AN EVALUATION OF RABBIT BREEDING AND PRODUCTION IN THE SUDAN

By

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Dedication

To my parents

My lovely children Saba, Ismail

My wife Selwa

My brother, sister s and friends

With my love

Ibrahim

List of contents

CHAPTER THREE

CHAPTER FIVE

List of tables

List of appendices

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Abstract

For the purpose of this study 62 adult rabbits of two breed were used as breeding stock. The breeds used are local Sudanese Baladi (40 does and 10 bucks) and New Zealand white (10 does and 2 bucks). The experiments start at June 2001 and ended in April 2003.

For production of F_1 from both breeds, the male and female matted to produce pure breed.

New Zealand white does matted with Baladi bucks to produce crosses.

Data concerning litter size, birth weight, weaning weight, maturity weight, gestation period and carcass characteristics of Baladi rabbit were analyze.

The genetic parameters were very variable, due to the small number of animal used. Heritability of weaning weight was 0.994 and mature weight was 0.856.

Phenotypic, genetic and environmental correlation between weaning weight and mature weight are positive; however correlation with average daily gain were negative.

The litter size at birth of the cross bred was 5.00 individuals per litter was greater than the litter size of New Zealand white breed which averaged 4.30 and Baladi type which averaged 3.93.

The Baladi shows the smallest birth weight (44.79 gs) as compared to the New Zealand white breed (57.40 gs) and the cross breed (54.99 gs).

The New Zealand white breed exhibited greater pre-weaning and post weaning weight gain (20.27 and 10.77 gs / day, respectively).

The joint as leg, ribs, front leg and back and flank shows no significantly differences between male and female of Baladi rabbits.

The male muscles shows greater moisture content than female muscles.

ملخص الأطروحة

استخدمت في هذه الدراسة 62 أرنب بالغ من نوعين مختلفين من الـسلالات، (40 إناث، 10 ذكور) من السلالة السودانية (بلدي) و (10 إناث ، 2 ذكور) من الـسلالة النيوزلندية البيضاء.

تم الحصول من السلالة البلدية على الجيل الأول من البلدي و كذلك من النيوزلنـدي الأبيض.

عند تهجين إناث سلالة النيوزلندي مع ذكور سلالة البلدي أظهـر الجيـل الأول مـن الهجين تفوق في حجم الولادة الواحدة. حيث أعطى 5 أفراد في الولادة بينما النيوزلندي و البلدي أعطيا (4.30 و 3.93) على التوالي. وزن الميلاد كان أكبر في الهجين (57.40 جم) مـن البلدي (44.79 جم) و النيوزلندي (54.99 جم).

الزيادة في الوزن اليومي قبل وبعد الفطام كانت أعلى في النيوزلندي الأبيض (10.77 جم/يوم) و (20.27 جم/يوم) عن البلدي والهجين.

قطعيات الذبيحة (الأرجل، الأضلاع، الأرجل الأمامية والجزء الخلفي) أظهـرت أنـه لاتوجد فروق معنوية بين الإناث والذكور في الأرانب البلدية.

القياسات الوراثية أظهرت فروقات مختلفة نسبة للأعداد القليلة من العينات.

المكافئ الوراثي لوزن الفطالم سجل (0.994) أما للوزن البالغ (0.856).

أظهر المسح عن الأرانب البلدية أنه لا توجد مزارع متخصصة لتربية الأرانب ما عدا بعض الوحدات الصغيرة التي تعمل في مجال البحوث. وكما أن لحوم الأرانب غير مرغـوب فيها على المائدة السودانية لمعظم المواطنين. كما أن هنالك إعتقاد سائد لكثير مـن النـاس إن الأرانب شبيهة بالقطط ولها دورة شهرية كما الإنسان.

Chapter One

Introduction

Rabbit production is so desirable for third world agriculture because of its low farming costs and its remarkable ability to digest leafy plant proteins and convert them efficiently into good quality meat.

Most plant materials cannot be digested by humans, which is the reason why ruminant animals like sheep, goats and cattle are used to convert them into milk and meat. These animals possess digestive systems well suited for the digestion of cellulose fiber very well, but excel in their ability to feed on a great variety of leafy plants and shrubs which are often indigenous and freely available in developing countries. Some of the better breeds of rabbits will reach 2-2.5Kg. at ten weeks of age, eating less than 3.5 Kg.for each 1 Kg.live weight gain. This conversion ratio of 3.5:1 includes the feed eaten by the mother from mating to birth, plus that eaten by the young before reaching market age. Any efficient producer of edible meat can't compete with rabbits, as they fast and can achieve rapid weight gain even when fed on common leafy plants and shrubs. These facts are now becoming more widely recognized, and interest is increasing in rabbits farming.

Rabbit meat could be a very important source of protein for humans, not only because of its quality but also because rabbits can eat a high fiber feed and transform it into high quality, low fat meat. An important prerequisite to development of a viable rabbits` meat industry is the establishment of steady supplies of product through out the year. However, there are numerous causes for current fluctuations in supply. One of the most important aspects of this fluctuation is the effects of season on productivity (McNitt and Moody, 1990).

Productivity in rabbits can be considered a function of reproductive and growth efficiency. Litter size at birth is probably the most important characteristic of reproductive performance in rabbits(Ferraz *et al.*,1991).Litter size and weight at 21 days of age are very good evaluation of does maternal ability.

Young rabbits depend, on their dams entirely until weaning. The entire litter weight at 21 days could provide an estimate of the does milk production (Lebas 1970; lukefar *et al*.1983,and Khalid *et al.*, 1987) and maternal or nursing ability. Litter size and weight at birth and at weaning are the most important estimates of doe productivity.

Environment effects must be considered in studies of productive traits, as in studies of almost all traits. The most important environmental factors amongst others, are season and parity (Corregal,1980.,Correged *at al*., 1980 ukerfahr *et al*.,1983;Afifi and Emara.,1987;Khalil *et al*.,1987,Estany *et al*. , 1989.,Khalil *et al*.,1989, Lukefahr .,1990,and Menitt and Moody,1990).

The livestock industry suffers from many constraints in spite of the high elasticity of demand of its products for the growing population of Sudan. Many livestock production systems depend on use of concentrate feeds which are more often suitable for direct human consumption. The pricing of such products puts them out of reach of the poor. It is of paramount importance to introduce other types of livestock that do not compete with concentrate- fed animals to avoid such conflict. Rabbits can satisfy this objective.

Rabbit meat production is of considerable interest since it supplies a high quality animal protein (Lebas, 1983).Rabbits are capable of supplying reasonable quantities of meat with relatively low levels of input, (Demiterov *et al*.,1991).It can covert plant proteins which are not consumed by man into animal protein. In Sudan, wild rabbits are hunted in many areas by villagers but the situation is not the same in the large towns.

Rabbits can also act as models for the studies of the problems of meat animals apart from their own right as meat supplies .They are considered as a delicacy by many people. In a preliminary survey, I have studied various markets in Khartoum area, and found a sizable trade of rabbits.

Studies on rabbits, as alternative source of meat, had received little attention in the Country. Further, there is very little scientific information on rabbits in the Sudan. The objective of this study were:

1. To improve the genetic make up of the local Baladi rabbits by crossing with the New Zealand white breed.
2. To evaluate the carcass characteristics and meat chemical composition of local Baladi rabbits.
3. To investigate the constraints facing rabbit breeders in the Sudan.

Chapter Two

Literature Review

2.1: History,Taxonomy,And Domestication Of The Rabbit:

The origin and evolution of the rabbit is difficult to trace, because rabbits` bones are small and fragile and often get destroyed or rearranged by predators. Fossil records trace the order Lagomorpha back to about 45 million years to the late Eocene period. The Leporids (rabbits and hares) appear to have originated in Asia. Rabbits were originally classified as rodents but are now placed in a separate order, the lagomorphs, primarily because they have two more incisor teeth theirs rodents(six instead of four).The lagomorphs are divided in two major families:pikas and rabbits and hares. The modern Lagomorphs consist of two families (Leporids and Ochotonides) with 12 genera. They range from the highly successful hares and rabbit of the Lepus, Oryctolagus, and Sylvilagus genera to several endangered genera and species.The Bunolaguus, with one species, the Bushman hare of south Africa, has not been seen since 1948 and may be extinct. Other rare endangred lagomorphs include the Sumatran hare in Indonesia, the Amani rabbits (Pentalagus furnessi)in Japan, and the volcano rabbits of Mexico (Peter *et al*., 1997).

2.2: Potential of the Rabbit for Meat and for Production:

The human population exerts increasing pressure on the world's food resources, it is likely that rabbits will assume an increasingly important role as a source of food. They possess various attributes that are advantageous in the comparison to other livestock. Rabbits can be successfully raised and diets are low in grain and high in rough age. Recent research which has been demonstrated, that normal growth and reproductive performance can be achieved on diets containing no grain at all. As competition between human and livestock for grains intensifies, rabbits will have a competitive advantage over poultry, since the latter cannot be raised on high roughage diets or diets that don't contain grain. Rabbits convert forage into meat more efficiently than ruminant animals such as cattle and sheep. From a given amount of alfalfa, rabbits can produce about five times as much meat as beef cattle (Peter *et al.*, 1997)**.**

A great number of rabbits are raised each year for pleasure, show, meat, fur, and research purposes. Domestic rabbit meat is a specialty item and is tin ding acceptance by consumers wherever methods of merchandizing are available. Rabbit meat can prepared and served in may ways. The all white meat of the domestic rabbit can be found in supermarkets packaged as 2 to 2.5 pound dryers or broilers, and the price of rabbit meat is competitive with beef. On a comparable basis, rabbit meat has less cholesterol, fewer calories, and a lower percentage of fat than beef, pork, chic ken or lamb, and has a grater protein content (Thomas *et al* 1999).

An exciting characteristic of rabbits is their high reproductive potential. This, of course, is well known, being the subject of numerous jokes regarding fertility. Because of their rapid growth rate, short gestation period, and ability to rebreed immediately after parturition (giving birth), the reproductive potential is staggering. Several animal released in Australia resulted in a few years in tens of million of rabbits. In commercial production, this high reproduction potential is of great importance. Recent research has demonstrated that normal growth and reproductive performance can be achieved on diets containing no grain at all. As competition between humans and livestock for grains intensifies, rabbits will have competitive advantage over swine and poultry, since the latter animals cannot be raised on high roughage diets or diets that don't contain grain. Rabbits convert forage into meat more efficiently than ruminant animal such as cattle and sheep**.** There is considerable potential for genetic improvement of rabbits raised commercially. Because of the short generation time, rapid selection progress can be made. The heritability of growth and carcass traits is relatively high, so rapid improvement of these traits through selection can be made. There has been comparatively little genetic selection of rabbits for such important commercial characteristics as carcass trait, so there is scope for considerable progress in these areas. Compared to other types of livestock production, there has been little commercial development of high performing hybrids, use of well designed crossbreeding schemes, or other techniques that are routine in the other types of livestock enterprises (Peter *et al.*, 1997).

2.3 Rabbits Breeds:

The definition of breed can only by very general. It is a group of animals; within a species, that has a common origin and certain physical characters that are readily distinguishable. Once these physical traits are removed, e.g. by skinning after slaughter it often becomes difficult to tell breeds apart. Thus the physical features act like a breed label. Isolation by barriers (e.g. mountain and seas), regulation social differences. Among their user and fashion have all helped to keep breeds separated. In genetic terms, isolation caused the genotype to drift a part (genetic drift). Genetic differences within a breed can be large and in some cases can be as a big or greater than those between breeds. The structure of the breed is important as it controls the way in which genetic improvement flows throughout the breed. Breeds are best visualized as a hierarchy, drawn as triangle (Dalton 1985).

The prospective rabbit raiser should decide on the purpose for which the rabbit will be raised, and then select a breed that will be best suited to his needs, one that will satisfy his or her personal preferences.

