CORRELATION BETWEEN BLOOD GLUCOSE LEVEL AND LIVER GLYCOGEN STORAGE IN JAPANESE QUAIL *(Coturnix coturnix japonica)*

BY

K. RAJI

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR

1997

DECLARATION

I hereby declare that the thesis entitled "**CORRELATION BETWEEN BLOOD GLUCOSE LEVEL AND LIVER GLYCOGEN STORAGE IN JAPANESE QUAIL (*Coturnix coturnix japonica*)**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Raji

Mannuthy
11 4 97

K. RAJI

CERTIFICATE

Certified that the thesis, entitled "**CORRELATION BETWEEN BLOOD GLUCOSE LEVEL AND LIVER GLYCOGEN STORAGE IN JAPANESE QUAIL** (***Coturnix coturnix japonica***)" is a record of research work done independently by **Mrs. K. Raji**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. K.P. Surendranathan
(Chairman, Advisory Committee)
Professor & Head
Department of Physiology & Biochemistry
College of Veterinary & Animal Sciences
Mannuthy

Mannuthy

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mrs. K. Raji**, a candidate for the degree of Master of Veterinary Science in Physiology, agree that the thesis entitled "**CORRELATION BETWEEN BLOOD GLUCOSE LEVEL AND LIVER GLYCOGEN STORAGE IN JAPANESE QUAIL (*Coturnix coturnix japonica*)**" may be submitted by Mrs. K. Raji, in partial fulfilment of the requirement for the degree.

Dr. K.P. Surendranathan
(Chairman, Advisory Committee)
Professor & Head
Department of Physiology & Biochemistry
College of Veterinary & Animal Sciences
Mannuthy

19/4/97

Dr. P.T. Philomina
Associate Professor
Department of Physiology & Biochemistry
College of Veterinary & Animal Sciences, Mannuthy
(Member)

Sri. M. Nandakumaran
Associate Professor
Department of Nutrition
College of Veterinary & Animal Sciences, Mannuthy
(Member)

Dr. G. Reghunathan Nair
Professor
Department of Poultry Science
College of Veterinary & Animal Sciences, Mannuthy
(Member)

External Examiner

ACKNOWLEDGEMENTS

I express my sincere gratitude and appreciation to Dr. K.P. Surendranathan, Professor and Head, Department of Physiology and Biochemistry, College of Veterinary and Animal Sciences, Mannuthy, my major advisor for his valuable guidance, creative suggestions and constant encouragement given to me during the entire course of my study and thesis work.

I wish to place on record my gratitude to Dr. P.T. Philomina, Associate Professor, Department of Physiology and Biochemistry for her inspiring advices and timely help given to me during the course of my work and thesis preparation as my minor advisor. I am very much grateful to Sri. M. Nandakumaran, Associate Professor, Department of Nutrition and Dr. G. Reghunanthan Nair, Professor, Department of Poultry Science, for their sincere efforts in helping me to complete my work and thesis as members of my advisory committee.

My sincere thanks are due to Dr. K.C. George, Professor and Head, Department of Statistics and Smt. K.P. Santhabai, Programmer, Department of Statistics for their help extended to me in the statistical analysis of the data and computer graphics.

I wish to record my sincere thanks to Dr. A. Rajan, Dean of the Faculty of Veterinary and Animal Sciences and Kerala Agricultural University for all the facilities provided for the conduct of my research work.

I am thankful to Indian Council of Agricultural Research, New Delhi for providing the financial assistance in the form of Junior Research fellowship during the period of my study.

I place on record my gratitude to all the staff of Department of Physiology and Biochemistry for the help rendered to me.

I am grateful to my friends, Dr. V. Beena and Dr. K.P. Mini who have shared their efforts in the successful completion of my research work.

I express my deep sense of gratitude to my beloved parents, husband and family members for their constant support and encouragement given to fulfil my task.

Lastly but never the least, to God Almighty for making this M.V.Sc. course a reality for me.

Mannuthy ***K. RAJI***

Dedicated To My Loving

Parents and Husband

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

Chapter 1

INTRODUCTION

Japanese quail was introduced in India during 1973. Since then, it has gathered importance as a laboratory animal model for poultry, and for biomedical research. It is also having good prospects for the commercial production of meat and eggs. The coturnix quail is recommended to interested investigators especially to embryologists and physiologists for use in research because of its hardiness, ease of handling, precociousness and great egg production capacity. Japanese quail is similar in numerous physiological characteristics to chicken and differs from them only in a few respects. Thus the small size, the lower feed and space requirements, easy maintenance and similarities to chicken in many characteristics make the quail a valuable laboratory animal model for research workers. Though, of late, much work has been done in the physiology of poultry, very little attention has been paid to quails. Hence information available on the physiology of quail is scanty. A thorough understanding of the physiology of these birds in all its aspects is an essential prerequisite for their proper and economic maintenance.

A nutrient is a substance that promotes the growth, maintenance, function and reproduction of a cell in an

organism. The principal nutrients in all feeding stuffs are water, organic and inorganic matter. Animal body contains about 3 per cent inorganic matter which are the constant constituents of animal tissues. It may seem strange to speak of water as a food but in view of the fact that the body is composed of about two-thirds water and that a food is any substance used by the body for building tissue, it is obvious that water is a very important food. Organic matter includes carbohydrates, proteins, lipids and vitamins. Lipids are the important energy storage compounds of animal kingdom and act as the structural compounds. Nearly half of the dry weight of a typical animal cell is protein. Structural components of the cell, antibodies and many of the hormones are proteins, but as much as 90 per cent of the cellular proteins are the enzymes upon which fundamental cellular functions are depended. Vitamins are essential for normal growth and development of tissues and for the maintenance of health.

