ± 0.02 and 0.45 to 0.97 among post weaning body weights, -0.21 ± 0.33 to 0.54 ± 0.27 and -0.09 to 0.25 among post weaning ADGs, respectively.

# CHAPTER I

# INTRODUCTION

Rabbits have been recognized to have a very important role to play in the supply of animal protein, especially in the developing countries. This is attributable to the rabbit's high rate of reproduction; early maturity; rapid growth rate; high genetic selection potential; efficient feed and land space utilization; limited competition with humans for similar foods and high-quality nutritious meat (Cheeke, 1980).

Rabbit makes efficient use of plant protein (Timon and Hamrahan, 1985). They can turn 20 per cent of the proteins they eat into edible meat (Castellanos, 1991) and can utilize up to 30% crude fibre as against 10% by most poultry species (Egbo *et al*., 2001). Rabbits have the potential of utilizing unconventional feedstuffs as pigeon pea seeds and other diverse plant materials (Igwebuike *et al*., 2001).

The world rabbit meat production is estimated to be 1.8 million tons of carcasses (Lebas, 2003). However, the share of India is highly negligible. One female rabbit may produce as many as 2900 to 3000 % of its own live weight per year (FAO 2001). Combes (2004) reported that rabbit meat contains 21.0 ± 1.5% protein, 1.2 ± 0.1% minerals and 59 mg/100g cholesterol. A ratio of omega 6/omega 3 of 5.9 make rabbit meat attractive for health purposes. Rabbit meat is a highly digestible, low calorie food, often recommended by nutritionists over other meats (Dalle Zotte, 2002).

In recent years, rabbit is becoming a popular animal because of specific characteristics of feeding behavior that favors its role in integrated farming systems. Rabbit is a pseudo-ruminant contributing to improved nutrition and economy in the family as a source of animal protein, as well as extra income by sale of animals. Rabbits can be fed many kinds of grasses, legumes, vegetables, leaves from trees, fruits, roots and tubers and by-products from the kitchen. The rabbit backyard technology is not well developed (Lopez *et al*., 1999).

For the overall improvement of the rabbit production and a profitable enterprise, the performance levels and the genetic components need to be established for the various genetic groups under the local climatic conditions. It is well known that the reproductive characters such as litter traits, growth and meat traits are very important determinants of the profitability of rabbit unit. However, it is also understood that these are low to medium heritable making genetic improvement a long drawn process.

Hence, to understand the performance levels and the genetic nature of different exotic breeds and certain synthetic genetic groups under the local climatic conditions, the present study is taken up with the following objectives.

- To study certain productive, reproductive and carcass traits of broiler rabbit breeds under local agro-climatic conditions.

- To evaluate and compare the performance of rabbits under back yard and conventional cage systems of rearing.

- To estimate genetic parameters for productive, reproductive and carcass traits in rabbits.

# CHAPTER II

# REVIEW OF LITERATURE

The literature published on litter traits, body weights, average daily gain, carcass traits, milk yield, feed efficiency and meat composition of rabbits in the recent past is reviewed below.

## 2.1 LITTER SIZE AND LITTER WEIGHT

The litter weights of litter bearing animals like rabbits are good indicators of prolificacy and mothering ability of dams and survivability and growth rates of bunnies. The mean litter size at birth and weaning and litter weight at birth and weaning as reported in the literature are detailed in Table 1. Higher litter size at birth (8.3) was reported in GG rabbits (Das and Nayak, 1991). Higher litter size at weaning (6.8) was reported in SC (Lahiri and Mahajan, 1983) and CW (Jaouzi *et al.*, 2005).

Significant effect of genetic group on litter weights at various pre-weaning ages was reported by Das *et al.* (1997), Reddy *et al.* (2000 a) and Das *et al.* (2006).

McNitt and Moody (1990) in CW, NZW, Palomino and White Satin and Afifi *et al.* (1992) in CW breeds reported a significant effect of month of kindling on litter size at birth and weaning while Lee *et al.* (1991) observed that litter weights were significantly affected by year and season of kindling.

Ozimba and Lukefahr (1991 a) analyzed data on 122 litters representing NZW and CW purebreds, CW X NZW and FG crossbreds over five seasons and found no breed differences for litter size.

Srinivasu (1992) evaluated the performance of FG, SC, NZW and their crosses and found that genetic group had no significant effect on litter weight, while litter size significantly influenced the litter weight at all the ages studied.

Prasad (1993) reported that litter size had a highly significant effect on litter weight from birth to 12 weeks of age.

Rao *et al.* (1994) reported that season had a significant effect on litter size at birth and weaning on NZW, local and cross bred rabbits. Ahmed and Marai (1998) reported that the breed affected ($P<0.05$) litter size at birth and litter weight at 21 days of age in Baladi Black, NZW and CW rabbits. Baladi Black rabbits showed higher ($P<0.05$) litter size at birth and litter weight at 21 days of age than NZW and CW rabbits.

El Maghawry *et al*. (1999) reported that season of kindling significantly ($P<0.01$) affected litter size and weight at birth, 21 days and weaning (4 weeks) in NZW, Rex rabbits and their crosses.

Reddy *et al.* (2000 a), in a study involving NZW, SC, FG and GG rabbits, found a significant effect of litter size at birth on litter weight at birth, 3 and 4 weeks age. Genetic group significantly influenced the litter weight at third week only.

Medellin and Lukefahr (2001) analyzed the data from 1,111 straight bred and reciprocally crossbred Altex and NZW rabbits and reported that mean litter size at weaning and litter weight at weaning were similar for Altex and NZW dams.

Belhadi *et al*. (2002) studied the influence of various non-genetic factors on rabbit reproduction in Algeria and reported that kindling season affected litter size at weaning significantly.

Prayaga and Eady (2002) reported that month-year of birth had significant effect on litter size at weaning and litter weight at weaning ($P<0.01$) in NZW, CW, FG and their crosses.

Bharat Bhushan *et al.* (2004) studied genetic and phenotypic parameters of pre-weaning traits on 202 litters from 40 NZW rabbits and found significant effects of season of birth on litter size and weight at birth and also at weaning. Litters born during April-September were found to be large and heavier at birth and weaning.

Zucchi and Desalvo (2004) analyzed the data on 440 females in Italy and found that the number of live born was significantly higher in February than in August or November (9.19 vs. 7.52 and 7.63).

Belhadi (2005) analyzed the influence of various non-genetic factors on litter size and on litter weights at weaning and at 70 days in 72 does of a local population. The general trend of year-season effect was favourable for both litter size and weights during pre-weaning period with a positive effect of spring kindlings on litter sizes from birth to weaning in relation to autumn of the same year. A high effect of winter and autumn on mean weight at weaning (646.7 and 611.7 g) was observed. The increased number of born alive mainly diminished mean weights at weaning and also, but less, mean weight at 70d and not significantly post weaning daily gain.

Chineke (2005) monitored the data on 259 rabbits from 73 litters representing 8 genotypes for genetic and non-genetic effects on Litter weight, Average litter weight and Litter size at weaning and post weaning ages of 35 and 56 days. Genotype differences were detected for 35-day litter weight ($P \leq 0.05$) and 56-day liter weight ($P \leq 0.05$). Sex differences ($P \leq 0.05$) were obtained for 35-day litter weight. Males weighed heavier than females in litter weight at 35 and 56 days.

Jaouzi *et al.* (2005) evaluated the production performances of local Moroccan rabbits and CW breed, both in pure and cross-breeding in Moroccan conditions and reported that litter sizes at birth and weaning were significantly different among the two genetic groups.

Rubio *et al*. (2005) conducted a diallel cross with NZW, CW, SC and Criollo rabbits and indicated significant breed differences for litter size and weight at birth and weaning.

Urmila *et al*. (2005) studied the effect of genetic and non-genetic factors on litter size and weight at birth and weaning in NZW, SC, GG, FG and BB breeds. Breed had significant effect on all litter traits. Year of kindling had highly significant effect on all reproductive traits. The effect of litter size at birth was highly significant on litter size at weaning and litter weight at birth and weaning.

Zerrouki *et al*. (2005 a) studied 287 females of local Kabylian rabbits and reported that the average prolificacy was low (7.2 ± 2.5 total born, 6.1 ± 3.0 born alive and 5.4 ± 2.3 weaned). The Algerian hot summer season did not affect litter size at weaning. The only significant effect ($P<0.01$) was a reduction of litter weight at weaning (-13%) compared with the average of the 3 other seasons (2070 vs 2368 g at 28 days).

Chineke (2006) analyzed the pre-weaning data on 466 kits from 109 litters, 280 kits from 78 litters and 261 kits from 74 litters at birth, 21 and 28 days of age, respectively representing NZW, SC and their crosses. The results showed that genotype, litter size, sex and season were important sources of variation for the performance characteristics studied. Litters born in wet season maintained superior body weights over dry season litters. The results of this study indicated that choice of breeds for commercial production should be based on pre-weaning performance. Moreover, genotype, litter size, sex and season as important sources of variation should be considered in improvement programmes to increase the meat yield from rabbit breeds and crosses.

Das *et al.* (2006) reported significant effect of breed in case of litter size at weaning and litter weight at weaning in NZW and SC rabbit breeds. Both were significantly higher in NZW than SC.

Ekambaram *et al.* (2006) found significant effect of litter size at birth on litter weights at all pre-weaning ages. Litter size at weaning influenced the litter weights through out the post weaning period in NZW, SC, GG and FG breeds.

Iraqi *et al*. (2006) studied the performance of Egyptian Gabali and NZW rabbits by utilizing data on litter traits of 1089 litters produced from 8 genetic groups (2 purebreds and 6 crossbreds). Results showed that differences between NZW and Gabali breeds were non-significant for all the studied litter traits. The differences among some crossbred groups and purebreds were significant ($P<0.05$) for litter size at weaning and litter weight at weaning.

Kumar *et al*. (2006) found that NZW rabbits had larger litters at birth (4.27 ± 0.20) but was not significantly different from WG and SC. Litter weight at birth also did not differ between breeds. However, it was higher in the winter and summer compared to the monsoon seasons. Average litter size at weaning was non-significantly higher in NZW rabbits. No significant difference in litter size at weaning was observed between seasons. NZW rabbits have the best overall productive and reproductive performances and are the most suitable for broiler rabbit production in all seasons.

Das and Yadav (2007) studied the performance of NZW, SC and Meghalaya Local does and found that the breed had significant ($P < 0.05$) effect on individual litter weight at weaning.

Das *et al.* (2007) observed significant effect of litter size at birth on litter weight at weaning in NZW, SC, Local rabbit and crossbred rabbit of SC & Local.

## 2.2 PRE-WEANING BODY WEIGHTS

The average pre-weaning body weights at birth, 1, 2, 3 and 4 weeks of age as reported in the literature are given in Table 2.

The averages reported for body weights at birth ranged from 49.11 to 60.15 g in NZW, 44.66 to 64.77 g in GG, 47.54 to 58.28 g in SC, 51.38 to 58.70 g in FG and 47.77 to 99.22 g in CW bunnies. The averages reported for body weights at 4 weeks age ranged from 290.50 to 761 g in NZW, 328.29 to 642 g in GG, 314.22 to 564 g in SC, 305.48 to 368 g in FG and 294.88 to 687.22 g in CW bunnies.

Nunes and Polastre (1990) reported significant effect of year and season of birth on body weight at weaning in Norfolk rabbits and Gupta *et al*. (1992) reported that NZW, GG, SC and WG bunnies born from September to December were heavier than those born from January to April. El Maghawry *et al*. (1999) reported that parity and season of kindling significantly ($P<0.01$) affected individual body weight in NZW, Rex rabbits and their crosses.

Gupta *et al.* (1999) found that season of birth, litter size at birth and genetic group significantly influenced the body weight at birth and weaning of NZW, GG, SC, FG and their six 2-breed crosses. Bunnies born in summer had higher body weights and ADG than those born in rainy and winter seasons.

Reddy *et al.* (2001) found that litter size at birth had significant effect on body weights of SC, NZW, GG and FG bunnies at birth, 1, 2, 3 and 4 weeks of age and the least-squares means decreased as the litter size at birth increased.

Poornima *et al.* (2002 a) observed that the body weights of CW bunnies at birth and 4 weeks of age were significantly affected by the month of birth, whereas the weights at 3 and 4 weeks age were influenced significantly ($P < 0.01$) by the litter size at birth.

Monika *et al*. (2004) reported that the season had no significant effect on the birth weight of rabbits ($p>0.05$).

Chineke (2006) analyzed the pre-weaning data on 466, 280 and 261 kits at birth, 21 and 28 days of age, respectively representing NZW, SC and their crosses and found that genotype, litter size, parity, sex and season were important sources of variation for the performance characteristics studied. Individual kit weight consistently increased with litter size at all ages. Females weighed significantly heavier than males at 21 days of age.

Kumar *et al*. (2006) found that NZW and SC kits had significantly higher weaning weights (0.761 ± 0.12 and 0.738 ± 0.15 kg, respectively) compared to WG kits (0.700 ± 0.19 kg). There was a gradual increase in weaning weight from summer to winter (0.680 to 0.809 kg). NZW and WG females were heavier than the males at weaning, but the opposite was true in SC rabbits.

## 2.3 POST WEANING BODY WEIGHTS

The average post weaning body weights as reported in the literature are summarized in Table 3. The averages for body weights at 6 weeks ranged from 497.4 to 947.2 g in NZW, 508.65 to 643.91 g in GG, 512.25 to 826.4 g in SC, 599.79 to 654.38 g in FG and 494.01 g in CW bunnies.

Lukefahr *et al*. (1989) analyzed data from 89 NZW rabbits and reported that the 28-d weaning weight, 56-d market weight were significantly influenced by litter size.

Ozimba and Lukefahr (1991a) analyzed the post weaning data on 643 rabbits from 122 litters representing NZW and CW purebreds, CW X NZW and FG crossbreds over five seasons and found non significant effect of breed type on weight at weaning.

Bharat Bhushan and Ahlawat (1999) studied genetic parameters for post-weaning body weights in NZW rabbits and observed non-significant effects of season of birth and sex on body weight at different ages except the significant effect of season on 8 week body weight.

Kumar *et al.* (2001) found significant effect of breed on body weight at 12 weeks of age in SC, WG and BB breeds of rabbits. Season of kindling significantly influenced the early period of growth with autumn born kits gaining a maximum weight until 10 weeks, and until 20 weeks for winter born animals. Animals from larger litters achieved lower individual body weights from 4 to 12 weeks of age, but attained higher litter weight.

Gupta *et al.* (2002) studied post-weaning body weights from 6 to 16 weeks in a diallel cross involving 960 bunnies of NZW, SC, GG, FG breeds of rabbits and reported significant influence of litter size and season of birth on body weights at all ages studied. Bunnies born in summer had higher body weights than in winter. Sex of bunny had no effect on any of the post weaning body weights studied.

Poornima *et al.* (2002 b) found that body weights of CW rabbits at 6, 8, 10, 12, 14 and 16 weeks of age were significantly ($P < 0.01$) effected by the month of birth, whereas sex of bunny had significant effect on body weight at 14 weeks age only. Bunnies born in January had higher average weights than those born in other months. Females weighed heavier ($P < 0.05$) than the males at 14 weeks of age.

Prayaga and Eady (2003) reported that the overall least-squares means for 5, 6, 7, 8, 9 and 10 wk body weights were 836, 1021, 1215, 1390, 1577 and 1791 g, respectively in NZW, CW and FG and their crosses.

Skandro *et al*. (2004) reported that the average live weight of male and female Sarajevo rabbits ranged from 1814.17 g (81-90 days) to 2737.92 g (151-160 days) and 2240.83 g (81-90 days) to 2428.33 g (151-160 days), respectively.

Zucchi and Desalvo (2004) analyzed the data on 440 mated females and found that the body weight at weaning was significantly higher following matings in October (931.2 g) than in April or July (771.2 and 775.1 g respectively), but body weight at 70 days was not significantly affected by month of mating.

Bianospino *et al*. (2005 b) studied the effects of genetic group (straight bred *vs* crossbred) and age on growth of 128 straight bred Botucatu and Botucatu x White German Giant crossbred rabbits. Crossbred rabbits were heavier than straight bred ones.

Chineke (2005) analyzed data on 259 rabbits from 73 litters representing 8 genotypes and found genetic effects on Individual Kit weight at 35 and 56 days ($P \leq 0.01$). Season mean values for 56-day Individual Kit Weight were different with dry season rabbits weighing more than wet seasons.

Devi *et al.* (2005) enumerated the factors influencing post-weaning body weights of 128 SC and 93 CW rabbits from 5 to 16 weeks of age and reported the overall least-squares meand for body weights to be ranging from 551.01 to 1564.40 g and from 476.56 to 1526.94 g, respectively, for SC and CW rabbits.

Ghosh *et al*. (2005) studied the productive and reproductive performances of 261 litters of NZW and SC breeds of rabbits under the sub-tropical climate of Tripura in India and reported that both the breed and sex of the rabbit had no significant effect on individual body weight at weaning (42 days). Season of kindling exerted highly significant ($P \leq 0.01$) effect on individual weight at weaning. Winter (November-March) was the most favourable season for kindling in terms of both their productive as well as reproductive efficiency, whereas summer (April-June) turned to be the most unfavourable season.

Kermauner and Zgur (2005) studied the performance of 4 genotypes, two lines of Slovene SIKA meat rabbit, their hybrid and Californian crossbreds and reported significant effect of genetic group on live weight at 91 days which ranged from 2720 to 3158 g.

Verga *et al*. (2005) reported the body weight of Italian rabbits at 75 days of age to be ranging from 2540 to 2626 g.

## 2.4 POST WEANING ADGs

The post weaning average daily gains as reported in the literature are summarized in the Table 4.

Lukefahr *et al*. (1989) found a significant effect of litter size on ADG (28-56 d) in a study involving 89 NZW rabbits while El-Maghawry (1993) reported that the effects of year and month of birth, parity and litter size were significant on ADGs from 5 to 12 weeks of age in NZW and CW breeds. Sex differences in daily gains were small and mostly non-significant.

Ekambaram (1997) observed that the post weaning ADG of SC, NZW, GG and FG rabbits during 5 and 6, 7 and 8, 9 and 10 and 11 and 12 weeks of age was significantly affected by the month of birth, whereas sex of bunny significantly affected the ADG during 7 and 8 and 11 and 12 weeks of age only. Bunnies born during February and March were lighter than those born in April, May and June and the males had higher ADG than the females.

Gupta (1998) reported that the post weaning ADG from 5 to 16 weeks of age of SC, NZW, GG and FG rabbits were significantly affected by the season of birth and litter size at birth but not by the sex of bunny. Bunnies born in summer had higher growth rates than those from winter and rainy seasons. The ADG declined as the litter size at birth increased from 3 to 9 bunnies.

El Maghawry *et al*. (1999) reported that season of kindling significantly ($P \leq 0.01$) affected daily gain in weight (post-weaning) in NZW, Rex rabbits and their crosses.

Skrivanova *et al*. (2000) studied the performance of NZW, CW, NZW x CW, Hyla 2000, Zika, Cunistar rabbits and reported that NZW rabbits had the lowest weight gain (25.4 g/day). Significantly higher ($P<0.05$) daily weight gains were observed in the NZW x CW, Zika and Cunistar rabbits (34.5, 33.0 and 33.0 g respectively).

Borthakur *et al.* (2002) studied factors affecting post weaning ADG in NZW rabbit and reported that the least-squares means for daily body weight gain during 42-90, 42-180 and 90-180 days of age were $18.624 \pm 0.387$, $14.362 \pm 0.312$, and $12.854 \pm 0.561$ g, respectively. Litter size at birth had significant effect on post weaning daily body weight gain during 42-90 days of age. The effect of season and year of birth on ADG was significant during all the 3 periods of growth.

Bianospino *et al*. (2005 b) studied the effects of genetic group on the performance of 128 straight bred Botucatu and Botucatu x White German Giant crossbred rabbits and reported that no difference between genetic groups was detected for average daily gain corrected for feed consumption, suggesting that feed efficiency was similar between groups.

Devi *et al*. (2005) studied the factors influencing the post weaning body weights and average daily gain of 128 SC and 93 CW rabbits from 5 to 16 weeks of age and reported that influence of season of birth was significant on ADG of CW rabbits at 7 and 8 weeks of age. Year of birth and sex of the bunny significantly influenced the ADG.

Jaouzi *et al* (2005) evaluated the production performances of local Moroccan rabbits and CW, both in pure and cross-breeding in Moroccan conditions and reported the ADG from weaning to slaughter as 24.5 and 35.1 g, respectively in local and CW rabbits. ADGs were significantly different among the two genetic groups.

Lakabi *et al*. (2005) studied the growth performance of 189 rabbits from the local Kabylian population from 4 to 11 weeks and for 90 of them until 15 weeks. The average growth rate was 27.7 ± 6.3 g/d between 4 and 8 weeks, and was reduced to 22.2 ± 5.4 g/d during the 3 following weeks, and to only 18.0 ± 6.3 g/d between 11 and 15 weeks. Growth rate was similar for both sexes. Growth rate was reduced by 13% in summer (weaned in June-July) when compared to spring (weaned in February).

Djellal *et al*. (2006) studied the productivity of local rabbit populations under small farm conditions in Algeria, from weaning (30 to 50 d) till selling (13 to 14 weeks) and reported an average daily gain of 12.3 g.

Metzger *et al.* (2006 a) studied the weight gain in Pannon White, Hyplus PS19 rabbits and their crosses and found that the genotype had a significant effect on weight gain (36.6 to 38.9 g/day).

Oluremi *et al.* (2006) studied the performance of twenty mixed breed broiler weaner rabbits between 9-11 weeks of age and reported that the ADG ranged from 9.92 to 12.00 g.

Olorunsanya *et al.* (2007) studied the growth performance of meat type rabbits and reported that the ADG ranged from 6.55 to 11.27g in broiler rabbits.

## 2.5 MILK YIELD

Mc Nitt and Lukefahr (1990) in a lactation study on CW, NZW, Palomino and White Satin rabbits found that average milk yield tended to differ ($P \leq 0.01$) between breeds, and was highest in CW rabbits. Peak lactation occurred approximately 20 days after kindling. As kit number increased, milk yield also increased to a predicted maximum when 12 kits were suckling.

El-Maghawry *et al.* (1993) reported that litter size was the most important non-genetic factor affecting milk yield through the suckling period in NZW and CW breeds.

El-Sayiad (1994) reported an average lactation milk yield of 3185.4 and 3436.5 g in NZW and CW rabbit breeds.

Singh (1998 a) studied milk production in NZW, SC, GG, WG and BB breeds of rabbits and reported that peak milk yield, daily milk yield and average daily litter weight gain to be 149.4, 87.5 and 89.3 g respectively in a lactation period of 42 days. It was observed that seven to nine kits were optimum for emptying the mammary glands resulting in higher peak milk yield and daily milk yield.

Ogundu (2001) reported a high linear relationship between mean milk suckled per kit per day and all litter performance traits in Dutch rabbits.

Echegaray *et al.* (2005) studied the effect of nursing frequency on the performance of 983 kits born to 122 does in Mexico and found that rabbits from does nursing twice a day were heavier by 14 and 30 g at 21 d and at weaning, respectively than rabbits from does nursing once a day.

Zerrouki *et al.* (2005 b) studied the milk production of local Kabylian rabbit population in Algeria, by following 299 parturitions for 21 days from parturition. The average litter size was 5.6 ± 2.3. The average milk production was 2180 ± 719 g in 21 days, which is 104 g of milk/day. The milk intake of young rabbits increased from 12.6 g/day/kit during the 1st week, to 27.2 g/day during the 3rd week of lactation. The number of young per litter influenced the does’ milk production very significantly: 62.8 g/d for 2 to 3 young per litter, and up to 127-131 g/day for more than 6 young, although milk production available per kit and per day decreased linearly with the number of kits in the litter for each of the 3 weeks considered. On the other hand, the average milk production expressed as quantity available per kit and per day was not significantly affected by the parity order: 20-21 g /kit /day on average for the 0-21 day period.

Ekambaram *et al.* (2006) studied milk production in NZW, SC, GG and FG rabbits and reported the mean lactation milk yields to be 1267.34 ± 23.78, 1043.67 ± 23.95, 1534.34 ± 56.34 and 1423.67 + 118.44 gms respectively, in a lactation spanning 18 days.

## 2.6 FEED EFFICIENCY

The average feed efficiency in various genetic groups and ages, reported in the literature is summarized in Table 5.

Ozimba and Lukefahr (1991 a) analyzed the post-weaning data on 643 rabbits from 122 litters representing NZW and CW purebreds, CW X NZW and FG crossbreds over five seasons and reported that the breed type differences were not significant for feed efficiency.

Prasad (1993) observed that sex of the bunny had no significant effect on FCR of bunnies from 4 to 12 weeks of age. The average FCR of males and females were 3.51 and

3.53 respectively. Genetic group of bunny significantly influenced the post weaning ADG during 4-6, 6-8, 8-10 and 10-12 weeks age.

Paci *et al*. (1999) reported that rabbits raised in the open air had a higher feed intake (141.1 and 127.6 g/d) and conversion (4.22 vs 3.62; $p<0.01$) when compared to cage reared rabbits.

Gupta *et al.* (2000 c) analyzed data on feed intake and feed conversion ratio of 17 purebred, 18 two-breed and 27 three breed cross bunnies from 5 to 16 wks age and reported significant effect of genetic group and season of birth of bunnies and non-significant effect of sex of bunny on feed intake and feed conversion ratio.

Skrivanova *et al*. (2000) studied the performance of NZW, CW, NZW x CW, Hyla 2000, Zika, Cunistar rabbits and reported that NZW rabbits had the poorest feed conversion (4.56 kg feed/kg gain). The best feed conversion was found in CW rabbits (2.98 kg feed/kg gain).

Bianospino *et al*. (2005 b) studied the effects of genetic group on the performance of 128 straight bred Botucatu and Botucatu x White German Giant crossbred rabbits and reported that the crossbred rabbits consumed more feed than straight bred ones. No difference between genetic groups was detected for average daily gain corrected for feed consumption, suggesting that feed efficiency was similar between groups.

Chang *et al.* (2005) studied the production performance of NZW rabbits and found that the ADG of weaning to 2 months was higher than that of 2 to 3 months ($P \leq 0.05$), which were 33.4 and 29.6 g, respectively. The feed/gain rate of weaning to 2 months rabbits was lower than that of 2 to 3 months ($P \leq 0.05$), which were 2.93:1 and 4.41:1, respectively.

Jaouzi *et al* (2005) evaluated the production performances of local Moroccan rabbits and CW , both in pure and cross-breeding in Moroccan conditions and reported the mean feed conversion index from weaning to slaughter as 2.91 and 2.06 g, respectively in local and CW rabbits.

Matics *et al.* (2005) reared weaned young (21 days) rabbits up to 10 weeks of age (n=116) and found that the feed consumption ranged from 101 to 102 g/day, body weight gain ranged from 38.1 to 38.6 g/day, feed conversion rate ranged from 2.61 to 2.66 g/g.

Oluremi *et al.* (2006) studied the performance of twenty mixed breed weaner rabbits between 9-11 weeks of age and reported that the daily feed intake and daily FCR ranged from 37.13 to 41.86 and 3.45 to 4.08, respectively.

Olorunsanya *et al*. (2007) studied the growth performance of meat type rabbits and reported that the daily feed intake and FCR ranged from 39.83 to 49.03g and 4.36 to 6.23.

## 2.7 CARCASS TRAITS

The averages for age and weight at slaughter, dressing percentage and weights of hot carcass, head, feet, pelt, edible offals and inedible offals, as reported in the literature are presented in the Table 6.

The dressing percentage reported in the literature ranged from 44.01 to 60.89 in NZW, 45.6 to 54.6 in GG, 45.8 to 56.16 in SC, 44.63 to 51.65 in FG and 51.46 to 60.5 in CW rabbits.

Lukefahr *et al*. (1989) analyzed the data from NZW rabbits (n = 89) on carcass traits such as pre-slaughter, abdominal fat, giblet, pelt, visceral and carcass weights and dressing percentage. Analysis of variance results revealed detectable ($P \leq 0.05$) effects of litter size class on all the traits studied except on visceral weight.

Gupta *et al.* (1990) in a study on SC, NZW, GG, WG and their crosses reported that sex of bunny had a significant effect on weights of the head, fore-quarter, mid-quarter and hind quarters. All the averages were found to be higher in males than in females.

Ozimba and Lukefahr (1991 b) analyzed data on 226 fryers of NZW and CW purebreds, CW x NZW and FG terminal crossbreds pertaining to carcass merit *Viz.* pre-slaughter and carcass weight, pelt, visceral, giblet and dressing percentage, percentages of carcass in loin, forequarter and hindquarter primal cuts. Breed influenced all traits except giblet and forequarter cut percentages. Season of birth significantly ($P \leq 0.05$) influenced all traits except percentage of loin cut. Gender of rabbit affected ($P \leq 0.05$) only the percentage of forequarter cut. NZW purebreds were generally inferior ($P \leq 0.05$) to the three other breed types for carcass yield traits. Purebreds were lighter for pre-slaughter and carcass weights than were CW x NZW crossbreds ($P \leq 0.05$). The FG crossbreds had heavier pre-slaughter and carcass weights than NZW, CW and CW x NZW.

Kulkarni *et al.* (1995) reported higher dressing percentage of GG rabbits than SC and NZW rabbits.

Blasco and Ouhayoun (1996) reported that the proportion of loin ranged from 23 to 28% and of hind legs from 27 to 29 % in the commercial rabbit carcasses.

Nofal *et al*. (1996) reported that genetic group had significant effect on carcass weight, loin weight, and weight of hind quarters in NZW, CW rabbits and their reciprocal crosses. There were significant sex effects for the weights of offal, carcass and forequarters. The body weight at slaughter and carcass weight averaged 2654, 2604, 2637 and 2694 g and 1276, 1235, 1268 and 1309 g in NZW, CW, NZW x CW and CW x NZW rabbits respectively, slaughtered at 14-16 weeks of age.

Karim (1998) studied slaughter characteristics of SC, WG, NZW, GG, BB and reported that higher dressing yield in males than females even with their lower pre-slaughter weight was because of sex related differences in muscle tissue development.

Gupta *et al.* (2000 b) observed that season of birth significantly influenced the slaughter weight and weights of carcass, head, feet, pelt, edible offals and non edible offals of SC, NZW, GG and FG rabbits and their crosses. The slaughter weights of bunnies born in summer were higher than those born in rainy and winter seasons. Males recorded significantly higher averages for all carcass traits than the females. Further Gupta *et al*., 2000 a), observed that genetic group significantly influenced all the meat traits studied in NZW, GG, SC, FG and their crosses.

Reddy *et al.* (2000 b) observed that sex of bunny had no significant effect on pre-slaughter weight, dressing percentage, edible offals and inedible offals weight in purebred SC, NZW, GG and FG rabbits. Genetic group had significant influence on edible and inedible offals weight.

Sen *et al.* (2000) reported that average dressing percentage ranged from 40.44 to 54.38 in SC, WG, BB breeds of rabbits.

Gupta *et al.* (2001) studied the genetic and non-genetic factors influencing the carcass trait percentages of NZW, GG, SC, FG purebred rabbits and their crosses using diallel analysis and reported that season of birth significantly affected all the traits studied except the feet and hindcut percentages. Rabbits born in summer had higher dressing percentage (47.54%), pelt (9.6%), forecut (14.8%) and midcut (14.2%) percentages than those born in rainy and winter seasons. Sex influenced the head, feet and forecut percentages. Females had significantly higher ($P \leq 0.01$) averages for head and feet percentages than males. Effect of genetic group on head and forecut percentages was significant.

Ortiz and Rubio (2001) studied the effect of breed and sex on carcass composition and meat quality in NZW, CW, CW and Rex and concluded that carcass yield was very similar for rabbits slaughtered at 2 kg.

Metzger *et al*. (2003) studied the effect of housing system on carcass traits and meat quality of NZW rabbit and reported that at 13 weeks of age, pen-housed rabbits (n=52) had lower body weight (2318 vs 2437 g; $P \leq 0.01$) and dressing percentage (59.8 vs 61.0 %; $P \leq 0.01$), higher proportion of the fore part (32.3 vs 31.4 %; $P \leq 0.01$) and hind part (40.3 vs 37.9 %; $P \leq 0.001$) and lower proportion of intermediate part of the carcass (27.5 vs 30.7 %; $P \leq 0.001$) than the cage-housed rabbits (n=68).

Poornima *et al.* (2003) studied carcass traits in CW rabbits and reported that month of birth had significant effect on all carcass traits while sex of rabbit had no significant effect.

Prayaga *et al*. (2003) reported that the overall least squares means for slaughter weight, carcass weight and dressing percentage were 2.28 kg, 1.23 kg, and 53%, respectively in NZW, CW and FG and their crosses.

Barron *et al*. (2004) studied carcass traits in NZW, CW and SC breeds and concluded that rabbits from the SC breed had the best weights of the different carcass components.

Kumar *et al*. (2004) compared the dressing percentage and carcass traits among 3 breeds of rabbits (6 each of NZW, WG and SC). The average dressing percentage pooled over breed was 45.78 ± 0.46. NZW and SC had a similar dressing percentage. The weight of head and skin were least in NZW (182.25 ± 14.40 g and 232.80 ± 13.67 g) rabbits.

Levai and Milisits (2004) reported that the ratio of liver (3.0 and 2.1%) and other edible organs (2.2 and 1.8%) to the live weight was higher in the offspring of fat rabbits, when compared to the offspring of lean rabbits, in Pannon White rabbits (n=195). However, a higher ratio of carcass was observed in lean animals (49.3 vs. 50.2%, respectively). When the carcass was dissected into three parts, the fore and hind parts had higher values in the offspring of lean rabbits. The ratio of the intermediate part to the live weight was higher in the offspring of fat rabbits, but the differences between the groups were statistically not significant.

Amaefule *et al.* (2005) studied the carcass characters of NZW and SC crosses having a pre-slaughter body weight of 1675-1842 g. and reported that the dressing percentage and per cent edible offals ranged from 60.00 to 69.90 and 4.40 to 4.75 per cent, respectively.

Bianospino *et al.* (2005 a) evaluated the effects of genetic group on carcass quality of 128 straight bred Botucatu and Botucatu x White German Giant crossbred rabbits. The effect of genetic group was non significant for the weights of commercial carcass, loin, fore part and hind part, after adjusting for pre-slaughter weight. The unadjusted weights of commercial carcass, loin, fore part, kidneys, liver and thoracic viscera for these rabbits slaughtered between 42 and 91 days of age ranged from 541.1 to 1492 g, 296 to 309, 283 to 298, 11.8 to 12.5, 68.3 to 73.2 and 26.2 to 30.8 g, respectively.

Bovera *et al.* (2005) investigated the carcass and meat characteristics of Ischia rabbits raised in pits. Fourteen rabbits were slaughtered at 4.5 months of age, on average. The results indicated that rabbits raised in pits, both due to their genetic type and the particular breeding technique adopted, is small (average weight at slaughter 1286 g ± 169) and has a low hot dressing percentage (52.9 % ± 3.5) due to the high percentage of the gastrointestinal tract (26.4 % ± 3.5).

Ghosh *et al.* (2005) studied the productive and reproductive performances of 261 litters belonging to NZW and SC breeds of rabbits under the sub-tropical climate of Tripura in India and reported that season of kindling exerted highly significant ($P\leq0.01$)

effect on weight at slaughter age (90 days). Winter season (November-March) was the most favorable season for kindling in terms of both their productive as well as reproductive efficiency where as summer season (April-June) turned to be the most unfavorable season.

Lakabi *et al*. (2005) studied the performance of 189 rabbits from the Kabylian population. Most of the slaughter traits were similar in males and females sacrificed at 15 weeks. Slaughter rate was the highest for rabbits slaughtered in August (compared to June and September) in relation with a significant reduction of the full digestive tract (11.2% vs 12.4-12.6% of body weight).

Marounek *et al*. (2005) slaughtered six rabbits and found that the caecum was the largest digestive organ with an average weight of 157 g (5.5% of the total body weight).

Nofal *et al*. (2005) studied the carcass traits of 105 rabbits slaughtered at 12 weeks of age, which consisted of 57 straight breds and 48 crossbreds, produced from Pannon White and Danish White. Dressing out percentage based on the ratio of hot carcass (with head, liver, kidneys, heart, lungs, perirenal fat) weight to live weight after 24-hour fasting of Pannon White, Danish White, Pannon White x Danish White and Danish White x Pannon White were: 58.0, 55.9, 58.5 and 57.5%, respectively. Breed group and sex had no effect on majority of the carcass traits except on slaughter weight ($P \leq 0.01$).

Pinna *et al.* (2005) studied 96 crossbred rabbits (NZW x CW) weaned at 28 days (Live wt. 493± 63 g), slaughtered at 77 days (Live wt. 2167± 157 g). The average dressing out percentage was 59.7 ± 8.1%.