There is no one breed that is the best for all purposes, but there are many with such different characteristics that should be little difficulty in making a selection. With respect to body conformation, there is considerable variation from the "racy type" of the Belgian hare to the compact body shape of the medium weight and heavy meat breeds. Weight range, from a mature weight of less than (1 kg.) for the Netherlands Dwarf to over (8-9Kg.) for some of the giant breeds. The length of the coat for different breeds ranges from the short. Furred rex to the Angora, which has an annual growth of the (8 to 10) inches of the wool. There also many different coat colors, and the rabbits may be solid black, blue, chocolate, fawn, gray, white, etc.. or with spots, or of mixed colors. Peter *et al*., 1987)**.**

In Europe, more than breeds are described by the national associations of rabbit breeders. Through the European association of rabbit breeders and the FAO national focal points, all the European countries have been asked to fill out a questionnaire describing their population of rabbits. A data bank is, being safe up, which will be included in the FAO. A sample of 10 breeds has been chosen (Flemish Gains, French lop, Belgian Hare, Vienna white Champagne Argente, Thuringer,Fauve de Bourgogne, Chinchilla, British) Their zoo technical value (reproduction, growth and carcass traits) had been evaluated on three experimental forms, in comparison with a control breed. At the same time, their genetic polymorphism and genetic distances between these 10 breed are calculated on the basis of the micro satellites, mitochondrial DNA. Other genetic markers and protein poly morphism. Finally, a bank of frozen embryos from these 10 breeds is being constituted. (Bolet *et al*., 1999).

2.3.1 Dwarf Breed:

The smallest breeds, the Dwarfs, vary in size from 1-3/4 to 3-1/2 lbs. they include:

1- Britannia Petite (white, black, black otter, or chestwt agouti) 1-1/2-2-1/2 lbs.

2- Dwarf hoto (white with black around its eyes)2-3 lbs.

3- Jersey woolly (many colors-Angora wool)2-3-1/2lbs.

4- Netherlands Dwarf (many colors)1-3/4-2-1/2lbs

5- Polish (black, blue, chocolate, blue eyed white, ruby eyed white, and broken) 2-3-1/2lbs.

These rabbits, as a group, are less than 3-1/2 pound mature weight. These are the rabbits you will want to raise if you want small pets since they don't consume much feed . (about 1/3-1/2 cup per day) and take up the least a mount of cage space (about 2-1/2 sq.ft).

2.3.2 **Small breeds:**

The next group of rabbits makes up the small size breeds. They vary from a bout 2-1/2 to 5pounds. These rabbits consume between 1/3 and 2/3 cup of feed per day and take up 3-1/2 sq ft. of cage space. The small breeds have characteristics between the dwarfs and the medium size breeds. They usually have 1-3 more babies in their litters than the dwarf breeds.

2.3.3: Medium size breeds:

The next group of rabbits makes up the medium size breeds. This group is characterized by weights ranging from 4-1/2 to 7 pounds mature.

These rabbits consume (100g) of feed per day and take up 5 sq ft of cage space. The medium breeds produce an acceptable a mount of meat. But they usually prefer the next group. The meat rabbits, Because of the high feed conversion ratio rabbits are better for meat production. Usually, those that raise the medium size rabbit like to show them and eat the ones that don't make the grade. Some of those rabbits are raised for their fur as well.

Rabbit that make up this group of medium breeds include the following:

1- American Sable(also good for meat)7-10 lbs

2- English Angora (many color)5-7 lbs

3- French Angora(many color-good also for meat)7-1/2-10-1/2lbs

4- Stain Angora (many colors)6-1/2-9lbs

5- Belgian Hare (not seen much-different body style)6-9-1/2lbs

6- Standard Chinchilla 5-7-1/2lbs

7- English Spot (white with spots of black, blue, chocolate, gold, gray, lilac, or tortoise)5-8 lbs

8- Florida white 4-lbs

9- Harlequin (Has alternative bands of color) 6-1/2-9-1/2lbs

10- Havana (black, blue, chocolate) 4-1/2-6-1/2 lbs

11- Lilac 5-1/2-8lbs

12- Mini Lop (lop ear- many colors) 4-1/2-6-1/2 lbs

13- Rhinelaner (white with spots of black and orange) 6-1/2-10lbs

14- Silver marten (black, blue, chocolate, of sable with white on belly, flanks, jaw lines, and eyes circles) 6-9-1/2 lbs

15- Tan (Blach, blue, chocolate, or lilac with tan on belly, flanks, jaw lines, and eye circles) 4-60lbs

2.3.4 **Meat Rabbits:**

They are characterized by weights between 3 kg and 5 kg. These rabbits are raised for both meat and fur. Some of these may also be considered fancy rabbits because they have unusual fur, color and ear characteristics. Rabbits in the meat group consume a bout 100g of feed per day and take up 7-1/2 sqft of cage space. The rabbits that make up the meat group include:

1- Beveren (Black, Blue or white) 8-12 lbs

2- Californian (white with black ears, nose, feed, and tail) 8-10-1/2 lbs

3- Champagne D`Argent (start as black, mature is silver) 9-12 lbs

4- American chinchilla 9-12 lbs

5- Cinnamon 8-1/2-11 lbs

6- Crème D`Argent 8-11 lbs

7- Hoto (white with black around its eyes) 8-11 lbs

8- English lop (Many colors-gaint lop ears) 9-14 lbs

9- French lop(many colors-regular lop ears)10-15 lbs

10- New Zealand (Black, red, or white) the standard meat rabbit 9-12 lbs

11- Palomino 8- 11 lbs (Raising rabbit)

12- Satin (Shiny coat- many color) 8-1/2-11 lbs

13- Silver fox (far resembles fox) 9-12 lbs

2.3.5: The giants:

These are raised because some breeds are just giants. They can sometimes weight up to 25 pounds. The giants require 1-3/4-2 cups of feed per day and 11-12 sq ft of cage space. The giants breeds also require stronger cages. Because few people raise these rabbits, they are mainly used for meat and fur. The feed-to- meat conversion is less than the meat group. The giants include:

1- Checkered Giant (white with spots of black or blue) weight over 11 lbs

2- Bouscat Gaint white 4-5 Kg.

3- Flemish Gaint (Mostly grey) 6-7 kg. sometime weight up to 10kg (Ghassan,1982).

In the Sudan the Baladi rabbit are raised for meat production. It is of multi coloration, white, black, brown, or grey, live weight range between 1.2-2kg.

Ghassan (1982) classified the rabbit according their production:-

1- For meat production

2- For skin and fur

3- For show

2.4: Classification and Description of the Gut:

In adult (4 to 4.5 Kg.) or semi-adult (2.5 to 3 Kg.) rabbits the total length of the alimentary canal is 4.5 to 5 m. After a short esophagus, there is a simple stomach which stores about 90-100 g. of a rather pasty mixture of feedstuffs. The adjoining small intestine is about 3m long and 0.8 to1 Cm in diameter. The contents are liquid, especially in the upper part. Normally these are small tracts, about 10cm, which are empty. The small intestine ends at the base of caecum. This second storage area is about 40-45 cm long with an average diameter of 3 or 4 cm. it contain 100 to 120 g. of a uniform pasty mix with matter content of about 22 percent . The caecal appendix (of 10-12 cm) has much smaller diameter at the end. Its walls are composed of lymph. Very near the end of the small intestine .are the entrance to the caecum, begins the exit to the colon. The caecum, thus appears to be a blind pouch branching off from the small intestine-colon axis. Physiological studies show that this blind pouch reservoir froms part of the digestive tract, the contents circulate from the base to the tip passing trough the centre of the caecum, then return towards the base, along the wall. The caecum is followed by a 1.5 m colon; this is the creased and dented for about 5 cm.(proximal colon) and smooth in the terminal section (distal colon). The alimentary canal, which develops rapidly in the young rabbit, is nearly full size in animal of 2.5 Kg, when it has reached only 60 to 70 percent of adult weight. Two major glands secrete into the small intestine; the liver and the pancreas. Bile from the liver contains bile salts and many organic substances. The reverse is true of pancreatic juice which contains a sizeable quantity of digestive enzymes allowing the break down of protein (trypsin, chymotryspin), starch (amylose) and fat (lipase). Generally speaking, the length of small intestine (3 to 3.5 m) and its relatively small capacity contrast with that of the storage area (the stomach and the caecum), which hold 70 to 80 percent of the total dry matter content of the digestive tract. The water content can vary markedly from one segment to the next owing to bodily secretion and water absorption (Lebas *et al*., 1997).

The first important compartment of the digestive system of the rabbit is the stomach which has a very weak muscular layer and is always partially filled. After caecotrophy the fundic region of the stomach which acts as a storage cavity for caecotrphs. Thus; the stomach is continuously secreting and the pH is acidic. The stomach pH range, from 1 to 5, depending on site of determination (funds VS Cardiac Pyloric region), the presence or absence of the soft faeces (Griffiths and Davies, 1963), the time from feed intake (Alexander and Chowdhury, 1958) and the age of the rabbit(Grobner, 1982). The absence of the soft faces, after 4 h of diet ingestion, and rabbits older than 5 weeks. The capacity of the stomach is about 0.34 of the total capacity of the digestive system (Portsmouth, 1977). The stomach is linked with coiled caecum by the small intestine approximately 3 m long where the secretion of bile, digestive enzymes and buffers occurs. The pH of the small intestine is close to 7 (Vernary and Ray naud., 1975). The caecum is characterized by having a weak muscular layer and contents with a dry matter of 200 g Kg^{-1}. The PH of the caecal contents is slightly acid (5.6-6.2) (Candau et al., 1986; Carabano et al., 1988). The capacity of the caecum is approximately 0.49 of total capacity of the digestive tract (Portsmouth 1977). The colon can be divided in two portions, the proximal colon (approximately 35 Cm long) and the distal colon (80-100 Cm long). The proximal colon can be further divided into three segments: the first segment possesses three tacniae with the formation of haustra between them, while the second segment has a single tacnia covering half of the circumference of the digestive tube, and the third segment of fusus coli has no taeniae or hamstra is densely enervated. Thus, it acts as a pacemaker for the colon during phases of hard faeces formation (Snipes *et al*., 1982).

2.5: Feed and Feeding Under Tropical Conditions:

One of the advantages of the production in tropical countries is that rabbits can be fed forages and agricultural by production not suitable for human consumption. In general, if available feed stuffs are suitable for poultry production, then it is more efficient to produce poultry rather rabbits. The role that rabbit production can play is in the utilization of fibrous by-products that are useful neither for poultry nor swine, and of forages that may by available in insufficient quantities for ruminants. When these feeds male up the bulk of the diet for rabbit, to use of the small quantity of concentrate feed to improve performance can be justified. The growth performance of the rabbits in studies reported from tropical countries is generally in the range of 10 to 20gm per day, in contrast with the 35-40gm per day which is commonly observed in temperate regions. The lower result in the former case may be attributed to number of factor, including heat stress as well as diet (Lukefahr *et al* 1996).

2.6: Performance:

Feed conversion ratio varies with the types and strain of rabbit. Best feed conversion efficiencies were in the range of 3.25-3 of the meat types (Eissa., 1985).

The success of fattening the Baladi type rabbit in Sudan at equal energy concentration depends on time which is stated in the literature to range between 3-6 months. Assessed on basis of performance (live weight gain, feed intake and feed conversion ratio) best energy protein ratio was 0.19 (2.25 g Mcal/Kg. with 11.96 % cp) (Saad., 1996).

The phenomena of growth are one of the most important processes in practical agriculture. Schloss (1911) defined growth as correlated increase in the mass of the body in definite intervals of time in way characteristic of the species. Brody (1945) defined growth as a relatively irreversible time change in the measured dimension. Desmond (1992) defined growth as the sum of those coordinated biological and chemical processes which start at fertilization of ovum and finish when the body size and physiogical function of the adult animal have been attained.