Animal tissue contains very small amount of carbohydrate but without which life will be at stake. The principal function of carbohydrate in the form of glucose and glycogen is to furnish energy for the body. More than 50 per cent of the energy value of the diet is provided by carbohydrates. It is said that fats and proteins are burnt (oxidised) in the flame of carbohydrates. It means that certain products of carbohydrate metabolism are absolutely essential for oxidation of fats and proteins. Some carbohydrates have highly specific

functions, like ribose in the nucleoprotein, galactose in glycolipids and lactose in milk. When intake of carbohydrate exceeds the requirement of the body, the excess is transformed to fats or even used for the carbohydrate skeleton of proteins.

The majority of carbohydrates taken in the body is essentially converted to glucose in a series of metabolic pathways. Glucose is the circulating carbohydrate of animals. The blood sugar of ruminants, pig, dog and laying chicken are in the range of 40 to 60, 80 to 120, 60 to 100 and 130 to 290 mg% respectively. Glycogen is the reserve form of carbohydrate in animal body and is often called as the animal starch and its level in animal tissue is relatively low as 1.5 to 4.0 per cent in the liver and 0.5 to 1 per cent in the muscle. Fasting animals mainly depend upon the glycogen stores in order to meet their glucose (energy) requirements for maintaining a proper metabolic balance.

The present study attempts to probe into some fundamental areas of carbohydrate utilization in Japanese quail. Avian carbohydrate metabolism differs in several respects from that of mammals, some of which include the bird's relative insensitivity towards high doses of insulin and the ability of the birds to maintain their blood glucose level, where the value is normally almost double that in most mammals, even during prolonged starvation. In contrast to the situation in

mammals, it is only in recent years that any concentrated effort on study has been made in this aspect of carbohydrate metabolism in domestic fowl. Over the years, numerous investigators have reported data concerning blood glucose level in birds. Much of these data were collected with an effort to use the circulating level of blood glucose as an indicator of general carbohydrate metabolism in birds. Unfortunately most of the information available on this topic concern only to one or two avian species and our general understanding of avian carbohydrate metabolism is a very restricted one indeed. The assessment of normal blood glucose level and tissue (liver) glycogen content at various ages and physiological conditions of the birds would certainly add much to the present knowledge of avian carbohydrate metabolism.

Considerable progress has been made in understanding the homeostatic mechanism which controls blood glucose concentration. Liver plays an important role in this process. Although there is considerable information available on carbohydrate metabolism in mammalian liver, that pertaining to avian liver is scanty. The present study was, therefore, undertaken to probe into some aspects of the role of liver with regard to carbohydrate metabolism in birds.

Numerous reports have shown that several species of animals were able to adapt their intermediary metabolism with

respect to the changes in dietary composition. Although data are available regarding the effect of feed restriction on growth for laboratory models like rat, similar data are sparse in Japanese quails. This study was also designed to examine the changes in growth and carbohydrate status of the bird as a result of feed restriction. Observations of the investigation may bring informations of fundamental nature which will have great practical application in the field of poultry husbandry.

Review of Literature

Chapter 2

REVIEW OF LITERATURE

2.1 Blood Glucose

According to Dukes, 1947 the blood glucose level in avian species had a wide range from 161 to 280 mg per cent in chicken and 175 to 210 mg per cent in turkey. The blood glucose value in ducks was low ranging from 129 to 152 mg per cent (Surendranathan, 1966). According to Scheer (1954) the blood sugar values are higher in flying birds, lower in cursorial species and lowest in aquatic forms. Darshan *et al.* (1987) proposed that the level of glucose in blood of chicken was a trait and there was a possibility of genetic control on the level of glucose in blood. They reported higher glucose values for males of Aseelpeela and Kadaknath than females, whereas the females of Aseelkagar showed higher glucose values. Darshan *et al.* (1987) observed that plasma glucose concentration in desi fowl was higher than the exotic breeds of fowl. Leelercq *et al.* (1987) studied two lines of broilers exhibiting low and high plasma glucose concentration. They observed that low glucose line was significantly fatter than high glucose line.

Reports on the influence of sex on blood glucose are varying. Higher blood glucose level in female chicken was

reported by Nirmalan and Aravindan (1963) and in female ducks by Surendranathan (1966). Kathe and Gadgil (1965) reported that fasting for 18 h in male and female Rhode Island Red chicken did not bring any variation in the blood sugar level. They observed no significant difference in the blood glucose level of male and female chicken. Kumar and Rawat (1975) reported higher glucose level for male White Leghorn birds. However, Olowookorun *et al.* (1980) observed no significant difference in the plasma glucose level of male and female guinea fowls. Poyraz (1988) recorded that plasma glucose level in female quails was higher than that of male quails.

Heller and Pursell (1937) estimated most of the chemical constituents of blood of chicken and found that blood glucose tended to decrease after one year of age. According to Kumar and Rawat (1975) age did not seem to influence the blood glucose values. Shibata and Watanabe (1981) reported a low blood sugar level in Japanese quail embryos which increased gradually after hatching. According to them blood sugar values in adult males and females were 354.4 mg/dl and 293.8 mg/dl respectively. Christensen and Donaldson (1991) reported that there was significant depletion of glycogen in poult embryos just prior to hatching accompanied by concomitant rise in plasma glucose concentration. According to Majumdar and Panda (1991) rate of egg production did not influence the plasma glucose concentration. Verma and Panda (1991) reported

that the laying quail showed the highest level of serum glucose at the time when the egg was in the magnum. Ducci *et al.* (1992) observed that Muscovy ducks had the highest blood sugar values at an age of six weeks. Kundu *et al.* (1993b) reported that young quails had a lower erythrocyte count than adult quails.