Santos *et al.* (2005) studied the effects of breed and sex on carcass yield and commercial cuts of 48 NZW and 48 CW rabbits with equal numbers of males and females. Results showed that CW breed showed the best loin yield. There were no statistical differences between breeds for the other parameters. The yields of hot carcass without head and loin, at 70 days of age, were smaller compared to the other ages.

Singh and Prasad (2005) studied the effect of breed, sex and stage of growth on the carcass characteristics of WG, SC and BB rabbits under farm conditions in Rajasthan. It was observed that the pre-slaughter, carcass and edible offal weights of grower rabbits were significantly ($P \leq 0.05$) higher in WG and SC compared to BB rabbits regardless of sex. However, carcass yield did not significantly differ between breeds and was 43.04-45.37% of the preslaughter weight. Inedible offal weight also did not significantly differ between breeds. Total saleable meat weight was higher in WG (1.04 kg) compared to SC (1.08 kg) and BB grower rabbits (0.90 kg). Sex did not significantly affect carcass weight between breeds but slaughter weight and total saleable meat weight were higher in males than in female BB grower rabbits. There were no significant differences in the slaughter and carcass weights of adult rabbits, although these values were higher in WG compared to BB rabbits. Inedible offal weight was similar between breeds. Slaughter, carcass, edible offal and total saleable meat weights were significantly higher in female compared to male adult rabbits regardless of breed. Based on the studies it was concluded that breed, sex and growth stage affected the carcass characteristics of meat-type rabbits.

Zgur and Kermauner (2005) slaughtered 73 rabbits of four genotypes (2 Sika lines and their crosses with CW) and found that the live weight at slaughter and dressing percentage were not influenced by genetic group.

Zotte (2005) compared the carcass traits of 41 Vienna Blue, Burgundy Fawn and hybrid rabbits. Carcass traits were not modified by the genetic group. The sex effect was significant only for the dressing out percentage, being higher in males than females (59.0 vs 57.6%; $P \leq 0.05$).

Yalcn *et al*. (2006) compared meat and carcass characteristics of 30 male and 30 female NZW rabbits aged 11 weeks. The mean values for cold carcass weight and cold dressing percentage were 832 g and 48.77% in male and 849 g and 48.69% in female, respectively with no significant differences between male and female rabbits.

## 2.8 MEAT COMPOSITION

The biochemical composition of rabbit meat, as reported by some authors is presented here below in Table 7. The percent protein reported in the literature ranged from 19.2 to 23.3 %.

Lukefahr *et al*. (1989) analyzed data on meat quality traits from NZW rabbits (n = 89) and found a non significant effect of litter size on the cholesterol content of muscle. Cholesterol content of uncooked rabbit meat was 163.6 ± 3.1 mg/100 g DM.

Bieniek *et al.* (1994) studied the meat quality traits in NZW and Black Toasted rabbit breeds and found that breed differences were significant for percentages of protein and fat in the carcass.

Zajac (1999) reported that the percent of protein in meat ranged from 21.4 to 22.3 in crosses involving Giant Chinchilla, NZW, White Termond and Alaska breeds of rabbits.

Bielanski *et al*. (2000) studied meat quality traits in White Termond, Alaskan, Giant Chinchilla, CW, NZW, Meat Line hybrid and Genia hybrid rabbits and reported that protein content in the *longissimus dorsi* ranged between 21.1 and 22.6% while the fat content ranged between 4.2 and 5.2%.

Sen *et al.* (2000) reported that the proximate composition did not vary much among WG, SC and BB rabbits.

Skrivanova *et al*. (2000) reported that the *longissimus dorsi* muscle contained more protein and less fat and cholesterol in NZW, CW, NZW x CW, Hyla 2000, Zika, Cunistar rabbits. Carcass of CW rabbits had the lowest fat and cholesterol contents. The highest fat content was found in Zika rabbits (16.2 g/kg) and NZW rabbits (41.4 g/kg) respectively.

Ortiz and Rubio (2001) studied the effect of breed and sex on carcass composition and meat quality in NZW, CW, SC and Rex and concluded that meat quality is very similar for rabbits slaughtered at 2 kg.

Das *et al.* (2002) reported that fat % was significantly higher in caged rabbits than in those housed in hutches. Final live weight was significantly higher in rabbits housed in smaller floor spaces. Protein and ash % was significantly higher in rabbits housed in smaller floor spaces.

Metzger *et al.* (2003) housed 161 weaned NZW rabbits in 0.4 x 0.4 m cages (3 rabbits/cage, 18.7 rabbits/m2) or in 3 x 3.3 m pen on deep litter (80 rabbits/pen, 8.1 rabbits/m2). At 13 weeks of age, the meat on the *m. longissimus dorsi* of pen-housed rabbits contained less protein (23.6 vs 23.9 %; $P \leq 0.05$) and fat (0.65 vs 0.90 %; $P \leq 0.05$) than those kept in cages. The housing system had no effect on ash content and pH value of the meat samples.

Combes (2004) reviewed the nutritional value of rabbit meat from 50 publications and stated that for rabbits at commercial slaughtering age and weight, protein (21.0 ± 1.5% of fresh meat) and total mineral (1.2 ± 0.1% of fresh meat) contents were relatively stable among different studies. A cholesterol content of 59 mg/100 g and a ratio of omega 6/omega 3 of 5.9 make rabbit meat attractive for health purposes.

Pla *et al.* (2004) evaluated the protein, fat and moisture content of retail cuts of rabbit meat and reported that meat from the forelegs had 20.2, 7.4 and 71.2%; thoracic cage meat had 18.7, 12.8 and 66.9%; Longissimus dorsi muscle had 22.1, 1.2 and 75.6%; abdominal walls had 20.9, 7.6 and 70.1%; spine meat had 20.7, 7.9 and 70.0%; hind leg meat had 21.2, 3.0 and 74.7% and meat from the whole carcass had 20.8, 7.1 and 71.2% protein, fat and moisture contents, respectively. Meat from the foreleg is a good predictor of the chemical composition of the whole carcass meat.

Zgur and Kermauner (2005) found non significant differences between genotypes in hind leg tissue composition of Sika, CW and crossbreds.

Polak *et al.* (2006) investigated the chemical composition of lean rabbit meat and reported that on an average, rabbit meat contained 71.5% of water, 22.0% of proteins, 1.17% of ash, 5.4% of intramuscular fat, 67.6 mg of cholesterol per 100 g of fresh meat.

Metzger *et al.* (2006 a) studied the carcass traits and meat quality of Pannon White, Hyplus PS19 and their crosses and reported that the genotype had a significant effect on all the carcass traits studied. Pannon White breed had an advantageous influence on the dressing out percentage (PP: 58.0%; PH: 58.7%; HP: 57.7%; HH: 57.6%; $P \leq 0.001$).

Significant differences were found between the meat samples of different genetic groups in the fat content of hind leg meat (PP: 2.38%, HH: 1.46%; P<0.001).

Szkucik and Libelt (2006) indicated that the saddle muscles contained the lowest fat and the highest protein content. The thigh muscles contained a significantly higher percentage of fat, but their protein level was comparable to that of the saddle. The shoulder muscles contained the least valuable chemical composition. Protein in rabbits' muscles have a valuable, almost ideal, exogenic amino acid content, with the exception of the shoulder muscles, which have a significantly lower level of tryptophan.

Olorunsanya *et al*. (2007) reported that the crude fat per cent of rabbit loin ranged from 12.14 to 17.56.

## 2.9 REARING SYSTEMS

Paci *et al*. (1999) studied effect of housing system on productive performance and meat quality of rabbit and reported that in summer, growth rate and feed conversion during the last month were improved (31.8 vs 31.0 g/d, and 3.37 vs 3.41, respectively). In winter, growth did not differ between the 2 groups, but rabbits raised in the open air had a higher feed intake (141.1 and 127.6 g/d) and conversion (4.22 vs 3.62; P≤0.01).

Das *et al.* (2002) studied the effect of housing, floor space and breed on the carcass traits and composition in NZW and SC rabbits and reported that housing had a significant effect ($P \leq 0.05$) on edible offal weight and fat % of meat. Fat% was higher in caged rabbits than in those housed in hutches.

Metzger *et al*. (2003) studied the effect of housing system on carcass traits and meat quality of NZW rabbit and reported that at 13 weeks of age, pen-housed rabbits (n=52) had lower body weight (2318 vs 2437 g; $P \leq 0.01$) and dressing percentage (59.8 vs 61.0 %; $P \leq 0.01$), higher proportion of the fore part (32.3 vs 31.4 %; $P \leq 0.01$) and hind part (40.3 vs 37.9 %; $P \leq 0.001$) and lower proportion of intermediate part of the carcass (27.5 vs 30.7 %; $P \leq 0.001$) than the cage-housed rabbits (n=68). The meat from *longissimus dorsi* muscle of pen-housed rabbits contained less protein (23.6 vs 23.9 %; $P \leq 0.05$) and fat (0.65 vs 0.90 %; $P \leq 0.05$) than those kept in cages. The housing system had no effect on ash content and pH value of the meat samples.

Cavani *et al*. (2004) studied the meat characters of rabbits housed in open-air in movable colony cages on pasture during the fattening period. A total of 60 rabbits were reared using conventionally and subsequently divided into two groups at a live weight of about 2.0 kg and at 62 days old. The indoor group was kept in conventional bi-cellular cages (2 animals per cage, 0.07 $m^2$ per rabbit), while the open-air group was reared in movable colony cages (6 animals per cage, 0.17 $m^2$ per rabbit) on a polyphyta natural pasture. The grass was cut on the pasture prior to moving the cages so that the rabbits would not be able to eat the grass. Both groups were fed *ad libitum* a commercial diet for fattening rabbits. The rabbits were slaughtered when 13 weeks old. Fourteen carcasses from each experimental group were randomly collected. Rabbits housed open-air in movable cages exhibited lower carcass weight (1110 vs 1243 g; $P \leq 0.01$).

Bovera *et al*. (2005) investigated the carcass and meat characteristics of Ischia rabbits raised in pits. Fourteen rabbits were slaughtered at 4.5 months of age, on average. The results indicated that rabbits raised in pits, both due to their genetic type and the particular breeding technique adopted, is small (average weight at slaughter 1286 g ± 169) and has a low hot dressing percentage (52.9 % ± 3.5) due to the high percentage of the gastrointestinal tract (26.4 % ± 3.5).

Das *et al.* (2005) studied the effect of cage and hutch housing system with high (0.36 $m^2$/rabbit) and low floor space (0.25 $m^2$/rabbit) in NZW and SC breeds. Housing had a significant ($P \leq 0.05$) effect on final live weight at 91 days in summer and weekly DM intake. Higher weekly live weight gain and final live weight were found in rabbits kept in cage than in the hutch. Weekly DM intake was significantly higher in rabbits kept in cage than those reared in hutch. During rainy season, FCR was found to be significantly higher in caged rabbits than those reared in hutch. Floor space and breed had no significant effect on the growth and feeding parameters.

Trocino *et al*. (2005) recorded the performance of 320 rabbits weaned at 29 d reared under two stocking densities (12 and 16 rabbits/m2) and within density, two types of cage floors (wire net and slat). Daily growth rate averaged 48.5 g/d and live weight at 71 days was 2655 g, with a feed efficiency of 0.327. Carcass and meat quality were unaffected by housing system. The highest stocking density stimulated daily weight gain during the first two weeks of trial (51.4 vs 52.9 g/d in D12 and D16 rabbits; $P \leq 0.05$) but tended to reduce feed intake in the last two weeks (185 vs 179 g/d, $P=0.06$). Although stocking density had no overall effect on final weight or feed intake, feed efficiency was higher in D16 rabbits ($P=0.05$).The effect of the type of cage floor was weak and limited to a slight reduction in feed intake during the last two weeks of trial, and therefore an improvement in feed efficiency throughout the study ($P=0.01$), by rabbits reared on the wire net floor in comparison with rabbits reared on the slatted floor (179 vs 185 g/d; $P=0.08$).

## 2.10 HERITABILITY ESTIMATES

### 2.10.1 Litter Size and Litter Weight

Rastogi *et al*. (2000) analyzed data on litter production traits of does, involving 1120 litters. Locally adapted does and bucks of predominantly NZW breed were involved. Heritability estimates for total litter size born and born alive, and litter size at 21 days, 28 days, and 84 days were 0.09, 0.12, 0.06, 0.09, and 0.07, respectively. For litter weight at 21 days, 28 days, and 84 days, heritability estimates were 0.08, 0.09, and 0.02, respectively.

Farid (2004) analyzed the data on 1198 litters of Bouscat Rabbits and 725 litters of CW rabbits and reported that the estimates of heritability for litter size and litter weight at birth and weaning were in most, of low or moderate magnitude and were slightly higher in Californian rabbits than in Bouscat ones. The estimates of heritability had reasonable standard errors.

Urmila *et al*. (2005) estimated the heritabilities for litter size and weight at birth and weaning in 5 breeds of broiler rabbits and found them to be moderate with high standard errors, except litter weight at weaning.

Iraqi *et al*. (2006) studied the performance of Egyptian Gabali and NZW rabbits by utilizing data on litter traits of 1089 litters produced from 8 genetic groups (2 purebreds and 6 crossbreds). Results showed that the heritability estimates were (generally low) 0.04, 0.01, 0.08, and 0.09 for LSB, LWB, LSW and LWW, respectively.

### 2.10.2 Pre-weaning and Post Weaning Body Weights

Lukefahr *et al.* (1992 a) analyzed the data on individual 90-day body weights of 687 rabbits in two successive generations. Paternal half-sib estimates of heritability for the first and second generations were 0.41 ± 0.19 and 0.43 ± 0.18; a pooled estimate of 0.42 was computed.

Ferraz and Eler (1994) gave heritability estimates for body weight in NZW and CW as 0.03, 0.19 and 0.26 at 6, 9 and 11 weeks of age.

Asuquo and Okon (1999) reported that the heritability estimates for body weights at 8, 10, 12 and 14 weeks to be 0.66 ± 0.09, 0.64 ± 0.12, 0.63 ± 0.13 and 0.63 ± 0.14, respectively.

Enab *et al.* (2000) reported that heritability of body weight estimated from full sibs were high in both NZW and CW rabbit breeds.

Paula *et al*. (2000) studied genetic parameters for CW rabbits raised in Brazil and reported that heritabilities for weaning weight, weight at 10 weeks and ADG from weaning to 10 weeks age were 0.23, 0.44 and 0.39, respectively.

Sabra *et al*. (2001) reported that estimates of $h^2$ for post weaning body weights ranged from 0.228 to 0.718 in NZW while the estimates ranged from 0.266 to 0.552 in CW.

Yolcu *et al*. (2004) reported that the heritabilities of body weight from weaning to 90 days of age in NZW rabbits were low and in the middle level.

Akanno and Ibe (2005) estimated heritabilities of growth traits at different ages in NZW and Dutch breeds of rabbits (363 progeny). Heritability estimates were high for body weight (BW) at 6 weeks (0.43 ± 0.35), moderate for BW at 12 weeks (0.36 ± 0.35) and low for BW at 9 weeks (0.11 ± 0.22).

Hassan (2005) reported the heritability to be 0.23, 0.36 and 0.38 for 5th week,8th week and 10th week boy weights respectively in NZW rabbits.

Ibrahim *et al.* (2007) studied the productivity of five rabbit genotypes namely: Locals, pure NZW, 50% and 75% NZW and 'Others' involving 45 sires and l45 dams. Estimates of $h^2$ for body weight (BW) at 7, 21, 42 and 56 days were mostly moderate to high (0.17-0.90).

### 2.10.3 Post Weaning ADG and Feed Efficiency

Moura *et al.* (1997) investigated the responses to selection for post-weaning ADG and feed conversion (FC) in a composite rabbit population and reported that estimates of heritability of ADG and FC were 0.48 and 0.29, respectively.

Ponce de leon *et al*. (2004) investigated the genetic parameters for growth traits in CW, SC, Semi giant and NZW rabbits raised in Cuba. It was shown that the heritability was 0.23 - 0.54 for weaning weight and 0.13 - 0.18 for average daily gain.

Larzul and Rochambeau (2005) estimated the heritability for residual feed consumption to be 0.45 ± 0.11, which was of the same order as the heritability estimated for average daily gain (0.41 ± 0.13) and higher than the heritability estimated for the feed conversion ratio (0.27).

### 2.10.4 Carcass Traits

Lukefahr *et al*. (1996) reported that the estimates of heritability were 0.04, 0.37 and 0.25 for 28-day weaning weight, carcass yield percentage and loin primal cut percentage, respectively in an experimental population of rabbits.

Larzul *et al*. (2005) reported that the heritability (h2) was 0.22 for 63-d body weight (N=4754), 0.64 for peri-renal fat proportion and 0.55 for dressing out percentage in rabbits.

## 2.11 GENETIC AND PHENOTYPIC CORRELATIONS

Lukefahr *et al*. (1989) reported that the individual 56-d market weight was related to dressing percent (r = 0.60) and carcass weight (r = 0.93).

Mc Nitt and Lukefahr (1990) in a lactation study on CW, NZW, Palomino and White Satin rabbits found that the correlations of milk yield with litter sizes at birth and weaning and litter weaning weight were 0.62, 0.87 and 0.86 respectively.

Enab *et al* (2000) reported that the genetic and phenotypic correlations among different body weights were high and positive in both NZW and CW rabbit breeds.

Paula *et al*. (2000) studied genetic parameters for CW raised in Brazil and found that the genetic correlations between weaning weight and weight at 10 weeks of age and between weaning weight and average daily gain from weaning to 10 weeks of age were high (0.66) and very low, respectively.

Gupta *et al.* (2002) studied post weaning body weights from 6 to 16 weeks in a diallel cross involving 960 bunnies of NZW, SC, GG, FG breeds of rabbits and reported that correlations between body weights at different post weaning ages were positive and significant ($P \leq 0.01$) and correlation coefficient ranged from 0.43 to 0.94.

Poornima *et al.* (2003) studied carcass traits in CW rabbits and reported that genetic and phenotypic correlations among the carcass traits studied were highly positive and significant.

Bharat Bhushan *et al.* (2004) studied genetic and phenotypic parameters of pre-weaning traits in NZW rabbits and reported that genetic and phenotypic correlations of individual body weight on litter size at birth, litter size at weaning and litter weight at weaning were negative and significant.

Ponce de leon *et al*. (2004) investigated the genetic parameters for growth traits in CW, SC, Semi Giant and NZW rabbits raised in Cuba. The genetic correlations were homogeneous in all breeds. The genetic correlations between ADG and final weight were high (0.64 - 0.87), but were low between weaning weight and ADG.

Al Sobayil *et al.* (2005) reported that the heritabilities for milk yield traits were moderate, ranging from 0.18 to 0.22, while they were low or moderate and ranging from 0.09 to 0.28 for milk component traits in pure bred Spanish maternal line (V-line) and Saudi Gabali (G) rabbits and their crosses.

Devi *et al.* (2005) observed that the genetic correlations among the body weights at various post weaning ages in SC rabbits were all positive and ranged from 0.24 to 0.94. The phenotypic correlations among the BW at various post weaning ages ranged from 0.05 to 0.45 in SC and from 0.14 to 0.48 in CW rabbits, while those between the BW and ADG varied from -0.19 to 0.33 in SC and from -0.12 to 0.39 in CW rabbits.

Larzul and Rochambeau (2005) reported that the residual feed consumption was negatively correlated with the hind part percentage (-0.71) and correlated positively with front part percentage (0.54). The genetic correlations with dressing percentage and carcass fatness were very low.

Urmila *et al.* (2005) studied reproductive performance of NZW, SC, BB, WG, GG breeds of rabbits and reported that the genetic and phenotypic correlations of litter size at birth were positive and high with litter weight and litter size at weaning and negative genetic correlations were observed with litter weight at weaning. Litter weight at birth was genetically negatively correlated with other traits except litter weight at weaning.

Ekambaram *et al.* (2006) in a study on NZW, SC, GG and FG breeds reported that the phenotypic correlations among the pre-weaning and post weaning litter weights were positive in four genetic groups and estimates ranged from moderate to high in magnitude.

Yalcn *et al*. (2006) studied meat and carcass characteristics of 30 male and 30 female NZW rabbits aged 11 weeks and found that slaughter weight was positively correlated with the weights of carcass, skin with head and limbs, lung, liver, kidney, heart and weights of joints ($P \leq 0.01$) and dressing percentage ($P \leq 0.05$).

Ibrahim *et al.* (2007) studied the productivity of five rabbit genotypes namely: Locals, pure NZW, 50% and 75% NZW and 'Others' and reported that the phenotypic and genotypic correlations between the body weights at 7, 21, 42 and 56 days were mostly positive and moderate to high (0.02-0.57 and 0.18-0.75 for phenotypic and genotypic correlations, respectively).

Singh *et al*. (2007) in a study on GG rabbits reported that the phenotypic correlation between 42 days and 84 days body weight was positive and highly significant.

# CHAPTER III

# MATERIALS AND METHODS

Data on 195 New Zealand White (NZW), 37 Grey Giant (GG), 34 Soviet Chinchilla (SC), 61 Flemish Giant (FG), 28 Californian White (CW), 25 APAU Fawn (FN) and 16 APAU Black (BL) bunnies born during the period November 2006 and July 2007 in the “Rabbit Production for Meat” scheme of the Department of Animal Genetics and Breeding, College of Veterinary Science, Rajendranagar, Hyderabad were utilized for the present study. APAU Fawn and APAU black were the two synthetic breeds developed in the “Rabbit Production for Meat” scheme by crossing NZW, GG and local white rabbits in $F_3$ and $F_4$ generations. Photographs of the breeds under present study are shown in Figures 1-7.

## 3.1 HOUSING AND MANAGEMENT

### 3.1.1 Cage Rearing System

Bucks and does were reared individually in galvanized iron mesh cages arranged in rows on an iron frame in “M” shape at a height of about 2.5 feet from the floor. Each buck was provided with a cage floor area of 3 square feet with the cage dimensions of 1.5 feet length, 2.0 feet width and 1.25 feet height and each doe was given a cage floor space of 6 square feet with the cage dimensions of 3.0 feet length, 2.0 feet width and 1.25 feet height. Each bunny was provided 1 square foot area by accommodating 6 bunnies in one doe’s cage as shown in Figure 8. Earthen pots of about half a litre capacity were used as feeders and waterers, which were cleaned and refilled every day. During summer, the asbestos roof of the rabbitry was covered with a thin layer of paddy straw, which was wetted with over head water sprinklers and gunny cloth curtains hanged around the sheds and wetted continuously to prevent undue rise of ambient temperature in the sheds.

### 3.1.2 Backyard Rearing System

About 50 per cent of the bunnies from each litter belonging to various breeds were randomly selected at weaning and reared under deep litter system of rearing (as shown in Fig. 9) and their production performance was compared with those reared conventionally in the cage system of rearing. A thatched roof shed with gravel floor and chain link wire mesh walls (as shown in Fig. 10) was erected for the purpose and the rabbits were provided a floor space of about 2 square feet per bunny. Concentrate feed and fresh and clean drinking water were made available *ad libitum* by using earthen bowls.

## 3.2 MATINGS

A total of 42 bucks and 75 does belonging to NZW, GG, SC, FG, CW, FN and BL breeds were utilized as parent stock in the present investigation. Before mating, the pedigree particulars of the bucks and does were examined and inbreeding was avoided.

Does were mated during early hours of the day by leaving a doe into the buck's cage and the doe was returned to her cage after mating. Pregnancy diagnosis was done on 14th day after mating by abdominal palpation. The does that were not pregnant were re-mated on the same day.

Wooden nest box was kept in pregnant doe's cage on 25th day after mating, so that the doe could prepare the nest. Each nest box was 45 cm long and 25 cm wide, with a height of 25 cm at the closed end and 15 cm at the open end. The box was covered partly to about 12.5 cm. The nest boxes were thinly padded with clean and dry paddy straw before arranging them in doe's cage.

The bunnies were reared in iron mesh cages along with their dams from birth to 4 weeks of age. The bunnies were sexed, ear tagged and weaned on 28th day after kindling.

## 3.3 FEEDING

Concentrate feed mash and fresh water were made available *ad-libitum* to all the experimental animals. The feed was offered twice daily. About 200 g of Lucerne or Berseem green fodder was offered to each weaned rabbit per day. The concentrate feed mixture contained maize (50%), groundnut cake (22%), wheat bran (25%) and mineral mixture (3%). Coccidiostat and Vitamins A, D, E and C were added to the feed mixture at recommended levels.

## 3.4 TRAITS STUDIED

The following traits were measured on each rabbit included in the study.

### 3.4.1 Litter Size

*Litter Size at Birth (LSB)*: Number of bunnies born alive, counted within 24 hours of birth.

*Litter Size at Weaning (LSW):* Number of bunnies weaned (at the age of 28 days).

### 3.4.2 Litter Weight

*Litter Weight at Birth (LWB)*: Total weight of all the bunnies born in a litter recorded with in 24 hours of birth.

*Litter Weight at Weaning (LWW):* Total weight of all the bunnies in a litter recorded at weaning.

### 3.4.3 Pre-weaning Body Weights

Pre-weaning body weights of bunnies were recorded from birth to weaning (up to 4 weeks of age) at weekly intervals.

### 3.4.4 Post Weaning Body Weights

Post weaning body weights were recorded from weaning to 16 weeks of age at fortnightly intervals.

### 3.4.5 Post Weaning ADGs

*Average Daily Gain (ADG):* Post-weaning ADG was computed for the bunnies, which survived until 16 weeks of age using the following formula.

$$\text{ADG during 5 and 6 weeks age} = \frac{\text{Body weight at 6 weeks - Body weight at 4 weeks}}{14}$$

Similarly, the ADGs during various stages of post-weaning period were calculated based on the corresponding body weights.

### 3.4.6 Milk Yield

The milk yield of does was measured from kindling to 21 days of lactation. The milk yield was computed as the difference in body weight of the bunnies before and after suckling for about 5 minutes, once in the morning and once in the evening. After suckling these bunnies were maintained in the nest boxes away from the doe as shown in Figure 11.

### 3.4.7 Feed Efficiency Experiment

#### 3.4.7.1 Feed intake

Daily feed intake of rabbits was measured as the difference between the feed offered and feed left over for each individual rabbit. The feed intake of rabbits from weaning to 16 weeks of age was calculated at weekly intervals.

#### 3.4.7.2 Weight gain

The body weight gain of rabbits from weaning to 16 weeks of age was recorded at weekly intervals.

#### 3.4.7.3 Feed efficiency

A total of four bunnies 2 males and 2 females from each of the NZW, GG, SC and FG breeds were randomly choosen for studying the feed efficiency. After weaning at 4 weeks of age, bunnies were reared in individual cages each measuring 2.0 x 1.5’. A measured quantity of concentrate feed mixture was offered to the bunnies and the left over feed was weighed next day and daily feed intake (kg) was calculated. Rabbits were weighed at weekly intervals upto 16 wks age and weight gain computed. Feed conversion ratio was estimated as the feed taken in kg per kg body weight gain.

### 3.4.8 Carcass Traits

Bunnies were slaughtered at 16 weeks of age as per the procedure described by Cheeke *et al*. (1987). Bunnies were fasted overnight and the pre-slaughter weight was recorded just before slaughter.

Weights of head, feet, pelt, hot carcass, edible offals (heart, liver, kidneys), inedible offals (lungs, trachea, stomach and intestines), and length of caecum (shown in Figures 12-16) were recorded. The carcass was then divided into the 3 primal cuts (as shown in Fig. 17) designated as forecut, midcut and hindcut. The forecut consisted the front portion of the carcass upto 7th thoracic vertebra. The midcut was the mid portion of the carcass from 7th thoracic to 7th lumbar vertebrae. The hindcut formed the rest of the carcass. The dressing percentage was recorded as the ratio of hot carcass weight to the pre-slaughter weight and expressed in percentage.

### 3.4.9 Meat Composition

Samples of *longissmus dorsi* muscle of rabbits belonging to different breeds were collected after slaughter and proximate composition of meat samples estimated.

#### 3.4.9.1 Dry matter

Moisture content in a sample was determined by heating it in an oven to a constant weight at 100-105$^0$ C under atmospheric pressure. The moisture was evaporated.

Moisture cup was dried in an oven at 100$^0$C and later cooled in a dessicator and its weight was recorded. About 10 g of sample was taken in to moisture cup and dried in hot air oven at $100^0$C for 8 hours. Moisture cup was removed from the oven and cooled in a dessicator. The process of heating and cooling was repeated till a constant weight was achieved. The constant weight of moisture cup with sample was recorded and the dry matter content was obtained as the ratio of the weights of dried sample to that of the sample before drying and expressed in percentage.

### 3.4.9.2 Total ash

Ash is the inorganic or mineral component of the sample left after its complete incineration at $600^0$C in a muffle furnace. Empty crucible was dried in an oven, cooled in dessicator and its weight recorded. About 5 g of oven dried sample was taken in to crucible. Sample was ignited on a burner initially till the smoke ended up. Crucible was then transferred in to muffle furnace with the help of a pair of metal tongs and kept at $600^0$ C for 2 hours. Later, the crucible was removed from the furnace, cooled in dessicator and its weight was recorded. The weight of empty crucible was subtracted from this and the weight of ash was determined as the ratio of ash in the original sample and was expressed in percentage.

### 3.4.9.3 Protein

The Protein content of the muscle was estimated as per Lowry *et al.* (1951). The principle in this method was that Proteins react with copper at an alkaline pH to form copper-protein complex. The complex, when treated with phosphomolybdic-phosphotungstic reagent (Folin - ciocalteu), forms blue color which was measured at 660 nm.

A total of 100 µl of muscle homogenate was made up to 1.0 ml with distilled water. To this, 5 ml of freshly prepared alkaline copper sulphate solution (a mixture of 50 ml of 2% sodium carbonate in 0.1N sodium hydroxide and 1.0 ml of copper sulphate in 1% potassium sodium tartarate) was added and kept for 10 min at room temperature. 0.5 ml of Folin-ciocalteu reagent was added and allowed to stand at dark for 30 min. The resultant blue color was read at 660 nm. Bovine serum albumin was used as standard.

#### 3.4.9.4 Fat

Muscle fat was estimated using the standard procedure of A.O.A.C (1997). Soxhlet apparatus was set in position. A thimble was taken and its weight was recorded. Two grams of mixed sample of meat was transferred into the thimble. Then the thimble was slided in to the soxhlet apparatus. The lower end of soxhlet extractor was fixed to a flask after recording the empty weight of the flask. About 10 ml of petroleum ether was poured from the top end of the apparatus and was plugged with cotton. The water circulation of the condenser was adjusted for efficient and uniform cooling at the condensing unit. The flask fitted with soxhlet extractor was placed on a heater and heated. The extraction was carried out for about 3 hrs. The apparatus was dismantled at the end. The flask was placed in oven, dried and again weighed with the contents after cooling. The percent ether extract was computed as the ratio of the weight of ether extract and the weight of the sample and is expressed as percentage.

#### 3.4.9.5 Cholesterol

Cholesterol was estimated from the ether extract collected in methanol in the above procedure, by using the diagnostic kit procured from Qualigens Fine Chemicals, Mumbai. The principle involved was that cholesterol esterase hydrolyzes cholesterol ester. Free cholesterol was oxidized by the cholesterol oxidase to cholest-4-en-3-one and hydrogen peroxide. Hydrogen peroxide thus formed reacts with 4-amino antipyrine and phenol in presence of peroxidase (POD) to produce pink colour quinoneimine dye. The intensity of color produced is proportional to the cholesterol concentration.

Three clean dry test tubes were taken and labeled as blank (B), standard (S) and test (T). The following reagents were pipetted in to the test tubes.

| | (B) | (S) | (T) |
|---|---|---|---|
| Enzyme reagent | 1.0 ml | 1.0 ml | 1.0 ml |
| Distilled water | 10 μl | - | - |
| Standard | - | 10 μl | - |
| Sample | - | - | 10 μl |

The contents were mixed well and incubated at $37^{o}$ C for 5 minutes. Absorbance of test (T) and standard (S) against blank (B) was measured on spectrophotometer at 505 nm.

## 3.5 STATISTICAL ANALYSIS

The data recorded on various productive and reproductive traits were subjected to least Squares analysis (Harvey, 1979) using the following fixed effects linear model to study the effect of genetic and non-genetic factors.

### 3.5.1 Litter Size and Litter Weight

The data generated on litter size and litter weight at birth as well as at weaning were analyzed using the following statistical model.

$Y_{ijk}$ = $\mu + G_i + S_j + e_{ijk}$ , where

$Y_{ijk}$ = Measurement on K $^{th}$ bunny belonging to j$^{th}$ season of birth and i$^{th}$ genetic group

$\mu$ = Overall mean

$G_i$ = Effect of i$^{th}$ genetic group ( i = 1 to 7, New Zealand White, Grey Giant, Soviet Chinchilla, Flemish Giant, Californian White, APAU Fawn, APAU Black)

$S_j$ = Effect of j$^{th}$ season of birth (j = 1 to 3, winter, summer, rainy classified as November to February, March to June and July to October respectively)

$e_{ijk}$ = Random error assumed to be normally and independently distributed with mean zero and variance $\sigma^2 e$

### 3.5.2 Pre-weaning Body Weights

The data recorded on pre-weaning body weights were analyzed using the following linear model.

$Y_{ijkl}$ = $\mu + G_i + S_j + L_k + e_{ijkl}$ , where

$Y_{ijkl}$ = Measurement on l th bunny belonging to kth litter size at birth, j th season of birth and ith genetic group.

$\mu$ = Overall mean

$G_i$ = Effect of ith genetic group (i= 1 to 7)

$S_j$ = Effect of jth season of birth (j = 1 to 3)

$L_k$ = Effect of kth litter size group at birth (k = 1 to 3, 4 to 6, 7 to 9 and 10 and 11 bunnies)

$e_{ijkl}$ = Random error assumed to be normally and independently distributed with mean zero and variance $\sigma^2 e$

### 3.5.3 Post Weaning Body Weights, Post Weaning ADG and Carcass Traits

The data recorded on post weaning body weights, post weaning ADG and carcass traits were analyzed using the following statistical model.

$Y_{ijklmn}$ = $\mu + G_i + R_j + X_k + S_l + L_m + e_{ijklmn}$ , where

$Y_{ijklmn}$ = Measurement on n th bunny belonging to mth litter size at birth, lth season of birth, kth sex of bunny, j th rearing system ith genetic group

$\mu$ = Overall mean

$G_i$ = Effect of ith genetic group ( i= 1 to 7 )

Rj = Effect of jth rearing system (j = 1 and 2 for cage rearing and backyard rearing, respectivley)

$X_k$ = Effect of kth sex of bunny ( k = 1 and 2 for male and female)

$S_l$ = Effect of lth season of birth (j = 1 to 3)

$L_m$ = Effect of mth litter size group at birth (k = 1 to 3, 4 to 6, 7 to 9 and 10 and 11 bunnies)

$e_{ijklmn}$ = Random error assumed to be normally and independently distributed with mean zero and variance $\sigma^2e$

### 3.5.4 Milk Yield

The data recorded on milk yield of does was computed using the following linear model.

$Y_{ijklm}$ = $\mu + G_i + M_j + L_k + W_l + e_{ijklm}$, where

$Y_{ijklm}$ = Measurement on mth bunny belonging to lth litter weight at weaning, kth litter size at birth, jth month of kindling and ith genetic group

$\mu$ = Overall mean

$G_i$ = Effect of ith genetic group ( i= 1 to 7)

$M_j$ = Effect of jth month of kindling ( j = 1 to 3, January, February and March)

$L_k$ = Effect of kth litter size at birth (k = 1 to 3, 4 to 6, 7 to 9 and 10 and 11 bunnies)

$W_l$ = Effect of litter weight at birth (m=1 and 2 for below 250 g and above 250 g)

$e_{ijklm}$ = Random error assumed to be normally and independently distributed with mean zero and variance $\sigma^2e$

### 3.5.5 Feed Intake, Weight Gain and Feed Efficiency

The data recorded on feed intake, weight gain and feed efficiency of bunnies were analyzed by using the following statistical model

$Y_{ijkl}$ = $\mu + G_i + X_j + S_k + e_{ijkl}$ , where

$Y_{ijkl}$ = Measurement on l $^{th}$ bunny belonging to k$^{th}$ season of birth,
j$^{th}$ sex of bunny and i$^{th}$ genetic group

$\mu$ = Overall mean

$G_i$ = Effect of i$^{th}$ genetic group (i= 1 to 7)

$X_j$ = Effect of j$^{th}$ sex of bunny (j = 1 and 2)

$S_k$ = Effect of k$^{th}$ season of birth (k = 1 to 3)

$e_{ijkl}$ = Random error assumed to be normally and independently
distributed with mean zero and variance $\sigma^2 e$

### 3.5.6 Meat Composition

The percentages were transformed in to angles using the arc-sin transformation Snedecor and Cochran, 1987) prior to least squares analysis.