2.7: Carcass Characteristics:

The economic value of carcass depends upon its yield of saleable meat as well as the cutting and processing quality of the meat. In industry the farmer is evaluated by subjectively assessing the conformation of the carcass and by the amount and distribution of visible carcass fat. Evaluation of the cutting and processing quality of the meat is strongly influenced by local customs and preferences (Devendra and Burn, 1970).

2.7.1: Dressing out Percentage:

The significance of the dressing percentage for both the consumer and the producer is that it defines the saleable part of the animal, the dressing percentage my be calculated on full or empty body weight basis. Factors affecting the dressing percentage include age, nutrition, species, breed and the conditions of weighing.

Population size of rabbits decreased from 2053000 in year 1975 to 1.994000 in year 1980. the deterioration in the population size of rabbit in Egypt may be due to the disease, the unbalanced teed, the lousing and hot summer and the fail in managerial conditions and hygiene control. Local breeds are raised on a small scale and are characterized by small size (1.75 – 3.5 kg adult weight), lower fecundity, poor carcass dressing percentage (48 – 49%), pare or spotted colors, but they are adapted to prevailing climatic conditions (Yamani 1990).

2.7.2: Rabbit meat:

Rabbit meat is high in protein and low in fat, cholesterol, and sodium. The meat is white, fine- grained, delicately floured, nutrition, and appetizing. It is low in calorie content. The size of the carcass, the fine quality of the meat, and the wide range in methods for its preparation make it an excellent and economical meat for use in many seasons of the year. In many areas it is available in the markets either in the cut-up and packaged fresh or frozen form, or in the whole carcass. While there appears to be a preference shown by consumers for the cut-up and packaged product, chefs and those in charge of the meat purchasing for institutions such as hospitals, clubs, and hotels prefer it as a whole carcass form so they may cut it in to suit their own requirements and methods of preparation (Peter *et al.*, 1987).

The consumption of rabbit meat in the ZMCM showed a clearly different pattern for the sample districts of Mexico city and the municipalities of its conurbation. This was probably derived from the outskirts location and this the presence of tourist corridors in these municipalities Buying the product was mainly due to the flavor and its characteristics, while only few people consumed it for nutritional reason.

Other problem was that producters did not after a constant volume of rabbit meat along the year due to technical and sanitary problems. This lack of reliability an offering the product has limited the development of the market (Lopez *et al* 2000).

A large number of rabbits are used by laboratories. Because the animal is small and does not require a large amount of space in the laboratory, and the feeding and core of it is relatively inexpensive. This species is exceptionally well adapted to many types of research. These include performing nutritional studies, testing new medical products, developing information relative to inheritance of malformations, and studying disease. The rabbit is being used more and more in connection with preliminary research tests with the large types of farm animals, and its blood is used quite extensively in making antis era. Rabbits used in research are tested humanly in some cases. As with the controversial Draize test for assessing effects of cosmetic on the eye, alternatives to animal testing are being explored (Peter *et al.*, 1987).

Rabbit's production was introduced in Tanzania in the late 1950s. People started raising them at the farmers training centers where farmers were taught how to take care of them. Rabbit production has spread to the villages and schools. The problem at present is to teach rabbit owners management systems which can lead to maximum returns in terms of meat and pelts on low labour and capital investment. The other problem is that of providing farmers with good breeding animals. The Ministry of Agriculture, therefore looking into ways of importing breeding animals from out side. In Tanzania. Animal Research Scientists in the Ministry and in the university of Dar es Salam have already initiated programs to compare performances of different breeds as well as to produce strains and breeds of rabbits which will do well in the different environments. (Malecela, J, S.1987)

The situation in developing countries is different in that a wide variety of breeds are used for meat production. Different breeds appear to be favored in different countries. In most cases, the use of a particular breed or breeds is purely fortuitous, depending on breeds that were originally available. These breeds were originally introduced to different countries for a variety of reasons (Owen *et al*., 1977). No where has a particular breed of rabbit been selected and developed specially for tropical back-yard conditions. Not with standing this, many of the well-known breeds (i.e. the New Zealand white) appear to have adapted very well to the varied tropical conditions. There is obviously more need for work to determine the most suitable breeds for use under various tropical conditions. It should be pointed out that the requirements of local farmers are often subjective and not always related to the performance of the animal. For instance size and color can play an important part in popularity of a given breed or strain. A larger breed may be preferred even though it may have poorer growth and reproductive performance than other smaller breeds. In Nepal for instance, white is not popular because of it association with pet rabbits. Even within one areas, there can be a diversity of demand with regard to color in rabbits (Craven,1977).

Rabbit carcasses are presented in different ways in different countries. Slaughter yield can vary greatly from one country to another. Yields also vary among breeds, according to age and diet. Slaughter yield improves with age. At a given carcass weight, animals with a high growth rate, receiving more balanced feeds, have a better carcass yield (Lebas *et al*.,1986). If dietary manipulation does not lead to any changes in the growth rate, dressing percentage (DP) remains unchanged dressing percentage, however, the diet should be changed. The improvement of (DP) is always accompanied by increase in the proportion of adipose and sometimes muscular tissue. On excessive feeding of protein, carcass fatness is reduced. The relative growth of tissue is governed by the growth rate, hence body weight determines to body composition regardless of age or nutritional history (Tulloh., 1974).

Rabbit meat is composed of 70 percent water, 21 percent crude protein, 8 percent ether extract, 1% crude ash of which 0.0015% is iron, 0.3% phosphorus, 0.30 % potassium, 0.40% sodium and 1.6 M cal/Kg. of energy (Lebas *et al.*, 1986). The carcass of rabbit has higher protein than other meats and is also similar to poultry although it contains rather more fat than poultry (Abd-Elmotti., 1977).

Rabbit fat contains less stearic and oleic acids than other species and higher proportion of essential polyunsaturated linolenic and linoleic fatty acid (Lebas *et al.*, 1986). No significant differences between different breeds in ash content or moisture of the Longissimus dorsi muscle (Boccignone *et al.*, 1986).

Rabbit meat does not have a strong flavour. It is comparable to, but not identical with chicken (Lebas and Ouhayoum, 1987).

The internal fat in the muscle improves the flavor which develop stronger with age. Muscle tenderness varies with age, and depend on changes in the protein and type of connective tissues supporting the muscle fibers (Lawrie., 1971). The organoleptic properties of rabbit meat supercede mutton, veal and beef in tenderness, juiciness and flavor (Lebas *et al.*, 1986). The rabbit has meat low fiber and it is easy to digest (Shauwir., 1978). Juiciness depends largely on the fat content of the carcass. So intensively rabbits raised have a higher proportion of intramuscular fat which gives the meat a lighter color (Lebas *et al*., 1986). The domestic rabbit meat is superior to the wild especially in fat and fibre content (Saud ford and Wood gate., 1986).

The local Baladi rabbit in the Sudan is an adapted breed to its environment. The small size is an adaptive means of coping with the hot tropical climate. The tolerance and adaptability is reflected by the absence of mortality. The marketed Baladi rabbit might resemble one breed or another owing to the wide differences in color, size, yield and adaptability. Recently crosses of the rabbits with exotic ones in the Sudan market are available, namely with the California and Newzeland white. Average size and weight of these crosses exceed the average Baladi by about 30% (1.5-2 Kg.). Ahmed, 1998 found that the range of body-weight of Baladi rabbits was (1-1.5 Kg.). The cross of the Egyptian Baladi (small size breed) with exotic oues to yield rabbits of weight reaching sometimes 3 Kg. (Alam., 1988). Elamin, 1978, suggested that the fatting cycle for exotic breeds was 70 days). There seems to be no studies determining the length of the fatting cycle for Sudan Baladi type. It is not clear whether the feeding period in this study (70 days) is sufficient, as set for the exotic breeds, to complete the cycle i.e. reaching certain carcass and points (Cross.,1983).

When rabbits are slaughtered at given weight, their body characteristics depend on how quickly they have reached this weight. Rapidly growing rabbits are thus characterized by a smaller relative development of the skin, the digestive tract and the bones as well as by better relative development of the muscles and especially the adipose tissue. They consequently have slaughter yield, muscle/bone ratio, total adiposity and muscle lipid content higher than those of slower growing rabbits. However, rabbits which are characterized by both rapid growth rate and high weight at weaning have a slaughter yield muscle bone ratio lower than slow- growing rabbits which are higher at weaning. They are thus characterized by maturity which corresponds to rabbit with a high potential adult weight. (Dc Blas *et al.,* 1998).

2.8: Rabbit Reproduction:

Reproduction is a complex process which requires hormonal coordination between the male and the female. The primary means of such coordination is through the nervous system and by the hormones, which are substances carried in the blood from special glands to the organs upon which the hormones have their effects. These effects make changes in the organs themselves (such as stimulating ovulation), or one hormone may stimulate the target organ to secrete a second hormone which in turn is carried to another organ where it has effect (Peter *et al.,* 1987).

2.8.1: The male:

The reproductive organs of the male fall into four basic categories: the primary sex organ, accessory sex glands, ducts, and external genitalia. The testes are the primary organs of reproduction of the male. They produce spermatozoa (sperm) and hormones (androgens), which affect reproductive function and behavior. The paired testes are ovoid structures measuring about 35×15 millimeters on average and weighing approximately 2 grams. The tests are essentially sacs of coiled tubules within which the sperms are formed. This process, known as spermatogenesis, involves changes from a rather normal looking circular cell into the highly specialized spermatozoon, which has transmission of genetic information to the ovum as it only functions (Peter *et al.,* 1987).

2.8.2: The female:

The organs of reproduction of the female include the ovaries, oviducts, uterus, cervices, vagina, and external genitalia. The ovary, the primary organ of reproduction of the female, produces the eggs, or ova, and hormones (primary estrogens and progesterone). The ovaries lie within the abdominal cavity, with one on each side near the kidneys. The ovaries components. The central portion or medulla of the ovary consists of connective tissue containing nervous and blood vessels. The outer layer or cortex contains the ova in the various stages of development as well as other types of tissue including blood vessels, nerves and muscle fibers. At the time of the doe's birth, thousands of un development ova are contained in the germinal epithelium layer of the cortex. From the time of puberty until death or the end of the reproductive life of the female, these under developed ova undergo development and shed (Ovulated) or they degenerate (Peter *et al.,* 1987).

2.8.3: Estrus and ovulation:

Does become receptive to bucks at about 3.5 months of age and become capable of conception at 4 or 4.5 months. These ages vary with the breed of rabbit, the smaller breeds generally reaching puberty earlier than the larger breeds. The level of nutrition will also affect the age of onset of reproduction function. It is generally not advisable to breed does during the first month or two that they are capable of reproduction, as they are still growing and the attainment of mature size may be prevented or delayed if the doe is also expected to produce and feed a litter at this time. Rabbits do not have a precise estrous cycle as is found in many other animals. At the time of puberty, follicle –stimulating hormone (FSH) from the anterior pituitary gland begins including growth of the follicles, with corresponding development of ova within them. The ova begin development with a single layer of follicle cells surrounding them. The number of follicular cells gradually increases until numerous layers are present. At follicle develops further, a fluid filled cavity with the ova located in the center upon a hillock of cells. By this time, the follicle has enlarged to such an extent that it bulges from the surface of the ovary. At ovulation the outer layer of follicle ruptures, and the ovum is expelled a long with the fluid. The follicles produce estrogens, which are the hormones that cause the female to be receptive to the male. Follicular development generally occurs in waves. With 5 to 10 folliculars on each ovary at the same stage of development at any time. Follicles continually commence development are always present. When follicles reach mature sex, they actively produce estrogens for about 12-14 days. After this period, if ovulation has not occurred, these follicles will degenerate with corresponding reduction in the estrogen level. After about 4 days a new wave of follicles will begin producing estrogen, and the doe will become receptive once a gain. The doe thus has a cycle of 16-18 days, with about 12- 14 days of receptivity and 4 days when the doe will refuse to mate. This timing is extremely variable due to individual differences, sexual stimulation, and environmental factors such as nutrition, light, and temperature. Ovulation in the rabbit occurs only after induction by an external stimulus such as mating intense sexual excitement or mounting on the doe by other rabbits may also induce ovulation. This may result in a condition known as pseudo pregnancy, which will be discussed below (Peter *et al.*, 1987).