Krebs and Yoshida (1963) reported that in chicken liver as well as kidney regulated the blood glucose level. Watford *et al.* (1981) proposed a major role for kidney in controlling blood sugar level by gluconeogenesis in chicken. Riesenfeld *et al.* (1982) proposed that intestine also had an important role in the glucose homeostasis. Majumdar and Panda (1991) studied the ability of intestinal glucose absorption in high, medium and non laying birds and reported that significantly more glucose was absorbed by the intestine of non laying birds.

Hazelwood and Lorenz (1959) observed that glucagon caused hyperglycaemia in nonfasted chicken and insulin resulted in hypoglycaemic rebound 24 h after each injection. Greenman and Zarrow (1961) reported that the hydrocortisone and corticosterone caused hyperglycaemic reactions in birds. According to them testosterone could lower blood glucose level whereas stilbesterol had no effect on blood glucose level. Grande (1968) observed an elevation of blood sugar level by

intravenous injection of glucagon in geese, turkeys and roosters. Grande (1970) studied the effect of glucagon and insulin on blood glucose level of owls and observed that insulin caused marked hypoglycaemia whereas glucagon caused significant hyperglycemia. Misra *et al.* (1977) studied the effect of epinephrine and propranalol on blood glucose level of chicken and observed that epinephrine could induce hyperglycaemia. Freeman *et al.* (1980) suggested that withdrawal of feed was a potent stressor resulting in hypoglycaemia in young fowl. According to Freeman *et al.* (1983) there was a transient increase and then decrease in the blood glucose level of chicken deprived of feed for 24 h. Nobukuni *et al.* (1989) reported that thyroidectomy had no significant effect upon blood glucose level of chicken. According to Hammouda *et al.* (1992) fasted birds were more sensitive to insulin than fed birds concerning glucose homeostasis. Joseph and Ramachandran (1992) reported that hypo and hypercortism could influence carbohydrate metabolism by influencing the secretory/activity ratio of pancreatic hormones in domestic fowl. Thurston *et al.* (1993) studied the effect of corticosterone and epinephrine on blood glucose in turkey, and chicken. According to them chicken showed more sensitivity to corticosterone whereas turkey showed more sensitivity to hyperglycaemic response of epinephrine.

Rodbard and Goldstein (1950) reported that blood glucose level in birds was highly sensitive to environmental temperature, hypothermia resulted in a reduction of blood glucose concentration in chicken. Darshan *et al.* (1987) reported that, to a considerable degree blood glucose depended upon the environmental conditions. Bhattacharya (1990) reported a higher blood glucose level in cold exposed Japanese quail.

Freeman *et al.* (1980) observed that withdrawal of feed in chicken resulted in hypoglycaemia. Savory (1987) reported that sight of feed and presentation of empty feed pan caused a slight increase in the blood glucose in 24 h feed deprived hens. According to Donaldson *et al.* (1992) diet was not having any influence on the blood glucose level of turkey poults. Warriss *et al.* (1993) reported that plasma glucose concentration in broilers was not significantly reduced by transportation.

2.2 Liver glycogen

The liver otherwise known as "Hepar" is the largest gland in the body and is engaged in amazingly varied array of biochemical activities indispensable for the normal functioning and well being of the body. Its central role in the metabolism of proteins, fats and carbohydrates is well

documented. Liver undergoes rapid changes in its chemical composition mainly due to the fact that protein and glycogen may be quickly added on to or withdrawn from the liver cells.

The glycogen content of liver in day old chicks was reported by Sturkie (1965) and Deb and Chakravarthy (1967) and that in six to ten weeks old chicks was reported by Golden and Long (1942), Hazelwood and Lorenz (1959) and Sturkie (1965). The value recorded by Sturkie (1965) for black birds and starlings was 4.9 per cent. The values reported for glycogen content in the liver of mammals were 1 to 6 per cent in man (West *et al.*, 1966), 3 to 4 per cent in rats and cats (Casirola *et al.*, 1956), 3 to 4 per cent in dogs (Dukes, 1955). Narasimhan (1971) analysed the liver glycogen content of ducks and chicken. The values were 4.06 ± 0.29 per cent and 3.82 ± 0.45 per cent for ducks and chicken respectively. Glycogen was stored in liver and muscle cells upto 5 to 8 per cent and 1 to 3 per cent of their weight respectively (Guyton and Hall, 1996).

The storage of reserve carbohydrate as glycogen in tissues was first demonstrated by the French physiologist Claude Bernard (1813-1878). According to Ganong (1991) liver functions as a sort of "glucostat" maintaining a constant circulating glucose level. Moudgil and Narang (1989) reported that, one of the major functions of the liver was to maintain

normal blood glucose level ensuring a regular and adequate supply of carbohydrates to extrahepatic tissues. Chatterjee (1992) proposed a variety of roles for the liver glycogen like a ready source of blood glucose, replenishing muscle glycogen, and helping the liver in detoxifying mechanism.

The hepatic glycogen content in birds varies with age, diet, hormonal and other factors. According to Golden and Long (1942) adult birds had a lower glycogen content in comparison to the growing ones. In the developing embryo of birds hepatic glycogen increased upto the 18th day and decreased thereafter (Lee, 1951, Watterson *et al.*, 1958, Thommes and Tambornino, 1962). Dutton (1963) reported that chicken liver was able to synthesise glycogen on the seventh day and the synthesis was undergoing even in the absence of insulin, a capacity that was not evidenced by mammalian embryos. Garcia *et al.* (1986) estimated glycogen levels in various tissues of chicken from 10th day of incubation to five days after hatching and compared with adult values and reported that glycogen stores in most tissues increased before hatching and even increased to adult values in muscle and liver.