$Y_{ijkl}$ = $\mu + G_i + X_j + R_k + e_{ijkl}$ , where

$Y_{ijkl}$ = Measurement on l $^{th}$ bunny belonging to k$^{th}$ rearing system,
j $^{th}$ Sex of bunny and i$^{th}$ genetic group.

$\mu$ = Overall mean

$G_i$ = Effect of $i^{th}$ genetic group ( i= 1 to 7)

$X_j$ = Effect of $j^{th}$ sex of bunny ( j = 1 and 2 )

$S_k$ = Effect of $k^{th}$ rearing system (j = 1 and 2)

$e_{ijkl}$ = Random error assumed to be normally and independently distributed with mean zero and variance $\sigma^2e$

The differences between seasons, litter size groups, sexes, rearing systems and genetic groups were tested for significance by Duncan's Multiple Range Test (D.M.R.T) as modified by Kramer (1957).

## Heritability estimates

Heritability estimates were computed for various traits studied based on the data adjusted for the effects of non genetic factors *Viz.* Season of birth, litter size at birth and rearing system by using paternal half-sib correlation method as per Becker (1985).

## Statistical model

$$Y_{ij} = \mu + S_i + e_{ij}$$

Where,

$Y_{ij}$ = Measurement on $j^{th}$ bunny belonging to $i^{th}$ sire

μ = Overall mean

$S_i$ = Effect of $i^{th}$ sire

$e_{ij}$ = Random error normally and independently distributed with mean Zero and variance $\sigma^2 e$

**Genetic Model**

$Cov_{HS} = \sigma^2_s = 1/4\ V_A + 1/16\ V_{AA} + 1/64\ V_{AAA} + \ldots\ldots$

Analysis of Variance Table

| Source of Variation | d.f. | SS | MS | EMS |
|---|---|---|---|---|
| Between Sires | S-1 | $SS_s$ | $MS_s$ | $\sigma^2_w + K\ \sigma^2_s$ |
| Progeny within sires | n.- S | $SS_w$ | $MS_w$ | $\sigma^2_w$ |

Where,

S = Number of sires

K = Average number of progeny per sire

n. = Total number of progeny

**Computational formulae**

| Source of variation | Sum of squares | Mean square |
|---|---|---|
| Between sires | $\sum_i \frac{Y^2_i}{n_i} - \frac{Y^2_{..}}{n.}$ | $\frac{SS_s}{(S-1)} = MS_s$ |
| Progeny within sires | $\sum_i \sum_k Y^2_{ik} - \sum_i \frac{Y^2_i}{n_i}$ | $\frac{SS_s}{(n. – S)} = MS_w$ |

Estimation of variance components

$$\sigma^2_s = \frac{MS_s - MS_w}{K} \qquad \text{where,}$$

K = Average number of progeny per sire. When the number of progeny per sire was unequal, the K value was calculated as shown overleaf

$$K = \frac{1}{S-1}\left[ n. - \frac{\sum n_i^2}{n.} \right]$$ Where,

$n_i$ = Number of progeny belonging to $i^{th}$ sire

$n.$ = Total number of progeny

$S$ = Number of sires

$$\sigma^2_w = MS_w$$

$$\sigma^2_s + \sigma^2_w = \sigma^2_p$$

$$t \text{ (intra class correlation)} = \frac{\sigma^2_s}{\sigma^2_p}$$

$$h^2 = 4t$$

The standard error or heritability estimate was calculated by the formula given below.

$$S.E. (h^2) = 4 \sqrt{\frac{2(1-t)^2[1+(K-1)t]^2}{}}$$

K(K-1) (S-1)

## Genetic and phenotypic correlations

The genetic and phenotypic correlations among litter weights, body weights and carcass traits were estimated by paternal half-sib correlation method as per the procedure described by Becker (1985).

The analysis of covariance between the two traits X and Y is given below:

| Source of variation | d.f. | Mean Cross Products (MCP) | Expected Mean Cross Products (EMCP) |
|---|---|---|---|
| Sires | S-1 | $MCP_{s(xy)}$ | $Cov_{w(xy)} + KCov_{s(xy)}$ |
| Progeny within sires | n.. - S | $MCP_{w(xy)}$ | $Cov_{w(xy)}$ |

## Computational formulae

Analysis of Covariance Table

| Source of variation | Sum of cross products (SCP) | Mean sum of cross products (MCP) |
|---|---|---|

| | | |
|---|---|---|
| Sires | $\sum_{i.} \dfrac{X_{i.}\,Y_{i.}}{n_i} - \text{C.F.}$ | $\dfrac{SCP_s}{(S-1)} = MCP_{s(xy)}$ |
| Progeny | $\sum_i \sum_k X_{ik}\,Y_{ik} - \sum_i \dfrac{X_{i.}\,Y_{i.}}{n_i}$ | $\dfrac{SCP_w}{(n_{..} - S)} = MCP_{w(xy)}$ |

## Estimation of $Cov_w$ and $Cov_s$

$$Cov_{w(xy)} = MCP_{w(xy)}$$

$$Cov_{s(xy)} = \frac{MCP_{s(xy)} - MCP_{w(xy)}}{K}$$

Where K = Average number of progeny per sire.

## Estimation of correlations

The genetic ($r_g$) and phenotypic correlations ($r_p$) were estimated as

$$r_g = \frac{COV_{s\,(xy)}}{\sqrt{\sigma^2 s(x)\;\sigma^2 s(y)}}$$

$$r_p = \frac{COV_{w\,(xy)} + COV_{s\,(xy)}}{\sqrt{[\sigma^2_{w(x)} + \sigma^2_{s(x)}]\,[\sigma^2_{w(y)} + \sigma^2_{s(y)}]}}$$

$$r_e = \frac{COV_{w\,(xy)} - 3COV_{s\,(xy)}}{\sqrt{[\sigma^2_{w(x)} - 3\sigma^2_{s(x)}]\,[\sigma^2_{w(y)} - 3\sigma^2_{s(y)}]}}$$

$$S.E\,(r_g) = \frac{1-r_g^2}{\sqrt{2}} \;X\; \sqrt{\frac{S.E\,(h_x^2)\;X\;S.E\,(h_y^2)}{h_x^2\;X\;h_y^2}}$$

# CHAPTER IV

# RESULTS

## 4.1 LITTER SIZE AT BIRTH AND WEANING

The results of the least-squares analysis of variance for the effect of genetic group and season of birth on litter size at birth and weaning are presented in Table 8 while the least-squares mean litter size at birth and weaning are presented in Table 9. Genetic group had no significant effect on litter size at birth and weaning, in the present investigation. Season of birth was found to be highly significant on litter size at weaning while it had no significant effect on litter size at birth.

The overall least-squares means for litter size at birth and weaning were 6.18 ± 0.28 and 3.75 ± 0.23 bunnies respectively. The litter size at birth varied from 5.00 ± 0.68 (FN) to 7.51 ± 0.64 bunnies (GG) among the genetic groups and from 5.82 ± 0.35 (winter) to 6.55 ± 0.34 bunnies (summer) among the seasons. Among the genetic groups, the highest litter size at weaning (4.27 ± 0.52) was recorded by GG bunnies while the lowest (3.16 ± 0.52) was recorded by CW bunnies. Winter season proved to be the favorable season of birth with higher litter size (4.19 ± 0.28) at weaning when compared to the significantly lower litter size (3.32 ± 0.27) at weaning in summer.

## 4.2 LITTER WEIGHT AT BIRTH AND WEANING

The least-squares analysis of variance and the least-squares means of litter weight at birth and weaning, obtained in the present study are presented in Table 8 and 9, respectively. The effect of genetic group was non-significant on both the litter weight at birth and weaning. Season of birth was found to be highly significant on litter weight at weaning while it had no significant effect on litter weight at birth.

The overall least-squares means for litter weight at birth and weaning were 305.16 ± 13.75 and 1190.93 ± 56.92 g, respectively. The litter weight at birth varied from 255.75 ± 33.36 (FN) to 380.28 ± 31.47 g (GG) among the genetic groups and from 303.22 ± 17.15 (winter) to 307.10 ± 16.55 g (summer) among the seasons. Litter weight at weaning ranged from 853.11 ± 130.24 g (CW) to 1352.15 ± 105.00 g (FG) between the genetic groups. Winter season proved to be the favorable season of birth with higher litter weight (1345.90 ± 70.98 g) when compared to the significantly lower litter weight (1035.97 ± 68.52 g) at weaning in summer.

## 4.3 PRE-WEANING BODY WEIGHTS

The results obtained from the least-squares analysis of variance of body weights at birth, 1, 2, 3 and 4 weeks of age for the influence of genetic group, season of birth and litter size at birth are presented in Table 10 while the least-squares mean body weights at birth, 1, 2, 3 and 4 weeks of age are given in Table 11.

The genetic group, season of birth and litter size at birth affected all the pre-weaning body weights highly significantly, except the non-significant genetic group effect on body weight at 1 week age.

The overall least-squares mean body weights were 50.00 ± 0.59, 104.52 ± 1.89, 175.10 ± 3.28, 239.50 ± 6.11 and 354.07 ± 9.19 g at birth, 1 2, 3 and 4 weeks age, respectively. Among the genetic groups, the mean weights at birth, 1, 2, 3 and 4 weeks ranged from 46.70 ± 1.02 (CW) to 55.10 ± 2.16 ( BL), from 100.43 ± 1.87 (NZW) to 110.00 ± 5.85 (BL), from 155.15 ± 6.35 (CW) to 190.37 ± 9.75 (BL), from 197.25 ± 11.14 (CW) to 274.31 ± 16.05 (BL) and from 307.26 ± 18.14 (CW) to 377.78 ± 15.99 (SC), respectively. In general, BL bunnies recorded consistently higher body weights at all the pre-weaning ages, while CW and NZW bunnies weighed less. The highest weaning weight (377.78 g) recorded by SC bunnies indicated the better mothering ability of the dams of this breed.

Bunnies born in rainy season recorded significantly higher body weights from 1 to 4 weeks age, followed by those born in winter and summer seasons. However, the birth weights of bunnies born during winter were significantly higher, followed by those born in rainy and summer seasons.

Litter size at birth significantly influenced the body weights at birth, 1 2, 3 and 4 weeks age. It was observed that mean body weights from birth to 3 weeks of age declined as the litter size at birth increased and a more or less similar trend was observed for the weaning weight.

The decline of body weights was significant between the litter size groups 1-3, 4-6 and 7-9 while the differences between the litter size groups 7-9 and 10 and 11 were non-significant.

### 4.4 POST WEANING BODY WEIGHTS

The least-squares analysis of variance conducted to know the influence of genetic group, rearing system, sex of bunny, season of birth and litter size at birth on the body weights from 6 to 16 weeks of age at bi-weekly intervals is given in Table 12 while the least-squares means for the post weaning body weights are presented in Table 13.

The effect of genetic group, season of birth and litter size at birth was highly significant on the body weights at all post weaning ages studied, while the rearing system and sex of the bunny did not influence all the post weaning body weights studied, except for the significant effect of sex of the bunny on the body weight at 16 weeks age.

The overall mean body weights at 6, 8, 10, 12, 14 and 16 weeks of age were 551.89 ± 16.84, 684.30 ± 19.68, 856.37 ± 23.33, 1018.79 ± 28.83, 1207.18 ± 31.98 and 1352.84 ± 37.93 g, respectively. The mean body weights across the genetic groups ranged from 471.13 ± 33.29 (CW) to 648.31 ± 25.16 (FG) at 6 weeks, 600.89 ± 39.13 (CW) to 760.45 ± 28.70 (FG) at 8 weeks, 713.63 ± 46.56 (CW) to 942.47 ± 42.64 (SC) at 10 weeks, 814.06 ± 59.14 (CW) to 1146.62 ± 52.92 (SC) at 12 weeks, 1001.63 ± 64.97 (CW) to 1356.01 ± 60.44 (SC) at 14 weeks and 1057.40 ± 76.96 (CW) to 1534.12 ± 73.13 (SC) at 16 weeks. The FG rabbits have recorded significantly higher weights up to 8 weeks age while SC rabbits though non-significantly, surpassed FG rabbits from 10th week age onwards.

The rearing system and sex of the bunny did not influence the post weaning body weights significantly except for the significant influence of sex of the bunny on 16 week body weight which was in favour of male bunnies. The body weights of bunnies born in winter were higher *Viz.* 620.39, 750.37, 943.29, 1131.39, 1335.91, 1469.65 g at 6, 8, 10, 12, 14 and 16 wks age while those born in summer recorded significantly lower body weights (483.40, 618.22, 769.45, 906, 1078.45 and 1236.03 g at corresponding ages).

Litter size at birth significantly affected all the post weaning body weights. The litter size classes 1-3 and 4-6 recorded higher body weights indicating the optimal litter size for the dams under the local conditions.

## 4.5 POST WEANING ADGs

The least-squares analysis of variance showing the effects of genetic group, rearing system, sex of the bunny, season of birth and litter size at birth on the ADG from weaning to 16 weeks of age, calculated at bi-weekly intervals are presented in Table 14. The genetic group of rabbits significantly ($P \leq 0.01$) influenced the average daily gain from weaning to 16 weeks of age. Rearing system influenced (($P \leq 0.01$) the ADGs at 9 and 10 and 15 and 16 weeks age. Season of birth significantly ($P \leq 0.01$) influenced the ADGs at 5 and 6, 9 and 10 and 11 and 12 weeks age while the litter size at birth influenced the ADGs at 7 and 8, 11and 12 and 13 and 14 weeks age highly significantly.

The least-squares mean average daily gains at different age periods are presented in Table 15. The overall least square mean ADG during 5 and 6, 7 and 8, 9 and 10, 11 and 12, 13 and 14 and 15 and 16 weeks was 17.55 ± 1.04, 9.06 ± 0.73, 10.91 ± 0.80, 10.46 ± 0.94, 14.47 ± 0.90 and 10.98 ± 1.0 g, respectively. Though the genetic group had a significant influence, there was no detectable trend and no single breed has excelled in the ADGs at all the ages.

The bunnies reared under cage system recorded significantly higher ADG at 9 and 10 and 15 and 16 weeks when compared to those reared under backyard system. Winter season significantly influenced the ADG in a favorable manner at 5 and 6, 9 and 10 and 11 and 12 week age. Litter size at birth significantly influenced ADG at 7 and 8, 11and12 and 13 and 14 weeks age and bunnies from smaller litters had higher ADG.

### 4.6 MILK YIELD

The least-squares analysis of variance of lactation milk yield for the influence of genetic group, month of kindling, litter size at birth and weight at birth is presented in Table 16. The least-squares mean lactation milk yields under each class and the overall milk yield are presented in Table 17 and the mean daily milk yields from day 1 to day 21 post kindling are presented in Table 18.

The month of kindling and litter weight at birth significantly influenced the lactation milk yield, in the present study while the genetic group and litter size at birth did not show any significant influence.

The overall least-squares mean lactation milk yield was 1116.21± 98.28 g, which ranged from 964.56 ± 228.22 (FN) to 1267.08 ± 83.06 g (NZW) among the genetic groups with non significant differences among genetic groups. In the present investigation, the does kindled during February recorded significantly higher milk yield (1334.35 ± 104.33 g) followed by those kindled in March (1056.21 ± 124.23) and January (958.08 ± 172.93). In case of litter weight at birth, the does whose litters weighted above 250 g at birth produced significantly more (1280.51 ± 99.81 g) milk than those with a litter weight at birth of below 250 g at birth. (951.92 ± 150.68 g).

The mean daily milk yield in NZW, GG, SC, FG, CW and FN rabbits was found to be 70.9 ± 1.5, 72.1 ± 3.2, 64.6 ± 3.4, 73.3 ± 2.1, 61.2 ± 2.1 and 66.4 ± 4.0 g. respectively. The peak yield during the 21 day lactation period was recorded on days 11, 12, 11, 13, 11 and 9 by NZW, GG, SC, FG, CW and FN rabbits, respectively and the milk yield was more during the second week of lactation when compared to the 1st and 3rd weeks (Fig. 18).

## 4.7 FEED EFFICIENCY EXPERIMENT

### 4.7.1 Feed Intake

The least-squares analysis of variance for the feed intake from weaning to 16 weeks of age at weekly intervals is presented in Table 19 while the least-squares means for the post weaning body weights are presented in Table 20.

The effect of genetic group was significant on feed intake from 8 weeks of age onwards, while the season of birth exerted a significant influence on the feed intake from weaning to 9 weeks age only. The sex of the bunny did not influence the feed intake at all the ages studied.

The overall least-squares mean feed intake from weaning to 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 weeks of age was found to be 0.10 ± 0.003, 0.26 ± 0.01**,** 0.48 ± 0.02, 0.72 ± 0.03, 1.00 ± 0.05, 1.30 ± 0.07, 1.67 ± 0.09, 2.06 ± 0.10, 2.48 ± 0.12, 2.97 ± 0.14, 3.54 ± 0.15 and 4.17 ± 0.17 kg. per bunny, respectively. Among the genetic groups, SC rabbits consumed significantly more feed while FG rabbits consumed less feed from 8 to 16 weeks from weaning.

### 4.7.2 Weight Gain

The results of the least-squares analysis of variance for the effect of genetic group, season of birth and sex of bunny on weight gain up to 5 to 16 weeks from weaning are presented in Table 21 while the least-squares mean weight gain are presented in Table 22. Genetic group, season of birth and sex of the bunny did not influence the weight gain during different periods studied, in the present investigation.

The overall least-squares mean body weight gains up to 5 to 16 weeks from weaning recorded in the present study are 0.10 ± 0.01, 0.19 ± 0.01, 0.26 ± 0.02, 0.33 ± 0.03, 0.42 ± 0.04, 0.51 ± 0.05, 0.60 ± 0.06, 0.73 ± 0.06, 0.85 ± 0.06, 0.94 ± 0.05, 1.08 ± 0.06 and 1.27 ± 0.06 kg., respectively.

### 4.7.3 Feed Efficiency

The results of the least-squares analysis of variance for the effect of genetic group, sex of bunny and season of birth on feed efficiency from weaning to 16 weeks age are presented in Table 23 while the least-squares mean feed efficiency are presented in Table 24.

Genetic group influenced the feed efficiency up to 6, 7 and 12 weeks age significantly while season of birth had a significant influence on feed efficiency up to 11, 12, 13 and 16 weeks age. The sex of the bunny did not influence the feed efficiency at all ages studied, in the present investigation.

The overall least-squares mean feed efficiency up to 5 to 16 weeks from weaning recorded in the present study were 1.07 ± 0.07, 1.47 ± 0.08, 2.02 ± 0.10, 2.43 ± 0.18, 2.62 ± 0.15, 2.80 ± 0.14, 3.01 ± 0.15, 3.03 ± 0.11, 3.11 ± 0.13, 3.26 ± 0.14, 3.38 ± 0.17 and 3.39 ± 0.15 respectively. FG rabbits recorded significantly lower efficiency up to 6 and 7 weeks than all other breeds studied, while feed efficiency up to 12 weeks age was higher in FG rabbits. The bunnies born in winter season recorded favorable feed efficiency up to 11, 12, 13 and 16 weeks age when compared to those born in summer season.

## 4.8 CARCASS TRAITS

The results obtained from analysis of variance of carcass traits are presented in Table 25 while the least-squares means for the carcass traits are presented in Table 26. The effect of genetic group was significant on all the carcass traits studied except on pelt weight, in the present investigation. The rearing system had a significant influence on the length of caecum only. The sex of bunny significantly affected the dressed weight, dressing percentage, forecut, midcut, hindcut, head, feet and pelt weights while the season of birth had significant effect on all carcass characters studied except the inedible offals weight and length of caecum. The litter size at birth did not have significant influence on any of the slaughter traits studied in the present investigation.

The overall least-squares means for pre-slaughter weight, dressed weight, dressing percentage, forecut, midcut, hindcut, head and feet, pelt, edible offals, inedible offals and length of caecum were 1451.14 ± 63.04 g, 695.33 ± 39.18 g, 46.69 ± 0.86, 245.73 ± 12.14 g, 174.41 ± 12.95 g, 275.19 ± 14.81 g, 193.79 ± 6.33 g, 141.11 ± 8.93 g, 57.44 ± 2.81g, 303.19 ± 11.47 g and 43.38 ± 0.85 cm, respectively.

Among the genetic groups, in general, NZW and SC rabbits recorded significantly higher values for traits such as the pre-slaughter weight, dressed weight, dressing percentage and primal cuts, while GG, along with NZW and SC rabbits recorded significantly higher values for head and feet and offal weights. FN recorded intermediate values but the means were significantly higher than some other breeds, for most of the carcass traits studied. The length of caecum was significantly lower in CW rabbits, when compared to that in NZW, SC, FG and FN genetic groups.

Rearing system was found to exert no significant influence on all the carcass traits studied except on the length of the caecum. The length of caecum was more in rabbits reared under backyard system than those reared in cages. All the carcass traits studied were significantly higher in males than in females except for pre-slaughter weight, weights of edible offals and length of caecum, which were also higher in males but were not significant statistically. Least-squares means of all carcass traits were significantly higher for rabbits born in winter than for those born in summer. The litter size at birth had no significant influence on any of the carcass traits studied.

## 4.9 MEAT COMPOSITION

The least-squares analysis of variance of proximate principles of meat is presented in Table 27 and the least-squares means are given in Table 28.

The effects of genetic group, sex of bunny and rearing system were found to have no significant influence on any of the meat quality traits studied. The overall least-squares means for dry matter, total ash, protein, fat and cholesterol were 24.3%, 1.3%, 20.3 g%, 4.1% and 0.1mg%, respectively. Higher protein content was recorded in NZW (21.6 g%) and lower cholesterol was recorded in SC rabbits (0.08 mg%), but these values were not significantly different from those of other breeds. The mean protein and fat contents in different genetic groups were illustrated in Fig. 19.

## 4.10 HERITABILITY

### 4.10.1 Litter Size and Litter Weight

All the estimates of heritability of litter size and litter weight at birth and weaning obtained in the present study were beyond the normal range and hence are not mentioned here.

### 4.10.2 Pre-weaning Body Weights

The heritability estimates of pre-weaning body weights are presented in Table 29. The heritability estimates of the pre-weaning body weights varied from 0.24 ± 0.18 at 4th week to 0.90 ± 0.26 at 1st week in NZW, 0.32 ± 0.26 at birth to 0.87 ± 0.50 at 2nd week in FG, 0.20 ± 0.46 at 2nd week to 0.49 ± 0.65 at 4th week in GG bunnies. Heritability estimates were 0.63 ± 0.43 (CW) and 0.91 ± 0.68 (FN) at birth, 0.33 ± 0.46 (SC) at 1st week and 0.45 ± 0.64 (CW) at 3rd week. The heritability estimates for other pre weaning body weights in the breeds under study were either outside the normal range or could not be estimated due to negative components of sire variances.

### 4.10.3 Post Weaning Body Weights

The heritability estimates of post weaning body weights as presented in Table 30. varied from 0.37 ± 0.29 at 12th week to 0.86 ± 0.39 at 8th week in NZW, 0.33 ± 0.88 at 10th week to 0.63 ± 0.96 at 14th week in SC, 0.38 ± 0.57 at 8th week to 0.80 ± 0.73 at 10th week in FG rabbits. The heritability estimates for post weaning body weights were beyond the normal range at 6th week in NZW, 16th week in SC and 12, 14 and 16 week in FG rabbits. The heritability estimates for other post weaning body weights in the remaining breeds under study were also either outside the normal range or could not be estimated due to negative components of sire variances.

### 4.10.4 Post Weaning ADGs

The heritability estimates for post weaning ADGs are presented in Table 31. The heritability estimates for post weaning ADG varied from 0.39 ± 0.29 during 11 and 12 weeks to 0.82 ± 0.38 during 13 and 14 weeks in NZW bunnies. Heritability estimates for post weaning ADGs were 0.96 ± 1.58 (ADG 13 and 14) and 0.18 ± 1.00 (ADG 15 and 16) in GG, 0.56 ± 0.95 (ADG 9 and 10) and 0.95 ± 1.02 (ADG 11 and 12) in SC, 0.39 ± 0.57 (ADG 13 and 14) and 0.49 ± 0.62 (ADG 15 and 16) in FG, 0.78 ± 1.14 (ADG 5 and 6) and 0.28 ± 0.98 (ADG 15 and 16) in CW and 0.98 ± 1.94 (ADG 7 and 8) and 0.03 ± 1.64 (ADG 15 and 16) in FN. Most of the estimates have recorded high standard errors. The remaining estimates were out of the normal range and hence are not presented.

### 4.10.5 Carcass Traits

The estimates of heritability which could be obtained only for pre-slaughter weight, pelt weight and length of caecum were 0.11± 0.69, 0.28 ± 0.75, 0.83 ± 0.88 in NZW respectively. The estimates of heritability for carcass traits in all other genetic groups in the present study were either beyond the normal range or could not be estimated due to negative components of sire variances.

## 4.11 GENETIC AND PHENOTYPIC CORRELATIONS

The correlations for pre-weaning body weights could not be estimated as individual identification of bunnies could not be done during the pre-weaning stage. The correlations for litter traits and carcass traits were out side the normal range and hence are not presented.

### 4.11.1 Post Weaning Body Weights

The estimates of genetic, phenotypic and environmental correlations among post weaning body weights wherever could be obtained in some of the genetic groups in which the heritabilities were with in normal range are presented in Table 32. The genetic correlations among the post weaning body weights varied from -0.48 ± 0.33 (4 and 16 weeks) to 0.98 ± 0.02 (12 and 14 weeks) in NZW, from 0.23 ± 1.08 (8 and 14 weeks) to 0.96 ± 1.02 (10 and 12 weeks) in SC and from -0.04 ± 1.75 (4 and 6 weeks) to 0.90 ± 0.32 (4 and 10 weeks) in FG rabbits. Majority of the genetic correlations between the post weaning body weights were positive. The phenotypic correlations varied from 0.45 (4 and 16 weeks) to 0.93 (12 and 14 weeks) in NZW, 0.77 (6 and12 weeks) to 0.97 (10 and 12 weeks) in SC and 0.67 (4 and 10 weeks) to 0.94 (6 and 8 weeks) in FG rabbits. All the phenotypic correlations among the post weaning body weights were positive.

### 4.11.2 Post Weaning ADGs

The genetic, phenotypic and environmental correlations among the post weaning ADG which could be obtained at various ages only in NZW genetic group are given in Table 33. The genetic correlations among the post weaning ADGs varied from -0.21 ± 0.33 to 0.54 ± 0.27 in NZW rabbits. The phenotypic correlations varied from -0.09 to 0.25. Majority of the phenotypic correlations among the post weaning ADGs were positive.

# CHAPTER V

# DISCUSSION

## 5.1 LITTER SIZE AT BIRTH AND WEANING

Both the genetic group and season of birth had a non-significant influence on litter size at birth while season of birth had a significant influence on litter size at weaning, in the present investigation. Non-significant effect of genetic group on litter size at birth and weaning was also reported by Iraqi *et al.* (2006) in Gabali and NZW rabbits and Kumar *et al.* (2006) in NZW, WG and SC rabbits while Jauozi *et al.* (2005), Rubio *et al.* (2005), Urmila *et al.* (2005) and Chineke (2006) found that the genotype was an important source of variation in case of litter traits at birth.

Season of birth influenced the litter size at weaning. Published literature also revealed that the season of birth was an important source of variation for litter traits at birth. Bharat Bhushan *et al.* (2004), Belhadi (2005), Chineke (2006) and Kumar *et al.* (2006) reported a significant influence of season on all litter traits at birth. Chineke (2006) found that the litters born in wet seasons were heavier over dry season litters, while Kumar *et al.* (2006) found that the litter size at birth was higher in winter and summer compared to monsoon seasons. Litters born during winter recorded a higher litter size at weaning in the present investigation. Season generally influences the litter traits through the factors such as ambient temperature, relative humidity and availability of feed and fodder resources.

The overall least squares mean litter size at birth was 6.18 ± 0.28 and varied from 5.00 ± 0.68 (FN) to 7.51 ± 0.64 bunnies (GG) among the genetic groups. Perusal of the literature revealed a litter size range of 4.27 to 7.6 at birth in NZW, GG, SC, Californian, FG, local, Moroccan and Kabyliyan rabbits (Prayaga *et al.*, 2002; Farid, 2004; Jaouzi *et al.,* 2005; Urmila *et al.*, 2005; Zerrouki *et al.*, 2005 a; Zucchi and Desalvo, 2005; Ghosh *et al.,* 2006; Kumar *et al.*, 2006; Das *et al.,* 2007 and Singh *et al.,* 2007). Litter size at birth obtained in the present investigation is within the range of the published literature.

The over all least-squares mean litter size at weaning in the present investigation was 3.75 ± 0.23 bunnies and ranged from 3.32 ± 0.27 (summer) to 4.19 ± 0.28 (winter). Published literature also revealed that the litter size at weaning ranged from 3.3 to 7.2 in NZW, WG, FG, Californian, Bouscat, Moroccan, Kabylian and local rabbits (Prayaga *et al.,* 2002; Farid, 2004; Jaouzi *et al.,* 2005; Urmila *et al.,* 2005; Zerrouki *et al.*, 2005 a; Zucchi and Desalvo, 2005; Kumar *et al.,* 2006; Das *et al.*, 2007 and Singh *et al.,* 2007).

## 5.2 LITTER WEIGHT AT BIRTH AND WEANING

The effect of genetic group was found to be non-significant on both the litter weight at birth and weaning, in the present investigation. Srinivasu (1992), Iraqi *et al.*, (2006) and Kumar *et al.* (2006) found non-significant effect of breed and season of birth on litter weight at birth and weaning in NZW, WG, SC, Californian and Egyptian Gabali rabbits. However, significant effect of genetic group was reported on litter weight at weaning (Rubio *et al.*, 2005; Urmila *et al.*, 2005; Das *et al.*, 2006 and Das and Yadav, 2007) in NZW, SC, Californian, Chinchilla, Criollo and Meghalaya Local does.

The effect of season of birth was found to be highly significant on the litter weight at weaning, in the present investigation with winter born litters having heavier litters at weaning when compared to those born in summer season. Rao *et al* (1994), El Maghawry *et al.* (1999), Prayaga *et al.*, (2002), Belhadi (2002), Bharat Bhushan *et al.* (2004), Zucchi and Desalvo (2004), Belhadi (2005) and Chineke (2006) also found significant effect of season on litter weights at weaning. Most of the workers reported that the litters born in wet/winter/spring season maintained superior body weights over dry/summer season litters. In contrast, Kumar *et al.*, (2006) found a non-significant effect of season on litter size at weaning. Litter weight at weaning is determined strongly by the milk production and mothering ability of the dam which in turn is influenced by the seasonal influence on the ambient temperature and availability of green fodder *etc.*

The reports already published indicated that the litter weight at birth in NZW, SC, FG, GG, Californian and Bouscat breeds of rabbits ranged from 240 to 453.7 g (Reddy *et al.,* 2000 a; Prayaga *et al.*, 2002; Farid, 2004; Urmila *et al.*, 2005; Ghosh *et al.*, 2006; Kumar *et al.,* 2006; Das *et al.*, 2007 and Singh *et al.*, 2007). In the present investigation, the overall least-squares mean litter weight at birth was found to be 305.16 ± 13.75 g, which was well within the wide range as observed from the published literature.

Previous reports indicated that the litter weight at weaning ranged from 730 to 3398.1 g among NZW, WG, FG, SC, GG, Californian, Bouscat, Kabylian and local rabbits (Reddy *et al.,* 2000 a; Prayaga *et al.,* 2002; Farid, 2004; Urmila *et al.,* 2005; Zerrouki *et al.*, 2005 a; Zucchi and Desalvo, 2005; Kumar *et al.,* 2006; Das *et al.,* 2007 and Singh *et al.*, 2007) while the overall least squares mean litter weight at weaning was found to be 1190.93 ± 56.92 g and ranged from 1035.97 ± 68.52 (summer) to 1345.90 ± 70.98 (winter).

## 5.3 PRE-WEANING BODY WEIGHTS

The genetic group, season of birth and litter size at birth affected all the pre-weaning body weights highly significantly, except the non-significant genetic group effect on body weight at 1 week age, in the present investigation. Perusal of the published literature also revealed significant effects of genetic group (Gupta *et al.,* 1999; Bianospino *et al.*, 2005 b and Chineke, 2006), season of birth (Nunes and Polastre, 1990; Gupta *et al.*, 1992; El Maghawry *et al.*, 1999; Gupta *et al.,* 1999; Zucchi and Desalvo, 2004; Chineke, 2006 and Ghosh *et al.,* 2005) and litter size at birth (Gupta *et al.,* 1999; Reddy *et al.,* 2001 and Chineke, 2006) on pre-weaning body weights in NZW, SC, GG, FG and WG rabbits, where as certain reports indicated the non-significant effects of genetic group (Ghosh *et al.,* 2005) and season of birth (Monika *et al.,* 2004) on pre-weaning body weights.

Bunnies born in rainy season recorded significantly higher body weights from 1 to 4 weeks age, followed by those born in winter and summer seasons. However, the birth weights of bunnies born during winter were significantly higher and were followed by those born in rainy and summer seasons. This might be due to the fact that these rabbits are native to temperate climate and the winter season of the location of the present study provides relatively more similar climate for the exotic rabbits. Kumar *et al.* (2006) found that the weaning weight increased from summer to winter.

Litter size at birth significantly influenced the body weights at birth, 1 2, 3 and 4 week age. It was observed that the mean body weight from birth to 3 weeks declined as the litter size at birth increased and a more or less similar trend was also observed for the weaning weight. The decline of body weights was significant between the litter size groups 1-3, 4-6 and 7-9 while the differences between the litter size groups 7-9 and 10-11 were non-significant. The association of litter size and body weights might be due to the increased competition for the resources within the litter group.

The overall least squares mean body weights obtained in the present investigation were 50.00 ± 0.59, 104.52 ± 1.89, 175.10 ± 3.28, 239.50 ± 6.11 and 354.07 ± 9.19 g at birth, 1 2, 3 and 4 weeks age, respectively. In general, BL rabbits have recorded consistently higher body weights at all the pre-weaning ages while CW and NZW rabbits weighed less. The highest weaning weight (377.78g) recorded by SC rabbits indicates the better mothering ability of the dams of this breed. The overall least-squares mean body weights obtained in the present study were almost similar to those reported by Prasad (1993), Gupta *et al.* (1999) and Reddy *et al.* (2001) but were lower than those reported by Ponce de Leon *et al.* (2002), Kumar *et al.* (2006) and Ghosh *et al.* (2006).

## 5.4 POST WEANING BODY WEIGHTS

The effect of genetic group, season of birth and litter size at birth was highly significant on the body weights at all post weaning ages studied, in the present study. Perusal of the published literature also revealed significant effects of genetic group (Kumar *et al.*, 2001; Bianospino *et al.*, 2005 b; Chineke, 2005 and Kermauner and Zgur, 2005), season of birth (Kumar *et al.*, 2001; Gupta *et al.,* 2002 and Chineke, 2005) and litter size at birth (Kumar *et al.*, 2001; Gupta *et al.,* 2002 and Poornima *et al.,* 2002 b) on post weaning body weights in NZW, SC, FG, GG, BB and CW rabbit breeds.

The rearing system did not influence all the post weaning body weights studied while Das *et al.* (2005) found a significant effect of housing system on the live weight of rabbits. The deep litter rearing system studied in the present investigation provided almost equal floor space and similar nutrition. This revealed that the mean body weights of the bunnies reared under backyard (deep litter) system would in no way has any adverse effect.

The sex of the bunny did not influence the post weaning body weights significantly except for the significant influence of sex of the bunny on 16 week body weight which was in favour of male bunnies. Gupta *et al.* (2002) also reported a non-significant influence of sex of bunny on all post weaning body weights while Poornima *et al.* (2002 b) found that females were heavier than males at 14 weeks of age.

In the present study, the body weights of bunnies born in winter were significantly higher than those born in summer. Poornima *et al.* (2002 b) also found that the bunnies born in January had higher weights than those born in other seasons while Gupta *et al.* (2002) and Chineke (2005) reported that dry season bunnies were heavier than wet season bunnies at 56 days of age.

The litter size classes 1-3 and 4-6 recorded significantly higher body weights indicating the optimal litter size for the dams under the local conditions, in the present study. Similar significant effect of litter size at birth on post weaning body weights was also reported by Gupta *et al.* (2002) in NZW, SC, GG, FG breeds of rabbits.