2.8.4: Body cells and germ cells:

Cells are broadly classified into body cells and germs cell. Body cells are found in the main structure of the animal whereas the germs cells are the spermatozoa (sperm) of the male and the ova (eggs) of the female. Each animal species has a definite number of chromosomes and these are arranged in pairs (called homologous) in the cell nucleus. For example: the rabbit has 44 (22pairs). The formation of these chromosomes in the cell nucleus is now a well documented routine. It is possible to have chromosomes examined (called kartyping) for defects of shape or missing parts. This is especially valuable in human genetic counseling, for example to predict the chances of parents producing abnormal children (Dalton., 1985).

2.9: Maternal environmental:

Breeders are very much concerned with the effects of the maternal environment that a mother provides for her offspring from conception to birth and thereafter up to warning. It affects the offspring's phenotype and not its genotype. The genotype of an animal cannot be affected greatly. An erroneous belief was that the physical environment of the dam could affect its offspring's genotype. It is most important to be aware of situations where improved performance in an offspring may appear to be due to superior genotype but is in fact caused by the maternal environment. The problem of maternal environment is especially important where litters of offspring are involved. Here litter size and hence competition in uterus before birth can limit subsequent genetic expression of growth traits (Dalton, 1985)

2.10: Breeding methods:

Breeding methods are divided broadly into close breeding which is the mating of related parents, and out breeding which is the mating of unrelated parents. The classification of different breeding methods was described by (Dalton 1985) as follows.

Classification of different breeding methods:

Close breeding (mating relatives)	Outer breeding Mating non-relatives
Inbreeding	Crossbreeding
Line breeding	Outer crossing
	Backcrossing
	Top crossing
	Grading up
	Mating likes
	Mating unlikes

- Inbreeding:

Inbreeding is the meeting of animals that are more closely related to each other than the average of the population i.e. mating animals that have one or more ancestors in common. Inbreeding simply reduces the number of gene pairs that are heterozygous in the population and increases the population of gene pairs that are homozygous, regardless of whether they are good or bad (Pichner., 1969).

- Line breeding:

Line breeding is like another form of inbreeding: it is often described as slower inbreeding in which the breeder aims for the benefits while trying to avoid troubles. It is trying to make haste slowly, or is like a ratchet mechanism holding known benefits while slowly trying to gain more merit one noch at a time.

- Out breeding:

Out breeding is the very opposite to close breeding: it is the mating of animal that are less closely related than the average of the population from which they came. It is the standard methods of increasing variation, both phenotypic and genetic, in the population. The heterozygosity of the population is increased lay out breeding and as a result, general fitness and adaptation of the animal to its environment are usually seen. The different types of out breeding are as follows:-

- Crossing species:

This has not been widely exploited in animal production because of the technical difficulty of getting species with different numbers of chromosomes to cross. The sperm may fertilize the egg but generally embryo survival is low. If the species cross survives to sexual maturity then it is usually sterile. Many species crosses are mainly of zoological interest at present, for example: lion ×tiger=liger.

- Crossing breeds:

This is the most common technique used throughout the world. Cross breeds generally perform better than the basic pure breeds in reproductive traits. A major practical problem with crossbreeding is remembering at what stage of the cross each animal is. This means that a recording scheme is essential for parentage as, well as performance.

2.11.3: Crossing line:

This is where strain, lines or families are crossed within or between populations.

- Crossing inbred lines:

Here specially produced inbred lines are crossed within population. It is sometimes called in cross breeding.

- Out crossing:

A breeding makes an out cross when he brings in some new genetic variation- often called `new blood`-into his flock or herd, and this is usually done by buying in a new drastic a change is needed. A breeder may buy a sire from another breeder with a similar programmer,this would be called a mild outcross- or he may obtain a sire from vastly different source and make a more severe outcross.

- Back crossing:

As described earlier, this is where a crossbred offspring is bred back to one of its parents, which are usually pure breds. It is often hoped that back crossing will hold some of the benefits of the F1 cross.

- Top cross and Gardening up:

These two techniques are very similar. A top cross is made when breeder goes back to the original genetics source of the breed of the breed or strain for some new genetic material.

Grading up is one breed is changed (graded up) to another by continued crossing. It has been wildly used throughout the world where ´native` stock were graded up by a number of crosses with registered sires of improved breeds. Most breed associations accept four generations of crossing with a registered sire as purebred status.

- Mating likes:

Mating likes is also called assortative mating. It is a very old technique and is still used today. In theory it means more than mating best to best; it must also mean mating worst to worst and average to average. These terms ´best` ´average` and ´worst` do not always refer to productive traits: they are generally more applicable to the phenotype of the animal.

It is a technique usually confined to mating best to best and is generally concerned with visual characteristics.

Lush warned against confusing assortative mating with inbreeding. The former is mating animals that have similar looks, while the latter is mating animals that have similar genes. He also pointed out that mating likes was not efficient in altering gene frequency compared to other selection and mating locks (Dalton., 1995).

2.11: Rabbit breeding systems:

In most rabbit herds some type of breeding system is consciously practiced. In breeding, line breeding, out crossing, cross breeding and random mating are the most common breeding systems currently utilized each of these breeding systems, to some extent, manipulates the amount genetic variation present in a rabbit population for traits of selective interest. The best breed system, for a rabbit producer depending on many factors. Initial genetic quality of the base herd, type of operation (fancy vs. commercial), economic, the physical environment in which production occurs, and personal preferences are a few such factors. For example, within a quality line of Britannia petites, line breeding may be the described breeding system. Regardless of which breeding system is used, one essential record in maintaining knowledge of the breeding background of an animal is the pedigree. A pedigree is a simple description of the ancestry of an individual. In this style, the upper ancestor for each bracket is the sire or male line for that particular mating and the lower, is the dam or female line. Each ancestor is shown separately for every mating involved which comprises the individual. In the discussions, of breeding systems, the relationship of two individuals can be expressed numerically as the percentage of genes the two have in common. These relationships are affected by the breeding system used and may vary from zero (no genetic relationship) to 100% (complete genetic relationship). Using the extremes as examples, two rabbits of different breeds could have a 0% genetic relation, while two rabbits which are identical twins would have a 100% genetic relationship. Relationship of 25% or greater are generally considered close in rabbit breeding. In addition, two individuals may share multiple relationships, for example, being related as both uncle- nice and cousins. In more sophisticated, large purebred rabbit operations the development of computer programs which are capable of drafting both bracket- and arrow- style pedigrees for the entire rabbit herd would be useful. The genetic relationship coefficient is the percentage of genes that an individual has in common with its dam, since it received half its inheritance from its dam at the time of fertilization. As the number of generations between a rabbit and one of its ancestors increases, the percentage of genes in common with that ancestor decreases proportionally at the rate of one- half per generation [$(1/2)^n$}, where n the number of generations. For example an individual is related to its sire by 50% [$(1/2)^1$], its grand- sire by 25% [$(1/2)^2$], and its great- grand- sire by 12.5% [$(1/2)^3$]. First cousins share the inheritance from one set of grand- parents, and double first cousins by a relication of the same set of grandparents (Peter *et al*., 1987).

There are many exciting possible developments in breeding. First there are the combinations of specially bred lines to give good reproductive performance on the female side, but with good meat characteristics in the slaughter generation. The best sire lines combine good distribution of meat with good meat quality. The possibilities for genetic engineering or highly selective breeding are illustrated by the potential of certain of the rabbit breed. If, for example, their greater prolificacy and sexual precocity could be transferred to the advanced breeds, without too great a cost in term of growth and efficiency, then there would be an enormous increase in potential. Genetic engineering might also be used in other ways. For example, it could be used to enhance the effects of natural growth substances, such as somatotrophin, or perhaps improve the immune system of animals to make it even more effective and so reduce losses due to poor performance. The possibilities are endless, but all are subject to the procedures and the products being acceptable to the consumer. Some studies in Australia have concentrated on the possibilities of producing animal which are capable of synthesizing limiting amino acids by introducing the genetically engineered pathways which are present in much simpler types of animals. This includes the synthesis of the sulphur amino acids in sheep and lysine in pigs (Lawrence *et al.*, 1997).

There are advantages to breeding animals for subsequent group housing "in-houses" land stauffechar,(1989,1991,1992) has published an interesting description of practical group breeding systems.

Consideration has to be given to the best strain of rabbit to use in research, but it is also important to select the best individuals for use in a breeding programmed, since there is some evidence that aggressive behavior is genetically determined (Krat.,1979).

It is important to select animals for their docility and ease of handling, and for being neither too dominant nor too fearful of other animals. A high reproductive index and growth rate might be desirable from the point of view of the breeder, but case should be taken as this may not be in the best interests of the animals or the science.

A rate of between 2 and 5 females to one buck has been found to be acceptable. One the male has mated he can be removed. One box per female should be provided so that each doe has the option of nesting alone, as is most typically the case.

Rabbits have also been successfully bred in groups with one buck and two females sharing the same pen. It is the does rather than the buck that are likely to kill the pups and the female must have neared together for this method to be successful. Domestic rabbits can live for 10-12 years (Notan *et al.*, 1993).

Individual rabbits vary some what in the rapidity with which they develop, so both development and age must be taken into consideration in determining the proper time to start them in production. Sexually, the smaller breeds mature much earlier than the heavier breed, the small polish usually being ready to start production at four months of age, the medium weight New Zealand, Californian, etc., at five to six months, and the heavy Flemish at six to seven months of age (Peter, *et al., 1987*).

The age of sexual maturity in rabbits varies with breed, size and can range from (4-12) months, often small breeds can be bred earlier than medium and large breeds.(Ewer,1982; Lebas *et al*.,1997).

Does generally reach sexual maturity earlier than the buck, and breeders always allow bucks to grow one month longer than does before using them for breeding.(Lebas,1997).

2.12: Number of Bucks:

Traditionally 1 buck for every 10 does has been used. This underutilized the buck and increases costs of operation. Research has demonstrated that the sperm count does not decrease below the level for optimum fertilization even when the buck is used daily for extended periods of time, or three or four times a day for a few days. The bucks should not be overfed. They should be on restricted feed, but when they are working hard and during the winter, they should be fed about all they can consume. The greatest cause of the decreased libido (sexual desire) in bucks is due to overweight (Peter *et al*.,1987) .

A ratio of between 2 and 5 females to one buck has been found to be acceptable (Morton *et al*.,1993).

2.13: The estrus cycle:

In most domestic mammals ovulation takes place at regular intervals when the female is in heat or estrus. The intervals between two periods of estrus represent the length of the estrus cycle (four days for rats, 17 days for ewes and 21 for cows). The female rabbit, however, does not have an estrus cycle with regular periods of heat during which ovulation will occur sponata neously. Does are considered to be in estrus more or less permanently. Ovulation occurs only after mating. A female rabbit is therefore considered to be in heat when she accepts service and in dioestrus when she refuses (Lebas *et al*., 1997). The female rabbit does not have an estrus cycle with regular heat period (James, 1988). Therefore the doe is considered on heat when she accepts service and dioestrus when she refused (IFS, 1978).

Ovulation is normally induced by the stimuli associated with coitus and occurs (10-12) hours after mating (Moret, 1980).