There exists species, breed and individual variation in the liver glycogen content. Elfvin *et al.* (1955) observed that the glycogen content of the liver of birds was more than that of mammals. Deb and Chakravarthi (1967) from their

studies concluded that White Leghorn and New Hamphire chicks had low liver glycogen level than the Rhode Island Red chicks. Analysis of liver glycogen in chicks conducted by Allen and Ruff (1981) revealed that there was considerable variation in glycogen levels among individual birds.

Liver glycogen content is known to vary considerably with diet. Hazelwood and Lorenz (1959) in their study in chicken observed that liver glycogen got rapidly depleted at the start of fast and got partially replaced afterwards. Seaton *et al.* (1978) reported that glycogen content of chick liver was known to vary considerably with diet. Shen and Mistry (1979) observed an increase in the activity of all the key gluconeogenic enzymes in kidney and enzymes such as fructose-diphosphatase and Glucose-6-phosphatase in the liver of chicken as a result of fasting. Allen and Ruff (1981) reported that liver glycogen was decreased rapidly after feed withdrawal in chicks. Didier *et al.* (1981) observed that 72 h starvation in Japanese quail resulted in the decrease of glycogen content in the liver. Matsumoto and Hamada (1981) reported that glycogen content in liver and skeletal muscle tended to be greater in chicken reared on the carbohydrate free diet than in birds fed on restricted diet. Reports by Warriss *et al.* (1988) indicated a reduction in liver glycogen content as a result of feed deprivation in broiler chicken. According to Donaldson *et al.* (1992) diets had no effect on

blood glucose level of turkey poults. Donaldson and Christensen (1993) observed that glycogen concentration in liver declined in newly hatched poults held for upto 72 h without feed and water. Warriss *et al.* (1993) examined the influence of food deprivation in broilers and observed that fasting for 10 h reduced the concentration of glycogen in the liver by 40 per cent.

The influence of hormones like insulin, glucagon, epinephine and cortisone on hepatic glycogen in birds had been studied by Hazelwood and Lorenz (1957 and 1959) and Clawson and Domer (1961). They observed that glucagon caused an elevation of cardiac and liver glycogen in non fasted domestic fowl whereas growth hormone had no influence on hepatic glycogen. Greenman and Zarrow (1961) studied the steroids and carbohydrate metabolism in the domestic bird and observed that hydrocortisoneacetate, corticosterone and 11-dehydrocorticosterone induced significant deposition of glycogen in fasting chick. Glucocorticoids had been known to stimulate gluconeogenesis as much as six to ten folds resulting in a marked increase in hepatic glycogen (Heald *et al.*, 1965). According to Misra *et al.* (1977) hyperglycaemia was induced by epinephrine in chicken. Experiments by Schulz and Mistry (1981) revealed that chicken hepatocytes were responsive to glucagon and epinephrine. Nobukuni *et al.* (1989) suggested that thyroid hormones played

an important role in the regulation of glycogen contents between the liver and muscle of chicken. Parkes *et al.* (1990) observed that incubation of chicken hepatocytes with glucose and glucose plus insulin induced glycogen synthesis. Kundu *et al.* (1993a) pointed out increased glycogen content in the liver of chicken treated with prednisolone.

Hepatic glycogen stores and blood glucose level in birds were highly sensitive to the environmental temperature. Sadhu and Chaudhari (1961) observed that an increase in body temperature resulted in enhanced hepatic glycogenolysis in birds when compared with mammals. Delphia *et al.* (1967) observed that glycogen storage in the liver was inhibited between seven and eight days by high temperature incubation of embryo. Allen and Ruff (1981) opined that diurnal variation occurred in the liver glycogen level in chickens.

2.3 Liver weight

Reports regarding the factors influencing the liver weight are scanty. Matsuzawa (1981) observed an increase in the liver weight of growing White Leghorn birds between one and twenty weeks of age. Lilja (1983) reported that in geese and some wild birds a rapid early development was observed for the liver as well as the digestive tract. According to them

growth pattern of turkeys and quails was characterised by an early rapid development of breast muscles and feathers.

Diet indeed has got a direct influence upon the liver weight. Shen and Mistry (1979) and Warris *et al.* (1988) observed a reduction in the liver weight of feed deprived chicken. Liver weight was found to be increased as a result of force feeding in Mullard ducks (Jouglar *et al.*, 1992). Palo *et al.* (1995) reported that there was a reduction in the liver weight in feed restricted birds due to reduction in the size and number of liver cells.

There exists a definite relation between the body weight and liver weight. Burger *et al.* (1962) reported that there was a control factor that can regulate the growth of organs relative to the body size. According to Kawahara and Satto (1976) liver weight had the highest correlation with body weight and muscle weight.

2.4 Body weight

Ahuja *et al.* (1978) and Jues and Houghes (1978) reported that quails attained sexual maturity at sixth week of age. According to Sharma and Panda (1978) Japanese quails reared in battery cages attained body weight of 108 g at eighth week of age. Sreenivasaiah *et al.* (1980) and Sato *et al.* (1981) determined the body weight of quail at different stages of

growth. Kohler (1984) studied the phenotypic parameters of Japanese quail and reported that the 42 day body weight of five unselected lines of quails averaged 118.152 g. Sachedev and Ahuja (1986) proposed that 200 g body weight was the optimum level to be attained at sexual maturity for high egg production.

Several investigators had reported the age related changes in body weight of Japanese quails. Tiwari and Panda (1978) and Thomas *et al.* (1993) recorded the average body weight of quail at different stages of growth. Panda *et al.* (1980) in evaluation of a quail line reported that growth rate got reduced considerably after the fourth week of age. Philomina (1994) recorded that body weight gain in Japanese quail was steadily on increase upto the 16th week of age and thereafter it was only marginal especially from the 19th week onwards.