The overall mean body weights at 6, 8, 10, 12, 14 and 16 weeks of age in the present study were 551.89 ± 16.84, 684.30 ± 19.68, 856.37 ± 23.33, 1018.79 ± 28.83, 1207.18 ± 31.98 and 1352.84 ± 37.93 g, respectively. FG rabbits have recorded significantly higher body weights up to 8 weeks age while SC rabbits though non-significantly, surpassed FG rabbits from 10th week age onwards. The overall least-squares means obtained in the present study were almost similar to those reported by Gupta *et al.* (2002), Poornima *et al.* (2002 b) and Devi *et al.* (2005) but were lower than the means obtained by Asuquo *et al.* (1999), Prayaga *et al.* (2003) among the common broiler breeds of rabbits.

## 5.5 POST WEANING ADGs

The genetic group of rabbits significantly (P≤0.01) influenced the ADG from weaning to 16 weeks of age. Significant effect of genetic group on ADG was also reported by Prasad (1993), Skrivanova *et al.* (2000) and Jaouzi *et al* (2005) in different broiler rabbit breeds while Bianospino *et al.* (2005 b) found a non significant effect of genetic group on ADGs adjusted for feed consumption. Rearing system influenced (P≤0.01) the ADGs at 9 and 10 and 15 and 16 weeks age in the present study, revealing the slight superiority of the bunnies reared in cages over those maintained in backyard system.

Season of birth significantly (P≤0.01) influenced the ADGs at 5 and 6, 9 and 10 and 11 and 12 weeks age with winter borne bunnies having higher ADG than those born in summer, in the present study. El-Maghawry (1993), Ekambaram (1997) and Borthakur *et al.* (2002) reported significant effect of month of birth on ADGs from 5 to 12 weeks of age in NZW, SC, GG, FG and Californian breeds while Gupta (1998) found a significant effect of season of birth on ADG from 5 to 16 weeks age. Winter born bunnies were exposed to pleasant and favourable climatic temperatures while those born in summer faced the vagaries of hot climate during their post weaning periods.

The litter size at birth influenced the ADGs at 7 and 8, 11and12 and 13 and 14 weeks age highly significantly. Lukefahr *et al.* (1989), El-Maghawry (1993), Gupta (1998) and Borthakur *et al.* (2002) also found a significant effect of litter size on ADG 4 to 8, 5 to 12, 5 to 16 weeks, 42-90 days in NZW, Californian rabbits. The ADGs declined as the litter size at birth increased, in the present study and as also reported by Gupta (1998).

The overall least-squares mean ADG during 5 and 6, 7 and 8, 9 and 10, 11 and 12, 13 and 14 and 15 and 16 weeks was 17.55 ± 1.04, 9.06 ± 0.73, 10.91 ± 0.80, 10.46 ± 0.94, 14.47 ± 0.90 and 10.98 ± 1.0 g., respectively in the present study. Though the genetic group had a significant influence, there was no detectable trend and no single breed has excelled in the ADGs all through their post weaning ages. The published literature revealed the ADGs to be in the range of 10.71 to 35.1g (Ekambaram, 1997; Poornima *et al.*, 2002 b; Urmila *et al.*, 2004; Zhu and Chang., 2004; Chang *et al.*, 2005; Devi *et al.*, 2005; Jaouzi *et al.*, 2005; Lakabi *et al.*, 2005; Abubakar *et al.,* 2006; Djellal *et al.*, 2006; Hue and Preston, 2006 and Oluremi *et al.,* 2006)

### 5.6 MILK YIELD

Ability of females to produce milk is one of the main factors involved in post natal growth rate of young (Baselga *et al.*, 1982) and in determination of litter size at weaning. Milk production is a complex trait influenced by a variety of factors.

In the present investigation, the effect of genetic group was found to be non-significant on milk yield. However, significant effect of genetic group on milk yield was reported by Mc Nitt and Lukefahr (1990).

The month of birth and litter weight at birth significantly influenced the milk yield, while the effect of litter size at birth did not show any significant influence. Mc

Nitt and Lukefahr (1990) found that the milk yield increased as the kit number increased while the literature suggested that 5 to 9 kits (Singh, 1998 a and Argente *et al.*, 2005) were optimum for emptying the mammary glands, resulting in higher Peak yield and daily milk yield. El-Maghawry *et al.* (1993) and Zerrouki *et al.* (2005 b) reported that litter size was the most important non-genetic factor affecting milk yield through the suckling period in NZW and Californian breeds while Carmona *et al.* (2005) found that litter weight at birth had a significant influence on milk yield.

The overall least-squares mean lactation milk yield was 1116.21± 98.28 g. It ranged from 964.56 ± 228.22 (FN) to 1267.08 ± 83.06 g (NZW) among the genetic groups with non-significant differences among genetic groups. The published literature revealed the average milk yield ranged from 1043.67 to 3436.5 g (El-Sayiad, 1994; Zerrouki *et al.*, 2005 b and Ekambaram *et al.*, 2006) in NZW, Californian and Kabylian rabbits in 21 days.

In the present investigation, the does kindled during February recorded significantly higher milk yield (1334.35 ± 104.33 g) followed by those kindled in March (1056.21 ± 124.23 g) and January (958.08 ± 172.93 g). In case of litter weight at birth,

the does whose litters weighed more than 250 g recorded significantly higher (1280.51 ± 99.81 g) milk yield than those with a litter weight at birth of below 250 g (951.92 ± 150.68 g).

The mean daily milk yield in NZW, GG, SC, FG, CW and FN rabbits was found to be 70.9 ± 1.5, 72.1 ± 3.2, 64.6 ± 3.4, 73.3 ± 2.1, 61.2 ± 2.1 and 66.4 ± 4.0 g, respectively while the peak yields in these genetic groups were 84.3 ± 5.4, 96.6 ± 16.7, 94.0 ± 11.0, 99.0 ± 10.0, 76.8 ± 7.5 and 102.0 ± 4.0, respectively. Mean daily milk yield of 87.5 g in NZW, SC, GG, WG and BB (Singh, 1998 a) and 104 g in Kabylian does (Zerrouki *et al.*, 2005 b) was found in the published literature while peak milk yield of 149.4 g was reported by Singh (1998 a) in a lactation period of 42 days in NZW, SC, GG, WG and BB rabbits. The peak yield during the 21 day lactation period was recorded on days 13, 12, 11, 9, 11 and 11 by FG, GG, NZW, FN, SC and CW rabbits, respectively.

## 5.7 FEED EFFICIENCY EXPERIMENT

### 5.7.1 Feed Intake

The effect of genetic group was significant on feed intake up to 8 to 16 weeks from weaning in the present study. Similar significant effect of genetic group on feed intake from 5 to 16 weeks age was reported by Gupta *et al.* (2000 c). Significant effect of season of birth on the feed intake from weaning to 9 weeks age observed in the present study is in agreement with the findings of Gupta *et al.* (2000 c) who reported a significant effect of season of birth on feed intake of rabbits from 5 to 16 weeks age. The sex of the bunny did not influence the feed intake for all the ages studied and Gupta *et al.* (2000 c) also reported a non significant effect of sex on feed intake.

The overall least-squares mean feed intake from weaning to 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 weeks of age was found to be 0.10 ± 0.003, 0.26 ± 0.01**,** 0.48 ± 0.02, 0.72 ± 0.03, 1.00 ± 0.05, 1.30 ± 0.07, 1.67 ± 0.09, 2.06 ± 0.10, 2.48 ± 0.12, 2.97 ± 0.14, 3.54 ± 0.15 and 4.17 ±

0.17 kg, respectively. Among the genetic groups, SC rabbits consumed significantly more feed while FG rabbits consumed less feed from 8 to 16 weeks from weaning.

### 5.7.2 Weight Gain

Genetic group, season of birth and sex of the bunny did not influence the weight gain during different periods studied (Table 21), in the present investigation while Kumar *et al.* (2004) and Metzger *et al* (2006 a) found that the genotype had a significant effect on weight gain in Pannon White, Hyplus PS19 rabbits and their crosses. The mean post weaning weight gains up to 16 weeks age varied from 1.02 in FG to 1.54 kg. in GG bunnies.

The overall least-squares mean body weight gain from 5 to 16 weeks age was 1.27 ± 0.06 kg.

### 5.7.3 Feed Efficiency

The present study revealed a significant genetic group effect on FE up to 6, 7 and 12 weeks age. Gupta *et al.* (2000 c) and Skrivanova *et al.* (2000) also reported significant effect of genetic group while Ozimba and Lukefahr (1991 a) found a non-significant effect of genetic group on FCE. Flemish Giant rabbits recorded significantly lower FE up to 6 and 7 weeks than all other genetic groups studied, while FE up to 12 weeks age was significantly high in FG rabbits. Up to 12 weeks age the FG bunnies proved to be the best feed converters although their feed intake as well as weight gains were lower. The NZW bunnies with their higher feed intake and lower weight gains were observed to be least efficient feed converters in the present study.

The sex of the bunny did not influence the FE at all ages studied, in the present investigation. A similar non significant effect of sex on FCE was found by Prasad (1993) and Gupta *et al.* (2000 c).

Season of birth had a significant influence on FE up to 11, 12, 13 and 16 weeks age. Bunnies born in winter season consistently recorded favorable FE up to 11, 12, 13 and 16 weeks age over those born in summer season. Gupta *et al.* (2000 c) also found a significant effect of season of birth on FE.

The overall least squares mean FE from weaning to 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 weeks were 1.07 ± 0.07, 1.47 ± 0.08, 2.02 ± 0.10, 2.43 ± 0.18, 2.62 ± 0.15, 2.80 ± 0.14, 3.01 ± 0.15, 3.03 ± 0.11, 3.11 ± 0.13, 3.26 ± 0.14, 3.38 ± 0.17 and 3.39 ± 0.15, respectively. A perusal of the published literature revealed that the feed conversion ratio ranged from 2.91 to 5.2 at different age periods (Prasad, 1993; Kumar *et al.*, 2004; Chang *et al.*, 2005; Jaouzi *et al.*, 2005; Matics *et al.,* 2005; Mbanya *et al.,* 2005; Abubakar *et al.,* 2006; Oluremi *et al.,* 2006 and Olorunsanya *et al.*, 2007)

## 5.8 CARCASS TRAITS

The effect of genetic group was significant on all the carcass traits studied except on pelt weight, in the present investigation. Among the genetic groups, in general, NZW and SC rabbits recorded significantly higher values for traits such as pre-slaughter weight, dressed weight, dressing percentage and primal cuts while GG, along with NZW and SC rabbits recorded significantly higher values for head and feet weight and offal weights. APAU Fawn recorded intermediate values but the means were significantly higher than some other genetic groups, for most of the carcass traits studied. The length of ceacum was significantly lower in CW rabbits when compared to NZW, SC, FG and APAU Fawn breeds.

Ozimba and Lukefahr (1991 b), Kulkarni *et al.* (1995), Nofal *et al.* (1996), Gupta *et al.* (2000 a), Reddy *et al.* (2000 b), Gupta *et al.* (2001), Barron *et al.* (2004), Kermauner and Zgur (2005), Singh and Prasad (2005) and Metzger *et al.* (2006 b) found that the genetic group had a significant influence on most of the carcass traits. However, Bianospino *et al.* (2005 a), Nofal *et al.* (2005) and Zgur and Kermauner (2005) found non-significant genetic group effect on most of the carcass traits.

Rearing system was found to exert no significant influence on all the carcass traits studied except on the length of the caecum. The length of caecum was more in rabbits reared under backyard system. Metzger *et al.* (2003) reported that pen-housed rabbits had lower body weight and dressing percentage, higher proportion of the fore and hind parts and lower proportion of intermediate part of the carcass than cage-housed rabbits. Cavani *et al.* (2004) stated that the rabbits housed open-air exhibited lower carcass weights.

Bovera *et al.* (2005) indicated that rabbits raised in pits had less weight at slaughter 1286 g ± 169 and low dressing percentage (52.9 % ± 3.5) at 4.5 months of age, due to the high percentage of the gastrointestinal tract (26.4 % ± 3.5).

The sex of bunny significantly affected the dressed weight, dressing percentage, fore cut, mid cut, hind cut, head and feet and pelt weights. All the carcass traits studied were significantly higher in males than in females except for pre-slaughter weight, weights of edible offals and length of caecum, which were also higher in males but were not significant statistically. Ozimba and Lukefahr (1991 b) and Nofal *et al.* (1996) found significant effect of sex on most of the carcass traits. A perusal of the published literature also revealed higher means in males for most of the carcass traits (Gupta *et al.*, 1990; Karim *et al.*, 1998; Gupta *et al.*, 2000 b; Singh and Prasad, 2005 and Zotte, 2005) which could be due to the sex related developmental differences in muscles and also the reproductive organs. Whereas Reddy *et al.* (2000 b) Poornima *et al.* (2003), Lakabi *et al.* (2005), Nofal *et al.* (2005) and Yalcn *et al.* (2006) observed that sex of bunny had no significant effect on most of the carcass traits.

The season of kindling had significant effect on all carcass characters studied except the inedible offals weight and length of caecum. Ozimba and Lukefahr (1991 b) and Gupta *et al.* (2000 b) also reported that the season of birth significantly ($P \leq 0.05$) influenced almost all the carcass traits. Least-squares means of all carcass traits were significantly higher for rabbits born in winter than for those born in summer except for inedible offals weight and length of caecum, on which the effect of season was non-significant. Ghosh *et al.* (2005) also found that the bunnies born in winter season had significantly higher means for all the carcass traits. On the contrary, Gupta *et al.* (2000 b) and Gupta *et al.* (2001) reported higher means for most of the carcass traits for bunnies born in summer than those born in rainy and winter seasons.

The litter size at birth did not have significant influence on any of the carcass traits studied in the present investigation while Lukefahr *et al.* (1989) found significant effect of litter size class on all the carcass traits except on visceral weight.

The overall least-squares means for pre-slaughter weight, dressed weight, dressing percentage, fore cut, mid cut, hind cut, head and feet, pelt, edible offals and inedible offals were 1451.14 ± 63.04 g, 695.33 ± 39.18 g, 46.69 ± 0.86, 245.73 ± 12.14g, 174.41 ± 12.95 g, 275.19 ± 14.81 g, 193.79 ± 6.33 g, 141.11 ± 8.93 g, 57.44 ± 2.81g, 303.19 ± 11.47 g and 43.38 ± 0.85 cm, respectively.

The length of the caecum was found to be 43.38 ± 0.85 cm in the present investigation. Marounek *et al.* (2005) also reported that the caecum was the largest digestive organ with an average weight of 157 g. Rabbits are pseudo ruminants and the role of caecum in the digestive physiology is very important. Caecal fermentation makes the rabbit a versatile animal by helping in the digestion of plant fibres. Rabbits can efficiently utilize 30% of the crude fibre when compared to poultry (10%).

Published literature revealed that the pre-slaughter weight ranged from 2654 to 3158 g while the carcass weight ranged from 541.1 to 1787 g (Nofal *et al.*, 1996; Bianospino *et al.*, 2005 a; Kermauner and Zgur, 2005 and Yalcn *et al.*, 2006) at 12-16 weeks of age. The dressing percentage was reported to be ranging from 40.44 to 61.0 (Sen *et al.*, 2000; Gupta *et al.*, 2001; Chaudhry *et al.*, 2003; Metzger *et al.*, 2003; Poornima *et al.*, 2003; Prayaga *et al.*, 2003; Kumar *et al.*, 2004; Kermauner and Zgur, 2005; Pinna *et al.*, 2005; Zotte, 2005; Metzger *et al.*, 2006 b; Oluremi *et al.*, 2006 and Yalcn *et al.,* 2006). The weights of head and skin were 182.25 and 232.80 respectively (Kumar *et al.*, 2004). The weights of fore cut, mid cut were 283-298, 296-309 g (Bianospino *et al.*, 2005 a).

## 5.9 MEAT COMPOSITION

Chemical composition of meat influences the meat quality and influences the consumption patterns depending on its suitability and usefulness to the consumer. Consumer preferences are now turning towards low cholesterol diets and rabbit suits the situation aptly. Hence, the dry matter, ash, protein, fat and cholesterol contents of rabbit meat are estimated in the present study.

The effects of genetic group, sex of bunny and rearing system were non-significant on any of the meat composition traits studied. Sen *et al.* (2000) Ortiz and Rubio (2001) and Zgur and Kermauner (2005) also found a non significant effect of genetic group on the proximate composition of rabbit meat while some of the published reports indicated significant effect of genetic group for percentages of protein (Bieniek *et al.*, 1994) and fat (Bieniek *et al.*, 1994 and Metzger *et al.,* 2006 a). Non-significant effect of sex was also reported by Ortiz and Rubio (2001).

The effect of rearing system was found to be non-significant on the meat composition traits studied in the present investigation. However, Das *et al.* (2002) reported that fat % was significantly higher in caged rabbits than in those housed in hutches. Protein and ash % was significantly higher in rabbits housed in smaller floor spaces. Metzger *et al.* (2003) reported that meat of pen-housed rabbits contained less protein and fat than those kept in cages. The housing system had no effect on ash content of the meat samples.

The overall least-squares mean dry matter was found to be 24.3%. A perusal of the published literature revealed a range of 20.4 to 26.5 per cent dry matter in the rabbit meat (Malik, 1988; Kulkarni *et al.*, 1995; Bhatt *et al.*, 1996 and Kalita *et al.*, 2000).

The overall per cent of protein was found to be 20.3 g% in the present study. A range of 19.5 to 23.9 per cent was reported in the literature (Malik, 1988; Kulkarni *et al.,* 1995; Bhatt *et al.,* 1996; Zajac, 1999; Bielanski *et al.*, 2000; Kalita *et al.*, 2000; Metzger *et al.*, 2003; Combes, 2004; Pla *et al.*, 2004 and Polak *et al.*, 2006).

Percent fat and cholesterol of rabbit meat was found to be 4.1% and 0.1mg%, respectively in the present investigation. Previous reports recorded a range of 2.5 to 6.8 per cent fat and 59 to 67.6 mg/100 g in rabbit meat (Malik, 1988; Kulkarni *et al.,* 1995; Bhatt *et al.,* 1996; Bielanski *et al.*, 2000; Kalita *et al.*, 2000; Skrivanova *et al.*, 2000; Combes, 2004 and Polak *et al.*, 2006).

Ash component of the rabbit meat was found to be 1.3%, in the present investigation. Previous workers reported a range of 1.1 to 2.4 per cent ash in rabbit meat (Malik, 1988; Kulkarni *et al.,* 1995; Bhatt *et al.,* 1996; Kalita *et al.*, 2000; Combes, 2004 and Polak *et al.*, 2006).

## 5.10 HERITABILITY

All the estimates of heritability of litter traits obtained in the present study were beyond the normal range and hence were not presented here. For the remaining characters also, meaningful heritability estimates could not be obtained or the standard errors were high and hence not presented. The small sample size that was available in these cases resulted in the estimates being out of range.

### 5.10.2 Pre-weaning Body Weights

The heritability estimates of the pre-weaning body weights varied from 0.24 ± 0.18 at 4th week to 0.90 ± 0.26 at 1st week in NZW, 0.32 ± 0.26 at birth to 0.87 ± 0.50 at 2nd week in FG, 0.20 ± 0.46 at 2nd week to 0.49 ± 0.65 at 4th week in GG bunnies. Heritability estimates were 0.63 ± 0.43 (CW) and 0.91 ± 0.68 (FN) at birth, 0.33 ± 0.46 (SC) at 1st week and 0.45 ± 0.64 (CW) at 3rd week. The heritability estimates for other pre-weaning body weights in the genetic groups under study were either outside the normal range or could not be estimated due to negative components of sire variances. The abnormal heritability estimates obtained in the present study could be due to the small sample size and higher environmental correlations among the litter mates.

In general, the heritability estimates observed in the present investigation ranged from 0.2 to 0.91. Ponce de leon *et al.* (2004) and Ibrahim *et al.*, (2007) found that the heritability estimates for pre-weaning body weights in rabbits were in the range of 0.17 - 0.90.

### 5.10.3 Post Weaning Body Weights

The heritability estimates for post weaning body weights varied from 0.37 ± 0.29 at 12th week to 0.86 ± 0.39 at 8th week in NZW, 0.33 ± 0.88 at 10th week to 0.63 ± 0.96 at 14th week in SC, 0.38 ± 0.57 at 8th week to 0.80 ± 0.73 at 10th week in FG bunnies. The heritability estimates for post weaning body weights were beyond the normal range at 6th week in NZW, 16th week in SC and 12, 14 and16 weeks in FG rabbits. The heritability estimates for other post weaning body weights in the genetic groups under study were also either outside the normal range or could not be estimated due to negative components of sire variances which might be due to fewer progeny per sire.

Published literature revealed that the heritability estimates for post weaning body weights were in the range of 0.03 to 0.90 (Lukefahr *et al.*, 1992; Ferraz and Eler, 1994; Asuquo *et al.*, 1999; Paula *et al.*, 2000; Sabra *et al.*, 2001; Yolku *et al.*, 2004; Akanno and Ibe, 2005; Hassan, 2005; Larzul *et al.*, 2005 and Ibrahim *et al.*, 2007) in NZW, California and Dutch rabbits.

### 5.10.4 Post Weaning ADGs

The heritability estimates for post weaning ADG varied from 0.39 ± 0.29 during 11 and 12 weeks to 0.82 ± 0.38 during 13 and 14 weeks in NZW bunnies. Heritability estimates for post weaning ADGs were 0.96 ± 1.58 (ADG 13 and 14) and 0.18 ± 1.00 (ADG 15 and 16) in GG, 0.56 ± 0.95 (ADG 9 and 10) and 0.95 ± 1.02 (ADG 11 and 12) in SC, 0.39 ± 0.57 (ADG 13 and 14) and 0.49 ± 0.62 (ADG 15 and 16) in FG, 0.78 ± 1.14 (ADG 5 and 6) and 0.28 ± 0.98 (ADG 15 and 16) in CW and 0.98 ± 1.94 (ADG 7 and 8) and 0.03 ± 1.64 (ADG 15 and 16) in APAU Fawn. Most of the estimates have recorded high standard errors. The remaining estimates were out of the normal range and hence are not presented.

Published literature revealed that the heritability estimates for ADG were in the range of 0.13 to 0.48 (Moura *et al.*, 1997; Paula *et al.*, 2000; Ponce de leon *et al.*, 2004 and Larzul and Rochambeau, 2005).

### 5.10.5 Carcass Traits

Heritability estimates which could be computed only for pre-slaughter weight, pelt weight and caecum length were 0.11± 0.69, 0.28 ± 0.75, 0.83 ± 0.88 respectively. A perusal of the available literature revealed that the heritability estimates for dressing percentage and loin primal cut percentage were 0.37 to 0.55 and 0.25, respectively (Lukefahr *et al.*, 1996; Larzul *et al.*, 2005)

## 5.11 GENETIC AND PHENOTYPIC CORRELATIONS

The correlations for litter traits were out side the normal range and hence are not presented here while the correlations for pre-weaning body weights could not be estimated as individual identification of bunnies could not be done during the pre-weaning stage.

### 5.11.1 Post Weaning Body Weights

The genetic correlations among the post weaning body weights varied from -0.48 ± 0.33 (4 and16 weeks) to 0.98 ± 0.02 (12 and 14 weeks) in NZW, from 0.23 ± 1.08 (8 and 14 weeks) to 0.96 ± 1.02 (10 and 12 weeks) in SC and from -0.04 ± 1.75 (4 and 6 weeks) to 0.90 ± 0.32 (4 and 10 weeks) in FG rabbits. Majority of the genetic correlations between the post weaning body weights were positive indicating the pleotropic effect of the genes involved. The phenotypic correlations varied from 0.45 to 0.93 in NZW, 0.77 to 0.97 in SC and 0.67 to 0.94 in FG rabbits. All the phenotypic correlations among the post weaning body weights were positive revealing the possibility of improving the body weights at later ages by selection of bunnies based on the early body weights.

The genetic and phenotypic correlations among different post weaning body weights were reported to be correlated at low to high level and were positive (0.02. to 0.94) in most of the broiler rabbit breeds. (Enab *et al.,* 2000; Paula *et al.*, 2000; Gupta *et al.*, 2002; Poornima *et al.,* 2003; Devi *et al.,* 2005; Ekambaram *et al.*, 2006; Ibrahim *et al.*, 2007 and Singh *et al.*, 2007).

### 5.11.2 Post Weaning ADGs

The genetic correlations among the post weaning ADGs varied from -0.21 ± 0.33 to 0.54 ± 0.27 in NZW bunnies. The phenotypic correlations varied from -0.09 to 0.25. Majority of the phenotypic correlations among the post weaning ADGs were positive.

In conclusion, the effect of genetic group was significant on litter size and weight at weaning, pre-weaning and post weaning growth and feed efficiency traits and carcass traits. Heritabilities for growth and carcass traits were low to moderate, with positive correlations among the body weights and among carcass traits indicating the possibility of genetic improvement with appropriate methodologies. The effect of season of birth and litter size was also significant on some of the production and reproduction traits. Both on the basis of the present study and also based on the previous literature, wet or cooler seasons appear to have an encouraging influence on these traits. Litter weight at birth of 250 gms. influenced the milk yield positively in the present study indicating the ability of the dams to support a litter of about five bunnies at birth, under the existing managemental and climatic conditions. The performance of synthetic breeds included in the study need to be further investigated on a larger scale to understand their production potentials under the local climatic conditions *vis a vis* the established breeds.

# CHAPTER VI

# SUMMARY

The present study was conducted on New Zealand White (NZW), Grey Giant (GG), Soviet Chinchilla (SC), Flemish Giant (FG), Californian White (CW) purebreds and two synthetics - APAU Fawn (FN) and APAU Black (BL) bunnies born during November 2006 and July 2007 in the “Rabbit Production for Meat” scheme, Department of Animal Genetics and Breeding, College of Veterinary Science, Rajendranagar, Hyderabad.

Bunnies were reared under cage and deep litter system. Data on litter traits, body weights from birth to 16 weeks, milk yield, feed efficiency traits, carcass traits and meat composition were subjected to least-squares analysis to study the effects of genetic and non-genetic factors. Genetic parameters were estimated on the data corrected for significant non-genetic effects.

Genetic group had no significant effect on litter traits while season of birth had a highly significant effect on litter size and weight at weaning. The overall least-squares means for litter size at birth (LSB) and weaning and litter weight at birth and weaning were 6.18 ± 0.28 and 3.75 ± 0.23 bunnies and 305.16 ± 13.75 and 1190.93 ± 56.92 g, respectively. Winter proved to be the favorable season of birth for litter size and weight at weaning.

Genetic group, season of birth and LSB in general, affected all the pre-weaning body weights highly significantly. The overall least-squares mean body weights were 50.00 ± 0.59, 104.52 ± 1.89, 175.10 ± 3.28, 239.50 ± 6.11 and 354.07 ± 9.19 g at birth, 1 2, 3 and 4 weeks age, respectively. In general, BL bunnies recorded consistently higher pre-weaning body weights. The highest weaning weight (377.78 g) recorded by SC bunnies indicated their better mothering ability. Bunnies born in rainy season recorded significantly higher body weights from 1 to 4 weeks age while the birth weights of bunnies born during winter were significantly higher. Mean body weights from birth to 3 weeks of age declined as the LSB increased.

The effect of genetic group, season of birth and litter size at birth was highly significant on the body weights at all post weaning ages studied. The overall mean body weights at 6, 8, 10, 12, 14 and 16 weeks of age were 551.89 ± 16.84, 684.30 ± 19.68, 856.37 ± 23.33, 1018.79 ± 28.83, 1207.18 ± 31.98 and 1352.84 ± 37.93 g, respectively. The FG rabbits have recorded significantly higher weights up to 8 weeks age while SC rabbits though non-significantly, surpassed FG rabbits from 10th week age onwards. Post weaning body weights of bunnies born in winter were higher. The litter size classes 1-3 and 4-6 recorded higher body weights.

The overall least square mean ADG during 5 and 6, 7 and 8, 9 and 10, 11 and 12, 13 and 14 and 15 and 16 weeks was 17.55 ± 1.04, 9.06 ± 0.73, 10.91 ± 0.80, 10.46 ± 0.94, 14.47 ± 0.90 and 10.98 ± 1.0 g, respectively. Though the genetic group had a significant influence, there was no detectable trend. The bunnies reared under cage system recorded significantly higher ADG at 9 and 10 and 15 and 16 weeks. Winter season significantly influenced the ADG in a favorable manner at 5 and 6, 9 and 10 and 11 and 12 week age. Bunnies from smaller litters had significantly higher ADG.

The overall least-squares mean lactation milk yield was 1116.21± 98.28 g. Does kindled during February recorded significantly higher milk yield (1334.35 ± 104.33 g). Does whose litters weighted above 250 g at birth produced significantly more milk. The mean daily milk yield ranged from 61.2 ± 2.1 to 73.3 ± 2.1.

The effect of genetic group was significant on feed intake from 8 weeks of age onwards, while the season of birth exerted a significant influence on the feed intake from weaning to 9 weeks age only. The overall least-squares mean feed intake from weaning to 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 weeks of age was found to be 0.10 ± 0.003, 0.26 ± 0.01**,** 0.48 ± 0.02, 0.72 ± 0.03, 1.00 ± 0.05, 1.30 ± 0.07, 1.67 ± 0.09, 2.06 ± 0.10, 2.48 ± 0.12, 2.97 ± 0.14, 3.54 ± 0.15 and 4.17 ± 0.17 kg. per bunny, respectively. FG rabbits consumed less feed from 8 to 16 weeks from weaning.

Genetic group, season of birth and sex of the bunny did not influence the weight gain during different periods studied. The overall least-squares mean body weight gains up to 5 to 16 weeks from weaning recorded in the present study are 0.10 ± 0.01, 0.19 ± 0.01, 0.26 ± 0.02, 0.33 ± 0.03, 0.42 ± 0.04, 0.51 ± 0.05, 0.60 ± 0.06, 0.73 ± 0.06, 0.85 ± 0.06, 0.94 ± 0.05, 1.08 ± 0.06 and 1.27 ± 0.06 kg., respectively.

The overall least-squares mean feed efficiencies up to 5 to 16 weeks from weaning were 1.07 ± 0.07, 1.47 ± 0.08, 2.02 ± 0.10, 2.43 ± 0.18, 2.62 ± 0.15, 2.80 ± 0.14, 3.01 ± 0.15, 3.03 ± 0.11, 3.11 ± 0.13, 3.26 ± 0.14, 3.38 ± 0.17 and 3.39 ± 0.15, respectively. FG rabbits recorded significantly higher efficiency up to 6 and 7 weeks. Bunnies born in winter season recorded favorable feed efficiency up to 11, 12, 13 and 16 weeks age. The sex of the bunny did not influence the feed efficiency at all ages studied.

The overall least-squares means for pre-slaughter weight, dressed weight, dressing percentage, forecut, midcut, hindcut, head and feet, pelt, edible offals, inedible offals and length of caecum were 1451.14 ± 63.04 g, 695.33 ± 39.18 g, 46.69 ± 0.86, 245.73 ± 12.14 g, 174.41 ± 12.95 g, 275.19 ± 14.81 g, 193.79 ± 6.33 g, 141.11 ± 8.93 g, 57.44 ± 2.81g, 303.19 ± 11.47 g and 43.38 ± 0.85 cm, respectively. Among the genetic groups, in general, NZW and SC rabbits recorded significantly higher values for pre-slaughter weight, dressed weight, dressing percentage and primal cuts. The length of caecum was significantly lower in CW rabbits. Most carcass traits studied were significantly higher in males. Means of all carcass traits were significantly higher for rabbits born in winter. Rearing system had a significant influence on the length of caecum only.

The overall least-squares means for dry matter, total ash, protein, fat and cholesterol were 24.3%, 1.3%, 20.3 g%, 4.1% and 0.1mg%, respectively.

Heritability estimates for litter traits were beyond the normal range. Heritability estimates of the pre-weaning and post weaning body weights and post weaning ADGs that could be computed varied from 0.20 ± 0.46 to 0.91 ± 0.68, 0.33 ± 0.88 to 0.86 ± 0.39 and 0.18 ± 1.00 to 0.98 ± 1.94, respectively. Heritability for pre-slaughter weight and length of caecum were 0.11± 0.69 and 0.83 ± 0.88, respectively in NZW.

The genetic and phenotypic correlations among the post weaning body weights varied from -0.04 ± 1.75 to 0.98 ± 0.02 and from 0.45 to 0.97, respectively. The genetic correlations among the post weaning ADGs varied from -0.21 ± 0.33 to 0.54 ± 0.27 in NZW rabbits while the phenotypic correlations varied from -0.09 to 0.25.

In conclusion, the effect of genetic group was significant on litter size and weight at weaning, pre-weaning and post weaning growth and feed efficiency traits and carcass traits. Heritabilities for growth and carcass traits were low to moderate, with positive correlations among the body weights and among carcass traits indicating the possibility of genetic improvement with appropriate methodologies. The effect of season of birth and litter size at birth was also significant on some of the production and reproduction traits. Cooler seasons appear to have an encouraging influence. The performance of synthetic breeds included in the study need to be further investigated on a larger scale.

# LITERATURE CITED

Abubakar M, Doma U D, Kalla D J U, Ngele M B and Augustine C L D. 2006. Effects of dietary replacement of maize with malted or unmalted sorghum on the performance of weaner rabbits. *Livestock Research for Rural Development.* **18**: Article # 65.

Afifi E A, Yamini K A, Marai I F M and El-Maghawry A M. 1992. Environmental and genetic aspects of litter traits in New Zealand White and Californian rabbits under the Egyptian Conditions. *Journal of Applied Rabbit Research* **15**: 335-51.

Ahmed I A, Kosba M A, El-Ezz Z R A and Korany M A 1986. Some factors affecting growth rates in two breeds of rabbits. Alexandria *J. Agr. Res*. **31** : 51-59. Cited from Anim. Breed. Abstr. 57: 6281.

Ahmed S S and Marai I F M. 1998. Milk yield and litter traits of rabbits as affected by breed, parity, number of nipples and Aminazine injection, under Egyptian sub-tropical conditions. *First international conference on animal production and health in semi arid areas,* El Arish, Egypt, 1-3 September, 1998. 407-415.

Akanno E C and Ibe S N. 2005. Estimates of genetic parameters for growth traits of domestic rabbits in the humid tropics. *Livestock Research for Rural Development*.**17**: Article # 86.

Al Sobayil K A, Al Homidan A H, Khalil M H and Mehaia M A. 2005. Heritabilities and genetic analysis of milk yield and components in crossing project of Saudi rabbits with Spanish V-line. *Livestock Research for Rural Development*. **17**: Article # 117.

Amaefule K U, Iheukwumere F C and Nwaokoro C C. 2005. A note on the growth performance and carcass characteristics of rabbits fed graded dietary levels of boiled pigeon pea seed (*Cajanus cajan). Livestock Research for Rural Development.* 17: Article # 48.

Anous M R. 1999. Growth performance, slaughter and carcass compositional traits in rabbits of a local strain and New Zealand White breed raised in Burundi.*World Rabbit Science.*7(3) : 139-143

A.O.A.C. 1997. Official methods of analysis, 16th edition. Association of Official Analytical Chemists, Washington,DC.

Argente M J, Muelas R, Baena P L, Rodriguez B and Garcia Pardo M L. 2005. Preliminary results of milk production in rabbits does F2 from crossing of two selected divergent lines for uterine capacity. *XI Jornadas sobre Produccion Animal*, Zaragoza, Spain, 11-12 Mayo, Volumes I and II. 159-161.

Asuquo B O and Okon B. 1999. A note on the heritability of body weight at various ages in growing rabbits. *Global Journal of Pure and Applied Sciences* **5**: 453-55.

Barron M del C, Herrera J G, Suarez M E, Zamora M M and Lemus C. 2004. Evaluation of carcass traits in three rabbit breeds. *Cuban Journal of Agricultural Science* **38**: 17-22.

Baselga M, Blasco A and Garcia F. 1982. Parametros geneticos de caracteres economicos en poblarciones de conejo. *II Congresso Mundial de Génética Aplicada a la produccion Ganadera, VI. Madrid. Ed, Garci*. p : 472.

Becker W A. 1985. *Manual of Quantitative Genetics*. Program in Genetics, Washington State University.

Belhadi S, Boukir M and Amriou L. 2002. Non genetic factors affecting rabbit reproduction in Algeria. *World Rabbit Science* **10**: 103-09.

Belhadi S. 2005. Characterisation of local rabbit performances in Algeria: environmental variation of litter size and weights. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 218-223.

Bharat Bhushan and Ahlawat S P S. 1999. Estimation of genetic parameters for post-weaning body weights in New Zealand White rabbits reared under agroclimatic conditions of Sikkim. *Indian Journal of Animal Science.* **69**: 511-513.