2.14: The mating process:

The doe gives evidence of being in heat by behaving restlessly; by rubbing the chin (chinnig) on the cage, water crock,feed troughs, etc.; and by making an effort to join other rabbits in nearby cages. The appearance of the vulva, whether it is pale or pinkish in color, is generally indicative of the receptivity of the doe. A doe with a dry, pale vulva is less likely to be receptive than one with a pinkish red, moist vulva. The doe is likely to another rabbit being placed in her own cage and quite often will attack and even injure the intruder, so she should always be taken to the buck's cage for mating. If she is ready for service and the buck is active, mating should occur almost immediately. When it is completed the buck usually falls over on his side. Because the buck's ejaculation occasionally misses the vagina, the doe should be bred twice before being returned to her cage.(Peter *et al.*,1987).

Strong smelling cleaning agents should also be, kept in mind that the small of a previously handled rabbit on clothing may be strong and cause adverse effects, especially when nervous rabbits are handled subsequently. These general recommendations may be more critical at times when a rabbits is particularly sensitive to odor, e.g. in the pregnant or postpartum doe, or when hierarchies are being established. Rabbits are able to detect sounds inaudible to humans (Ultra Sound). They are particularly sensitive to sounds between 2-16 KHz and can detect noise up to 42 KHz (Fay, 1988).

Breeding in the morning is the best, and if the does nest box is closed off, does should be bred before allowing sucking. These two actions avoid the circadian variation of prolactin level around 1500 to 1900 hours. The rise in prolactin during and after sucking has a negative effect on receptivity (Mc Nitt, 1992).

Young does should be bred to new bucks. If a normal doe refused the buck, she can be force mated, but usually the conception rate in this cases will be very low even if the mating is successful.(Berepube *et al*.,1993).

2.15: Gestation period:

The gestation period, or time from successful mating of the doe to kindling of the litter, averages 31 days. About 98% of normal litters will be kindled between the thirtieth and thirty- third days, but a small percentage may be kindled as early as the twenty- ninth or as late as the thirty-fifth day. In cases of prolonged gestation, the litter may contain only few individuals with one or more abnormally large kits. Often the young may be born dead.(Peter *et al*.,1987).

2.16: Pseudo pregnancy:

Pseudo pregnancy can result from a sterile mating or from stimulation caused by one doe riding another, or by a doe riding the young in her own litter. This condition lasts for about 17 days (Peter *et al*., 1987).

Lebas *et al*. (1997) reported that if does are kept together for longer than 3 months, they may show signs of sexual maturity by riding one another, frequently fighting and developing periods of pseudo-pregnancy which may affect conception.

Sometime false pregnancy (pseudo-pregnancy) occurs when a normal receptive doe is mated and conception has not occurred or even she is ridden by other does.(Berepube *et al.*,1993;Harkness and Wagner,1983) during the period of false pregnancy which may extend to 17 days, the doe will not conceive even if it is mated with a fertile buck.(Labas *et al*.,1997).

2.17: Litter size and fostering:

Dim *et al*. (1990)found that the greater the number of kids per litter, the shorter the gestation length and McNitt and Moody(1991)who found that as litter size increased from 2 to 14 kids, gestation length declined from 33.83 to 31.40 days.

The mean weight of litter born alive was highest for the does that delivered higher number of kids. The mean litter weight born alive ranged between 359.49 and 586.28 g. for the does that delivered less than 5 kids and more than 10 kids, respectively. Moreover, litter size at 21 days of age and at wearing (8.86 and 8.84, respectively) was higher for the does that delivered more kids alive (El-sheikh *et al*., 1994). Similar observation were reported by Khalil and Khalil(1991).

Frequently does give birth to a large number of young than they can nurse. It is good herd management to foster does's excess kids to another doe with a smaller litter. In raising Angoras for the meat market, there is a distinct advantage in reducing the size of the large litter to the number that the doe can develop uniformly; in the case of show rabbits it is especially important to reduce the litter even to four or five so that the young can have an opportunity to develop to the maximum of their inherited possibilities. In order to distribute the transferred young for fostering, it is advisable when planning the breeding program to mate the does so that several will kindle as near possible to the same mate. The new born litter should be inspected as soon as possible after the doe has quieted down following kindling, and a memorandum made of the number to be removed from or added to each litter. When all the does due at that time have kindled, the surplus young should be removed and permanently marked with a tattoo, ear punch, etc., so that the transferred young in each litter can be identified at weaning. When transferring the young, it is not necessary to use any method for destroying the scent of the human hand or scent of the dam of the young being transferred. Does do not make any distinction of young, even if they are of different color or size. When selecting litter for fostering, it is advisable to watch carefully for any evidence of infection among the litters or does, as the transfer procedure could be a means for spreading disease. Under no circumstances should kids be fostered from a doe with mastitis to another doe, because the young carry the bacteria and will infect the mammary gland of the foster mother (Peter *et al*., 1987).

Chapter three

Material and Methods

A survey and two Experiments were designed for this study as fellows:

3.1: Survey for investigation of rabbit breeders in Sudan:

The survey cover following points:

- Types of rabbits.
- Productivity.
- Husbandry.
- Feeding.
- Marketing.

3.2: Experimental One:

3.2.1: Experimental animals:

40 females and 10 males adult local Sudanese baladi rabbits were selected and purchase from Khartoum North Market and Elhag Yousif market.

10 females and 2 males New Zealand white rabbit four months and average white 1972.2, 2780 gm respectively. The New Zealand white were obtain from Balasm Company for Medicine and Drugs at Khartoum North Industrial area rabbit, with average live weight 1277.59gm and 1400gm respectively.

On arrival at Kuku Research, Station all the experimental rabbit were treated with ivomic for control of internal and external parasites and ear tagged.

3.2.2: Housing:

Rabbits were housed in a large room with dimensions (16×8×4 meters). The animals were kept in 4 Cages (250×170×60 cm). Pregnant does were kept in individual cages size (50×40×50 cm). Cages were provided with nests each (40×30×50 cm). Concrete floors were used to facilitate easy cleaning.

3.2.3: Feeds:

The animals were fed ad libitum on complete diet composed of 58% dura, 22% groundnut cake, 8%wheat bran, 5% calcium, 2% salt, and 5% molasses were added to improve palatability and avoid some respiratory problem which may arise due to mash diet of feed (Ahmed,1998), as shown in table (1).

3.2.4: Design of the experiment:

The experimental rabbits were randomly allocated into four groups with five does in each group as follows.

Group I:

Does from the Baladi breeds were serviced by the baladi bucks to produce pure F_1 Baladi (P.B)

Group II:

Does from New Zealand white were mated by New Zealand bucks to produce pure F_1 New Zealand (N.N.)

Group III:

Does from baladi were crossed by New Zealand bucks to produce F^1 (B.N.).

Group IV:

Does from New Zealand white were crossed with Baladi bucks to produce F^1 (N.B.). Age of service and body weight of each doe and buck were recorded.

First generation of the rabbits from the four mentioned experimental group were raised together until they reached three months of age.

Table (1) Ingredients Percentage of the Experimental Diet and its Chemical Composition:

Item (Ingredients)	Percent
Dura	58
Groundnut cake	22
Wheat bran	8
Calcium	5
Salt	2
Molasses	5

Determined chemical composition:

Crude Protein	18.05
Crude fiber	5.64
Ether Extract	3.5
Ash	3.9
N.E.E	68.01
Dry Matter	93.2
Metabolizable energy	(MJ/KG) 11.96

* Calculated according to Ellis (1981).

In all the mentioned mating, the does were introduced to bucks (Labas, 1983, Sandford and Woodgate,1986) and breeding normally take place in the morning (MCN,1992). Then the doe is returned back to its cage after a few minutes after mating once again.

Once again the doe was brought to the buck (one hour later) for coitus to increase the possibility of conception (El-Dara wany and Abd-El Hafiz, 2000).

3.2.5: Management:

Rabbits were observed for any signs of disease or digestion disorders. Feeders and drinkers were cleaned regularly. Daily cleaning of the cage with the removed of the waste.

- Pregnancy diagnosis (by palpation) was always done on day 11 after mating and rechecked on day 25 for confirmation. Non pregnant does were re-mated when ever they show signs of heat such as swelling of the vulva (Berepubo *et al*.,1993) or if they show any other signs indicating their acceptance of the buck.
- On day 28, the nest was cleaned and prepared for kidding by adding a bout 2.5 cm. of wood shavings on the bottom and sides.
- Animals with infertility problems and cage floor sours are checked at the first day after kindling for detection of litter size, still births, young born out-side the nest.. ete.
- Weighing of the does before and after kidding.
- Weighing of the new born kids at first day of kidding by using a sensitive balance.
- On day 15 the bedding of the nest was removed and changed by new wood shavings.
- Weaning weight was taken at age of 35 days.
- Sexing was always done at 3 months of age then males were separated from females.

3.3: Slaughter procedure and Slaughter data:

Ten Baladi males rabbit and equal number of females with average live weight 1220gm of males and 1295gm of females were bought from local market, they were weighed individually and left to rest for 24 hours before slaughtered.

The procedure of slaughtering followed the local Muslim practices, i.e. by severing both the jugular veins and carotid arteries by a sharp knife without stunning.

3.3.1: Dressing procedures :

Rabbits were skinned and eviscerated as soon as possible after sacrificing and while the carcass is warm.

3.3.2: Skinning procedure :

-Removal of the head at the atlas joint.

-Removal of the fore feet at the carpus/ radiusulna joint.

-Cutting of the tail

-Severing the left hind feet at the first joint.

-Cutting the pelt around the right rear leg at the hock.

-Slitting the pelt inside the leg from the hock to the base of the tail.

-Cutting fat away from pelt down off the carcass.

-Rinsing the carcass with high pressure cool

($< 40\ ^{o}F$) water.

After dressing and eviscerating, the internal organs and offal were removed and weighed. The carcass was weighed and chilled for overnight at $4^{0}c$.

3.3.3: Cutting the carcass:

After chilling, the cold carcass was weighed and cut following the procedure of Paul.P.G. (1998).

1- Legs: Remove rear legs and tail.

Cut parallel to and on each side of tail forward until knife contacts leg bones.

Cut perpendicular to spine in front hip joint on each leg.

Remove by twisting to separate joint.

Cut through spine to remove tail and tail head.

2-Back and Flanks:

Cut through spine and long ribs.

3-Front legs:

Remove through the natural seam between the fore leg and ribs.

4- Ribs:

Split the ribs with cleaver or large knife by cutting through and parallel to the spine.

3.3.4: Sample preparation for chemical analyses:

Left hind muscles were dissected for chemical analysis. Sample for chemical analysis were immediately minced and stored at -10^{o}C waiting analysis.

3.3.5: Meat Chemical composition :

Proximate analysis:

Determination of total moistures ash, total protein and fat (ether extraction) were performed according to AOAC (1980) procedures.

3.4: Statistical analysis:

Data were examined and analyzed by using SAS (1996) package. Mean and variances of various traits studied were estimated. Hybrid vigor was calculated as deviation other mid- parents from the hybrid. The genetic analysis was carried out using Harvey's (1990) Least Squares and Maximum Likelihood Programmed. The models used were as follows:

Model 1:

$$\mathbf{Y_{jj} = \mu + S_i + b_1(X\text{-}X) + b_2(X\text{-}X)^2 + e_{jj}}$$

Where:

Y_{jj} = The observation on the j^{th} litter from the i^{th} sire.

μ= The overall mean of cumulative weight or cumulative weight gain

S_i= The random effect of the i^{th} sire.

b_1, b_2 = The linear regression and quadratic regressions on litter size.

X, X = The litter size and average litter size, respectively.

e_{jj}= The random error term associated with each observation (mean= 0 and variance= σ^2)

Heritability estimates were obtained from the sire component, dam component, and from full sibs. The heritability was calculated from the intra-class correlation in the following manner (Becker, 1985):

$$h^2_{phs}=4\sigma^2 s/(\sigma^2 s+\sigma^2 d+\sigma^2 w)$$

Where: h^2_{phs}= The estimate of heritability based on paternal half sibs.

$\sigma^2 s$= The variance component between sires.