The body weight was a trait which was found to be influenced by various factors. Sefton and Siegel (1974) studied the inheritance of body weight in Japanese quail and reported that there was an acceleration of weight gain in female quails just prior to sexual maturity. Jues and Houghes (1978) reported a difference in growth rate and body weight gain between Coturnix quail and Bob White quail. Sato *et al.* (1981) studied the genetic parameters of body weight in

Japanese quail and observed that female quails had higher body weight and according to them the influence of sex on the variation of body weight was evident at significant levels from three weeks of age onwards. Kumar *et al.* (1990) determined the influence of parental age on body weight. Boztepe and Ozturk (1993) studied the influence of dietary protein on body weight gain in Japanese quail and observed that maximum live weight gain was attained by diets with 22 per cent protein than 16 per cent and 28 per cent. Growth comparison in Japanese quails was done by Thomas *et al.* (1993) revealed that the difference in body weight between sexes was significant from nineth week of age onwards and initial body weight had no influence on the growth rate.

2.5 Feed restriction

Reports regarding the effect of feed restriction are rare. Available literatures are mainly concentrating on the effects induced by fasting. Restricted feeding has got influence on the blood glucose level. According to Houpt (1958), chicks were able to maintain their normal blood glucose level during starvation. Hazelwood and Lorenz (1959) observed that prolonged fasting caused a rise in blood glucose level of chicken which reached a maximum level on the sixth day. Kathe and Gadgil (1965) studied the blood glucose levels of fasted male and female Rhode Island Red chickens.

Brady *et al.* (1978) reported that blood glucose level in chicken remained constant with fasting. Freeman *et al.* (1980) observed that withdrawal of feed was a potent stressor in young fowl resulting in hypoglycaemia. Riesenfeld *et al.* (1981) conducted a study on glucose kinetics in fed and fasted chickens and observed that glucose oxidation contributed 31 per cent and 12 per cent of the total heat production in fed and fasted chickens respectively. Freeman *et al.* (1983) reported a transient increase and then decrease in the blood glucose level of chicken when feed was deprived for 24 h. Savory (1987) observed that when food was removed from free feeding hens there was minor declining tendency of plasma glucose level. Warrisset *al.* (1988) found that longer periods of food deprivation in broilers reduced circulating glucose concentration. According to Hammouda *et al.* (1992) fasted turkey birds were more sensitive to insulin than fed birds concerning glucose homeostasis. Rayo *et al.* (1992) observed that acute and intermittent starvation increased the intestinal absorption of the glucose in chicken. Warriss *et al.* (1993) reported that there was a decrease in the plasma glucose concentration when food was deprived in broilers.

Hazelwood and Lorenz (1959) reported that liver glycogen was rapidly depleted at the start of fast and was replaced partially in later days. According to Shen and Mistry (1979), hepatic fructose-diphosphatase and glucose-6-phosphatase

levels were increased markedly as a result of fasting in chicken. Didier *et al.* (1981) reported that 72 h starvation in Japanese quail resulted in a decrease in concentration of liver glycogen. Matsumoto and Hamada (1981) observed that feed restricted chicken had the lowest amount of liver glycogen when compared to birds provided carbohydrate free diet and control diet. According to Warriss *et al.* (1988 and 1993) liver glycogen level was reduced as a result of food deprivation in broilers. Donaldson and Christensen (1993) observed that liver glycogen concentration was declined in newly hatched poults subjected to feed deprivation.

There are also reports showing the reduced relative growth rate of various organs due to restricted feeding. Shen and Mistry (1979), reported that liver weight and kidney weight decreased due to fasting in chicken. Warriss *et al.* (1988) observed that longer periods of food deprivation reduced the liver weight in broiler chickens. According to Jouglar *et al.* (1992) liver weight was found to be increased as a result of force feeding in Mullard ducks. Warriss *et al.* (1993) observed that fasting for 10 h reduced the liver weight in broilers. According to Palo *et al.* (1995) restricted feeding upto an age of 14 days in broiler chicken did not decrease the relative weight of organs except for the liver.

Robblee *et al.* (1979) studied the body weight response in chicken with restricted feed intake and observed a reduction in body weight with restricted diet. Shen and Mistry (1979) reported that in chicken body weight was lost during fast which regained after normal feeding. Gildersleeve *et al.* (1980) reported that quails on restricted feed had reduced body weight gain and final body weights. According to Van (1980) exposure of chickens to heat stress and feed restriction resulted in retardation of growth. Plavnik and Hurwitz (1985) reported an improved feed efficiency in feed restricted group of broiler chicken during refeeding. Plavnik and Hurwitz (1987) observed that feed restriction for seven days in male chicks resulted in an improved feed efficiency. Hohtola *et al.* (1991) observed feed deprivation induced a well defined nocturnal hypothermea in Japanese quails that was significantly correlating with body mass loss. Jouglar *et al.* (1992) reported an increase in carcass weight as a result of force feeding in Mullard ducks. According to McLeod *et al.* (1993) the broiler breeder fowl responded to restricted feed intake by a reduction in heat production. Restriction of feed intake reduced the body weight and increased the size of oesophagus and crop (Zulkifle *et al.*, 1993). According to Chopra and Aggrawal (1994) feed restriction in turkeys resulted in lower body weight. Susbilla *et al.* (1994) studied the growth rate and relative growth rate of various organs in broiler chicken fed *ad libitum* as well as with restricted feed

and observed a reduction in the body weight when feed intake was restricted upto an age of 14 days. Santaso *et al.* (1995) also reported about the reduced growth rate of fowls due to restricted feeding.