Bharat Bhushan, Pushpendra Kumar and Koul G L. 2004. Genetic and Phenotypic parameters of preweaning traits in New Zealand While rabbits under agroclimatic conditions of Sikkim. *Indian Journal of Animal Sciences* **74**: 1079-1081.

Bhasin V and Singh R N. 1998. Strategic approach to Maximize Rabbit Production under Indian conditions. In: Golden Jubilee Seminar on sheep, goat and rabbit production and utilization. Jaipur 24-26, April, 1998, *Lead papers and Abstracts Compendium*. pp59-64.

Bhasin V, Sastry V R B, Singh D, Gulyani R, Mathai R S, Kishore K, Singh R N, Lahiri S S, Rai R B and Dash P K. 1989. Performance of broiler rabbits in sub-temperate Himalayan region. *Journal of Applied Rabbit Research*. **12**: 263-64.

Bhasin V, Sawal R K and Bhatia D R. 1996. Genetic and non genetic factors affecting preweaning growth in broiler rabbits. *International Journal of Animal Sciences* **11**: 257-61.

Bhatt R S, Bhasin V and Bhatia D R 1996. Growth patterns in Soviet Chinchilla weaners fed four levels of Robinia leaves. In : World rabbit congress. Toulouse, Proceeding 1 : 93-96.

Bhatt R S, Sharma S R, Singh Umesh and Risam K S. 2003. Effect of weaning age on the production performance of Soviet Chinchilla rabbits under sub-temperate conditions in India. *Egyptian Journal of Rabbit Science* **13**: 11-19.

Bhatt R S, Sharma S R, Singh Umesh Kumar, Davendra and Bhasin V. 2002. Effect of different seasons on the performance of Grey Giant rabbits under sub-temperate Himalayan conditions. *Asian-Australian Journal of Animal Sciences* **15**: 812-20.

Bianospino E, Moura A S A M T, Wechsler F S, Fernandes S and Roca R O. 2005 a. Carcass and meat quality of straightbred and crossbred rabbits. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1354-1359.

Bianospino E, Wechsler F S, Moura A S A M T and Fernandes S. 2005 b. Growth traits and dressing percentage of straightbred and crossbred rabbits. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1360-1365

Bielanski P, Zajac J and Kowalska D. 2000. Meat quality traits of rabbits of different breeds. *Roczniki Naukowe Zootechniki* Supl.z.8: 125-29.

Bieniek J, Dorozynska D, Stalinski Z, Koczak T. 1994. Studies on rabbit meat production. II. Effect of age on meat quality. *Prace I Materialy Zootechniczne*. **46**: 65-73.

Blasco A, Ouhayoun J. 1996. Harmonization of criteria and terminology in rabbit meat research. Revised proposal. *World Rabbit Science.* **4**: 93-99.

Bokade S P, Gore A K, Kothekar M D, Deshmukh S N. 1993. Diallel analysis of three month body weight in rabbits. *Journal of Veterinary and Animal Sciences* **24**: 129-32.

Bokova I, Rafay J and Parkany V. 1990. Postnatal growth of two meat breeds of rabbits and their crossbreds. Pol' nohospodarstvo. 36 : 824 – 829. Cited from Anim. Breed.Abstr. 60 : 5325

Borthakur B, Das D, Das G C, Goswami R N and Buzarbarua K M. 2002. Studies on factors affecting post weaning daily body weight gain in New Zealand White rabbit. *Indian Veterinary Journal*. **79**: 30-32.

Borthakur B, Das D, Das G C, Goswami R N and Das A. 2003. Studies on carcass characteristics of New Zealand White breed of rabbit. *Indian Veterinary Journal* **80**: 56-58.

Bovera F, Di Meo C, Barone C, Gazaneo M P, Taranto S and Nizza A. 2005. A survey on carcass and meat characteristics of Ischia rabbits raised in pits. *Proc. of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1366-1371.

Bujarbaruah K M, Saxena S C, Bardoloi R K and Singh L P. 1989. Reproductive behavior of rabbits. *Indian Journal of Animal Science*s. **59**: 739-41.carcass merit. *J. Appl. Rabbit Res*. **13** : 193-198.

Carmona F J, Blas E, Cervera C and Pascual J J. 2005. The measure of milk rabbit. Proceedings of the 8th World Rabbit Congress September 7-10,2004, Pueblo,Mexico. 824-828

Carregal R D and Lui J F. 1984. Effect of mothering ability and general combining ability in crossbred rabbits. *Revista da Sociedade Brasileira de Zootecnia* **13** : 440-446.Cited from Animal Breeding Abstracts 9: 6025.

Cavani C, Bianchi M, Petracci M, Toschi T G, Parpinello G P, Kuzminsky G, Morera P and Finzi A. 2004. Influence of open – air rearing on fatty acid composition and sensory properties of rabbit meat. *World Rabbit Science* **12**: 247-258

Chang Li Fu, Lei Qiu Xia and Zhang Xiu Ling. 2005. Comparative studies on growth performance, nutrient digestibility, immunity index and protease activities between weaning-2 month and 2-3 month New Zealand rabbits. *Proc. of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 885-890.

Cheeke P R, Paton N M, Lukefahr S D and Mc Nitt J I. 1987. “Rabbit Production” Inter state printers and publishers Inc.,Illinois, U.S.A.

Cheeke P R. 1980. The potential role of the rabbit in meeting world food needs. *Journal of Applied Rabbit Research.* **3**: 3-5.

Chineke C A. 2005. Genetic and non-genetic effects on weaning and post-weaning traits in rabbit breeds and crosses. *Pakistan Journal of Biological Sciences.* **8**: 1402-1410.

Chineke C A. 2006. Evaluation of rabbit breeds and crosses for pre-weaning reproductive performance in humid tropics. *Journal of Animal and Veterinary Advances*. **5**: 528-537.

Choudhury H, Goswami R N, Das D, Das A and Roychoudhury R. 2003. Carcass characteristics of Soviet Chinchilla breed of rabbit in Meghalaya. *Indian Veterinary Journal* **80**: 435-36.

Combes S. 2004. Nutritional value of rabbit meat: a review. *INRA Productions Animales*. **17**: 373-383.

Csatellanos F. 1991. Conejos. Editorial *Trillas,* S.A. de C.V México

Dalle Zotte A. 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. *Livestock Production Science.* **75**: 11-32.

Das R K and Nayak J B. 1991. Performance of broiler rabbits under hot and humid conditions. *Indian Journal of Animal Production and Management*. **7**: 219-24.

Das S K and Yadav B P S. 2007. Effect of mating system, parity and breed on the reproductive performances of broiler rabbits under the agro - climatic condition of Meghalaya. *Livestock Research for Rural Development*. **19**: Article # 118.

Das S K, Das A and Bujarbaruah K M. 2006. Productive performance, reproductive performance and carcass traits of broiler rabbits in different generations under agroclimatic condition of Meghalaya. *Indian Journal of Animal Research*. **40**: 38-41.

Das S K, Roy A K, Pyne and Datta Gupta R. 1997. Influence of genetic group and season of conception on some reproductive and productive traits of rabbits in West Bengal. *Indian Veterinary Journal* **74**: 226-229.

Das S K, Sarkar A B, Bora N N, Nath D R and Barua K K. 2002. Effect of housing, floor space and breed on the carcass traits and composition of broiler rabbits. *Indian Veterinary Journal* **79**: 1051-1054.

Das S K, Sarker A B, Buzarbaruah K M, Yadav B P S and Verma N D. 2005. Effect of housing, floor space and breed on the physiological response of broiler rabbit. *Indian Veterinary Journal*. **82**: 457-458.

Das S K, Yadav B P S and Sikka A K. 2007. A note concerning effects of genetic and non genetic factors on weaning weight of rabbits in Eastern Himalayan region of India. *Livestock Research for Rural Development*. **19**: Article # 101

De Salvo F and Zucchi P.1984. A breed study of the main characteristics of rabbits. *Rivista di coniglicoltura* **21** : 27-33. Cited from Animal Breeding Abstracts 53 : 3941.

Deb S M and Gaur G K. 1996. Performance of broiler rabbits in sub-temperate hills. *Indian Veterinary Medical Journal* **20**: 184-89.

Devi D S, Gupta B R and Rao G N. 2005. Genetic study on post weaning body weights and Average Daily Gain of Soviet Chinchilla and Californian White rabbits. *Journal of Research ANGRAU*. **33**: 35-41.

Djellal F, Mouhous A and Kadi S A. 2006. Performances de l'élevage fermier du lapin dans la région de Tizi-Ouzou, Algérie. *Livestock Research for Rural Development*. **18**: Article # 100.

Echegaray T J L, Rebolledo Ch O, Rodrigucz H J C and Salcedo Baca R. 2005. Effect of nursing frequency on rabbits productive performance. *Proc. Of 8th World Rabbit Congress*, Sept. 7-10, 2004, Pueblo, Mexico 1122-1127.

Egbo M L, Doma U D and Lacdaks A B. 2001. Characteristics of small scale rabbit production and management in Bauchi metropolis. *Proc. of the 26th Annual Conference of Nigerian Society for Animal Production (NSAP)*, 18 - 21 March, 2001, ABU Zaria: 160 -162.

Ekambaram B, Rao V P, Murthy A S R, Satyanarayana A and Ramesh Gupta B. 2006. Genetic and non-genetic factors affecting the litter traits of broiler rabbits. *Indian Journal of Animal Research*. **40**: 9-14.

Ekambaram B. 1997. Genetic and non-genetic factors affecting broiler rabbit production. M.V.Sc. Thesis, Acharya N.G.Ranga Agricultural University, Hyderabad.

El Maghawry A M, Ahmed S S, Yamani K A and Radwan H. 1999. Some reproductive and productive traits of New Zealand White, Rex rabbits and their crosses. *Egyptian Journal of Rabbit Science* **9**: 159-77.

El-Maghawry A M, Soliman A M, Khalil H H. 1993. Doe milk production as affected by some genetic and environmental factors in New Zealand White and Californian rabbits under the Egyptian conditions. *Egyptian Journal of Rabbit Science*. **3**: 141-150.

El-Maghawry A M, Yamani K A, Fayez I and Marai M. 1988. A preliminary study on performance of some productive traits in New Zealand White and Californian rabbits under Egyptian environments. Proceedings of 4th Congress of the World Rabbit Science Association, Budapest, Hungary, pp 264-275

El-Maghawry A M. 1993. Post-weaning daily gain and mortality rate in New Zealand White and Californian rabbits, as affected by some genetic and environmental factors, under Egyptian conditions. *Egyptian Journal of Rabbit Science* **3**: 91-102.

El-Sayiad G H A. 1994. A study on milk production of New Zealand White and Californian rabbits under Egyptian conditions. *Egyptian Journal of Rabbit Science*. **4**: 47-59.

Enab A A, El-Weshahy O A and Abdou F H. 2000. Genetic analysis of some economic traits in rabbits. *Egyptian Journal of Rabbit Science* **10**: 327-39.

FAO. 2001. Press release No. PR 01/57 f. FAO. Rome.

Farghaly H M and El-Mahdy M R 1999. Genetic and non genetic factors affecting live, carcass and non-carcass traits of NewZealand White rabbits in Egypt. *Indian Journal Of Animal Sciences*. 69(8) 596-603.

Farid A. 2004. Some genetic parameters for some doe litter traits in Bouscat and Californian rabbits raised in Egypt. *Annals of Agricultural Science*, **42**: 1039-1051.

Ferraz J B S and Eler J P. 1994. Use of different animal models in prediction of genetic parameters of 23 traits of Californian and New Zealand White rabbits raised in tropics and suggestion of selection criteria. **In**: 5th World Congress on Genetics Applied to Livestock Production, Guelph, Canada. Proceedings, 20: 348-351.

Ferraz J B S, Johnson R K and Eler J P. 1991. Genetic parameters for growth and carcass traits of rabbits. Journal of Applied Rabbit Research 14 : 187-192.

Ghosh Nilotpal, Sil B K and Mandal L. 2006. Reproductive performance of Soviet Chinchilla and Grey Giant rabbits reared under hot humid conditions of West Bengal. *Indian Journal of Animal Research.* **40**: 52-54.

Ghosh S K, Das A, Bujarbaruah K M, Das Asit, Dhiman K R and Singh N P. 2004. Studies on the productive and reproductive performance of Soviet Chinchilla and New Zealand White breeds of rabbits under the sub tropical conditions of Tripura. In: *Proceedings of 8th World Rabbit Congress,* Mexico pp 1188-1193.

Ghosh S K, Das A, Bujarbaruah K M, Das Asit, Dhiman K R and Singh N P. 2005. Studies on the productive and reproductive performances of Soviet Chinchilla and New Zealand White breeds of rabbits in the subtropical conditions of Tripura. *Proc. of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1188-1193.

Gour D, Gopikrishna G and Swain N. 1995. Carcass Evaluation studies in Soviet Chinchilla and White Giant rabbits. *Indian Journal of Animal Research* **29**: 33-36.

Gupta B R, Jayaramakrishna V, Chaitanyam K, Prabhakar Rao V and Eswara Reddy C. 1990. A study on meat traits of some broiler rabbits. *Journal of Research, APAU* **18**: 146-152.

Gupta B R, Prabhakar Rao V, Eswara Reddy C, Satyanarayana A and Reddy P P. 2000 b. Effect of sex and season on carcass characters in rabbits. *Cheiron* **29**: 121-123.

Gupta B R, Rao V P, Eswara Reddy C, Satyanarayana A and Reddy P P. 1999. Factors influencing preweaning body weights in broiler rabbits. *Indian Journal of Animal Research* **33**: 115-120.

Gupta B R, Rao V P, Eswara Reddy C, Satyanarayana A and Reddy P P. 2000 c. Feed intake and feed conversion ratio in purebred and crossbred broiler rabbits. *Indian Journal of Animal Research* **34**: 64-67.

Gupta B R, Rao V P, Eswara Reddy C, Satyanarayana A and Reddy P P. 2002. Effect of genetic and non genetic factors on post weaning body weights and carcass traits of broiler rabbits. *Indian Journal of Animal Science*. **72**: 70-74.

Gupta B R, Rao V P, Reddy C E, Satyanarayana A and Reddy P P 2000 a. Meat characters of crossbred broiler rabbits. Indian Journal of Animal Sciences 70 : 751-753.

Gupta B R, Rao V P, Reddy C E,Satyanarayana A and Reddy P P.2001.Diallel analysis of carcass characteristics in broiler rabbits. Indian-Journal-of-Animal-Research. 2001; 35(1): 40-43

Gupta B R. 1998. Genetic analysis of the performance of crossbred broiler rabbits. Ph.D. Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.

Gupta S C, Riyazuddin, Gupta N and Gurmej Singh. 1992. Growth performance of meat rabbits in semi arid tropical conditions in India. *Journal of Applied Rabbit Research* **15**: 766-74.

Harvey W A. 1979.Least Squares analysis of data with unequal subclass members. U.S. Department of Agriculture Research Science and Education Administration.

Hassan N S. 2005. New Zealand White rabbits BLUP values for post-weaning individual body weight under Egyptian conditions. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 69-75.

Hue K T and Preston T R. 2006. Effect of different sources of supplementary fibre on growth of rabbits fed a basal diet of fresh water spinach (*Ipomoea aquatica*). *Livestock Research for Rural Development* 18: Article # 58.

Ibrahim T, Mbap S T, Russom Z Abdul S D and Ahmed M S. 2007. Genetic analysis of meat production traits of rabbits in Dagwom Farms, Vom, Nigeria. *Livestock Research for Rural Development.* **19**: Article # 9.

Igwebuike J U, Anugwa F O I, Ikurior S A and Ehiobu N G. 2001. Effect of feeding graded levels of soaked *Acacia albida* pods on the performance and organ weights of growing rabbits. *Proc. of the 26th Annual Conference of Nigerian Society for Animal Production (NSAP)*, 18 - 21 March, 2001, ABU Zaria: 165 -167.

Iraqi M M, Ibrahim M K, Hassan N S H and El Deghadi A S. 2006. Evaluation of litter traits in purebred and crossbred rabbits raised under Egyptian conditions. *Livestock Research for Rural Development.* **18**: 83

Jaouzi T, Barkok A, Bouzekraoui A and Bouymajjane Z. 2005. Evaluation of some production parameters in rabbit. Comparative study of local Moroccan rabbit and Californian breed in pure and cross breeding. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1194-1201.

Jayaramakrishna V, Ramesh Gupta B, Chaitanyam K, Prabhakar Rao V and Eswara Reddy C.1990. A study on growth performance of some broiler rabbits. *J. Res.* APAU. **18** : 20-23

Jensen N E and Rasmussen B. 1983. The rabbit testing station in 1982. *Beretning frastatens Husdrybrugs forsog* 545: 40. Cited from Animal Breeding Abstracts 54: 3361.

Jiabi P, Pelant R K and Youqing Q. 1990. Results of a shipment of 200 rabbits to china in November , 1985. *Journal of Applied Rabbit Research* **13** : 138-140

Kalita P, Bhojan R and Konwar B K. 2000. Carcass characteristics and meat composition of broiler rabbits on different dietary levels of protein and energy. *Indian Veterinary Journal* **77**: 972-75.

Karim S A. 1998. Slaughter characteristics of five genetic groups of broiler rabbits. *Indian Journal of Animal Science* **68**: 684-685.

Kermauner A and Zgur S. 2005. Fattening and slaughter traits of four rabbit genotypes. *Italian Journal of Animal Science*. **4**: 36-38.

Kpodekon M, Djago Y, Farougou S, Coudert P and Lebas F. 2005. Results of the technical management of four rabbit farms in Benin. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1134-40.

Kramer, C.Y. 1957. Extension of multiple range tests to group correlated adjusted means. Biometrics.13:13.

Kulkarni V V, Gupta K, Bhatt R and Manuja N K. 1995. Growth, carcass traits and meat composition of broiler rabbits. *Indian Journal of Animal Science* **65**: 599-601.

Kumar R A, Murugan M, Thiruvenkadan A K and Iyue M. 2006. Reproductive and productive traits of broiler rabbits as influenced by breed and season. *Indian Veterinary Journal* **83**: 577-579.

Kumar R A, Thiruvenkadan A K, Iyue M and Murugan M. 2004. Growth rate and carcass characteristics in meat rabbits. *Indian Veterinary Journal*. **81**: 1131-1133.

Kumar S, Gulyani R, Vinay-Kumar, Singh R N and Kumar V. 2001. Effect of genetic and non-genetic factors on weekly body weight of broiler rabbits in semi arid region of Rajasthan. *Indian Journal of Animal Sciences* **71**: 1075-77.

Kumar Sushil, Gulyani Rajiv, Singh Gurmej and Singh R N. 1998. Reproductive efficiency and reproductive performance of broiler rabbit does in the semi arid region. In: Golden Jubilee Seminar on sheep, goat and rabbit production and utilization. Jaipur, 24-26 April, 1998, *Lead papers and Abstracts compendium* pp 33 (abstr.)

Lahiri S S and Mahajan J M. 1982. Note on the inheritance of age at first breeding, litter size and weight in rabbits. *Indian Journal of Animal Sciences*. **52**: 1148-50.

Lahiri S S and Mahajan J M. 1983. Weaning characteristics of different mating types in rabbits. *Indian Journal of Animal Sciences*. **53**: 1363-65.

Lahiri S S and Mahajan J M. 1984. Performance of different crossbred groups of rabbits: Birth characteristics. *Indian Journal of Animal Sciences*. **54**: 138-40.

Lakabi D, Zerrouki N, Lebas F and Berchiche M. 2005. Growth performances and slaughter traits of a local Kabylian population of rabbits reared in Algeria: effects of sex and rearing season. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1396-1402.

Larzul C and Rochambeau H de. 2005. Selection for residual feed consumption in the rabbit. *Livestock Production Science*. **95**: 67-72.

Larzul C, Gondret F, Combes S and Rochambeau H. 2005. Divergent selection on 63-day body weight in the rabbit: response on growth, carcass and muscle traits. *Genetics*, *Selection*, *Evolution*. **37**: 105-122.

Lebas F. 2003. Sistemas de producción de carne de conejos. *CIHEAM,* IAMZ, Zragoza España 13 – 24.

Ledur M C and Carregal R D. 1988. Evaluation of heterosis in meat rabbits. Revista-de-Sociedade-*Brasileira-de Zootechnia* **17**: 434-439. Cited from Animal Breeding Abstracts 57: 7507.

Ledur M C, Carregal R D and Bianchini Sobrinho E. 1994. Evaluation of heterosis and maternal ability in rabbits during the growing period. *Revista da Sociedade Brasileirade Zootecnia*. **23** : 165-172.Cited from Commonwealth Agricultural Bureau(CAB) Abstracts 1995.

Lee H K, Yoo C H, Choi J S and Park T J. 1991. Inbreeding effect of pre weaning traits in rabbits. *Korean Journal of Animal Science* **33**: 13-17.

Levai A and Milisits G. 2004. Comparison of some slaughter traits of growing rabbits selected for high and low body fat content by means of the TOBEC method. *Buletinul Universitatii de Stiinte Agricole si Medicina Veterinara Cluj Napoca Seria Zootehnie si Biotehnologii*. **60**: 72-77

Lopez M, Losada H, Sandoval S, Bennett R, Arias L, Rangel J, Soriano R and Cortes J. 1999. The influence of urban tourism on backyard agriculture: the rabbit as a new guest in the southeast of the Metropolitan area of Mexico City. *Livestock Research for Rural Development,* **11**: 126-132.

Lowry O H, Rosenbrough M J, Farr A L and Randell R A. 1951. Protein measurement with the folin phenol reagent. *Journal of Biological Chemistry.* **193**: 265-275.

Lukefahr S D, Roberts J D, Atakora J K A and Hamilton H H 1992 b. Evaluation of Californian , Champagne D'Argent, New Zealand White and Palomino as potential sire breeds. II. Carcass yield and lean cutability traits. *J. Appl. Rabbi.t Res.* **15** : 287-298.

Lukefahr S D, Atakora J K A and Opoku E M. 1992 a. Heritability of 90-day Body Weight in Domestic Rabbits from Tropical Ghana, West Africa. *Journal of Heredity***.** 83: (2) 105-108.

Lukefahr S D, Nwosu C V and Rao D R. 1989. Cholesterol level of rabbit meat and trait relationships among growth, carcass and lean yield performances. *Journal of Animal Science.* **67**: 2009-17.

Lukefahr S D, Odi H B and Atakora J K A. 1996. Mass selection for 70-day body weight in rabbits. *Journal of Animal Science* **74**: 1481.

Mach k, Trojan V and Nedvedova V. 1986. Fertility growth and feed consumption in Californian and New Zealand White purebred and crossbred rabbits. *Zivocisna Vyroba* **44** : 109-123. Cited from Animal Breeding Abstracts 50 : 5298

Mahajan J M and Lahiri S S 1983. Inheritance of broiler traits in New Zealand White rabbits. *Indian J. Anim. Sci.* **53** : 1365-1367

Mahajan J M, Sastry V R B, Dash P K and Lahiri S S. 1980. New Zealand White rabbits for meat and pelt. *Indian Farming* **30**: 30-32.

Malik A H. 1988. Studies on rabbit meat patties, M.V.Sc. Thesis. Indian Veterinary Research Institute, Izatnagar, UP, India.

Marounek M, Skrivan M, Skrivanova V and Savka O. 2005. Weights of digestive organs, caecal metabolites and fermentation stoichiometry in coypus and rabbits. *Proceedings of the 8th World Rabbit Congress,* September 7-10, 2004, Pueblo, Mexico. 1103-08.

Marykutty T and Nanda Kumar P.2000. Factors influencing litter traits and body weight up to 12 weeks among temperate rabbit breeds in humid tropics. *World Rabbit Science* . **8**(2) : 67-70

Matics Z S, Szendro Z S, Radnai I, Biro Nemeth E, Gyovai M, Orova Z. 2005. Study of a two phase rearing method for growing rabbits. *Proc. of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1141-1145.

Mbanya J N, Ndoping B N, Mafeni J M and Fomunyam D W. 2005. The effect of different protein sources and their combination on the performance of growing rabbits in tropical conditions. *Livestock Research for Rural Development.* **17**: Article # 32.

McNitt J I and Moody G L Jr. 1990. Effect of month, breed and parity on doe productivity in southern Louisiana. *Journal of Applied Rabbit Research* **13**: 169-75.

McNitt J I, Lukefahr S D. 1990. Effect of breed, parity, day of lactation and number of kits on milk production of rabbits. *Journal of Animal Science.* **68**: 1505-1512.

Medellin M F and Lukefahr S D. 2001. Breed and heterotic effects on postweaning traits in Altex and New Zealand White straightbred and crossbred rabbits. *Journal of Animal Science* **79**: 1173–78.

Metzger S, Kustos K, Szendro Z, Szabo A, Eiben C and Nagy I. 2003. The effect of housing system on carcass traits and meat quality of rabbit. *World Rabbit Science* **11**: 1-11.

Metzger S, Odermatt M, Szendro Z, Mohaupt M, Romvari R, Makai A, Biro Nemeth E, Sipos L, Radnai I and Horn P. 2006 b. A study of the carcass traits of different rabbit genotypes. *World Rabbit Science*. **14**: 107-114.

Metzger S, Odermatt M, Szendro, Z, Mohaupt, M, Romvari R, Makai, A, Biro Nemeth E, Radnai I and Sipos L. 2006 a. Comparison of carcass traits and meat quality of Hyplus hybrid, purebred Pannon White rabbits and their crossbreds. *Archiv fur Tierzucht.* **49**: 389-399.

Monika G, Hoffmann R and Zalka M. 2004. Examination of different effects on the birth weight of rabbits. *Buletinul Universitatii de Stiinte Agricole si Medicina Veterinara Cluj Napoca,Seria Zootehnie si Biotehnologii.* **60**: 62-66.

Moura A S A M T, Kaps M, Vogt D W and Lamberson W R. 1997. Two way selection for daily gain and feed conversion in a composite rabbit population. *Journal of Animal Science* **75**: 2344-48.

Nagpure N S, Kothekar M D, Gore A K and Deshmukh S N. 1991.Estimation of heterosis in crosses of four breeds of rabbits. *J.Appl. Rabbit Res.* **14** : 34-37

Narayan A D and Rawat S. 1982. Reproductive performance in selected and control lines of rabbits. *Indian Journal of Animal Sciences.* **52**: 542-46.

Nofal R Y, Toth S and Virag G Y.1995. Carcass traits of purebred and crossbred rabbits. World Rabbit Science 3: 167-170.

Nofal R Y, Toth S and Virag G M. 1996. Carcass traits of New Zealand White, Californian rabbits and their reciprocal crosses. *Allattenyesztes es Takarmanyozas* **45**: 31-37.

Nofal R, Szendro Z S, Kenessey A and Jensen J E. 2005. Crossbreeding effects on carcass traits at 12 weeks of age in Pannon and Danish white rabbits and their reciprocal crosses. *Proceedings of the 8th World Rabbit Congress,* September 7-10, 2004, Pueblo, Mexico. 102-10.

Nunes J R V and Polastre R. 1990. Environmental and inbreeding effects on litter traits at weaning in Norfolk rabbits. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia* **42**: 407-25.

Ogundu U E. 2001. Repeatability estimates and prediction of milk suckled per kit from performance traits in Dutch rabbit. *Journal of Sustainable Agriculture and the Environment* **3**: 149-54.

Olorunsanya B, Ayoola M A, Fayeye T R, Olagunju T A and Olorunsanya E O. 2007. Effects of replacing maize with sun-dried cassava waste meal on growth performance and carcass characteristics of meat type rabbit. *Livestock Research for Rural Development* **19**: Article # 55.

Oluremi O I A, Bogbenda M and Mkah T P. 2006. The effect of *Cirina forda* larva meal in rabbit diets on performance, carcass quality and nutrient digestibility. *Livestock Research for Rural Development.***18**: Article # 92.

Ortiz Hernandez J A and Rubio Lozano M S. 2001. Effect of breed and sex on rabbit carcass yield and meat quality. *World Rabbit Science* **9**: 51-56.

Ozimba C E and Lukefahr S D. 1991 a. Comparison of rabbit breed types for post-weaning litter growth, feed efficiency and survival performance traits. *Journal of Animal Science*, **69**: 3494-3500.

Ozimba C E and Lukefahr S D. 1991b. Eevaluation of purebred and crossbred rabbits for carcass merit. *Journal of Animal Science.* **69:** 2371-2378.

Ozimba C. E. and Lukefahr S.D.1990. Evaluation of purebred and crossbred rabbits for carcass merit. *J. Appl. Rabbit Res*. 13 : 193-198.

Paci G, Cossato M M F di, Piloni S and Bagliacca M. 1999. Effect of season and housing system on productive performance and meat quality of rabbit. *Rivista di Coniglicoltura* **36**: 30-36.

Paula M G, Ferraz J B S and Eler J P. 2000. Genetic parameters for Californian rabbits raised in Brazil. *Arquivo Brasileiro deMedicinaVeterinaria e Zootecnia* **52**: 544-48.

Pinna W, Marongiu M L, Sedda P, Moniello G, Nizza A and Piccolo G. 2005. Linear measurements of carcasses as a tool to improve the evaluation of the rabbit meat production. *Proc. of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1447-1451.

Pla M, Pascual M and Arino B.2004. Protein, fat and moisture content of retail cuts of rabbit meat evaluated with the NIRS methodology. *World Rabbit Science* **12**: 149-58.

Polak T, Gasperlin L, Rajar A and Zlender B. 2006. Influence of genotype lines, age at slaughter and sexes on the composition of rabbit meat. Food-Technology-and-Biotechnology. 2006; 44(1): 65-73

Ponce de Leon R, Guzman G, Pubillones O, Garcia J and Mora M. 2002. Performance of imported rabbit breeds. Evaluation of pre-weaning growth. *Cuban Journal of Agricultural Science* **36**: 313-19.

Ponce de Leon R, Guzman G, Pubillones O, Mora M and Quesada M E. 2004. Genetic parameters of growth traits in four rabbit breeds. *Cuban Journal of Agricultural Science*. **38**: 231-236.

Poornima K, Gupta B R, Rao G N and Satyanarayana A. 2003. Evaluation of Californian White rabbits for carcass traits. *Indian Journal of Animal Science* **73**: 564-566.

Poornima K, Ramesh Gupta B, Narasimha Rao G and Satyanarayana A. 2002 a. Genetic study on pre-weaning body weights and growth rates in Californian White rabbits. *Indian Journal of Animal Science*. **72**: 601-603.

Poornima K, Ramesh Gupta B, Narasimha Rao G and Satyanarayana A. 2002 b. Factors affecting post weaning body weights and growth rates of Californian White rabbits. *Indian Journal of Animal Research* **36**: 39-42.

Prasad K V S. 1993. Studies on purebred, F2 and three way crosses of certain meat type rabbits in Andhra Pradesh. M.V.Sc thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Prayaga K C and Eady S J. 2002. Performance of purebred and crossbred rabbits in Australia: doe reproductive and pre-weaning litter traits. *Australian Journal of Agricultural Research* **53**: 993-1001.

Prayaga K C and Eady S J. 2003. Performance of purebred and crossbred rabbits in Australia: individual growth and slaughter traits. *Australian Journal of Agricultural Research* **54**: 159-166.

Purandhar B. 1991.Genetic study of four meat type rabbit breeds under diallele mating. M.V.Sc thesis, Andhra Pradesh Agricultural University, Hyderabad.

Rajkumar U.1994. Genetic evaluation of certain purebred rabbits and their 2-way (F3) and 3-way crosses. M.V.Sc. Thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Rao K V, Ulaganathan V, Sethumadhavan V, Ahmed N M and Easwaran B M. 1994. Genetic and non genetic factors affecting production characteristics in rabbits. *International Journal of Animal Science* **9**: 95-96.

Rao S T V. 1988. Evaluation and genetic analysis of some meat type rabbits. M.V.Sc thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Rastogi R K, Lukefahr S D and Lauckner F B. 2000. Maternal heritability and repeatability for litter traits in rabbits in a humid tropical environment. Livestock Production Science. 67(1): 123-128.

Reddy S S. 1996. Effect of inbreeding on performance of broiler rabbits. M.V.Sc. Thesis, Andhra Pradesh Agricultural University, Hyderabad.

Reddy N V. 1994. Genetic analysis of the performance of exotic broiler rabbits under Indian Conditions. M.V.Sc thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Reddy S S, Eswara Reddy C, Ramesh Gupta B and Satyanarayana A. 2001. Effects of litter size, genetic group and inbreeding on pre-weaning growth of broiler rabbits. *Cheiron*. **30**: 122-125.

Reddy S S, Eswara Reddy C, Ramesh Gupta B and Satyanarayana A. 2000a. Effect of inbreeding on preweaning litter weights of broiler rabbits. *Indian Veterinary Journal* **77**: 597-599.

Reddy S S, Eswara Reddy C, Ramesh Gupta B and Satyanarayana A. 2000b. Effects of inbreeding on slaughter traits of broiler rabbits. *Indian Journal of Animal Research* **34**: 40-42.

Reid Y N, Toth S and Virag G.1995. Effects of crossbreeding on body weight, daily gain and feed efficiency of rabbits. Allattenyesztes-es-Takarmanyozas 44: 329-336.Cited from Animal Breeding Abstracts 63: 7639

Roberts J D and Lukefahr S D. 1992. Evaluation of Californian, Champagne D' Argent, New Zealand White and Palomino as potential sire breeds.I. Post weaning litter traits. *Journal of Applied Rabbit Research* **15**: 274-286.

Rohilla P P and Bujarbaruah K M. 2004. Growth, production and reproduction performance of rabbit in NEH-region. In: National seminar on Angora Rabbit Wool and Cashmere Production and Utilization, 25-26th September, 2004, Manali (HP), *Souvenir of Lead Papers and Abstracts* pp 215 (Abstr. 40).

Rubio R M, Torres Hernandez G, Martinez Garza A, Mastache Lagunas A A and Lagunas Silva M G. 2005. Genetic components of litter performance in a diallel cross involving four rabbit breeds. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 152-157.

Sabra Z A, Khalil M H, Hanafi M, Gad H A. 2001. Estimation of sire and paternal grand dams breeding values for growth traits in New Zealand White and Californian rabbits using the animal model. *Egyptian Journal of Rabbit Science* **11**: 103-14.

Salroo G M, Prasad V S S and Gupta S C 1989. Effect of age on carcass traits of Soviet Chinchilla rabbits. *Indian Journal of Animal Sciences* **59** : 890-892.

Santos J C dos, Abreu R D, Carvalho G J L de, Ledo C A da S, Leao K R B, Santana M L de A C, Leite A P L and Barbosa J A. 2005. Yield of carcass and main cuts of New Zealand White and California rabbits at different ages. *Magistra* **17**: 114-18.

Satyanarayana C. 1992.Genetic evaluation of meat production traits in certain purebred rabbits and crosses. M.V.Sc thesis, Andhra Pradesh Agricultural University, Hyderabad.

Sen A R and Bhagawan P S K 1999.Appraisal of two genetic groups of rabbits for carcass and meat quality traits in males and females.*Indian Journal Of Animal Sciences*. **69**(8) : 631-633

Sen A R, Gulyani R and Singh R N. 2000. Carcass and Meat characteristics of three genetic groups of rabbits. *Journal of Food Science and Technology* **37**: 549-550.

Singh Gurmej. 1998a. Factors affecting milk yield and associated traits of rabbits. *Indian Journal of Animal Science.* **68:** 681-683.

Singh Gurmej. 1998b. Growth and reproduction profile of broiler rabbits under hot semi-arid climate. In: Golden Jubilee seminar on sheep, goat and rabbit production and utilization, Jaipur 24-26 April, 1998, *Lead papers and Abstracts compendium*, pp 34 (abstr.)

Singh N P and Prasad R. 2005. Carcass characteristics of meat rabbits under farm feeding management. *Indian Journal of Small Ruminants*. **11**: 58-61

Singh Umesh, Sharma S R , Bhatt R S , Bhasin V and Risam K S. 2007. Growth and reproductive performance of Grey Giant rabbits under sub-temperate conditions in Himachal Pradesh. *Indian Journal of Animal Sciences* **77**: 328-30.

Singh Umesh, Sharma S R, Bhatt R S, Bhasin V and Risam K S. 2003. Estimates of genetic and non genetic parameters of growth and reproductive traits in New Zealand White rabbits under sub temperate Himalayan conditions in India. *Egyptian Journal of Rabbit Science* **13**: 1-9.

Skandro M, Aklovica F, Gagic A, Kobilic Zubevic V, Smajlovic M, Kustura A and Goletic T. 2004. Slaughter yield of rabbit carcasses produced in besieged Sarajevo during war years 1992-1995. *Praxis Veterinaria Zagreb.* **52**: 273-281.

Skrivanova V, Marounek M, Tumova E, Skrivan M and Lastovkova J. 2000. Performance, carcass yield and quality of meat in broiler rabbits: a comparison of six genotypes. *Czech Journal of Animal Science* **45**: 91-95.