$\sigma^2 w$= The variance component within dams within sires.

$$h^2_{mhs}=4\sigma^2 d/(\sigma^2 s+\sigma^2 d+\sigma^2 w)$$

Where:

h^2_{mhs}= The estimate of heritability based on paternal half sibs.

$\sigma^2 d$= The variance component between dams.

$$h^2_{fs}=2(\sigma^2 s+\sigma^2 d)/(\sigma^2 s+\sigma^2 d+\sigma^2 w)$$

The correlations were estimated from the sire component of variance and covariance in the manner described by Becker (1985) as follows:

The genetic correlation:

$r_G = cov_s / \sqrt{(\sigma^2_{s(x)} . \sigma^2_{s(y)})}$

The environmental correlation:

$r_E = cov_w - 2cov_s / \sqrt{(\sigma^2_{w(x)} - 2 \sigma^2_{s(x)})} . \sqrt{(\sigma^2_{w(y)} - 2 \sigma^2_{s(y)})}$

Where x and y stand for the two traits whose correlation is being calculated.

Model 2:

$Y_{jjk} = \mu + S_i + D_{ij} + b_1(X-X) + b_2(X-X)^2 + e_{jjk}$

Where:

Y_{jj} = The observation on the kth offspring of the jth dam and the ith sire.

μ= The overall mean of cumulative weight or cumulative weight gain

D_{ij} = The random effect of the jth dam within the ith sire.

The remaining terms as in model 1 above.

Chapter four

Results

4.1. Survey of rabbit breeders in the Sudan

4.1.1. Type of rabbits in Sudan:-

4.1.1.1. Baladi types:

The baladi is small in size weight range from 1000-1500 gm. Body is covered with short fur and multi colored.

Productivity:

An adult female can give birth to 5-8 young ones per litter.

4.1.1.2. Roomi:

This type is covered with relatively long fur. It is multi colored and larger in size compared to the Baladi type.

Productivity:

Is lower compared to the Baladi type, an adult female produce 3-5 young ones per litter.

4.1.1.3. French:

This an another local name for the Newzealand white breed, which is an inter nationally recognized breed. It is rare in local rabbit markets.

4.1.1.4. Wild type:

It is brown in color, larger than the Baladi type and is rarely found in the market.

4.1.2. Rabbit husbandry:

Rabbit rearing is practiced as a hobby by some people. Rearing methods are mainly traditional where rabbits are left to wonder freely in a large area or around houses. This type of rearing is done in suburban areas and villages.

4.1.3:Feeding:

Depends mainly on scavenging around the rearing area or houses. Some producer offer food left-oves, cereals and green fodder such as barseem.

4.1.4:Marketing:

The marketing of rabbits is rather slow. Total sales will not exceed 30 pairs / day in the three markets of the capital Khartoum. However, sales rise in certain occasions such as in Christmas and new year celebrations where rabbit meat is consumed in greater numbers by Christians. Asians and other consumers. Local people do not prefer rabbit meat with the exception of hunters or those who depend on wild rabbit as a meat source in some rural areas. Rabbits are usually marketed at ages of 3-4 months.

4.1.5: Prices:

Prices varying between 1500-2000 Sudanese Dinars for a pair of rabbits in the normal marketing days and my jump up to 3000-4000 Sudanese Dinars a pair during Christmas and new year celebration.

4.1.6: Disease:

Some of the most important disease of rabbit are the following:-

4.1.6.1: Mange:

It is a parasitic disease of rabbits and other animals. It occurs in two forms. The ear form and skin form. It is characterized by scab in the affected areas.

4.1.6.2: Coccidiosiss:

It is a parasitic disease of rabbits caused by coccidia. It is characterized by diarrhea, loss of body condition and anorexia. Heavy infestations lead to high mortality rates in young rabbits.

4.2: Experiment One:

4.2.1: pre-weaning and Post-weaning traits:

Table (2) shows the data related to pre-weaning and post-weaning traits.

Litter size at birth was no significant deference's, put slightly greater in cross 5.0 than New Zealand white 4.30 and Baladi 3.92 young/liter.

Liter size at weaning in Baladi, New Zealand and cross was 2.82, 1.60 and 3.60 respectively. The differences was significant ($P<0.05$).

The birth weight in Baladi, New Zealand and cross was 44.7gm, 54.99gm and 57.40gm respectively. The differences was highly significant ($P<0.001$) between Baladi and two group (New Zealand and cross).

The average weaning weight in Baladi, New Zealand and cross was 373.01gm, 729.69 and 823.33 respectively. The differences was significant ($P<0.001$).

The pre-weaning gain in Baladi, New Zealand and cross was 9.81gm, 20.27 and 16.17gm/day respectively. The differences was significant ($P<0.001$).

The post- weaning gain was no significant differences but greater in New- Zealand (10.77gm/day) than Baladi (7.38gm/day) and cross (7.83gm/day).

The mature weight in Baladi, New Zealand and cross was 1277.59gm, 1972.20gm and 1500 gm respectively. The differences was significant ($P<0.01$) between New Zealand and two groups (Baladi and cross).

The per- partum weight in Baladi, New Zealand and cross was 1749.14gm, 5305gm and 3400gm respectively. The differences was significant ($P<0.001$) but no significant differences between New Zealand and cross.

The post- partum weight in Baladi, New Zealand and cross 1640.02gm, 3280gm and 3270gm respectively. The differences was significant ($P<0.001$) between Baladi compare with New Zealand and cross.

The gestation period in Baladi, New Zealand and cross was 31.76 day, 31.4 and 32.0 day respectively. The differences was significant ($P<0.05$) but no significant differences between Baladi and New Zealand.

The mature sire weight in Baladi, New Zealand and cross was 1400gm, 2780gm and 1450gm respectively. The differences was significant ($P<0.01$) between New Zealand and two groups (Baladi and cross) but no significant differences between and cross.

Table (2): Means and standard errors of pre-weaning and post–weaning traits

Genetic Group	Baladi		New Zealand		Cross bred		Level of (P)
No.	**29**		**10**		**5**		
Trait	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Liter size at birth	3.92[a]	± 1.39	4.30[a]	±2.36	5.00[a]	±1.87	N.S
Liter size at weaning	2.82[a]	± 1.26	1.60[b]	±1.17	3.60[c]	±1.67	*
Birth weight(g)	44.79[a]	± 6.12	54.99[b]	±6.53	57.40[b]	±2.79	***
Average weaning weight(g)	373.01[a]	±127.6	729.69[b]	±116.1	823.33[c]	±131.9	***
Pre weaning gain(g/day)	9.81[a]	± 3.28	20.27[b]	±1.74	16.17[c]	±3.76	***
Post weaning gain(g-day)	7.38[a]	± 4.63	10.77[a]	±5.19	7.83[a]	±1.06	N.S
Mature weight(g)	1277.59[a]	± 591.8	1972.20[b]	±508	1500.00[a]	±79.05	**
Pre-partum weight(g)	1749.14[a]	± 159.59	3505.00[b]	±529.91	3400.00[b]	±266.93	***
Post partum weight(g)	1640.017[a]	± 177.2	3280.00[b]	±474.45	3270.00[b]	±323.27	***
Gestation period(day)	31.76[a]	± 0.44	31.4[a]	±0.84	32.00[b]	0.00	*
Mature sire weight(g)	1400[a]	± 74.4	2780[b]	±147.6	1450.00[a]	±35.4	**

In this and sub sequent tables:

*: P < 0.05

**: P<0.01

***: P<0.001

N.S: Not Significant

Table (3). Mean of hybrids compared parents:

Trait	Hybrid	Mean of parents	Difference (hybrid vigor)
Litter size at birth	5.00	4.11	0.89
Litter size at weaning	3.00	2.21	0.79
Birth weight (g)	57.40	49.89	7.51
Average weaning weight (g)	823.33	551.35	271.98
Pre-weaning gain (g/day)	16.17	15.04	1.13
Post-weaning gain (g/day)	7.83	9.08	-1.25
Mature weight (g)	1500.00	1624.85	-124.85
Pre-partum weight (g)	3400.00	2627.05	772.95
Post-partum weight (g)	3270.00	2460.00	810.00
Gestation period (day)	32.00	31.58	0.42
Mature size weight (g)	1450.00	2090.00	-640.00

4.3: Table (3) show the mean of hybrids compared of parent:

The hybrids vigor in liter size at birth and weaning was 0.89 and 0.97 respectively. The difference between the mean of parents and the hybrid in the birth weight and average weaning weight was 7.51gm and 27.89gm respectively.

The hybrid in pre – weaning gain was 1.13g/day, while in post weaning was -1.25g/day. The difference between the hybrid and mean of parents in pre- partum weight and post-partum weight was 772.95gm and 810.0gm respectively.

In gestation period hybrid record 0.42/day while in nature size weight was -642gm.

4.4 Carcass characteristics and composition of baladi rabbits:-

Table (4) shows data related to carcass characteristics and composition of the Baladi rabbits. The slaughter weight in males was 1220g. and in female was 1295 g. but was not significantly different. The hot carcass weight was not significantly different, but tends to be higher in female. The cold carcass weight was 525 g. in males and 595g. in females which was slightly higher in females. For Carcass shrinkage was not difference between males and females.

4.5: Body components of baladi rabbits:

Table (5) shows the body component of baladi rabbits as percentage slaughter weight. The stomach (full, empty) and intestines (full, empty) was significantly different in males and females. The head and fore feet where not significantly different in those components. Skin and heart were significantly ($P<0.05$) higher in males than females. Liver was significantly ($P<0.05$) heavier in females. Lung, kidneys- knob fats were not significantly different.

Table (4). Carcass characteristics and composition of baladi rabbits

Trait	Males			Females			
	No.of animals	Mean	S.D.	No.of animals	Mean	S.D.	(p)
Slaughter weight(g)	10	1220	±308.00	10	1295	±309.50	N.S.
Empty body weight(g)	10	1025	±284.77	10	1017	±268.90	N.S.
Hot Carcass weight(g)	10	605	±204.70	10	665	±198.68	N.S.
Cold Carcass weight(g)	10	585	±205.9	10	650	±189.20	N.S.
Carcass shrinkage(%)	10	3.31	±0.91	10	2.25	± 0.7	N.S.
Dressing%	10	49.59	±15	10	51.35	± 19	N.S

Table (5). Body components of rabbits as percentage of slaughter weight

Trait	Males			Females			
	No.of animals	Mean	S.D.	No.of animals	Mean	S.D.	(p)
Stomach full (%)	10	7.2	2.26	10	8.57	3.32	N.S.
Stomach empty (%)	10	0.911	0.15	10	0.94	0.31	N.S.
Intestine full	10	14.01	5.60	10	14.24	4.20	N.S.
Intestine empty	10	3.72	1.76	10	6.77	8.76	N.S.
Head	10	11.68	1.99	10	1051	2.26	N.S.
Four feet	10	5.2	1.16	10	4.76	1.66	N.S.
Skin	10	9.53	2.50	10	8.06	2.00	*
Liver	10	2.1	0.58	10	2.49	0.57	*
Heart	10	0.24	0.06	10	0.19	0.05	*
Lung diaphragm and trachea	10	0.47	0.08	10	0.51	0.09	N.S.
Kidney	10	0.44	0.09	10	0.39	0.12	N.S.
Kidney knob fat	10	0.23	0.16	10	0.35	0.09	N.S.
Gut fill	10	1.47	0.66	10	1.39	0.72	N.S.

4.6: Carcass composition:

4.6.1: Yield and commercial cuts:

Table (6) shows yield and commercial cuts from carcass side of baladi rabbits. Joint as leg, Ribs and front leg were not significantly different in male and female baladi rabbits. Back and Flank were slightly heavier in males but were not significantly different.

4.6.2: composition of various joints :

Table (7) shows the composition of various joints of baladi rabbits as percentage of cut weight. The proportion of muscle was generally higher in all joints in males than female. There was no significant difference between males and females.