2.6 Feed consumption

For feeding quails efficiently and economically they are classified as starter, grower and layer. The starter period is the most crucial period and needs special management and care. The young actively growing bird makes a larger gain in live weight per unit weight of feed consumed. Rajini *et al.* (1988) proposed that Japanese quail fed diet containing 2800 Kcal of metabolizable energy (M.E.) during starting period and 2600 Kcal of M.E. during growing period recorded optimal weight gain and feed efficiency. Panda (1990) suggested the level of nutrients in feed for Japanese quail. Shukla *et al.* (1994) reported that the most efficient feeding schedule for Japanese quail was feeding of the layer ration right from the onset of lay.

Feed consumption varies with age of bird, diet, production and various other factors. Wilson *et al.* (1961) reported that to put on 122 g of body weight a quail consumed 496 g of feed. Panda *et al.* (1977) incorporated different protein levels in quail ration and observed the average feed

intake per day as 24.30 g/bird at 22 per cent crude protein level. Tiwari and Panda (1978) reported the average feed efficiency (feed/egg) ratio in quail as 3.8. Costa *et al.* (1980) observed that feed intake got a positive correlation with the increase in body weight. Sreenivasaiah *et al.* (1980) recorded the daily feed consumption at 40 days and 120 days of age as 19.94 g and 27.59 g respectively. Yamane *et al.* (1980) observed the daily energy requirement of Japanese quail for egg production as 260 KJ M.E.

Materials and Methods

Chapter 3

MATERIALS AND METHODS

3.1 Experimental design

The experiment was carried out in 440, Japanese quail chicks of the same strain (egg type) and hatch procured from the Kerala Agricultural University, Poultry Farm, Mannuthy.

In the first phase of study blood glucose and liver glycogen levels were estimated in 40, day-old-quail chicks. Blood was collected by decapitating the birds and the liver was quickly collected. Twenty, pooled samples were taken for the estimation of blood glucose (Hyravinen and Nikila, 1962) and liver glycogen (Seifter *et al.*, 1950).

In the second phase, 400, two-week old quail chicks were maintained on a standard quail ration (Panda, 1990 and Philomina, 1994) upto the age of sixteen weeks (Table 1.1, 1.2 and Table 2.1, 2.2). The male and female quails were separated at four weeks of age and grouped into G_1 and G_2. They were housed in separate cages comprising of 20 birds in each subgroup. Feed and water were provided *ad libitum*. Artificial brooding conditions were provided upto an age of four weeks. The laying quails, were provided a photoperiod of sixteen hours. Twenty birds each from G_1 and G_2 group were

sacrificed at fortnightly intervals from the second to sixteenth week of age for the estimations in blood and liver. Body weight of individual birds was recorded at the time of sacrifice. Female quails were watched for the on set of egg production and rate of laying. At fortnightly intervals feed consumption was also recorded.

At the sixth week of age two sets of male quails (from G_1 group) and two sets of female quails (from G_2 group) were selected and reared on half the quantity of ration (ie. feed was given by noting the previous days feed consumption of birds in the control group) for a period of four weeks. At eighth (two weeks feed restriction) and tenth (four weeks feed restriction) week of age twenty birds each from the control and feed restricted G_1, G_2 groups were sacrificed for collection of blood and liver.

Table 1.1 Composition of prelayer ration (2 to 6 weeks)

Ingredients	Parts per 100 kg
Yellow maize	42.0
Groundnut cake	45.0
Gingelly oilcake	2.0
Fish meal	3.0
Rice polish	7.0
Common salt	0.5
Shell meal	0.5

For every 100 kg of feed the following vitamins and minerals were added.

1. Vitamins

Rovibe 75 g

Rovimix: 25 g

Choline chloride 100 g

Rovibe (Roche Products Ltd.): Potency/g: vitamin B_1-4 mg, B_6-8 mg, B_{12}-40 mg, Niacin-60 mg, calcium pantothenate 40 mg and vitamin E 40 I.U.

Rovimix A, B_2, D_3 (Roche Products Ltd.): Potency/g: Vitamin A - 40,000 I.U., B_2-20mg, D_3-5,000 I.U.

2. Mineral mixture

Ferrous sulphate 25 g, manganese sulphate 25 g, zinc sulphate 25 g, copper sulphate 1.5 g and potassium iodate 100 mg.

Table 1.2 Chemical composition of the prelayer ration

Metabolizable energy (Kcal/kg)*	2821.0
Crude protein (%)**	24.0
Calcium (%)**	0.7
Phosphorus (%)**	0.67
Lysine (%)*	0.92
Methionine (%)*	0.45

* Calculated value
** Analysed value

Table 2.1 Composition of layer ration (6 to 16 weeks)

Ingredients	Parts per 100 kg
Yellow maize	38.0
Groundnut cake	38.0
Gingelly oilcake	5.0
Fish meal	5.0
Rice polish	5.0
Salt	0.5
Shell meal	3.5
Mineral mixture[1]	3.0
Fat	2.0

1. Mineral mixture:

   Poultrymin (Aries Agro. Vet. Industries Private Ltd.)

   Calcium (min) 32.00%, phosphorus (min) 6.00%, copper (min) 100 ppm, cobalt (min) - 60 ppm, manganese (min) - 2700 ppm, iodine - 100 ppm, zinc - 2600 ppm, iron - 0.1% and magnesium - 1000 ppm.