Snedecor G W and Cochran W G. 1987. *Statistical Methods.* 6th Ed. Oxford and IBH Publishing Co., Calcutta, Bombay and New Delhi.

Srinivasu T. 1992. Studies on combining ability of certain meat type breeds of rabbits. M.V.Sc. Thesis, Andhra Pradesh Agricultural University, Hyderabad.

Sundaram R N S and Bhattacharyya A R. 1991. Growth performance of exotic meat rabbit and its crosses under the tropical coastal climatic conditions. *Indian Veterinary Journal* **68**: 693-94.

Sundaram R N S and Bhattacharyya A R. 1992. Performance of exotic meat rabbit under tropical coastal climatic conditions. *Indian Journal of Animal Science* **26**: 109-10.

Szkucik K and Libelt K. 2006. Nutritional value of rabbit meat. *Medycyna Weterynaryjna*. **62**: 108-110.

Timon V M and Hamrahan J P. 1985. Small ruminant production in developing countries. *Proc. of an Expert Consultation held in Sofia*, Bulgaria. July, 1985. pp. 58.

Trocino A, Xiccato G, Queaque P I and Sartori A. 2005. Group housing of growing rabbits: effect of stocking density and cage floor on performance, welfare, and meat quality. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1277-1282.

Urmila Pannu, Beniwal B K, Singh V K and Gahlot R S. 2004. Post weaning growth performance of different breeds of rabbits : Average daily gain. *Indian Journal of Small Ruminants.* **10**: 15-20.

Urmila Pannu, Beniwal B K, Singh V K and Gahlot R S. 2005. Reproductive performance and economic value of does in different broiler breeders of rabbit under semiarid conditions. *Indian Journal of Animal Sciences* **75**: 425-428.

Verga M, Zingarelli I, Heinzl E, Ferrante V, Martino P A and Luzi F. 2005. Effect of housing and environmental enrichment on performance and behaviour in fattening rabbits. *Proceedings of the 8th World Rabbit Congress*, September 7-10, 2004, Pueblo, Mexico. 1283-1288.

Yalcn S, Onbaslar E E and Onbaslar I. 2006. Effect of sex on carcass and meat characteristics of New Zealand white rabbits aged 11 weeks. *Asian Australasian Journal of Animal Sciences*. **19**: 1212-1216.

Yolcu H I, Balcoglu M S, Frat M Z and Karabag K. 2004. Estimation of variance components for liveweights of New Zealand White rabbits by using different methods. *Ziraat Fakultesi Dergisi Akdeniz Universitesi*. **17**: 81-85.

Zajac J. 1999. The effect of genotype and sex on some quality traits in rabbits. *Roczniki Naukowe Zootechniki* **26**: 29-39.

Zerrouki N, Lebas F, Berchiche M and Bolet G. 2005 b. Evaluation of milk production of a local Algerian rabbit population raised in the Tizi Ouzou area (Kabylia). *World Rabbit Science.* **13**: 39-47.

Zerrouki N, Bolet G, Berchiche M and Lebas F. 2005 a. Evaluation of breeding performance of a local Algerian rabbit population raised in the Tizi-Ouzou area (Kabylia). *World Rabbit Science*. **13**: 29-37.

Zgur S and Kermauner A. 2005. Carcass traits of four rabbit genotypes. *Italian Journal of Animal Science*. **4**: 172-174.

Zhu S Z and Chang L F. 2004. Effects of digestible energy level on growth performance, nitrogen utilization, immune parameters and caecum fermentation of New Zealand rabbits from weaning to 2 months old. *Chinese Journal of Animal Science.* **40**: 16-18.

Zotte A D. 2005. Influence of the genetic origin and sex on live performance and carcass traits in the rabbit. Preliminary results. Italian Journal of Animal Science. **4**: 175-177.

Zucchi P and Desalvo F. 2004. An analysis on the effects of month of mating on the performance of rabbits. *Rivista di Coniglicoltura*. **41**: 16-19.

Zucchi P and Desalvo F. 2005. Analysis of breeding parameters in male rabbits. *Rivista di Coniglicoltura*.**42**: 16-18.

Table 10. Least-squares analysis of variance for pre-weaning body weights

| Source of Variation | BW0 | | BW1 | | BW2 | | BW3 | | BW4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares |
| Genetic groups | 6 | 748.29$^{**}$ | 6 | 1062.39 | 6 | 8541.59$^{**}$ | 6 | 20194.47$^{**}$ | 6 | 26217.76$^{**}$ |
| Season of birth | 2 | 2536.75$^{**}$ | 2 | 8051.95$^{**}$ | 2 | 31352.60$^{**}$ | 2 | 39853.20$^{**}$ | 2 | 115530.78$^{**}$ |
| Litter size at birth | 3 | 769.35$^{**}$ | 3 | 17854.54$^{**}$ | 3 | 61295.62$^{**}$ | 3 | 77006.34$^{**}$ | 3 | 156761.72$^{**}$ |
| Error | 1076 | 95.94 | 669 | 586.04 | 587 | 1606.13 | 522 | 3790.99 | 470 | 7758.87 |

$^{**}$ Significant ($P \leq 0.01$)

Table 11. Least-squares means of pre-weaning body weights (g)

| | BW0 | | BW1 | | BW2 | | BW3 | | BW4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE |
| Overall | 1088 | 50.00 ± 0.59 | 681 | 104.52 ± 1.89 | 599 | 175.10 ± 3.28 | 534 | 239.50 ± 6.11 | 482 | 354.07 ± 9.19 |
| **Genetic group** | | | | | | | | | | |
| New Zealand White | 542 | 46.97$^{bc}$ ± 0.56 | 357 | 100.43 ± 1.87 | 310 | 168.98$^{ab}$ ± 3.25 | 279 | 232.46$^{b}$ ± 5.92 | 243 | 342.21$^{bc}$ ± 9.07 |
| Grey Giant | 76 | 52.07$^{a}$ ± 1.19 | 59 | 109.44 ± 3.45 | 48 | 179.03$^{a}$ ± 6.35 | 44 | 251.27$^{ab}$ ± 10.80 | 43 | 342.65$^{abc}$ ± 15.75 |
| Soviet Chinchilla | 117 | 51.38$^{a}$ ± 1.00 | 59 | 101.90 ± 3.48 | 50 | 175.88$^{a}$ ± 6.22 | 43 | 239.37$^{ab}$ ± 10.89 | 42 | 377.78$^{a}$ ± 15.99 |
| Flemish Giant | 166 | 47.82$^{bc}$ ± 0.83 | 102 | 105.48 ± 2.66 | 92 | 188.55$^{a}$ ± 4.59 | 85 | 252.36$^{a}$ ± 7.91 | 80 | 374.37$^{a}$ ± 11.55 |
| Californian White | 113 | 46.70$^{c}$ ± 1.02 | 54 | 103.35 ± 3.65 | 49 | 155.15$^{b}$ ± 6.35 | 39 | 197.25$^{c}$ ± 11.14 | 30 | 307.26$^{c}$ ± 18.14 |
| APAU Fawn | 52 | 49.95$^{ab}$ ± 1.40 | 31 | 101.05 ± 4.48 | 31 | 167.75$^{ab}$ ± 7.47 | 27 | 229.51$^{b}$ ± 12.59 | 27 | 367.87$^{ab}$ ± 18.25 |
| APAU Black | 22 | 55.10$^{a}$ ± 2.16 | 19 | 110.00 ± 5.85 | 19 | 190.37$^{a}$ ± 9.75 | 17 | 274.31$^{a}$ ± 16.05 | 17 | 366.36$^{ab}$ ± 23.12 |
| **Season of birth** | | | | | | | | | | |
| Winter | 408 | 52.24$^{a}$ ± 0.71 | 308 | 104.37$^{b}$ ± 2.16 | 285 | 165.28$^{b}$ ± 3.76 | 269 | 225.35$^{b}$ ± 6.43 | 260 | 328.45$^{b}$ ± 9.36 |
| Summer | 475 | 47.41$^{c}$ ± 0.64 | 240 | 97.51$^{c}$ ± 2.15 | 200 | 167.35$^{b}$ ± 3.77 | 183 | 231.44$^{b}$ ± 6.73 | 176 | 327.79$^{b}$ ± 9.80 |
| Rainy | 205 | 50.35$^{b}$ ± 0.88 | 133 | 111.68$^{a}$ ± 2.76 | 114 | 192.68$^{a}$ ± 4.88 | 82 | 261.72$^{a}$ ± 9.15 | 46 | 405.97$^{a}$ ± 15.70 |
| **Litter size at birth** | | | | | | | | | | |
| 1-3 | 46 | 51.81$^{a}$ ± 1.49 | 23 | 132.55$^{a}$ ± 5.17 | 23 | 228.35$^{a}$ ± 8.56 | 13 | 315.06$^{a}$ ± 17.52 | 13 | 439.74$^{a}$ ± 25.10 |
| 4-6 | 438 | 51.61$^{a}$ ± 0.58 | 286 | 104.66$^{b}$ ± 1.74 | 258 | 175.44$^{b}$ ± 3.00 | 233 | 237.88$^{b}$ ± 5.07 | 209 | 352.27$^{b}$ ± 8.18 |
| 7-9 | 485 | 48.97$^{ab}$ ± 0.60 | 312 | 91.60$^{c}$ ± 1.80 | 272 | 149.93$^{c}$ ± 3.14 | 247 | 207.32$^{c}$ ± 5.27 | 222 | 296.51$^{c}$ ± 8.23 |
| 10 and 11 | 119 | 47.61$^{b}$ ± 1.03 | 60 | 89.28$^{c}$ ± 3.55 | 46 | 146.69$^{c}$ ± 6.68 | 41 | 197.76$^{c}$ ± 10.97 | 38 | 327.76$^{bc}$ ± 16.43 |

Means followed by similar superscript(s) do not differ significantly ($P \leq 0.05$)

Table 12. Least-squares analysis of variance of post weaning body weights

| Source of Variation | BW6 | | BW8 | | BW10 | | BW12 | | BW14 | | BW16 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares | d.f. | Mean Squares |
| Genetic groups | 6 | 184084.93$^{**}$ | 6 | 95723.92$^{**}$ | 6 | 165862.15$^{**}$ | 6 | 284042.94$^{**}$ | 6 | 444759.26$^{**}$ | 6 | 681328.47$^{**}$ |
| Rearing system | 1 | 10530.23 | 1 | 17695.71 | 1 | 109170.55 | 1 | 4540.78 | 1 | 43378.69 | 1 | 339100.17 |
| Sex of bunny | 1 | 17235.89 | 1 | 10099.64 | 1 | 13750.91 | 1 | 15826.12 | 1 | 199332.90 | 1 | 442850.93$^{*}$ |
| Season of birth | 1 | 1606947.75$^{**}$ | 1 | 1470566.11$^{**}$ | 1 | 2439498.96$^{**}$ | 1 | 3771127.06$^{**}$ | 1 | 4119405.84$^{**}$ | 1 | 2418407.81$^{**}$ |
| Litter size at birth | 3 | 137363.43$^{**}$ | 3 | 299835.77$^{**}$ | 3 | 435340.84$^{**}$ | 3 | 586356.26$^{**}$ | 3 | 796978.55$^{**}$ | 3 | 965316.15$^{**}$ |
| Error | 383 | 25764.18 | 377 | 32527.64 | 362 | 42302.70 | 343 | 63654.75 | 303 | 72547.12 | 262 | 96240.95 |

$^{*}$ Significant ($P \leq 0.05$); $^{**}$ Significant ($P \leq 0.01$)

Table 13. Least-squares means of post weaning body weights (g)

| | BW6 | | BW8 | | BW10 | | BW12 | | BW14 | | BW16 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE | n | Mean ± SE |
| Overall | 396 | 551.89 ± 16.84 | 390 | 684.30 ± 19.68 | 375 | 856.37 ± 23.33 | 356 | 1018.79 ± 28.83 | 316 | 1207.18 ± 31.98 | 275 | 1352.84 ± 37.93 |
| **Genetic group** | | | | | | | | | | | | |
| New Zealand White | 195 | $509.79^{cd}$ ± 17.58 | 192 | $672.81^{bc}$ ± 20.30 | 187 | $850.58^{b}$ ± 24.39 | 176 | $1031.78^{b}$ ± 30.38 | 165 | $1302.02^{ab}$ ± 33.78 | 135 | $1489.49^{ab}$ ± 42.62 |
| Grey Giant | 37 | $580.44^{ab}$ ± 30.36 | 36 | $702.19^{ab}$ ± 34.84 | 33 | $899.30^{ab}$ ± 41.54 | 32 | $1036.07^{ab}$ ± 51.70 | 23 | $1209.20^{abc}$ ± 63.06 | 22 | $1360.14^{bc}$ ± 74.34 |
| Soviet Chinchilla | 34 | $528.35^{bcd}$ ± 31.31 | 33 | $693.86^{abc}$ ± 35.88 | 30 | $942.47^{a}$ ± 42.64 | 29 | $1146.62^{a}$ ± 52.92 | 26 | $1356.01^{a}$ ± 60.44 | 24 | $1534.12^{a}$ ± 73.13 |
| Flemish Giant | 61 | $648.31^{a}$ ± 25.16 | 61 | $760.45^{a}$ ± 28.70 | 61 | $910.01^{ab}$ ± 33.44 | 60 | $1088.48^{ab}$ ± 41.28 | 54 | $1337.88^{a}$ ± 46.21 | 48 | $1484.11^{ab}$ ± 55.96 |
| Californian White | 28 | $471.13^{d}$ ± 33.29 | 27 | $600.89^{c}$ ± 39.13 | 25 | $713.63^{c}$ ± 46.56 | 23 | $814.06^{c}$ ± 59.14 | 22 | $1001.63^{d}$ ± 64.97 | 21 | $1057.40^{d}$ ± 76.96 |
| APAU Fawn | 25 | $555.15^{bcd}$ ± 33.38 | 25 | $692.66^{abc}$ ± 37.56 | 23 | $881.56^{ab}$ ± 44.46 | 21 | $1067.32^{ab}$ ± 56.82 | 13 | $1082.45^{cd}$ ± 76.65 | 12 | $1199.12^{cd}$ ± 92.30 |
| APAU Black | 16 | $570.08^{abc}$ ± 42.97 | 16 | $667.22^{bc}$ ± 48.55 | 16 | $797.06^{bc}$ ± 55.79 | 15 | $947.19^{bc}$ ± 70.36 | 13 | $1161.07^{bcd}$ ± 80.38 | 13 | $1345.48^{bc}$ ± 93.06 |
| **Rearing system** | | | | | | | | | | | | |
| Cages | 200 | 557.11 ± 18.90 | 199 | 691.11 ± 21.81 | 194 | 873.62 ± 25.85 | 184 | 1022.40 ± 32.02 | 162 | 1219.10 ± 35.61 | 140 | 1388.73 ± 42.69 |
| Backyard | 196 | 546.68 ± 18.53 | 191 | 677.49 ± 21.67 | 181 | 839.12 ± 25.51 | 172 | 1015.18 ± 31.66 | 154 | 1195.26 ± 35.38 | 135 | 1316.94 ± 42.27 |
| **Sex of bunny** | | | | | | | | | | | | |
| Male | 178 | 558.65 ± 19.36 | 175 | 689.50 ± 22.40 | 166 | 862.55 ± 26.50 | 156 | 1025.60 ± 32.85 | 143 | 1233.17 ± 36.41 | 122 | $1394.55^{a}$ ± 43.69 |
| Female | 218 | 545.14 ± 18.13 | 215 | 679.09 ± 21.15 | 209 | 850.19 ± 24.93 | 200 | 1011.98 ± 30.92 | 173 | 1181.19 ± 34.80 | 153 | $1311.13^{b}$ ± 41.53 |
| **Season of birth** | | | | | | | | | | | | |
| Winter | 242 | $620.39^{a}$ ± 18.30 | 238 | $750.37^{a}$ ± 21.36 | 225 | $943.29^{a}$ ± 25.49 | 220 | $1131.39^{a}$ ± 31.69 | 212 | $1335.91^{a}$ ± 34.67 | 204 | $1469.65^{a}$ ± 41.57 |
| Summer | 154 | $483.40^{b}$ ± 19.56 | 152 | $618.22^{b}$ ± 22.62 | 150 | $769.45^{b}$ ± 26.47 | 136 | $906.19^{b}$ ± 32.95 | 104 | $1078.45^{b}$ ± 37.78 | 71 | $1236.03^{b}$ ± 47.28 |
| **Litter Size at Birth** | | | | | | | | | | | | |
| 1-3 | 10 | $514.67^{b}$ ± 52.83 | 9 | $713.36^{ab}$ ± 62.69 | 8 | $905.66^{ab}$ ± 76.11 | 8 | $1073.12^{ab}$ ± 93.65 | 8 | $1462.37^{a}$ ± 102.09 | 8 | $1612.05^{a}$ ± 118.40 |
| 4-6 | 165 | $597.51^{a}$ ± 13.90 | 164 | $738.54^{a}$ ± 15.67 | 160 | $910.17^{a}$ ± 18.19 | 151 | $1089.03^{a}$ ± 23.03 | 131 | $1236.07^{b}$ ± 27.93 | 116 | $1414.82^{a}$ ± 34.05 |
| 7-9 | 185 | $527.78^{b}$ ± 14.51 | 181 | $634.94^{b}$ ± 16.39 | 172 | $782.04^{b}$ ± 19.18 | 162 | $936.41^{b}$ ± 24.35 | 148 | $1087.19^{c}$ ± 28.54 | 129 | $1242.75^{b}$ ± 35.19 |
| 10 and 11 | 36 | $567.63^{ab}$ ± 29.36 | 36 | $650.35^{b}$ ± 33.01 | 35 | $827.61^{b}$ ± 38.35 | 35 | $976.60^{b}$ ± 47.45 | 29 | $1043.09^{c}$ ± 55.63 | 22 | $1141.73^{b}$ ± 72.05 |

Means followed by similar superscript(s) do not differ significantly ($P \leq 0.05$)

Table 19. Least-squares analysis of variance of feed intake

| Source of variation | d.f | Mean Squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Up to 5 weeks | Up to 6 weeks | Up to 7 weeks | Up to 8 weeks | Up to 9 weeks | Up to 10 weeks | Up to 11 weeks | Up to 12 weeks | Up to 13 weeks | Up to 14 weeks | Up to 15 weeks | Up to 16 weeks |
| Genetic groups | 3 | 0.0002 | 0.0005 | 0.0081 | 0.0817* | 0.2378** | 0.4290* | 0.6648* | 1.0692** | 1.2316* | 1.4925* | 1.6856* | 1.9762* |
| Sex of bunny | 1 | 0.0002 | 0.0003 | 0.0000005 | 0.0010 | 0.0118 | 0.0147 | 0.0319 | 0.0618 | 0.0895 | 0.1570 | 0.2269 | 0.3376 |
| Season of birth | 1 | 0.0002 | 0.0009 | 0.0010 | 0.0512 | 0.1787* | 0.3103 | 0.3119 | 0.2471 | 0.3039 | 0.5033 | 0.4249 | 0.3472 |
| Error | 10 | 0.0001 | 0.0004 | 0.0056 | 0.0156 | 0.0344 | 0.0677 | 0.1145 | 0.1595 | 0.2049 | 0.2782 | 0.3399 | 0.4159 |

* Significant ($P \leq 0.05$); ** Significant ($P \leq 0.01$)

Table 20. Least-squares means of feed intake (kg)

|  | n | Up to 5 weeks | Up to 6 weeks | Up to 7 weeks | Up to 8 weeks | Up to 9 weeks | Up to 10 weeks | Up to 11 weeks | Up to 12 weeks | Up to 13 weeks | Up to 14 weeks | Up to15 weeks | Up to 16 weeks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overall | 16 | 0.10 ± 0.003 | 0.26 ± 0.01 | 0.48 ± 0.02 | 0.72 ± 0.03 | 1.00 ± 0.05 | 1.30 ± 0.07 | 1.67 ± 0.09 | 2.06 ± 0.10 | 2.48 ± 0.12 | 2.97 ± 0.14 | 3.54 ± 0.15 | 4.17 ± 0.17 |
| **Genetic group** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| New Zealand White | 4 | 0.09 ± 0.01 | 0.24 ± 0.02 | 0.48 ± 0.06 | $0.83^{ab}$±0.10 | $1.21^{a}$±0.15 | $1.62^{a}$±0.20 | $1.97^{ab}$±0.27 | $2.30^{ab}$±0.31 | $2.74^{ab}$±0.35 | $3.30^{ab}$±0.41 | $3.86^{ab}$±0.46 | $4.58^{ab}$±0.51 |
| Grey Giant | 4 | 0.11 ± 0.01 | 0.28 ± 0.02 | 0.51 ± 0.06 | $0.72^{ab}$±0.10 | $0.96^{a}$±0.15 | $1.26^{a}$±0.20 | $1.72^{ab}$±0.27 | $2.29^{ab}$±0.31 | $2.76^{a}$±0.35 | $3.20^{ab}$±0.41 | $3.81^{ab}$±0.46 | $4.47^{ab}$±0.51 |
| Soviet Chinchilla | 4 | 0.09 ± 0.01 | 0.24 ± 0.01 | 0.51 ± 0.04 | $0.90^{a}$±0.07 | $1.31^{a}$±0.11 | $1.69^{a}$±0.15 | $2.11^{a}$±0.20 | $2.49^{a}$±0.23 | $2.93^{a}$±0.26 | $3.52^{a}$±0.41 | $4.11^{a}$±0.34 | $4.75^{a}$±0.38 |
| Flemish Giant | 4 | 0.10 ± 0.01 | 0.26 ± 0.02 | 0.41 ± 0.06 | $0.44^{b}$±0.10 | $0.51^{b}$±0.15 | $0.63^{b}$±0.20 | $0.88^{b}$±0.27 | $1.15^{b}$±0.31 | $1.51^{b}$±0.35 | $1.87^{b}$±0.41 | $2.39^{b}$±0.46 | $2.90^{b}$±0.51 |
| **Sex of bunny** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Male | 8 | 0.09 ± 0.004 | 0.25 ± 0.01 | 0.48 ± 0.03 | 0.73 ± 0.04 | 1.03 ± 0.07 | 1.33 ± 0.09 | 1.72 ± 0.12 | 2.12 ± 0.14 | 2.56 ± 0.16 | 3.08 ± 0.19 | 3.67 ± 0.21 | 4.33 ± 0.23 |
| Female | 8 | 0.10 ± 0.004 | 0.26 ± 0.01 | 0.48 ± 0.03 | 0.71 ± 0.05 | 0.97 ± 0.07 | 1.27 ± 0.10 | 1.62 ± 0.13 | 1.99 ± 0.15 | 2.41 ± 0.17 | 2.87 ± 0.20 | 3.42 ±0.22 | 4.02 ± 0.25 |
| **Season of birth** |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Winter | 7 | 0.11 ± 0.01 | 0.27 ± 0.01 | 0.46 ± 0.05 | 0.59 ± 0.59 | $0.74^{b}$±0.13 | 0.96 ± 0.19 | 1.33 ± 0.24 | 1.76 ± 0.29 | 2.15 ± 0.33 | 2.55 ± 0.38 | 3.15 ± 0.42 | 3.82 ± 0.47 |
| Summer | 9 | 0.09 ± 0.01 | 0.24 ± 0.01 | 0.50 ± 0.04 | 0.86 ± 007 | $1.25^{a}$±0.11 | 1.64 ± 0.15 | 2.01 ± 0.20 | 2.36 ± 0.23 | 2.82 ± 0.26 | 3.40 ± 0.31 | 3.94 ± 0.34 | 4.53 ± 0.38 |

Means followed by similar superscript(s) do not differ significantly ($P \leq 0.05$)

Table 21. Least-squares analysis of variance of weight gain

| Source of variation | d.f | Mean Squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Up to 5 weeks | Up to 6 weeks | Up to 7 weeks | Up to 8 weeks | Up to 9 weeks | Up to 10 weeks | Up to 11 weeks | Up to 12 weeks | Up to 13 weeks | Up to 14 weeks | Up to15 weeks | Up to 16 weeks |
| Genetic groups | 3 | 0.0015 | 0.0058 | 0.0184 | 0.0416 | 0.0453 | 0.0503 | 0.0371 | 0.0599 | 0.0860 | 0.0845 | 0.0970 | 0.1832 |
| Sex of bunny | 1 | 0.0002 | 0.0015 | 0.0060 | 0.0047 | 0.0131 | 0.0189 | 0.0147 | 0.0125 | 0.0354 | 0.0167 | 0.0129 | 0.0126 |
| Season of birth | 1 | 0.0001 | 0.0006 | 0.0003 | 0.0011 | 0.0009 | 0.0000 | 0.0243 | 0.1342 | 0.0379 | 0.0092 | 0.0360 | 0.0932 |
| Error | 10 | 0.0005 | 0.0018 | 0.0074 | 0.0148 | 0.0237 | 0.0368 | 0.0531 | 0.0525 | 0.0532 | 0.0400 | 0.0462 | 0.0618 |

Table 22. Least-squares means of weight gain (kg)

| | n | Up to 5 weeks | Up to 6 weeks | Up to 7 weeks | Up to 8 weeks | Up to 9 weeks | Up to 10 weeks | Up to 11 weeks | Up to 12 weeks | Up to 13 weeks | Up to 14 weeks | Up to15 weeks | Up to 16 weeks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overall | 16 | 0.10 ± 0.01 | 0.19 ± 0.01 | 0.26 ± 0.02 | 0.33 ± 0.03 | 0.42 ± 0.04 | 0.51 ± 0.05 | 0.60 ± 0.06 | 0.73 ± 0.06 | 0.85 ± 0.06 | 0.94 ± 0.05 | 1.08 ± 0.06 | 1.27 ± 0.06 |
| **Genetic group** | | | | | | | | | | | | | |
| New Zealand White | 4 | 0.11 ± 0.02 | 0.23 ± 0.03 | 0.30 ± 0.07 | 0.36 ± 0.10 | 0.47 ± 0.12 | 0.59 ± 0.15 | 0.62 ± 0.18 | 0.63 ± 0.18 | 0.95 ± 0.18 | 1.11 ± 0.16 | 1.17 ± 0.17 | 1.29 ± 0.19 |
| Grey Giant | 4 | 0.11 ± 0.02 | 0.19 ± 0.03 | 0.29 ± 0.07 | 0.38 ± 0.10 | 0.45 ± 0.12 | 0.53 ± 0.15 | 0.67 ± 0.18 | 0.91 ± 0.18 | 0.95 ± 0.18 | 1.01 ± 0.16 | 1.22 ±0.17 | 1.54 ± 0.19 |
| Soviet Chinchilla | 4 | 0.12 ± 0.01 | 0.21 ± 0.02 | 0.32 ± 0.05 | 0.44 ± 0.07 | 0.52 ± 0.09 | 0.62 ± 0.11 | 0.68 ± 0.13 | 0.75 ± 0.13 | 0.91 ± 0.13 | 0.96 ± 0.12 | 1.09 ± 0.13 | 1.23 ± 0.15 |
| Flemish Giant | 4 | 0.07 ± 0.02 | 0.11 ± 0.03 | 0.14 ± 0.07 | 0.16 ± 0.10 | 0.22 ± 0.12 | 0.29 ± 0.15 | 0.45 ± 0.18 | 0.63 ± 0.18 | 0.61 ± 0.18 | 0.69 ± 0.16 | 0.85 ± 0.17 | 1.02 ± 0.19 |
| **Sex of bunny** | | | | | | | | | | | | | |
| Male | 8 | 0.10 ± 0.01 | 0.20 ± 0.01 | 0.28 ± 0.03 | 0.35 ± 0.04 | 0.45 ± 0.05 | 0.54 ± 0.07 | 0.64 ± 0.08 | 0.76 ± 0.08 | 0.90 ± 0.08 | 0.98 ± 0.07 | 1.11 ± 0.08 | 1.30 ± 0.09 |
| Female | 8 | 0.10 ± 0.01 | 0.18 ± 0.02 | 0.24 ± 0.03 | 0.32 ± 0.05 | 0.39 ± 0.06 | 0.47 ± 0.07 | 0.57 ± 0.09 | 0.70 ± 0.09 | 0.81 ± 0.09 | 0.91 ± 0.08 | 1.05 ± 0.08 | 1.24 ± 0.10 |
| **Season of birth** | | | | | | | | | | | | | |
| Winter | 7 | 0.11 ± 0.01 | 0.17 ± 0.01 | 0.25 ± 0.03 | 0.31 ± 0.09 | 0.40 ± 0.11 | 0.51 ± 0.14 | 0.70 ± 0.17 | 0.95 ± 0.17 | 0.97 ± 0.17 | 1.00 ± 0.14 | 1.20 ± 0.16 | 1.46 ± 0.18 |
| Summer | 9 | 0.09 ± 0.01 | 0.20 ± 0.02 | 0.27 ± 0.03 | 0.35 ± 0.07 | 0.43 ± 0.09 | 0.50 ± 0.11 | 0.51 ± 0.13 | 0.51 ± 0.13 | 0.74 ± 0.13 | 0.89 ± 0.12 | 0.97 ± 0.13 | 1.09 ± 0.15 |

Table 14. Least-squares analysis of variance of post weaning ADGs

| Source of variation | d.f. | Mean Squares | | | | | |
|---|---|---|---|---|---|---|---|
| | | ADG 5 and 6 | ADG 7 and 8 | ADG 9 and 10 | ADG 11 and 12 | ADG 13 and 14 | ADG 15 and 16 |
| Genetic group | 6 | 640.21** | 158.39** | 157.38** | 174.35** | 293.62** | 362.02** |
| Rearing System | 1 | 4.01 | 48.56 | 333.24** | 63.54 | 3.58 | 565.55** |
| Sex of bunny | 1 | 0.47 | 29.10 | 49.78 | 83.56 | 31.00 | 85.56 |
| Season of birth | 1 | 4261.47** | 89.89 | 564.04** | 1133.39** | 3.72 | 216.44 |
| Litter size at birth | 3 | 55.68 | 371.16** | 69.57 | 163.58* | 379.26** | 31.06 |
| Error | 262 | 72.76 | 35.78 | 43.12 | 59.15 | 53.60 | 66.65 |

* Significant ($P \leq 0.05$); ** Significant ($P \leq 0.01$)

Table 15. Least-squares means of post weaning ADGs (g)

|  | n | ADG 5 and 6 | ADG 7 and 8 | ADG9 and 10 | ADG11 and 12 | ADG13 and 14 | ADG15 and 16 |
|---|---|---|---|---|---|---|---|
| Overall | 275 | 17.55 ± 1.04 | 9.06 ± 0.73 | 10.91 ± 0.80 | 10.46 ± 0.94 | 14.47 ± 0.90 | 10.98 ± 1.00 |
| **Genetic group** |  |  |  |  |  |  |  |
| New Zealand White | 135 | 14.50$^{cd}$ ± 1.17 | 11.71$^{a}$ ± 0.82 | 11.75$^{bc}$ ± 0.90 | 12.25$^{a}$ ± 1.06 | 18.96$^{a}$ ± 1.01 | 14.09$^{ab}$ ± 1.12 |
| Grey Giant | 22 | 20.88$^{ab}$ ± 2.04 | 7.69$^{b}$ ± 1.43 | 13.43$^{ab}$ ± 1.57 | 7.53$^{b}$ ± 1.84 | 14.11$^{bc}$ ± 1.75 | 11.31$^{ab}$ ± 1.96 |
| Soviet Chinchilla | 24 | 13.72$^{d}$ ± 2.01 | 11.43$^{a}$ ± 1.41 | 15.40$^{a}$ ± 1.55 | 13.87$^{a}$ ± 1.81 | 13.99$^{c}$ ± 1.73 | 14.90$^{a}$ ± 1.92 |
| Flemish Giant | 48 | 23.90$^{a}$ ± 1.54 | 7.48$^{b}$ ± 1.08 | 10.27$^{bcd}$ ± 1.18 | 12.71$^{a}$ ± 1.39 | 17.60$^{ab}$ ± 1.32 | 9.71$^{bc}$ ± 1.47 |
| Californian White | 21 | 15.64$^{bcd}$ ± 2.12 | 9.37$^{ab}$ ± 1.48 | 7.62$^{d}$ ± 1.63 | 6.83$^{b}$ ± 1.91 | 12.42$^{c}$ ± 1.82 | 5.52$^{d}$ ± 2.03 |
| APAU Fawn | 12 | 14.16$^{cd}$ ± 2.54 | 8.35$^{ab}$ ± 1.78 | 8.83$^{cd}$ ± 1.95 | 11.17$^{ab}$ ± 2.29 | 11.43$^{c}$ ± 2.18 | 6.72$^{cd}$ ± 2.43 |
| APAU Black | 13 | 20.08$^{abc}$ ± 2.56 | 7.38$^{b}$ ± 1.79 | 9.10$^{bcd}$ ± 1.97 | 8.87$^{ab}$ ± 2.31 | 12.77$^{c}$ ± 2.20 | 14.65$^{ab}$ ± 2.45 |
| **Rearing system** |  |  |  |  |  |  |  |
| Cages | 140 | 17.43 ± 1.17 | 9.49 ± 0.82 | 12.04$^{a}$ ± 0.90 | 9.97 ± 1.06 | 14.58 ± 1.01 | 12.45$^{a}$ ± 1.12 |
| Backyard | 135 | 17.68 ± 1.16 | 8.63 ± 0.81 | 9.79$^{b}$ ± 0.89 | 10.95 ± 1.05 | 14.35 ± 1.00 | 9.52$^{b}$ ± 1.11 |
| **Sex of bunny** |  |  |  |  |  |  |  |
| Male | 122 | 17.51 ± 1.20 | 9.40 ± 0.84 | 11.36 ± 0.92 | 11.04 ± 1.08 | 14.82 ± 1.03 | 11.56 ± 1.15 |
| Female | 153 | 17.60 ± 1.14 | 8.72 ± 0.80 | 10.47 ± 0.88 | 9.89 ± 1.03 | 14.12 ± 0.98 | 10.40 ± 1.09 |
| **Season of kindling** |  |  |  |  |  |  |  |
| Winter | 204 | 22.46$^{a}$ ± 1.14 | 9.77 ± 0.80 | 12.70$^{a}$ ± 0.88 | 12.99$^{a}$ ± 1.03 | 14.61 ± 0.98 | 9.88 ± 1.09 |
| Summer | 71 | 12.65$^{b}$ ± 1.30 | 8.35 ± 0.91 | 9.13$^{b}$ ± 1.00 | 7.93$^{b}$ ± 1.17 | 14.32 ± 1.12 | 12.09 ± 1.24 |
| **Litter size at birth** |  |  |  |  |  |  |  |
| 1-3 | 8 | 14.45 ± 3.26 | 14.48$^{a}$ ± 2.28 | 12.13 ± 2.51 | 12.08$^{a}$ ± 2.94 | 24.02$^{a}$ ± 2.79 | 11.40 ± 3.12 |
| 4-6 | 116 | 19.14 ± 0.94 | 10.04$^{a}$ ± 0.66 | 11.52 ± 0.72 | 12.16$^{a}$ ± 0.84 | 11.12$^{b}$ ± 0.80 | 11.70 ± 0.90 |
| 7-9 | 129 | 18.92 ± 0.97 | 6.65$^{b}$ ± 0.68 | 9.69 ± 0.74 | 10.43$^{ab}$ ± 0.87 | 12.64$^{b}$ ± 0.83 | 10.51 ± 0.93 |
| 10 and 11 | 22 | 17.71 ± 1.98 | 5.06$^{b}$ ± 1.39 | 10.31 ± 1.52 | 7.18$^{b}$ ± 1.79 | 10.10$^{b}$ ± 1.70 | 10.32 ± 1.90 |

Means followed by the same superscript(s) do not differ significantly ($P \leq 0.05$)

Table 23. Least-squares analysis of variance of feed efficiency

| Source of variation | d.f. | Mean Squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Up to 5 weeks | Up to6 weeks | Up to7 weeks | Up to8 weeks | Up to 9 weeks | Up to10 weeks | Up to 11 weeks | Up to12 weeks | Up to 13 weeks | Up to 14 weeks | Up to 15 weeks | Up to 16 weeks |
| Genetic groups | 3 | 0.26 | $0.41^{*}$ | $0.97^{*}$ | 0.79 | 0.21 | 0.05 | 0.16 | $0.92^{*}$ | 0.13 | 0.33 | 0.30 | 0.57 |
| Sex of bunny | 1 | 0.05 | 0.08 | 0.18 | 0.45 | 0.28 | 0.49 | 0.27 | 0.05 | 0.02 | 0.01 | 0.10 | 0.18 |
| Season of birth | 1 | 0.01 | 0.08 | 0.01 | 0.05 | 0.31 | 0.63 | $2.21^{*}$ | $6.53^{**}$ | $1.90^{*}$ | 1.38 | 1.82 | $2.26^{*}$ |
| Error | 10 | 0.07 | 0.10 | 0.16 | 0.46 | 0.33 | 0.30 | 0.33 | 0.16 | 0.23 | 0.30 | 0.43 | 0.35 |