The bones were heavier in the front legs of males ($P<0.05$) than females. Non- significant differences in bones were found in the legs, ribs, back and flank.

4.7: chemical composition of the Meat:

Table (8) gives to chemical composition of both males and females Baladi rabbits muscles determined on fresh muscle base. The percentage of moister content was not significantly ($P> 0.05$) lower for females and compared with males. The protein showed the trend as moisture percentage but it was lower in males than the females.

The ether extract (fat) and ash content between the muscles of the two sexes was significantly difference ($P<0.05$) the muscles of the females had significantly ($P<0.05$) higher ether extract than males but the ash content higher in the males than that of the females.

Table (6) Yield and commercial cuts from carcass side (Value and percentage of cold carcass side weight)

	Males			Females			
Item	**No.of animals**	**Mean**	**S.D.**	**No.of animals**	**Mean**	**S.D.**	**(S.L.)**
Leg	10	20.16	± 3.62	10	21.41	4.54	N.S.
Ribs	10	14.17	± 3.68	10	14.33	3.17	N.S.
Front leg and shoulder	10	10.97	± 3.13	10	11.23	2.61	N.S.
Back and flank	10	28.24	± 8.03	10	26.06	.12	N.S.

Table(7). Composition of various joints of balad rabbits (Value and percentage of cut weight)

	males			Females			
Item	**No.of animals**	**Mean**	**S.D.**	**No.of animals**	**Mean**	**S.D.**	**(p)**
Leg	10			10	79.53	7.01	N.S.
Muscles		78.8	6.03		17.67	5.61	N.S.
Bones		18.74	5.41				
Ribs	10			10			
Muscles		60.22	8.87		38.81	14.76	N.S.
Bones		36.22	8.73		38.57	10.04	N.S.
Front leg & Shoulder	10			10			
Muscles		72.43	8.89		77.69	7.57	N.S.
Bones		25.16	6.49		16.24	9.1	N.S.
Back and flank	10			10			
Muscles		16.68	16.68		58.48	15.84	N.S.
Bones		16.57	16.57		52.51	18.15	N.S.

Table(8). Rabbit meat chemical composition

Trait	Males		Females		P
	Mean	SD	Mean	SD	
Moisture	74.78	0.51	73.9	3.81	NS
Ash	1.27	0.21	1.15	0.22	*
Ether extract	2.13	0.71	2.48	0.13	*
Crude protein	20.3	1.74	20.9	2.28	NS

4.8. Genetic analysis:

The genetic analysis is presented in tables 9-13. Table (9) shows the least square analysis of weaning weight using model 2. The effects of both sires were significant ($P<0.05$) and dams within sires were highly significant ($P< 0.01$). The effects of both the linear and quadratic regressions on litter size were not significant.

Table (10) shows the least squares analysis of variance of average daily gain. The effects of sires were not significant ($P>0.05$) but the effects of dams within sires were highly significant ($P<0.01$). Again the linear and quadratic regressions on litter size were not significant.

Table (11) gives the estimates of heritability, phenotypic ,genetic and environmental correlations as obtained from full sibs, paternal and maternal half sibs. Estimates of heritability obtained were too high (exceeding 1) except for the heritability of average daily gain (0.688±0.448) obtained from paternal half sibs. The reasons for the high estimated are related to the small sample size. Estimates of genetic correlations between average daily gain and weaning weight ranged from -.760 from maternal half sibs to -0.487 as estimated from paternal half sibs. Phenotypic correlations from all types of relationships were about -0.504. Environmental correlations ranged from 1.74 from full sibs analysis to -0.252 from paternal half sibs.

Table(9) : Least-squares analysis of variance Weaning Weight

Source	D.F.	Sum of Squares	Mean Squares	F	PROB	Error Line
Sires	8	2919930.24	364991.28	3.639	0.0256	DA:SI
Dams within Sires	11	1103436.88	100312.44	6.166	0.0000	Remainder
Regressions On:						
Litter size (Linear)	1	36855.65	36855.65	2.265	0.1382	Remainder
Litter size (Quadratic)	1	9607.38	9607.38	0.591	0.4456	Remainder
Remainder	53	862254.31	16268.95			

Table (10) : Least-squares analysis of variance Average Daily Gain

Source	D.F.	Sum of Squares	Mean Squares	F	PROB	Error Line
Sires	8	114.0467	14.2558	0.644	.7285	DA:SI
Dams within Sires	11	243.6778	22.1525	5.364	.0000	Remainder
Regressions On:						
Litter size (Linear)	1	2.5209	2.5209	0.610	0.4381	Remainder
Litter size (Quadratic)	1	9.0982	9.0982	2.203	0.1436	Remainder
Remainder	53	218.8650	4.1295			

Table (11): Estimates of heritabilities, phenotypic, genetic and environmental correlations

From Full Sibs:

Trait	Weaning Weight	Average Daily Gain
Weaning Weight	1.561±0.166	-0.504= r_p -0.728= r_a 1.746= r_e
Average Daily Gain		1.124±0.261

From Paternal Half Sibs:

Trait	Weaning Weight	Average Daily Gain
Weaning Weight	1.790±0.648	-0.504= r_p -0.487= r_a -0.252= r_e
Average Daily Gain		0.688±0.448

From Maternal Half Sibs:

Trait	Weaning Weight	Average Daily Gain
Weaning Weight	1.332 ±0.522	-.504= r_p -.760= r_a 1.260= r_e
Average Daily Gain		

Table (12) presents least squares means and standard errors of linear and quadratic regression estimates of both weaning weight and average daily gain on litter size. All estimates were not significant as shown by the analysis of variance tables 8 and 9 above.

Table (13)shows the results of the analysis of variance using model 1. The effects of sires were highly significant in both weaning weight and mature weight ($P<0.01$) and were significant ($P<0.05$) with regard to average daily preweaning weight gain.

The estimates of heritabilities, phenotypic, genetic and environmental correlations of all three traits are given in table (14). Heritabilities of weaning Weight, mature weight and average daily pre-weaning gain were 0.994 ± 0.05, 0.856 ± 0.074, and 0.342 ± 0.204. The genetic correlations between mature weight and the other two traits were 0.973 and -1.119. The genetic correlations between average daily gain and weaning weight was -1.044.

Least – squares means and standard errors of weaning weight, mature weight and average daily pre-weaning gain are presented in table (15). They were 434.67±85.53, 1375.81±258.90, and 4.56±0.73, respectively.

Table (12): Least squares means and standard errors for regression estimates on litter size

Trait	Independent Variable	N	Effective No	Constant Estimate	Standard Error	Least Squares Mean	Standard Error
Weaning Weight	Overall mean	75	39.1	508.1720	120.0198	508.1720	120.0198
	Linear Reg. On litter size			21.4457	14.2485	21.4457	14.2485
	Quadratic Reg. On litter size			-6.0100	7.8208	-6.0100	7.8208
Average daily gain	Overall mean	75	39.1	4.0401	.8561	4.0401	.8561
	Linear Reg. On litter size			-.1774	.2270	-.1773	.2270
	Quadratic Reg. On litter size			.1849	.1246	.1849	.1246

Table (13): Least-squares analysis of variance Weaning Weight, mature weight and average daily pre-weaning gain Weaning Weight

Source	D.F.	Sum of Squares	Mean Squares	F	PROB	Error Line
Sires	8	1330318.50	166289.81	32.013	.0000	Remainder
Remainder	22	114278.27	5194.47			

Mature weight

SOURCE	D.F.	Sum of Squares	Mean Squares	F	PROB	Error Line
Sires	8	1624166.67	1530648.52	20.733	.0000	Remainder
Remainder	22	114278.27	73825.76			

Average daily pre-weaning gain

SOURCE	D.F.	Sum of Squares	Mean Squares	F	PROB	Error Line
Sires	8	108.11	13.51	2.718	.0301	Remainder
Remainder	22	109.37	4.97			

Table (14): Estimates of heritabilities, phenotypic, genetic and environmental correlations of three traits

	WWT	MATURE	ADG
WWT	0.994 ± 0.051		
MATURE	0.973=ra 0.909=rp 0.450=re	0.856±0.074	
ADG	-1.044=ra -0.689=rp -0.431=re	-1.119=ra -0.537=rp 0.224=re	0.342±0.204

Table (15): least – squares means and standard errors of three traits

Trait	Effective number	Least squares mean	Standard error
Weaning weight	31.0	434.67	85.53
Mature weight	31.0	1375.81	258.90
Average daily gain	31.0	4.56	0.73

Chapter Five

Discussion

5.1: Survey of rabbit breeders in the Sudan

The survey covered all rabbit markets in Khartoum, Khartoum North and Omdurman and came up with the following conclusion:-

The first constraint is that the country lacks highly organized and specialized farms for rabbit production with the exception of few small units where rabbits are kept for research purposes.

The second most important constraints is that most of the Sudanese people do not prefer rabbit meat and it is not in the list of their food items. Added to that, most of them have beliefs that rabbits are like cats and have menstrual cycle like humans.

The consumption of rabbit meat in the ZMCM showed a clearly different pattern for the sample districts of Mexico city and the municipalities of its conurbation. This was probably derived from the outskirts location and this the presence of tourist corridors in these municipalities Buying the product was mainly due to the flavor and its characteristics, while only few people consumed it for nutritional reason. Other problem was that producters did not after a constant volume of rabbit meat along the year due to technical and sanitary problems. This lack of reliability an offering the product has limited the development of the market (Lopez *et al* 2000).

5.2: Mean and Stander errors of pre – weaning and post- weaning:

In this study litter size at birth in the crossbred animals was 5.0 individuals per/ litter and was greater than the litter size of the New

Zealand breed which averaged 4.30 and the Baladi type with an average of 3.93. The litter size at weaning among the crossbred animals was also greater than the New Zealand and Baladi. Rabbit endowed with high fecundity, fertility and prolificacy. If re-mating takes place within 3 days of parturition and with a gestation period of 31 days, the maximum of litters per year per doe is around 11. Under good management and feeding it is theoretically possible that 15young per litter could be produced(Hafez, 1964). Elamin (1978) found the number of born baladi 4.7, californian 7.1 and newzealand 7.49. Ismail (1997) found the litter size in baladi was 4.83, in cross 5.1 and 8.33 in newzealand.The birth weight was 44.79 g in baladi, 54.99 g in New Zealand and 57.4 g in cross. The average weaning weight was 373.01g in baladi, 729.69g in New Zealand and 823.33g in cross. Elamin (1978) reported that birth weight in baladi rabbit was 40 g, californian 63 g and New Zealand was 58 g. This indicates that half bred animals often benefit from the effect of heterosis, as described by (Lebas *et al*., 1997 and Carregual, 1980).

Ismail, (1997) found that the body weight at birth of New Zealand x Baladi crosses was heavier than the average birth weight of their purebred parent breeds.

The New Zealand breed exhibited greater pre weaning and post weaning weight gain compared to both the Baladi types and the crosses. As a breed the New Zealand originated in the USA and from the outset it was selected for use in large meat production units. It is acclimatized to temperate regions (Europe) where it is valued for its breeding qualities, prolificacy, maternal performance, and fast growth rate (Lebas, 1997). The mature weight was 1277.5 g in baladi, 1972.2g in New Zealand and 1500 gram in cross. Elamin (1978) reported the mature weight in baladi was 1308 g, 3791 g in californian and 3312g in New Zealand. Ismail (1997) found the mature weight in New Zealand was 2520 g, 1460 in baladi. The mature weight was obviously affected by breed and type. The New Zealand is +heaviest weight combare to baladi breed and cross but actually it is lesser than normal mature body weight of New Zealand breed, which record (3-4 kg) as reported by (Lebas et al., 1986). This difference might be due to occurrence of high ambient temprature (above 30ºc), that frequently happend in the experimental house during the hot season (March to June)due to the irregeular power supply, which meets the period of rearing (weaning to maturity). Lebas (1983) reported that in tropical zones one of the most important stress factors are high temperature (30-35ºc) which have a deleterious effect on production.