2. Vitamins: For every 100 kg feed added the following vitamins.

   Rovibe (Roche Products Ltd.): 75 g
   Rovimix (Roche Products Ltd.): 25 g
   Choline chloride: 50 g

Table 2.2 Chemical composition of the layer ration

Metabolizable energy (Kcal/kg)*	2751.00
Crude protein (%)**	22.00
Calcium (%)**	3.00
Phosphorus (%)**	0.65
Lysine (%)*	0.91
Methionine (%)*	0.46

* Calculated value
** Analysed value

3.2 Blood and tissue analyses

To minimise the possible influence of diurnal variation on the results, birds were sacrificed between 10 AM and 12 PM. Body weight of the birds were recorded before sacrifice. Birds were sacrificed by decapitation and blood was collected in tubes having sodium fluoride as anticoagulant (10 mg/ml of blood). Soon after the sacrifice the whole liver was collected, weighed and preserved in 30 per cent potassium hydroxide (KOH) solution. For zero day old quail chicks (on day of hatch) blood and liver from two chicks were pooled. At two weeks of age the birds were sexed after sacrifice by noting the development of testes in male birds. Blood glucose concentration and liver glycogen content were estimated by the method of Hyravinen and Nikila (1962) and Seifter *et al.* (1950) respectively.

3.2.1 **Determination of glucose in blood** (Hyravinen and Nikila, 1962)

Principle

Glucose reacts with O-toluidine in glacial acetic acid in the presence of heat to yield a blue green N-glycosylamine, the absorbance of which is measured at 625 nm. For whole blood or moderately haemolysed serum, deproteinization is required.

Reagents

1. Tungstic acid reagent (stabilised): Dissolved 1.0 g polyvinyl alcohol in 100 ml of distilled water with gentle warming, cooled and transferred to a one litre volumetric flask containing 11.1 g reagent grade sodium tungstate ($Na_2WO_4.2H_2O$) previously dissolved in about 100 ml of distilled water, mixed by swirling. To about 300 ml of distilled water taken in a separate vessel added 2.10 ml of reagent grade H_2SO_4. This was added to the tungstate solution taken in the volumetric flask, mixed well and diluted to 1000 ml with distilled water.

2. O-Toluidine reagent (stabilized): To 5.0 g thiourea, reagent grade, added 90.0 ml O-Toluidine and diluted to one litre with glacial acetic acid, stored in amber coloured bottle.

3. Glucose standard (100 mg/100 ml): Dissolved 1.0 g pure anhydrous glucose in one litre of distilled water containing 1.5 g benzoic acid and stored in a refrigerator.

Procedure

Deproteinized blood sample was prepared by transferring 0.2 ml of blood sample into a test tube containing 1.8 ml of tungstic acid reagent. Mixed well and kept it undisturbed for

5 minutes. Then centrifuged at 3000 rpm for 5 minutes. Added 1.0 ml aliquot of the centrifugate to 5.0 ml O-toluidine reagent, mixed and labelled the unknown. The blank and the standard were set up as follows.

Blank : 5.0 ml O-toluidine reagent + 1.0 ml distilled water

Standard: 5.0 ml O-toluidine reagent + 0.9 ml distilled water + 0.1 ml glucose standard

Mixed the contents thoroughly and placed all the tubes in a boiling water bath for about 10 minutes and then removed and placed in cold tap water bath. When cooled the absorbances of the standard and unknown were read against the blank in a spectrophotometer at 625 nm within 30 minutes.

Calculation

$$\text{Glucose in mg/100 ml} = \frac{Ax}{As} \times \frac{0.1}{0.1} \times 100 = \frac{Ax}{As} \times 100$$

Where Reading of unknown = Ax

Reading of standard = As

3.2.2 Determination of liver glycogen (Seifter *et al.*, 1950)

Principle

The liver tissue is digested with Potassium hydroxide (KOH) and the digesta is treated with anthrone reagent. The sulphuric acid medium of anthrone reagent causes dehydration of the sugar to a furfural derivative which presumably condenses with anthrone to form a blue coloured compound. The colour produced is compared with a standard in a spectrophotometer at 620 nm.

Reagents

1. 30% KOH solution: Dissolved 300 g of reagent grade potassium hydroxide pellets in distilled water in a beaker, cooled, transferred quantitatively to a 1 litre volumetric flask and diluted to the mark.

2. 95%, Sulphuric acid: Mixed one litre of concentrated sulphuric acid with 50 ml distilled water and cooled.

3. 0.2% Anthrone reagent: The reagent was prepared by dissolving 0.2 g anthrone in 100 ml, 95% sulphuric acid. The reagent was prepared fresh whenever required.

4. Standard glucose solution (20 µg/ml): The stock standard was prepared by dissolving 1.0 g of highest purity

anhydrous glucose in saturated benzoic acid solution and diluting to 100 ml with the same. The working standard was prepared by diluting one ml of stock standard to 500 ml with distilled water.

Procedure

Approximately 0.5 g of liver was placed in a test tube containing 3 ml of 30% KOH solution. The tissue was digested by heating the tube for 20 minutes in boiling water bath. The sample was then cooled and quantitatively transferred into a 50 ml volumetric flask and diluted to the mark with distilled water. After thorough mixing, 5 ml of the solution was pipetted into a second 50 ml volumetric flask and diluted to the mark.

Unknown : 5 ml of digesta prepared at the end of final dilution of 50 ml.

Standard: 5 ml of glucose working standard.

Blank : 5 ml of distilled water

The unknown, standard and blank (5 ml each in labelled test tubes) were kept in a cold water bath and added 10 ml of anthrone reagent to each of the three test tubes from a fast flowing burette. Mixed the reactants by swirling the test tubes. After cooling, covered the mouth of test tubes with

glassmarble and heated for 10 minutes in boiling water bath. Then immediately cooled by placing them in cold water bath. The readings were taken against the blank at 620 nm in a spectrophotometer.