$^{*}$ Significant ($P \leq 0.05$); $^{**}$ Significant ($P \leq 0.01$)

Table 24. Least-squares means of feed efficiency

| | n | Up to 5 weeks | Up to 6 weeks | Up to 7 weeks | Up to 8 weeks | Up to 9 weeks | Up to 10 weeks | Up to 11 weeks | Up to 12 weeks | Up to 13 weeks | Up to 14 weeks | Up to15 weeks | Up to 16 weeks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overall | 16 | 1.07 ± 0.07 | 1.47 ± 0.08 | 2.02 ± 0.10 | 2.43 ± 0.18 | 2.62 ± 0.15 | 2.80 ± 0.14 | 3.01 ± 0.15 | 3.03 ± 0.11 | 3.11 ± 0.13 | 3.26 ± 0.14 | 3.38 ± 0.17 | 3.39 ± 0.15 |
| **Genetic group** | | | | | | | | | | | | | |
| New Zealand White | 4 | 0.85 ± 0.21 | 1.08$^{b}$ ±0.25 | 1.58$^{b}$ ±0.31 | 2.34 ± 0.53 | 2.69 ± 0.45 | 2.90 ± 0.43 | 3.39 ± 0.45 | 4.00$^{a}$ ±0.32 | 3.11 ± 0.38 | 3.19 ± 0.43 | 3.53 ± 0.51 | 3.79 ± 0.46 |
| Grey Giant | 4 | 1.10 ± 0.21 | 1.50$^{b}$ ±0.25 | 1.87$^{b}$ ±0.31 | 2.21 ± 0.53 | 2.35 ± 0.45 | 2.65 ± 0.43 | 2.82 ± 0.45 | 2.26$^{b}$ ±0.32 | 2.93 ± 0.38 | 3.14 ± 0.43 | 3.01 ± 0.51 | 2.65 ± 0.46 |
| Soviet Chinchilla | 4 | 0.74 ± 0.16 | 1.14$^{b}$ ±0.19 | 1.65$^{b}$ ±0.23 | 2.03 ± 0.40 | 2.55 ± 0.33 | 2.78 ± 0.32 | 3.30 ± 0.34 | 3.87$^{a}$ ±0.24 | 3.44 ± 0.28 | 3.73 ± 0.32 | 3.91 ± 0.38 | 4.07 ± 0.34 |
| Flemish Giant | 4 | 1.58 ± 0.21 | 2.15$^{a}$ ±0.25 | 2.97$^{a}$ ±0.31 | 3.16 ± 0.53 | 2.90 ± 0.45 | 2.88 ± 0.43 | 2.54 ± 0.45 | 1.98$^{b}$ ±0.32 | 2.96 ± 0.38 | 2.95 ± 0.43 | 3.08 ± 0.51 | 3.04 ± 0.46 |
| **Sex of bunny** | | | | | | | | | | | | | |
| Male | 8 | 1.01 ± 0.09 | 1.40 ± 0.11 | 1.91 ± 0.14 | 2.26 ± 0.24 | 2.48 ± 0.20 | 2.62 ± 0.19 | 2.88 ± 0.20 | 2.97 ± 0.14 | 3.07 ± 0.17 | 3.28 ± 0.19 | 3.47 ± 0.23 | 3.50 ± 0.21 |
| Female | 8 | 1.13 ± 0.10 | 1.54 ± 0.12 | 2.13 ± 0.15 | 2.61 ± 0.26 | 2.76 ± 0.22 | 2.99 ± 0.21 | 3.15 ± 0.22 | 3.09 ± 0.16 | 3.14 ± 0.19 | 3.23 ± 0.21 | 3.30 ± 0.25 | 3.28 ± 0.23 |
| **Season of birth** | | | | | | | | | | | | | |
| Winter | 7 | 1.12 ± 0.19 | 1.63 ± 0.23 | 2.07 ± 0.29 | 2.30 ± 0.49 | 2.29 ± 0.41 | 2.33 ± 0.40 | 2.11$^{b}$ ±0.42 | 1.49$^{b}$ ±0.29 | 2.28$^{b}$ ±0.35 | 2.55 ± 0.40 | 2.57 ± 0.47 | 2.48$^{b}$ ±0.42 |
| Summer | 9 | 1.01 ± 0.16 | 1.30 ± 0.19 | 1.97 ± 0.23 | 2.57 ± 0.40 | 2.95 ± 0.33 | 3.28 ± 0.32 | 3.91$^{a}$ ±0.34 | 4.57$^{a}$ ±0.24 | 3.94$^{a}$ ±0.28 | 3.96 ± 0.32 | 4.20 ± 0.38 | 4.29$^{a}$ ±0.34 |

Means followed by the same superscript(s) do not differ significantly ($P \leq 0.05$)

Table 18. Mean daily milk yield (g) of various genetic groups

| | New Zealand White (n=20) | Grey Giant (n=5) | Soviet Chinchilla (n=2) | Flemish Giant (n=10) | Californian White (n=6) | APAU Fawn (n=2) |
|---|---|---|---|---|---|---|
| Overall | 70.9 ± 1.5 | 72.1 ± 3.2 | 64.6 ± 3.4 | 73.3 ± 2.1 | 61.2 ± 2.1 | 66.4 ± 4.0 |
| Day of lactation | | | | | | |
| 1 | 24.5 ± 4.3 | 20.4 ± 7.4 | 26.5 ± 10.5 | 12.1 ± 3.5 | 22.3 ± 4.9 | 6.5 ± 2.5 |
| 2 | 54.2 ± 4.2 | 71.6 ± 7.9 | 58.0 ± 7.0 | 59.0 ± 6.7 | 58.8 ± 9.6 | 63.0 ± 4.0 |
| 3 | 75.9 ± 7.4 | 82.2 ± 11.3 | 64.5 ± 1.5 | 51.8 ± 6.7 | 69.5 ± 8.0 | 52.0 ± 1.0 |
| 4 | 80.6 ± 7.7 | 92.8 ± 12.1 | 61.5 ± 6.5 | 75.2 ± 7.3 | 63.3 ± 10.8 | 66.5 ± 4.5 |
| 5 | 77.0 ± 7.0 | 77.8 ± 13.0 | 67.0 ± 20.0 | 74.6 ± 8.6 | 87.0 ± 12.3 | 83.5 ± 5.5 |
| 6 | 82.9 ± 7.1 | 93.2 ± 20.2 | 82.0 ± 6.0 | 70.6 ± 7.9 | 66.2 ± 6.0 | 63.5 ± 3.5 |
| 7 | 78.8 ± 7.8 | 73.2 ± 12.1 | 90.5 ± 0.5 | 77.0 ± 7.7 | 72.3 ± 5.2 | 78.5 ± 2.5 |
| 8 | 82.3 ± 4.2 | 73.6 ± 16.1 | 93.5 ± 5.5 | 78.7 ± 10.0 | 73.2 ± 14.4 | 77.0 ± 1.0 |
| 9 | 79.8 ± 7.2 | 77.2 ± 13.8 | 87.5 ± 1.5 | 72.7 ± 10.9 | 56.7 ± 11.1 | 102.0 ± 4.0 |
| 10 | 79.2 ± 5.9 | 69.8 ± 16.4 | 68.0 ± 23.0 | 90.7 ± 5.6 | 69.8 ± 9.9 | 70.0 ± 42.0 |
| 11 | 84.3 ± 5.4 | 91.8 ± 12.8 | 94.0 ± 11.0 | 82.6 ± 6.5 | 76.8 ± 7.5 | 82.5 ± 7.5 |
| 12 | 76.0 ± 4.7 | 96.6 ± 16.7 | 77.5 ± 10.5 | 81.7 ± 13.0 | 71.5 ± 9.7 | 83.5 ± 20.5 |
| 13 | 81.6 ± 5.6 | 90.2 ± 16.4 | 49.0 ± 30.0 | 99.0 ± 10.0 | 68.8 ± 10.2 | 76.0 ± 7.0 |
| 14 | 81.8 ± 5.0 | 68.0 ± 17.3 | 50.0 ± 3.0 | 90.5 ± 6.4 | 50.8 ± 6.0 | 91.5 ± 21.5 |
| 15 | 83.6 ± 7.6 | 71.4 ± 17.5 | 77.5 ± 8.5 | 98.0 ± 9.7 | 71.5 ± 11.4 | 72.5 ± 0.5 |
| 16 | 79.3 ± 6.6 | 76.6 ± 12.2 | 68.0 ± 11.0 | 88.2 ± 7.1 | 60.8 ± 6.1 | 76.5 ± 14.5 |
| 17 | 67.7 ± 5.5 | 74.2 ± 14.7 | 57.5 ± 4.5 | 74.1 ± 9.1 | 57.5 ± 6.9 | 63.5 ± 9.5 |
| 18 | 67.0 ± 7.0 | 66.8 ± 6.5 | 49.0 ± 3.0 | 72.7 ± 8.2 | 60.7 ± 8.3 | 55.0 ± 23.0 |
| 19 | 59.0 ± 5.4 | 57.8 ± 9.9 | 50.5 ± 12.5 | 74.2 ± 7.4 | 44.7 ± 3.6 | 62.0 ± 3.0 |
| 20 | 51.4 ± 6.5 | 48.8 ± 6.8 | 46.5 ± 10.5 | 64.0 ± 6.0 | 38.8 ± 3.3 | 38.0 ± 20.0 |
| 21 | 41.3 ± 6.6 | 40.0 ± 6.6 | 38.0 ± 8.0 | 51.7 ± 8.3 | 44.3 ± 3.2 | 30.5 ± 16.5 |

Table 25. Least-squares analysis of variance of carcass traits

| Source of Variation | d.f. | Mean Squares | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre-Slaughter weight | Dressed weight | Dressing percentage | Forecut | Midcut | Hindcut | Head and Feet | Pelt | Edible Offals | Inedible Offals | Length of ceacum |
| Genetic groups | 6 | 494363.96$^{**}$ | 219612.98$^{**}$ | 95.47$^{**}$ | 22638.69$^{**}$ | 14485.75$^{**}$ | 30484.75$^{**}$ | 2469.68$^{*}$ | 4033.73 | 1140.85$^{**}$ | 7342.76$^{*}$ | 40.57$^{*}$ |
| Rearing system | 1 | 25570.59 | 4037.18 | 10.64 | 4307.68 | 6668.95 | 499.81 | 32.78 | 919.08 | 74.35 | 94.70 | 75.14$^{*}$ |
| Sex of bunny | 1 | 336143.33 | 209258.46$^{*}$ | 130.39$^{**}$ | 15463.35$^{*}$ | 22987.07$^{*}$ | 26179.64$^{*}$ | 7126.36$^{**}$ | 8207.03$^{*}$ | 157.30 | 255.01 | 20.80 |
| Season of birth | 1 | 1006949.50$^{**}$ | 424638.65$^{**}$ | 118.87$^{*}$ | 38320.25$^{**}$ | 30596.38$^{**}$ | 54915.06$^{**}$ | 15475.76$^{**}$ | 22504.86$^{**}$ | 1009.65$^{*}$ | 12807.95 | 8.00 |
| Litter size at birth | 3 | 115435.53 | 56183.92 | 21.84 | 4652.25 | 8115.91 | 6852.08 | 973.46 | 2460.99 | 104.40 | 5656.93 | 16.44 |
| Error | 94 | 96367.08 | 37233.12 | 17.73 | 3576.91 | 4065.58 | 5322.51 | 972.35 | 1932.78 | 191.44 | 3189.23 | 17.54 |

$^{*}$ Significant ($P \leq 0.05$); $^{**}$ Significant ($P \leq 0.01$)

Table 26. Least-squares means of various carcass traits

|  | n | Pre-slaughter weight (g) | Dressed weight (g) | Dressing percentage | Forecut (g) | Midcut (g) | Hindcut (g) |
|---|---|---|---|---|---|---|---|
| Overall | 107 | 1451.14 ± 63.04 | 695.33 ± 39.18 | 46.69 ± 0.86 | 245.73 ± 12.14 | 174.41 ± 12.95 | 275.19 ± 14.81 |
| **Genetic groups** |  |  |  |  |  |  |  |
| New Zealand White | 31 | 1693.39$^{a}$ ± 91.56 | 855.92$^{a}$ ± 56.91 | 50.00$^{a}$ ± 1.24 | 293.60$^{a}$ ± 17.64 | 218.01$^{a}$ ± 18.81 | 343.53$^{a}$ ± 21.52 |
| Grey Giant | 15 | 1444.93$^{bc}$ ± 106.08 | 676.42$^{b}$ ± 65.94 | 46.04$^{b}$ ± 1.44 | 242.96$^{bc}$ ± 20.44 | 176.15$^{ab}$ ± 21.79 | 266.14$^{b}$ ± 24.93 |
| Soviet Chinchilla | 13 | 1667.74$^{ab}$ ± 114.46 | 880.47$^{a}$ ± 71.14 | 51.31$^{a}$ ± 1.55 | 297.11$^{a}$ ± 22.05 | 219.19$^{a}$ ± 23.51 | 330.20$^{a}$ ± 26.90 |
| Flemish Giant | 25 | 1441.01$^{c}$ ± 92.60 | 687.26$^{b}$ ± 57.56 | 46.93$^{b}$ ± 1.26 | 242.31$^{bc}$ ± 17.84 | 176.08$^{ab}$ ± 19.02 | 272.94$^{b}$ ± 21.76 |
| Californian White | 12 | 1094.88$^{d}$ ± 124.39 | 501.32$^{b}$ ± 77.32 | 43.77$^{b}$ ± 1.69 | 173.84$^{d}$ ± 23.97 | 124.72$^{b}$ ± 25.55 | 203.06$^{b}$ ± 29.23 |
| APAU Fawn | 6 | 1567.73$^{abc}$ ± 149.83 | 723.85$^{ab}$ ± 93.13 | 45.91$^{b}$ ± 2.03 | 279.19$^{ab}$ ± 28.87 | 176.64$^{ab}$ ± 30.78 | 282.29$^{a}$ ± 35.21 |
| APAU Black | 5 | 1248.32$^{cd}$ ± 160.80 | 542.07$^{b}$ ± 99.95 | 42.88$^{b}$ ± 2.18 | 191.07$^{cd}$ ± 30.98 | 130.06$^{b}$ ± 33.03 | 228.13$^{b}$ ± 37.79 |
| **Rearing systems** |  |  |  |  |  |  |  |
| Cages | 53 | 1435.18 ± 69.34 | 688.99 ± 43.10 | 47.01 ± 0.94 | 239.17 ± 13.36 | 182.56 ± 14.24 | 272.95 ± 16.30 |
| Backyard | 54 | 1467.11 ± 71.13 | 701.67 ± 44.22 | 46.36 ± 0.96 | 252.28 ± 13.70 | 166.26 ± 14.61 | 277.42 ± 16.72 |
| **Sex of bunny** |  |  |  |  |  |  |  |
| Male | 55 | 1510.93 ± 72.19 | 742.50$^{a}$ ± 44.87 | 47.86$^{a}$ ± 0.98 | 258.55$^{a}$ ± 13.91 | 190.04$^{a}$ ± 14.83 | 291.87$^{a}$ ± 16.97 |
| Female | 52 | 1391.36 ± 69.17 | 648.16$^{b}$ ± 43.00 | 45.51$^{b}$ ± 0.94 | 232.90$^{b}$ ± 13.33 | 158.77$^{b}$ ± 14.21 | 258.50$^{b}$ ± 16.26 |
| **Season of birth** |  |  |  |  |  |  |  |
| Winter | 82 | 1628.55$^{a}$ ± 76.51 | 810.54$^{a}$ ± 47.55 | 48.61$^{a}$ ± 1.04 | 280.34$^{a}$ ± 14.74 | 205.33$^{a}$ ± 15.71 | 316.62$^{a}$ ± 17.98 |
| Summer | 25 | 1273.73$^{b}$ ± 90.1 | 580.12$^{b}$ ± 56.01 | 44.76$^{b}$ ± 1.22 | 211.12$^{b}$ ± 17.36 | 143.48$^{b}$ ± 18.51 | 233.75$^{b}$ ± 21.18 |
| **Litter size at birth** |  |  |  |  |  |  |  |
| 1-3 | 3 | 1528.25 ± 243.65 | 815.44 ± 151.45 | 51.50 ± 3.30 | 283.72 ± 46.94 | 212.67 ± 50.05 | 312.77 ± 57.26 |
| 4-6 | 49 | 1454.73 ± 64.69 | 679.12 ± 40.21 | 45.30 ± 0.88 | 245.16 ± 12.46 | 170.03 ± 13.29 | 273.06 ± 15.20 |
| 7-9 | 46 | 1330.98 ± 66.10 | 601.42 ± 41.09 | 44.84 ± 0.90 | 222.80 ± 12.74 | 139.38 ± 13.58 | 244.52 ± 15.54 |
| 10 and 11 | 9 | 1490.61 ± 130.23 | 685.34 ± 80.95 | 45.10 ± 1.77 | 231.23 ± 25.09 | 175.56 ± 26.75 | 270.40 ± 30.61 |

Means followed by the same superscript(s) do not differ significantly ($P \leq 0.05$)

Table 26. Contd.

|  | n | Head and Feet (g) | Pelt (g) | Edible Offals (g) | Inedible Offals (g) | Length of Caecum (cm) |
|---|---|---|---|---|---|---|
| Overall | 107 | 193.79 ± 6.33 | 141.11 ± 8.93 | 57.44 ± 2.81 | 303.19 ± 11.47 | 43.38 ± 0.85 |
| **Genetic groups** |  |  |  |  |  |  |
| New Zealand White | 31 | $207.67^{a}$ ± 9.20 | 159.04 ± 12.97 | $58.58^{b}$ ± 4.08 | $308.62^{ab}$ ± 16.66 | $43.90^{a}$ ± 1.24 |
| Grey Giant | 15 | $197.13^{a}$ ± 10.66 | 141.78 ± 15.02 | $68.46^{a}$ ± 4.73 | $305.74^{ab}$ ± 19.30 | $42.43^{ab}$ ± 1.43 |
| Soviet Chinchilla | 13 | $210.12^{a}$ ± 11.50 | 163.53 ± 16.21 | $68.99^{a}$ ± 5.10 | $301.44^{bc}$ ± 20.82 | $45.71^{a}$ ± 1.54 |
| Flemish Giant | 25 | $207.57^{a}$ ± 9.30 | 153.69 ± 13.11 | $50.39^{b}$ ± 4.13 | $296.56^{bc}$ ± 16.85 | $43.00^{a}$ ± 1.25 |
| Californian White | 12 | $164.76^{b}$ ± 12.50 | 101.49 ± 17.62 | $43.28^{b}$ ± 5.54 | $247.77^{c}$ ± 22.63 | $39.25^{b}$ ± 1.68 |
| APAU Fawn | 6 | $186.71^{ab}$ ± 15.05 | 135.81 ± 21.22 | $62.26^{ab}$ ± 6.68 | $382.51^{a}$ ± 27.26 | $46.46^{a}$ ± 2.02 |
| APAU Black | 5 | $182.55^{ab}$ ± 16.15 | 132.41 ± 22.77 | $50.13^{b}$ ± 7.17 | $279.70^{bc}$ ± 29.25 | $42.89^{ab}$ ± 2.17 |
| **Rearing systems** |  |  |  |  |  |  |
| Cages | 53 | 194.36 ± 6.97 | 144.14 ± 9.82 | 56.58 ± 3.09 | 304.16 ± 12.61 | $42.51^{b}$ ± 0.94 |
| Backyard | 54 | 193.21 ± 7.15 | 138.08 ± 10.07 | 58.30 ± 3.17 | 302.22 ± 12.94 | $44.24^{a}$ ± 0.96 |
| **Sex of bunny** |  |  |  |  |  |  |
| Male | 55 | $202.49^{a}$ ± 7.25 | $150.45^{a}$ ± 10.22 | 58.74 ± 3.22 | 301.54 ± 13.13 | 43.85 ± 0.97 |
| Female | 52 | $185.08^{b}$ ± 6.95 | $131.77^{b}$ ± 9.80 | 56.15 ± 3.08 | 304.84 ± 12.58 | 42.91 ± 0.93 |
| **Season of birth** |  |  |  |  |  |  |
| Winter | 82 | $215.78^{a}$ ± 7.68 | $167.63^{a}$ ± 10.83 | $63.06^{a}$ ± 3.41 | 323.20 ± 13.92 | 43.88 ± 1.03 |
| Summer | 25 | $171.79^{b}$ ± 9.05 | $114.59^{b}$ ± 12.76 | $51.82^{b}$ ± 4.02 | 283.18 ± 16.39 | 42.88 ± 1.22 |
| **Litter size at birth** |  |  |  |  |  |  |
| 1-3 | 3 | 190.96 ± 24.47 | 175.38 ± 34.51 | 49.28 ± 10.86 | 221.13 ± 44.32 | 39.86 ± 3.29 |
| 4-6 | 49 | 200.13 ± 6.50 | 134.84 ± 9.16 | 57.79 ± 2.88 | 327.73 ± 11.77 | 43.97 ± 0.87 |
| 7-9 | 46 | 187.79 ± 6.64 | 120.75 ± 9.36 | 58.08 ± 2.95 | 323.35 ± 12.03 | 43.50 ± 0.89 |
| 10 and 11 | 9 | 196.26 ± 13.08 | 133.47 ± 18.44 | 64.62 ± 5.80 | 340.55 ± 23.66 | 46.18 ± 1.76 |

Means followed by the same superscript(s) do not differ significantly ($P \leq 0.05$)

Table 27. Least-squares analysis of variance for meat composition

| Source of Variation | d.f. | Mean Squares | | | | |
|---|---|---|---|---|---|---|
| | | Dry matter | Total ash | Protein | Fat | Cholesterol |
| Genetic groups | 6 | 0.336 | 0.425 | 3.480 | 6.226 | 0.049 |
| Sex of bunny | 1 | 2.124 | 0.514 | 0.252 | 0.093 | 0.037 |
| Rearing system | 1 | 2.485 | 0.003 | 0.174 | 0.001 | 0.100 |
| Error | 36 | 1.452 | 1.523 | 2.954 | 3.514 | 0.082 |

Table 28. Least-squares means for meat compostition

| | n | Dry matter (%) | Total ash (%) | Protein (g%) | Fat (%) | Cholesterol (mg %) |
|---|---|---|---|---|---|---|
| Overall | 45 | 24.3 | 1.3 | 20.3 | 4.1 | 0.10 |
| **Genetic groups** | | | | | | |
| New Zealand White | 7 | 24.6 | 1.2 | 21.6 | 4.5 | 0.11 |
| Grey Giant | 7 | 24.2 | 1.2 | 19.7 | 3.1 | 0.10 |
| Soviet Chinchilla | 7 | 23.9 | 1.3 | 21.4 | 4.6 | 0.08 |
| Flemish Giant | 7 | 24.7 | 1.3 | 20.0 | 3.9 | 0.10 |
| Californian White | 6 | 23.9 | 1.3 | 19.5 | 5.1 | 0.10 |
| APAU Fawn | 6 | 24.3 | 1.5 | 21.0 | 4.3 | 0.10 |
| APAU Black | 5 | 24.5 | 1.1 | 18.8 | 3.4 | 0.09 |
| **Sex of bunny** | | | | | | |
| Male | 22 | 24.7 | 1.2 | 20.2 | 4.1 | 0.10 |
| Female | 23 | 24.0 | 1.3 | 20.4 | 4.1 | 0.09 |
| **Rearing system** | | | | | | |
| Cages | 22 | 23.9 | 1.3 | 20.2 | 4.1 | 0.10 |
| Backyard | 23 | 24.7 | 1.3 | 20.4 | 4.1 | 0.09 |

Table 32. Correlations among post weaning body weights

| | **4 weeks** | **6 weeks** | **8 weeks** | **10 weeks** | **12 weeks** | **14 weeks** | **16 weeks** |
|---|---|---|---|---|---|---|---|
| **4 weeks** | | | | | | | |
| New Zealand White | | £ | 0.24 ± 0.36 | 0.07 ± 0.46 | -0.46 ± 0.40 | -0.38 ± 0.36 | -0.48 ± 0.33 |
| Flemish Giant | | -0.04 ± 1.75 | 0.49 ± 1.60 | 0.90 ± 0.32 | £ | £ | £ |
| **6 weeks** | | | | | | | |
| Soviet Chinchilla | £ | | 1.00 ± 0.03 | 0.90 ± 0.09 | 0.88 ± 0.28 | 0.70 ± 0.61 | £ |
| Flemish Giant | 0.77 | | 0.82 ± 0.28 | 0.32 ± 0.61 | £ | £ | £ |
| **8 weeks** | | | | | | | |
| New Zealand White | 0.57 | £ | | 0.83 ± 0.12 | 0.61 ± 0.27 | 0.48 ± 0.27 | 0.27 ± 0.34 |
| Soviet Chinchilla | £ | 0.92 (0.83) | | 0.83 ± 0.48 | 0.56 ± 0.84 | 0.23 ± 1.08 | £ |
| Flemish Giant | 0.74 (0.86) | 0.94 | | 0.87 ± 0.20 | £ | £ | £ |
| **10 weeks** | | | | | | | |
| New Zealand White | 0.52 (0.92) | £ | 0.83 | | 0.83 ± 0.15 | 0.66 ± 0.24 | 0.55 ± 0.31 |
| Soviet Chinchilla | £ | 0.84 (0.72) | 0.92 | | 0.96 ± 0.12 | 0.64 ± 0.84 | £ |
| Flemish Giant | 0.67 | 0.78 | 0.90 | | £ | £ | £ |
| **12 weeks** | | | | | | | |
| New Zealand White | 0.49 | £ | 0.72 | 0.84 (0.85) | | 0.98 ± 0.02 | 0.93 ± 0.06 |
| Soviet Chinchilla | £ | 0.77 (0.65) | 0.87 | 0.97 (1.00) | | 0.86 ± 0.29 | £ |
| **14 weeks** | | | | | | | |
| New Zealand White | 0.46 | £ | 0.66 | 0.75 (0.93) | 0.93 (0.98) | | 0.90 ± 0.07 |
| Soviet Chinchilla | £ | 0.79 (0.93) | 0.80 | 0.91 | 0.95 | | £ |
| **16 weeks** | | | | | | | |
| New Zealand White | 0.45 | £ | 0.59 | 0.70 (0.88) | 0.89 (0.90) | 0.92 (0.97) | |

Above diagonal are genetic correlations and below diagonal are phenotypic correlations.

Environmental correlations are in parenthesis below diagonal

£ – Not estimable or out of range

Table 8. Least-squares analysis of variance of litter traits

| Source of variation | d.f. | Mean Squares | | | |
|---|---|---|---|---|---|
| | | Litter Size | | Litter Weight | |
| | | at Birth | at Weaning | at Birth | at Weaning |
| Genetic groups | 6 | 7.60 | 2.70 | 14269.42 | 247281.70 |
| Season of birth | 1 | 12.78 | 17.57** | 351.89 | 2250180.11** |
| Error | 92 | 3.71 | 2.41 | 8901.36 | 152486.30 |

** Significant ($P \leq 0.01$)

Table 9. Least-squares means of litter traits

| | n | Litter Size | | Litter Weight (g) | |
|---|---|---|---|---|---|
| | | at birth | at weaning | at birth | at weaning |
| Overall | 100 | 6.18 ± 0.28 | 3.75 ± 0.23 | 305.16 ± 13.75 | 1190.93 ± 56.92 |
| **Genetic group** | | | | | |
| New Zealand White | 48 | 6.81 ± 0.28 | 4.09 ± 0.23 | 313.86 ± 13.71 | 1194.73 ± 56.76 |
| Grey Giant | 9 | 7.51 ± 0.64 | 4.27 ± 0.52 | 380.28 ± 31.47 | 1237.66 ± 130.24 |
| Soviet Chinchilla | 10 | 6.25 ± 0.61 | 3.33 ± 0.49 | 301.18 ± 30.09 | 1224.41 ± 124.54 |
| Flemish Giant | 14 | 6.96 ± 0.52 | 4.23 ± 0.42 | 335.41 ± 25.37 | 1352.15 ± 105.00 |
| Californian White | 9 | 5.63 ± 0.64 | 3.16 ± 0.52 | 290.56 ± 31.47 | 853.11 ± 130.24 |
| APAU Fawn | 8 | 5.00 ± 0.68 | 3.25 ± 0.55 | 255.75 ± 33.36 | 1136.00 ± 138.06 |
| APAU Black | 2 | 5.13 ± 1.38 | 3.93 ± 1.11 | 259.06 ± 67.42 | 1338.47 ± 279.05 |
| **Season of birth** | | | | | |
| Winter | 56 | 5.82 ± 0.35 | $4.19^a$ ± 0.28 | 303.22 ± 17.15 | $1345.90^a$ ± 70.98 |
| Summer | 44 | 6.55 ± 0.34 | $3.32^b$ ± 0.27 | 307.10 ± 16.55 | $1035.97^b$ ± 68.52 |

Means followed by similar superscript(s) do not differ significantly ($P \leq 0.05$)

Table 16. Least-squares analysis of variance of lactation milk yield

| Source | d.f. | Mean squares |
|---|---|---|
| Genetic groups | 5 | 48679.4 |
| Month of kindling | 2 | 365918* |
| Litter size at birth | 3 | 36650.4 |
| Litter weight at birth | 1 | 331996* |
| Error | 33 | 82099.9 |

* Significant ($P \leq 0.05$)

Table 17. Least-squares means of lactation milk yield (g)

|  | n | Lactation milk yield (g) |
|---|---|---|
| Overall | 45 | 1116.21±98.28 |
| **Genetic groups** |  |  |
| New Zealand White | 20 | 1267.08 ± 83.06 |
| Grey Giant | 5 | 1185.75 ± 148.15 |
| Soviet Chinchilla | 2 | 1008.99 ± 239.67 |
| Flemish Giant | 10 | 1159.87 ± 128.58 |
| Californian White | 6 | 1111.02 ± 146.67 |
| APAU Fawn | 2 | 964.56 ± 228.22 |
| **Month of kindling** |  |  |
| January | 6 | $958.08^{b} \pm 172.93$ |
| February | 28 | $1334.35^{a} \pm 104.33$ |
| March | 11 | $1056.21^{b} \pm 124.23$ |
| **Litter size at birth** |  |  |
| 1 - 3 | 2 | 971.56 ± 248.70 |
| 4 - 6 | 18 | 1219.86 ± 99.07 |
| 7 - 9 | 21 | 1186.58 ± 140.95 |
| 10 and 11 | 4 | 1086.85 ± 206.16 |
| **Litter weight at birth** |  |  |
| Below 250g | 7 | $951.92^{b} \pm 150.68$ |
| Above 250g | 38 | $1280.51^{a} \pm 99.81$ |

Means followed by similar superscript(s) do not

differ significantly ($P \leq 0.05$)

Table 29. Heritability estimates for pre-weaning body weights

| Genetic group | BW0 | BW1 | BW2 | BW3 | BW4 |
|---|---|---|---|---|---|
| New Zealand White | 0.85 ± 0.23 | 0.90 ± 0.26 | 0.60 ± 0.23 | 0.27 ± 0.17 | 0.24 ± 0.18 |
| Grey Giant | £ | £ | 0.20 ± 0.46 | 0.33 ± 0.56 | 0.49 ± 0.65 |
| Soviet Chinchilla | £ | 0.33 ± 0.46 | £ | £ | £ |
| Flemish Giant | 0.32 ± 0.26 | 0.48 ± 0.38 | 0.87 ± 0.50 | £ | £ |
| Californian White | 0.63 ± 0.43 | £ | £ | 0.45 ± 0.64 | £ |
| APAU Fawn | 0.91 ± 0.68 | £ | £ | £ | £ |

£ – Not estimable or out of range

Table 30. Heritability estimates for post weaning body weights

| Genetic group | BW6 | BW8 | BW10 | BW12 | BW14 | BW16 |
|---|---|---|---|---|---|---|
| New Zealand White | £ | 0.86 ± 0.39 | 0.46 ± 0.31 | 0.37± 0.29 | 0.67 ± 0.36 | 0.59 ± 0.34 |
| Soviet Chinchilla | 0.50 ± 0.93 | 0.55 ± 0.94 | 0.33 ± 0.88 | 0.52 ± 0.93 | 0.63 ± 0.96 | £ |
| Flemish Giant | 0.66 ± 0.68 | 0.38 ± 0.57 | 0.80 ± 0.73 | £ | £ | £ |

£ – Not estimable or out of range

Table 31. Heritability estimates of post weaning ADGs

| Genetic group | ADG 5 and 6 | ADG 7 and 8 | ADG 9 and 10 | ADG 11 and 12 | ADG 13 and 14 | ADG 15 and 16 |
|---|---|---|---|---|---|---|
| New Zealand White | £ | 0.57 ± 0.33 | 0.64 ± 0.35 | 0.39 ± 0.29 | 0.82 ± 0.38 | 0.72 ± 0.37 |
| Grey Giant | £ | £ | £ | £ | 0.96 ± 1.58 | 0.18 ± 1.00 |
| Soviet Chinchilla | £ | £ | 0.56 ± 0.95 | 0.95 ± 1.02 | £ | £ |
| Flemish Giant | £ | £ | £ | £ | 0.39 ± 0.57 | 0.49 ± 0.62 |
| Californian White | 0.78 ± 1.14 | £ | £ | £ |  | 0.28 ± 0.98 |
| APAU Fawn | £ | 0.98 ± 1.94 | £ | £ |  | 0.03 ± 1.64 |

£ – Not estimable or out of range

| **Genetic group** | **Age** | **ADG** | **Author(s)** |
|---|---|---|---|

Table 33. Correlations among ADGs in New Zealand White rabbits

| | ADG 7 and 8 | ADG 9 and 10 | ADG 11 and 12 | ADG 13 and 14 | ADG 15 and 16 |
|---|---|---|---|---|---|
| ADG 7 and 8 | | 0.25 ± 0.37 | 0.09 ± 0.46 | 0.02 ± 0.37 | 0.44 ± 0.31 |
| ADG 9 and 10 | 0.04<br>(-0.28) | | 0.29 ± 0.41 | 0.08 ± 0.35 | 0.54 ± 0.27 |
| ADG 11 and 12 | 0.14<br>(0.19) | -0.02<br>(-0.36) | | 1.03 ± 0.03 | 0.35 ± 0.38 |
| ADG 13 and 14 | 0.05<br>(0.15) | 0.01<br>(-0.20) | 0.25<br>(-0.99) | | -0.21 ± 0.33 |
| ADG 15 and 16 | 0.20<br>(-0.24) | 0.16<br>(-0.63) | 0.25<br>(0.15) | -0.09<br>(0.29) | |

Above diagonal are genetic correlations and below diagonal are phenotypic correlations.
Environmental correlations are in parenthesis below diagonal

|  |  |  |  |
|---|---|---|---|
| SC | 5 and 6 weeks | 15.26 | Ekambaram (1997) |
|  | 7 and 8 weeks | 13.31 |  |
|  | 9 and 10 weeks | 10.71 |  |
|  | 11 and 12 weeks | 15.39 |  |
| CW | 5 and 6 weeks | 14.54 | Poornima *et al*. (2002 b) |
|  | 15 and 16 weeks | 26.28 |  |
| NZW, CW, FG and crossbreds |  | 27.2 | Prayaga and Eady (2003) |
| BB, GG, NZW, SC and WG | 4-6 weeks | 18.7 | Urmila *et al.* (2004) |
|  | 6-8 weeks | 19.5 |  |
|  | 8-12 weeks | 21.1 |  |
|  | 12-24 weeks | 11.6 |  |
|  | 4-24 weeks | 15.0 |  |
| NZW | 4-8 weeks | 25 | Zhu and Chang (2004) |
| SC | 5-16 weeks | 12.23 - 18.01 | Devi *et al*. (2005) |
| CW | 5-16 weeks | 10.89 to 16.05 |  |
| Moroccan | Weaning to Slaughter | 24.5 | Jauozi *et al.* (2005) |
| CW | Weaning to Slaughter | 35.1 |  |
| Kabylian | 4 -8 wks | 27.7 | Lakabi *et al.*(2005) |
|  | 8-11 wks | 22.2 |  |
|  | 11-15 wks | 18.0 |  |
| NZW | 8-14 weeks | 22.37 - 25.72 | Abubakar *et al.* (2006) |
|  | 40-70days | 18.1 – 23.1 | Hue and Preston (2006) |

Table 4. Post weaning ADGs as reported in the literature

Table 5. Average feed efficiency as reported in the literature

| Breed | Age | Feed efficiency | Author |
|---|---|---|---|
| NZW | 4 to 12 weeks | 3.61 | Prasad (1993) |
| SC | 4 to 12 weeks | 3.53 | Prasad (1993) |
| FG | 4 to 12 weeks | 3.51 | Prasad (1993) |
| NZW |  | 4.56 | Skrivanova *et al.* (2000) |
| CW |  | 2.98 | Skrivanova *et al.* (2000) |
| NZW | 4-16 weeks | 4.43 | Kumar *et al*. (2004) |
| WG | 4-14 weeks | 3.80 | Kumar *et al*. (2004) |
| SC | 4-13.5 weeks | 5.02 | Kumar *et al*. (2004) |
| NZW | 8-14 weeks | 2.18-2.64 | Abubakar *et al.* (2006) |

Table 6. Averages for carcass traits as reported in the literature

| Age at Slaughter | Pre-Slaughter Weight (g) | Dressing Percentage | Hot Carcass (g) | Head (g) | Feet (g) | Pelt (g) | Edible offals (g) | Inedible Offals (g) | Author(s) |
|---|---|---|---|---|---|---|---|---|---|
| **New Zealand White** | | | | | | | | | |
| 7 weeks | 562-600 | 44.9-50.8 | 445-1062 | - | - | - | - | - | Mahajan *et al.* (1980) |
| 13 weeks | 2168-2212 | - | - | - | - | - | - | - | Mahajan *et al.* (1980) |
| 21 weeks | 2843-3018 | 45.2-52.0 | 832-1470 | - | - | - | - | - | Mahajan *et al.* (1980) |
| 26.4 weeks | 2188 | 47.3 | 1053 | - | - | 202 | - | - | Mahajan and Lahiri (1983) |
| 24 weeks | 2344 | 44.01 | 1041 | - | - | - | - | - | Bhasin *et al.* (1989) |
| 90 days | 1581.9 | 45.98 | 743.63 | 154.09 | 53.25 | 139.69 | - | - | Gupta *et al.* (1990) |
| - | 1967 | 53.9 | 971 | - | - | - | - | - | Ozimba and Lukefahr (1990) |
| - | 1767 | 52.4 | 849 | - | - | - | - | - | Lukefahr *et al.* (1992 b) |
| - | 2000 | 51.57 | 977.1 | 188.4 | 62.2 | 182.81 | 62.37 | 307.95 | Satyanarayana (1992) |
| - | 2000 | 45.26 | 973.31 | 155.86 | 69.91 | 193.25 | 58.75 | 244.41 | Reddy (1994) |
| 14 weeks | 2106 | 45.8 | 968 | - | - | - | - | - | Kulkarni *et al.* (1995) |
| 14-16 weeks | 2529 | 60.6 | - | - | - | - | - | - | Nofal *et al.* (1995) |
| 121 days | 1798 (male) | 54.3 | 862 | 159.6 | | 166.6 | 82.6 | 818 | Karim (1998) |
| 159 days | 2189 (female) | 52.1 | 1019 | 214.7 | | 212.6 | 77.1 | 1009 | Karim (1998) |
| - | 2056.3 | 46.8 | 842.8 | - | - | - | - | - | Anous (1999) |
| - | 1987.2 | 59.8 | 1193.9 | - | - | - | 87.8 | 282.9 | Farghaly *et al.* (1999) |
| 16 weeks | 1632.5 | 50 | - | - | - | - | 61.48 | 320.42 | Reddy *et al.* (2000 b) |
| 90 days | 2553 | 60.89 | 1550 | 260.04 | - | - | - | - | Borthakur *et al.* (2003) |
| 90 days | 2000 | 46.62 | - | 182.25 | - | 232.8 | - | - | Kumar *et al.* (2004) |
| 90 days | 1980 | 52.02 | 941 | - | - | - | 94 | 857 | Das *et al.* (2006) |
| 11 weeks | male | 48.77 | 832 | - | - | - | - | - | Yalcn (2006) |
| 11 weeks | female | 48.69 | 849 | - | - | - | - | - | Yalcn (2006) |

Contd.