The gestation period in New Zealand, cross and Baladi was 31.40 days 32.00 days and 31.76 day. This was close to estimates found by other researchers. Dim *et al*., (1990) found that the greater number of kids per litter, the shorter the gestation length. Also McNitt and Moody (1991) found that as litter size increased from 2 to 14 kids, gestation length declined from 33.83 to 31.40 days.

5.3: Mean of hybrids compared parents:

The hybrids vigor in liter size at birth and weaning was 0.89 and 0.97 respectively. The difference between the mean of parents and the hybrid in the birth weight and average weaning weight was 7.51gm and 27.89gm respectively.

The hybrid in pre – weaning gain was 1.13g/day, while in post weaning was -1.25g/day. The difference between the hybrid and mean of parents in pre- partum weight and post-partum weight was 772.95gm and 810.0gm respectively.

In gestation period hybrid record 0.42/day while in nature size weight was -642gm.

Cross breeding to make advantage of heterosis and nicking ability requires the selection of several pure populations. The first step is to select local populations and trains derived from imported animals. They are cross bred to first the potential improvement of the local populations. (Lebas *et al* 1986).

5.4: Carcass characteristics and composition of baladi rabbits:

Table 4 shows data related to carcass characteristics and composition of the Baladi rabbits. The slaughter weight, hot carcass weight and cold carcass weight was not significantly (P>0.05) different between males and females.

Population size of rabbits decreased from 2053000 in year 1975 to 1.994000 in year 1980. the deterioration in the population size of rabbit in Egypt may be due to the disease, the unbalanced teed, the lousing and hot summer and the fail in managerial conditions and hygiene control. Local breeds are raised on a small scale and are characterized by small size (1.75 – 3.5 kg adult weight), lower fecundity, poor carcass dressing percentage (48 – 49%), pare or spotted colors, but they are adapted to prevailing climatic conditions (Yamani 1990).

5.5: Body components of rabbits as percentage of slaughter weight:

Table 5 shows the body components of Baladi rabbits. The stomach (full, empty), intestine (full, empty), head and four feet. There were no significant (P>0.05) differences between males and females with regard to all these measurements. However, the skin was heavier in males compared to females. Louca and Hancock (1977) found that the intact male kids had significantly (P<0.01) heavier skin than castrates.

5.6: Yield of commercial cuts:

Table 6 shows total yield and the commercial cuts from carcass side. Joint as leg, ribs and front leg, back and flank were not significantly (P>0.05) different among males and females.

5.7: Composition of various joints:

There were no significant differences in composition of various joints.

The bones were heavier in front legs of male (P<0.05) compared to those of female. Colomer and Kirton (1992) found that the neck and shoulder were greater in males than females.

5.8: Meat chemical composition:

Meat chemical composition of the rabbits is shown in Table (7). Male muscle had greater moisture content than female muscles. These findings were supported by Everitt and Jurry (1966[b]) and Lawrie (1979) who reported that entire animals had a higher percentage of moisture than castrated ones. The crude protein was 17.3 and 18.9 in male and female respectively. Wilson (1964) found crude protein in young rabbit 20.7 and in old rabbit 20.9. The rabbit meat contain 70% water, 21% protein (Lebas et al., 1986). Pascual reported moisture percentage was 74.5, protein 20.97 and fat 2.97. The carcass of rabbit has higher protein than other meat and in most similar to poultry (Abd- Elmotti, 1977).

5.9: Genetic improvement selection of cross breeding:

Rabbit are highly prolific, producing a large of individual per parent. Genetic improvement through breeding is a technical complicated process. However according to theoretical consideration, selection is very useful in units of between 100 to zero does. Units of this size serve breeding reproduction and are economically feasible.

The objective of selection to improving within-breed performance and giving a goal chance for genetically superior animal to transfer their genes to future generation.

The other massage of improving production cross breeding which is very fast for improving production but requires other consideration for genetic improvement. Its usually enhances intra population genetic improvement.

It can be seen from table (8) – (13) that the genetic parameters were very variable, due to the small number of animal used.

It can be seen from table (13) that heretabilites of weaning weight (wwt) was (0.994) and mature weight (0.856) were rather high due to sampling errors.

The heritability of post-weaning average daily gain (ADG) was (0.342± 0.204) which was comparable to other studies in the literature (Medellin *et al*., 2000 and Rastogi *et al*., 2002).

Phenotypic, genetic and environmental correlations with average daily gain were negative and the effects of sampling were very noticeable. Rabbit are known for high maternal which are usually carried post-weaning period.

Conclusions and Recommendations

Cross breeding between the Sudanese Baladi rabbits and rabbits of temperate origin gave a significant improvement in body weight and body weight gain. There was a clear heterosis effect which indicated the possibility of using crossbreds either in a perpetual crossbreeding system or for the formation of a new breed.

The effect of heterosis as obtained in this study was based on one generation only and a relatively small sample of animals. Further experimentation is required in order to ascertain the amount of heterosis. Preferably the experiment should compare at least three breeds and run for a minimum of two successive generations to study both offspring and maternal characteristics.

Today, no improved breed of rabbit has been developed through selection or crossbreeding under tropical conditions (Luker and Cheeke, 1991). Consequently, research in this promising area is strongly recommended.

It is a well known fact that the best crossing results are obtained when the parental populations are improved. This means that selection efforts are required to improve the local Baladi in order to give good results when used in crosses with temperate breeds. Crossbreeding should be followed with stringent selection for both adaptation and production characteristics. Improvement through crossbreeding and consequent selection may be set as the primary goal for government breeding research centers.

Chapter Six

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Appendices

fig. (1) Housing external view :

Fig. (2) Housing from inside:

Fig. (3) Rabbit individual room:

Fig. (4) New Zealand white rabbits:

Fig. (5) Sudanese breed (Baladi) with kids:

Fig. (6) Crosses rabbits:

Fig.(7) Carcass side of rabbit:

Fig. (8) Cuts from carcass side of rabbit

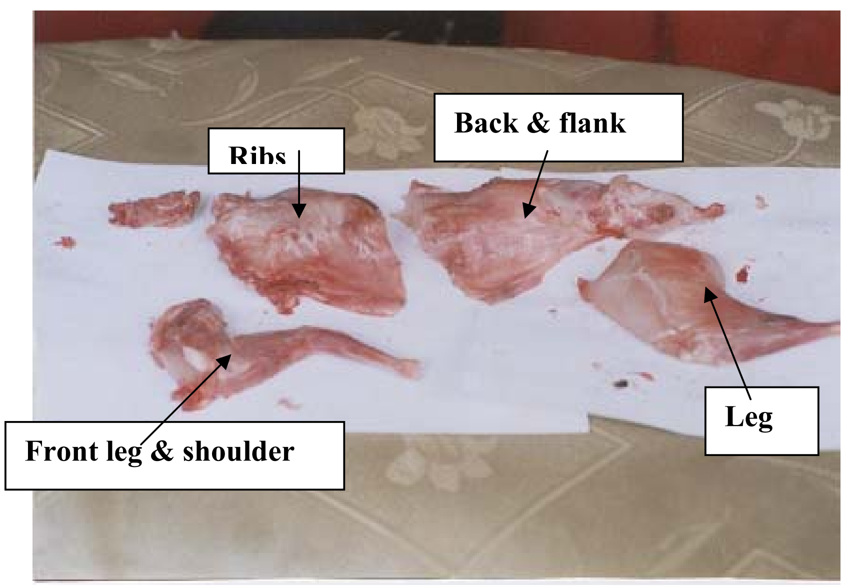

Fig (9) Ambient temperature during the experimental period:

Season	*MAX.temp.(°c)*	*MIN.temp. (°c)*
D.S.	42.9	17.6
WS	35.6	14.2
W.S.	39.7	23

(Sudan meteorological department)

D.S = Dry summer is months of March, April, May and June.

WS = Winter is months of November, December, January and February.

W.S = Wet summer is monthsb of July, August, September and October.

Fig. (10) Kids' weight at birth, weaning and sexual maturity

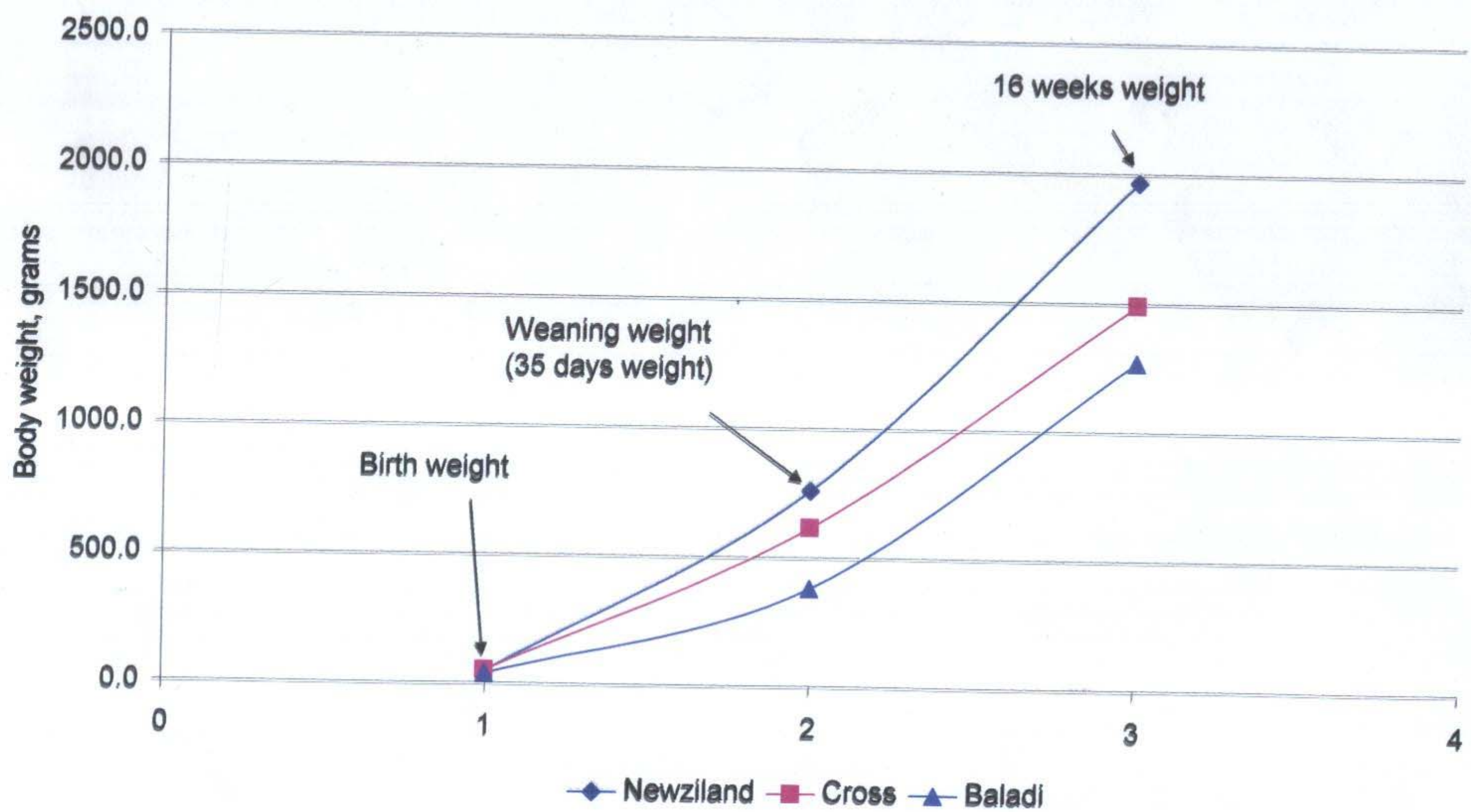

Fig. (11) Mortality and alive rates of the two types of rabbit