Table 6. Continued

| Age at Slaughter | Pre-Slaughter Weight (g) | Dressing Percentage | Hot Carcass (g) | Head (g) | Feet (g) | Pelt (g) | Edible offals (g) | Inedible Offals (g) | Author(s) |
|---|---|---|---|---|---|---|---|---|---|
| **Grey Giant** | | | | | | | | | |
| 24 weeks | 2370 | 48.7 | 1156 | - | - | - | - | - | Bhasin *et al.* (1989) |
| 90 days | 1629.2 | 47.03 | 770.69 | 153.31 | 52.73 | 143.92 | - | - | Gupta *et al.* (1990) |
| 14 weeks | 1884 | 48.9 | 921 | - | - | - | - | - | Kulkarni *et al.* (1995) |
| 112 days | 1797 (male) | 54.5 | 879 | 159.7 | - | 165.9 | 80.5 | 823 | Karim (1998) |
| 140 days | 2446 (female) | 54.6 | 1194 | 236.8 | - | 236.3 | 91.3 | 1084 | Karim (1998) |
| 16 weeks | 1506.7 | 47.26 | - | - | - | | 64.22 | 339.51 | Reddy *et al.* (2000 b) |
| 12 weeks | - | 45.6-52.7 | 654 -1013 | - | - | - | - | - | Bhatt *et al.* (2002) |
| - | - | 48.9-54.4 | 817-1066 | - | - | - | - | - | Bhatt *et al.* (2002) |
| **Soviet Chinchilla** | | | | | | | | | |
| 24 weeks | 2390 | 48.1 | 1152 | - | - | - | - | - | Bhasin *et al.* (1989) |
| 16-24 weeks | 1920 | 49.79 | 960 | - | - | - | 74 | 880 | Salroo (1989) |
| >24 weeks | 2980 | 52.93 | 1620 | - | - | - | 103 | 1351 | Salroo (1989) |
| 90 days | 1530.9 | 45.8 | 706.44 | 143.81 | 48.94 | 126.44 | - | - | Gupta *et al.* (1990) |
| - | 2000 | 51.7 | 1029.51 | 188.12 | 67.58 | 193.76 | 62.74 | 339.7 | Satyanarayana (1992) |
| - | 2000 | 48.17 | 978.36 | 155.76 | 71.62 | 188.61 | 63.19 | 273.26 | Reddy (1994) |
| 84 days | 1840 | 51.08 | 940 | - | - | 177.5 | 71.2 | 806.65 | Gour *et al.* (1995) |
| 14 weeks | 1549 | 45.5 | 713 | - | - | - | - | - | Kulkarni *et al.* (1995) |
| 119 days | 1790 (male) | 52.6 | 838 | 160.3 | - | 161.9 | 77 | 834 | Karim (1998) |
| 132 days | 2088 (female) | 50.2 | 927 | 207.8 | - | 200 | 75 | 1017 | Karim (1998) |
| - | 2620 (male) | 56.16 | 1370 | - | - | - | - | - | Sen *et al.* (1999) |
| - | 3040 (female) | 54.01 | 1530 | - | - | - | - | - | Sen *et al.* (1999) |
| 16 weeks | 1468.1 | 51.64 | - | - | - | - | 54.55 | 295.98 | Reddy *et al.* (2000 b) |
| 12 weeks | 1620-1707 | 48.3 - 49.3 | 737-771 | - | - | - | - | - | Bhatt *et al.* (2003) |
| 90 days | 2730 | 51.96 | 1700 | - | - | - | - | - | Choudhury *et al.* (2003) |
| - | 2000 | 46.19 | - | 208.33 | - | 300 | - | - | Kumar *et al.* (2004) |
| - | 1937 | 52.38 | 926 | - | - | - | 104 | 801 | Das *et al.* (2006) |

Contd..

Table 6. Contd.

| Age at Slaughter | Pre-Slaughter Weight (g) | Dressing Percentage | Hot Carcass (g) | Head (g) | Feet (g) | Pelt (g) | Edible offals (g) | Inedible Offals (g) | Author(s) |
|---|---|---|---|---|---|---|---|---|---|
| **Flemish Giant** | | | | | | | | | |
| - | 2000 | 51.45 | 961.89 | 191.19 | 73.09 | 185.01 | 63.16 | 320.74 | Satyanarayana (1992) |
| - | 2000 | 44.63 | 956.39 | 956.39 | 68.49 | 184.35 | 62.9 | 254.72 | Reddy (1994) |
| 16 weeks | 1597.14 | 49.86 | - | - | - | - | 61.39 | 324.19 | Reddy *et al.* (2000 b) |
| **Californian White** | | | | | | | | | |
| 90 days | 2515.55 | 57.60 | - | - | - | - | - | - | De Salvo and Zucchi (1984) |
| 51 days | 1650.00 | - | 1000 | - | - | - | - | - | Jiabi *et al.* (1990) |
| 71-73days | 1870 | 55.9 | 961 | - | - | - | - | - | Ozimba and Lukefahr (1991 b) |
| 87 days | 2294.11 | 51.63 | 1184.53 | - | - | - | - | - | Ferraz *et al.* (1991) |
| 71-73days | 1895 | 54.79 | 950.11 | - | - | - | - | - | Roberts and Lukefahr (1992) |
| 14 -16weeks | 2459 | 60.5 | 1235 | - | - | - | - | - | Nofal *et al.* (1995) |
| 16weeks | 1575.67 | 51.46 | 817.76 | 149.79 | 54.93 | 164.31 | 55.61 | 336.33 | Poornima *et al.* (2003) |

Table 7. Biochemical composition of rabbit meat as reported in the literature.

| **Author(s)** | | **Moisture (%)** | **Dry matter (%)** | **Protein (%)** | **Fat (%)** | **Total ash (%)** |
|---|---|---|---|---|---|---|
| Malik (1988) | M | 74.5 | - | 19.5 | 4.6 | 1.0 |
| | F | 72.6 | - | 19.2 | 6.8 | 1.0 |
| Kulkarni *et al.* (1995) | SC | - | 26.5 | 21.5 | 1.4 | 2.4 |
| | NZW | - | 23.7 | 19.6 | 2.2 | 1.8 |
| | GG | - | 26.5 | 21.7 | 1.7 | 1.2 |
| Bhatt *et al.* (1996) | SC | - | 26.1 | 20.9 | 0.9 | 1.0 |
| | | - | 26.6 | 23.3 | 2.1 | 1.4 |
| Kalita *et al.* (2000) | | 74.1 | - | 20.4 | 2.5 | 1.1 |
| | NZW | 75.0 | 20.4 | 21.1 | 2.8 | 1.4 |

Table 1. Average litter size at birth and weaning and litter weight at birth and weaning (kg) as reported in the literature

| enetic group | LSB | LSW | LWB (kg) | LWW (kg) | Author (s) |
|---|---|---|---|---|---|
| | 7.4 | 6.0 | -- | -- | Mahajan *et al.* (1980) |
| | 6.9 | 5.6 | 0.37 | 3.93 | Lahiri and Mahajan (1982) |
| | 4.4 - 5.2 | 1.7-2.9 | -- | -- | Narayan and Rawat (1982) |
| G, WG, SC | -- | 4.8, 5.5, 5.3, 6.8 | -- | 3.45, 3.26, 2.84, 4.07 | Lahiri and Mahajan (1983) |
| ds | 7.0 - 10.5 | -- | 0.41 - 0.60 | -- | Lahiri and Mahajan (1984) |
| G, WG, SC | 6.1, 6.4, 6.0, 6.3 | 4.6, 4.6, 4.5, 4.4 | 0.30, 0.33, 0.31, 0.33 | 2.88, 3.30, 3.19, 3.05 | Bhasin *et al.*(1989) |
| C | 5.4, 5.9 | -- | -- | -- | Bujarbaruah *et al.*(1989) |
| WG | 6.6, 8.3, 6.0 | 5.7, 5.4, 5.2 | 0.33, 0.31, 0.33 | 3.14, 2.65, 2.95 | Das and Nayak (1991) |
| sbred, L | 7.0, 5.2, 4.6 | 5.0, 4.9, 4.0 | 0.38, 0.27, 0.21 | 2.10, 1.73, 1.77 | Sundaram and Bhattacharya |
| V, WG, GG | 6.0, 6.7, 5.3, 5.0 | -- | 0.59, 0.64, 0.69, 0.61 | -- | Sundaram and Bhattacharya |
| Crossbreds | 5.2 | 4.5 | -- | -- | Deb and Gaur (1996) |
| NZW, WG | 6.1, 6.7, 6.4, 6.6 | 4.5, 4.5, 4.4, 4.7 | 0.32, 0.34, 0.34, 0.34 | -- | Bhasin and Singh (1998) |
| SC | 6.4, 6.8 | 4.9, 5.7 | 0.34, 0.35 | 1.75, 2.07 | Kumar *et al.* (1998) |
| G, WG, SC, BB | 6.8 | 5.1 | 0.38 | 3.40 | Singh (1998 a) |
| , SC, BB | 6.5 | 5.9 | 0.35 | 2.17 | Singh (1998 b) |
| C, FG, GG | | | 0.27 | 1.52 | Reddy *et al.*(2000 a) |
| | 5.7 - 7.4 | 5.6 - 6.4 | 0.26 - 0.34 | 2.66 - 3.11 | Bhatt *et al.* (2002) |
| W, FG, Crossbreds | 6.9 | 3.3 | 0.40 | 2.80 | Prayaga and Eady (2002) |
| | 6.2 | 5.4 | 0.33 | 3.5 | Singh *et al.* (2003) |

Contd.,

Table 1. Continued

| Genetic group | LSB | LSW | LWB (kg) | LWW (kg) | Author (s) |
|---|---|---|---|---|---|
| NZW | 5.07 | 4.32 | 0.24 | 2.20 | Bharat Bhushan *et al.* (2004) |
| SC, NZW | 6.5, 6.1 | -- | 0.35, 0.32 | -- | Ghosh *et al.* (2004) |
| Bouscat, CW | 6.8, 6.7 | 4.7, 4.8 | 0.32, 0.35 | 2.49, 2.57 | Farid (2004) |
| SC | 8.1 | 6.3 | 0.37 | 3.39 | Rohilla and Bujarbaruah (2004) |
| -- | 6.0 | 4.8 | -- | -- | Kpodekon *et al*. (2005) |
| Local Moroccan, CW | 6.0, 8.9 | 4.25, 6.80 | -- | -- | Jaouzi *et al.* (2005) |
| NZW, SC, BB, WG, GG | 6.1 | 5.2 | 0.33 | 2.72 | Urmila *et al.* (2005) |
| -- | 6.9-7.6 | 6.1-7.2 | -- | 0.68-0.80 | Zucchi and Desalvo (2005) |
| SC, GG | 5.89, 6.71 | 4.26, 5.36 | 0.33, 0.36 | 2.78, 3.24 | Ghosh *et al.* (2006) |
| NZW, WG, SC | 3.92 | 2.63 | 0.24 | 0.73 | Kumar *et al.* (2006) |
| NZW, SC, L | 6.23, 5.97, 6.03 | 4.80, 4.60, 4.40 | 0.31, 0.31, 0.31 | 2.00, 2.09, 2.03 | Das *et al.* (2007) |
| GG | 6.39 | 5.48 | 0.31 | 3.39 | Singh *et al.* (2007) |

Table 2. Average pre-weaning body weights (g) as reported in the literature

| Birth | 1 week | 2 weeks | 3 weeks | 4 weeks | Author(s) |
|---|---|---|---|---|---|
| **New Zealand White** | | | | | |
| 55.07 | 107.16 | 164.87 | 224.83 | 347.61 | Rao (1988) |
| 54.7 | - | 176.67 | - | 444.23 | Nagpure *et al*. (1991) |
| 58.35 | 118.2 | 189.82 | 279.28 | 454.18 | Purandhar (1991) |
| - | - | - | - | 295.42 | Satynarayana (1992) |
| 49.11 | 107.13 | 157.15 | 202.8 | 296.97 | Srinivasu (1992) |
| 50.1 | 103.9 | 166.7 | 226.4 | 290.5 | Prasad (1993) |
| 56.42 | - | - | 292.17 | - | Ledur *et al*. (1994) |
| 56.48 | 110.61 | 173.34 | 238.25 | 413.96 | Raj Kumar (1994) |
| - | - | - | - | 423.72 | Reddy (1994) |
| 54 | - | - | 266 | 380.3 | Bhasin *et al*. (1996) |
| | - | - | 222.5 | 476.7 | Anous (1999) |
| 50.9 | - | - | - | 310.41 | Gupta *et al*. (1999) |
| | - | - | - | 614 | Marykutty and Nanda Kumar (2000) |
| 54.86 | 103.91 | 150.46 | 197.73 | 319.6 | Reddy *et al*. (2001) |
| | - | - | - | 570 | Ponce de Leon *et al*. (2002) |
| 60.15 | - | - | - | 761 | Kumar *et al*. (2006) |
| **Grey Giant** | | | | | |
| 55.64 | 104.97 | 173.14 | 241.1 | 361.54 | Rao (1988) |
| 44.66 | - | 137.89 | - | 403.12 | Nagpure *et al*. (1991) |
| 50.62 | - | - | - | 328.29 | Gupta *et al*. (1999) |
| 55.93 | 118.78 | 175.35 | 243.13 | 348.11 | Reddy *et al*. (2001) |
| 64.77 | - | - | - | 621.96 | Ghosh *et al*. (2006) |
| - | - | - | - | 642 | Marykutty and Nanda Kumar (2000) |
| **Soviet Chinchilla** | | | | | |
| 50.41 | 88.6 | 141.68 | 189.59 | 323.9 | Rao (1988) |
| 52.98 | - | - | - | 433.73 | Jayaramakrishna *et al*. (1990) |
| 51.84 | 107.08 | 156.43 | - | 422.28 | Nagpure *et al*. (1991) |
| 58.28 | - | 177.3 | 251.33 | 398.55 | Purandhar (1991) |
| - | 95.96 | - | - | 381.17 | Satynarayana (1992) |
| 47.54 | 101.6 | 153.7 | 219.89 | 336.45 | Srinivasu (1992) |
| 51.4 | 113.27 | 162.4 | 217.4 | 315.2 | Prasad (1993) |
| 56.88 | - | 169.47 | 247.09 | 379.16 | Raj Kumar (1994) |

Contd.,

Table 2. Continued

| Birth | 1 week | 2 weeks | 3 weeks | 4 weeks | Author(s) |
|---|---|---|---|---|---|
| **Soviet Chinchilla** | | | | | |
| - | - | - | - | 428.23 | Reddy (1994) |
| 52.53 | - | - | - | 314.22 | Gupta *et al*. (1999) |
| - | - | - | - | 564 | Marykutty and Nanda Kumar (2000) |
| 54.88 | 99.4 | 142.86 | 193.04 | 306.74 | Reddy *et al*. (2001) |
| - | - | - | - | 559 | Ponce de Leon *et al*. (2002) |
| 58.85 | - | - | - | 654 | Ghosh *et al*. (2006) |
| 66.5 | - | - | - | 738 | Kumar *et al*. (2006) |
| **Flemish Giant** | | | | | |
| - | - | - | - | 362 | Ahmed *et al*.(1986) |
| - | - | - | - | 347.88 | Satyanarayana (1992) |
| 57.6 | 107.6 | 153.03 | 215.2 | 322.81 | Srinivasu (1992) |
| 51.4 | 104 | 170.1 | 244.6 | 361.7 | Prasad (1993) |
| 51.38 | 98.08 | 148.48 | 185.25 | 305.48 | Raj Kumar (1994) |
| - | - | - | - | 329.09 | Reddy (1994) |
| 54.7 | - | - | 273 | 410.2 | Bhasin *et al*. (1996) |
| 58.7 | - | - | - | 280.82 | Gupta *et al*. (1999) |
| 53.88 | 106.2 | 155.21 | 223.8 | 345.48 | Reddy *et al*. (2001) |
| **Californian White** | | | | | |
| 65.56 | - | - | - | 687.22 | Carregal and Lui (1984) |
| 62 | - | - | - | 594 | Mach *et al*. (1986) |
| 63.04 | - | - | - | 598.28 | EI-Maghawry *et al*. (1988) |
| 58.52 | - | - | 296.31 | 475.33 | Ledur and Carregal (1988) |
| - | - | - | - | 514 | Roberts and Lukefahr (1992) |
| - | - | - | - | 536 | Ponce de Leon *et al*. (2002) |
| 47.77 | 88.84 | 150.36 | 209.54 | 294.88 | Poornima *et al*. (2002 a) |
| 99.22 | - | - | - | 527.92 | Jaouzi *et al*. (2005) |

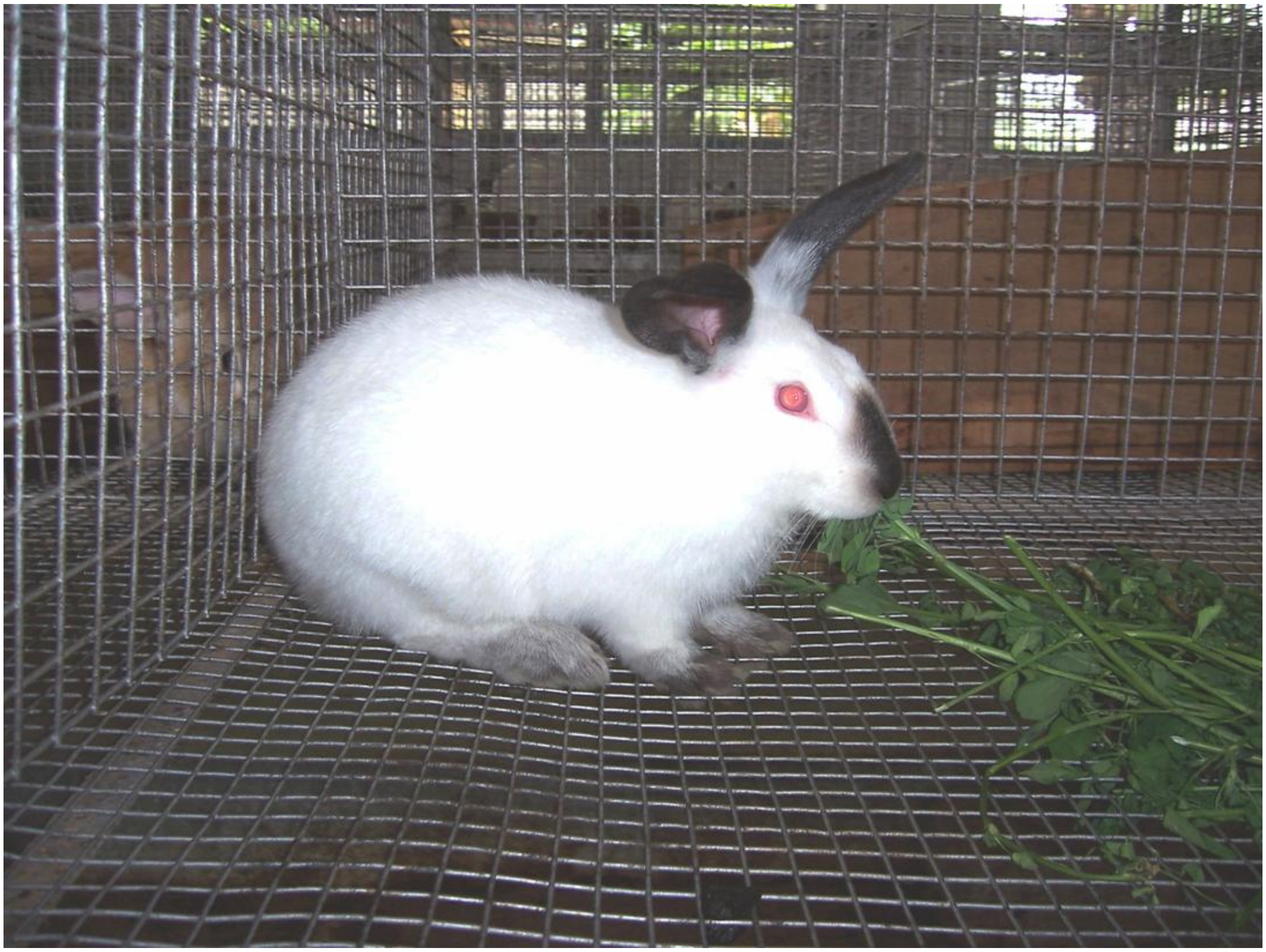
Table 3. Average post weaning body weights (g) as reported in the literature

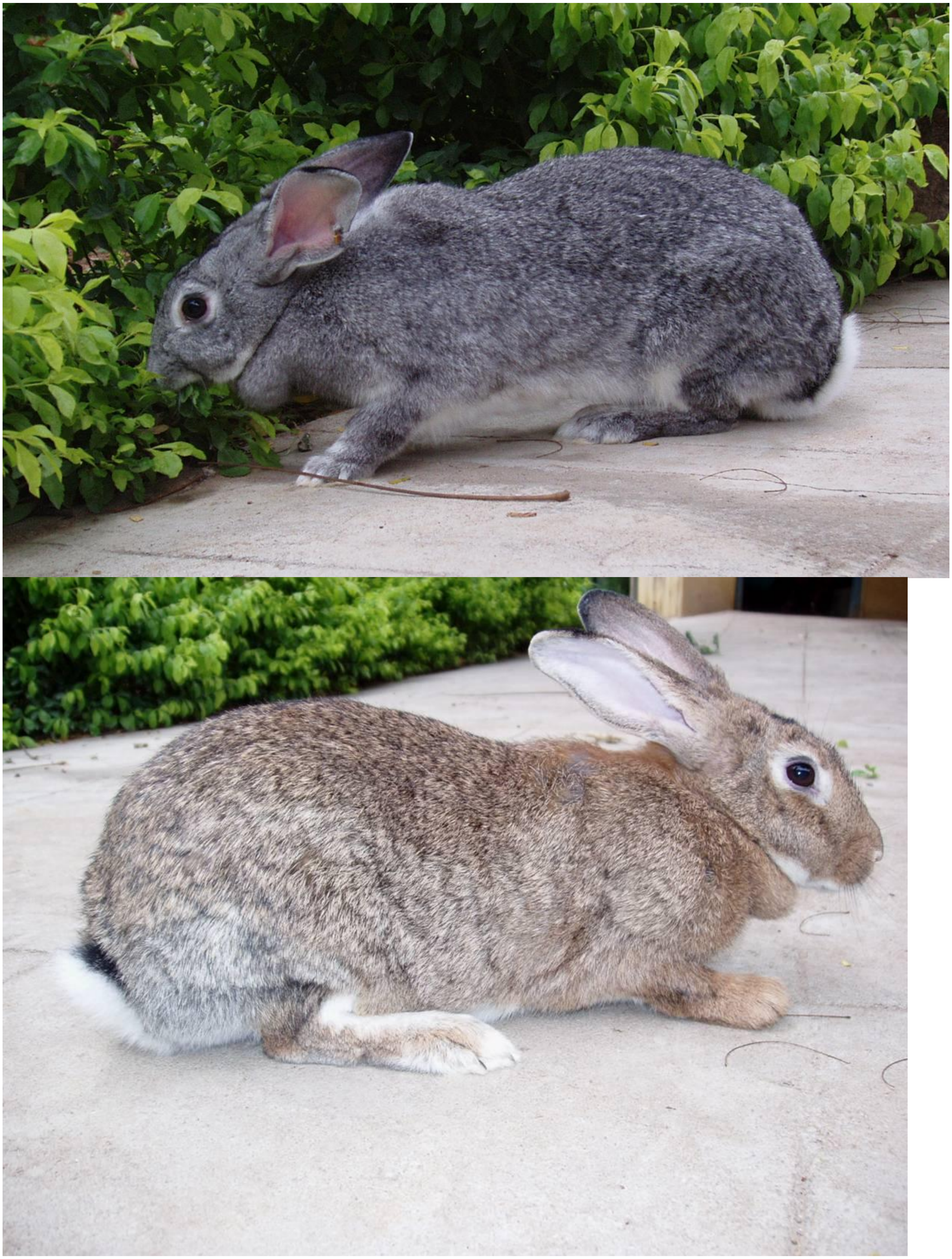
| 6 weeks | 8 weeks | 10 weeks | 12 weeks | 14 weeks | 16 weeks | Author(s) |
|---|---|---|---|---|---|---|
| **New Zealand White** | | | | | | |
| 624.46 | 868.42 | 1172.82 | 1435.69 | - | - | Rao (1988) |
| 863 | 1290 | 1724 | 2224 | - | - | Bokova *et al.* (1990) |
| 765.68 | 987.1 | 1219.65 | 1464.46 | - | - | Purandhar (1991) |
| - | 731.06 | - | 1618.82 | - | - | Satyanarayana (1992) |
| 531.7 | 793.4 | 1027.1 | 1253.7 | - | - | Prasad (1993) |
| - | - | 1669.77 | - | - | - | Ledur *et al.* (1994) |
| 791.87 | 1126.54 | 1467.68 | 1781.16 | - | - | Reddy (1994) |
| 798 | 1166 | 1353 | 1652 | 1999 | - | Kulkarni *et al.* (1995) |
| 713.5 | - | - | - | - | - | Bhasin *et al.* (1996) |
| 659.69 | 905.85 | 1076.92 | 1301.13 | - | - | Reddy (1996) |
| 530 | 800 | 1010 | 1190 | 1380 | 1530 | Bharat Bhushan and Ahlawat (1999) |
| 947.2 | 1321.8 | 1655 | 1947.5 | - | - | Anous (1999) |
| - | 600.37 | 1002.15 | 1155.08 | 1291.12 | - | Asuquo and Okon (1999) |
| - | - | - | 1133 | - | - | Marykutty and Nanda Kumar (2000) |
| 497.4 | 679.61 | 834.92 | 1050.38 | 1241.88 | 1392.6 | Gupta *et al.* (2002) |
| - | 1638 | - | - | - | - | Zhu and Chang (2004) |
| **Grey Giant** | | | | | | |
| 595 | - | - | - | - | - | Lahiri and Mahajan (1983) |
| 643.91 | 918.23 | 1180.89 | 1435.52 | - | - | Rao (1988) |
| - | - | - | 1225 | - | - | Nagpure *et al.* (1991) |
| - | - | - | 1039.6 | - | - | Bokade *et al.* (1993) |
| 539 | 900 | 1290 | 1709 | 1884 | - | Kulkarni *et al.* (1995) |
| 628.82 | 910.18 | 1076.56 | 1267.04 | - | - | Reddy (1996) |
| - | - | - | 1121 | - | - | Marykutty and Nanda Kumar (2000) |
| 508.65 | 686.34 | 836.68 | 991.98 | 1173.83 | 1338.96 | Gupta *et al.* (2002) |
| **Soviet Chinchilla** | | | | | | |
| 603 | - | - | - | - | - | Lahiri and Mahajan (1983) |
| 549.71 | 803 | 1085.71 | 1293.54 | - | - | Rao (1988) |
| - | - | - | 1371.59 | - | - | Nagpure *et al.* (1991) |
| 712 | 942.21 | 1114.7 | 1371.28 | - | - | Purandhar (1991) |
| - | - | - | - | - | 2000 | Sundaram and Bhattacharya (1991) |

Contd.,

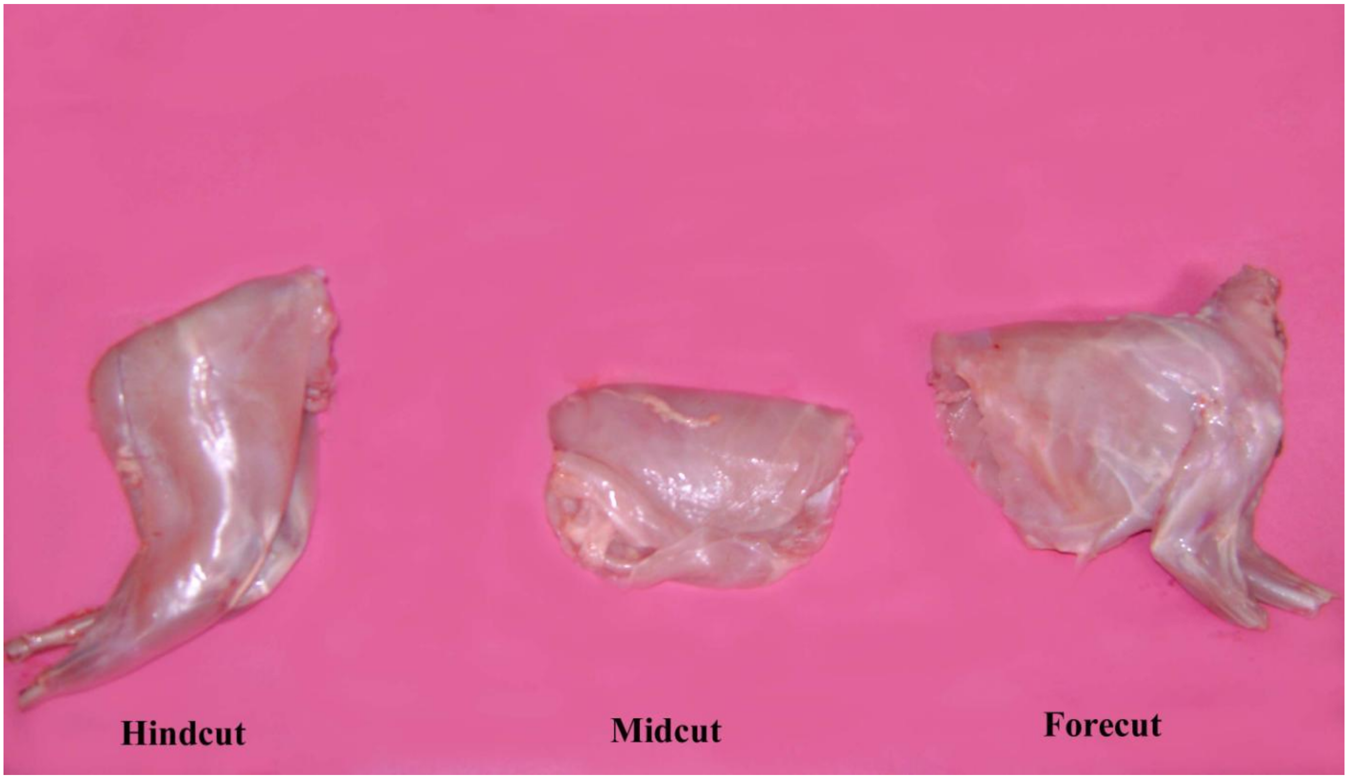
Table 3. Continued

| 6 weeks | 8 weeks | 10 weeks | 12 weeks | 14 weeks | 16 weeks | Author(s) |
|---|---|---|---|---|---|---|
| **Soviet Chinchilla** | | | | | | |
| - | 928.56 | - | 1163.94 | - | - | Satyanarayana (1992) |
| 564.6 | 830 | 1095.9 | 1346.8 | - | - | Prasad (1993) |
| 826.4 | 1182.1 | 1479.9 | 1856.76 | - | - | Raj kumar (1994) |
| - | 1227.88 | - | 1868.12 | - | - | Reddy (1994) |
| 628 | 1086 | 1523 | 1892 | - | - | Gour *et al.* (1995) |
| 635.56 | 990 | 1203.33 | 1428.89 | 1584.44 | - | Kulkarni *et al.* (1995) |
| 778 | - | - | - | - | - | Bhasin *et al.* (1996) |
| 618.34 | 857.24 | 993.71 | 1183.04 | - | - | Reddy (1996) |
| - | - | - | 1238 | - | - | Marykutty and Nanda Kumar (2000) |
| 512.25 | 689.13 | 836.52 | 994.92 | 1172.86 | 1351.96 | Gupta *et al.* (2002) |
| **Flemish Giant** | | | | | | |
| - | 925.21 | - | 1633.87 | - | - | Satyanarayana (1992) |
| 625.5 | 893.5 | 1155.5 | 1425.8 | - | - | Prasad (1993) |
| 654.38 | 1009.77 | 1314.68 | 1673.11 | - | - | Raj kumar (1994) |
| - | 1031.22 | - | 1651.63 | - | - | Reddy (1994) |
| 599.79 | 843.66 | 1024.4 | 1276.17 | - | - | Reddy (1996) |
| 446.09 | 684.02 | 967.5 | 1124.39 | 1261.97 | 1391.54 | Gupta *et al.* (2002) |
| **Californian White** | | | | | | |
| - | - | - | 2630 | - | - | Jensen and Rasmussen (1983) |
| - | - | 1823.75 | - | - | - | Ledur *et al.* (1994) |
| - | - | - | - | - | 2604 | Nofal *et al.* (1995) |
| - | - | - | 2084.7 | - | - | Reid *et al.* (1995) |
| 494.01 | 705.24 | 896.65 | 1113.18 | 1330.35 | 1552.41 | Poornima *et al.* (2002 b) |






8
918 923
919 926
921 927


Hindcut
Midcut
Forecut