Calculation

$$\text{Percentage of glycogen in the wet tissue} = \frac{Ax}{As} \times \frac{100}{1.11} \times \frac{500}{5} \times \frac{100}{\text{wt. of tissue in grams}} \times \frac{1}{1000000}$$

Reading of unknown = Ax
Reading of standard = As

Concentration of standard in μg = 100

$$\text{Correction factor for conversion of glucose to glycogen} = \frac{1}{1.11}$$

$$\text{Dilution factor} = 500/5 = \frac{100}{1}$$

$$\text{Factor for expressing value in \%} = \frac{100}{1000000}$$

Statistical analysis of the data was carried out as outlined by Snedecor and Cochran, 1967.

Chapter 4

RESULTS

Results observed in the present experiment with regard to blood glucose concentration, liver glycogen level, liver weight and body weight are presented below.

4.1 Blood glucose

The mean blood glucose level on the day of hatch (zero day) in Japanese quails was 244.425 ± 2.204 mg/dl (Table 3). The mean blood glucose level recorded at fortnightly intervals, from two to sixteen weeks of age of male quails was ranging from 228.548 ± 7.241 mg/dl (two weeks of age) to 151.851 ± 5.992 mg/dl (sixteen-weeks of age) vide Table 4.1.1 and Fig.1. The corresponding values in females were 241.308 ± 7.221 mg/dl (two-weeks of age) and 173.217 ± 6.996 mg/dl (sixteen-weeks of age) vide Table 4.2.1 and Fig.1. Significant difference ($P \leq 0.05$) in blood sugar level of male quails was observed between zero and two weeks and eight and ten weeks of age (Table 4.1.2). The difference was highly significant ($P \leq 0.01$) between four and six weeks, 10 and 12 weeks, 12 and 14 weeks and 14 and 16 weeks of age (Table 4.1.2). In the case of females highly significant difference ($P \leq 0.01$) was evident between two and four weeks and six and eight weeks of age (Table 4.2.2). Significant

Table 3. Blood glucose, liver glycogen, liver weight and body weight of Japanese quail chicks on the date of hatch (zero day)

Blood[1] glucose (mg/dl)	Liver[2] glycogen (% of wet tissue)	Liver weight (g)	Body weight (g)
		0.1922	6
236.61	1.64		
		0.1685	6
		0.1611	5
241.33	2.40		
		0.1757	6
		0.1639	6
237.40	1.44		
		0.1868	6
		0.1344	6
255.18	1.84		
		0.2110	7
		0.1726	6
228.74	2.20		
		0.1901	6
		0.1247	6
261.02	1.90		
		0.1670	6
		0.1509	7
238.97	1.80		
		0.1934	5
		0.2407	6
229.13	1.60		
		0.1754	7
		0.1645	7
250.39	1.66		
		0.2009	6
		0.2428	6
237.00	1.76		
		0.2450	7

Contd.

Table 3 (Contd.)

Blood[1] glucose (mg/dl)	Liver[2] glycogen (% of wet tissue)	Liver weight (g)	Body weight (g)
		0.1739	7
253.93	2.40		
		0.1944	6
		0.1780	7
232.32	1.38		
		0.1752	6
		0.1323	6
256.66	1.76		
		0.2198	6
		0.1930	6
254.26	2.40		
		0.2180	6
		0.1808	7
237.00	2.60		
		0.2248	8
		0.2094	8
240.94	3.00		
		0.2270	7
		0.2330	8
242.51	2.80		
		0.2190	7
		0.1636	6
252.75	1.72		
		0.1950	8
		0.2192	6
248.03	2.28		
		0.1930	7
		0.1797	6
254.33	2.20		
		0.2032	8
Mean ±SE 244.425± 2.204	2.039± 0.102	0.190± 0.005	6.525± 0.129

1&2 - Pooled value of two samples

Table 4.1.1 Blood glucose level (mg/dl) of male Japanese quails at fortnightly intervals

Age in weeks							
2	4	6	8	10	12	14	16
256.98	222.41	188.50	160.25	216.47	161.73	199.12	151.64
264.71	172.84	167.00	155.33	196.29	185.02	184.07	149.91
230.28	207.33	171.50	130.32	185.00	166.39	176.02	124.10
251.83	209.48	170.50	161.89	225.93	156.68	181.86	140.08
124.24	223.71	137.50	166.80	213.58	169.51	185.84	128.68
206.25	238.36	149.20	204.51	191.38	154.25	180.00	119.67
221.32	188.79	159.16	161.48	171.60	190.28	194.37	137.62
234.92	179.31	160.20	164.75	197.53	153.56	194.69	134.09
212.13	254.31	150.00	179.51	165.88	149.80	169.91	177.87
249.63	220.69	131.00	178.64	217.64	178.54	188.05	126.55
202.94	262.50	299.86	168.20	165.88	198.02	208.41	130.08
252.94	241.38	122.00	170.20	146.11	150.29	208.85	124.18
263.60	231.47	157.35	136.46	138.11	156.23	180.97	166.55
237.13	214.22	154.98	164.26	166.47	156.68	179.99	150.90
215.81	244.39	162.00	180.00	191.76	140.08	161.15	177.87
245.96	226.72	163.98	163.26	156.47	168.59	180.08	196.31
240.07	222.41	184.98	156.26	268.74	129.96	179.99	177.87
191.91	190.00	182.94	160.00	214.58	159.12	154.42	188.83
257.35	184.79	190.24	172.36	190.28	173.30	190.76	146.31
210.95	232.32	177.72	184.00	176.24	148.99	186.73	188.62
Mean 228.548±	218.372±	165.534±	168.934±	189.297±	161.826±	184.264±	151.851±
±SE 7.241	5.613	7.959	3.544	7.032	3.734	3.023	5.992

Table 4.1.2 Comparison of blood glucose level of male quails between age groups at fortnightly intervals from zero to sixteen weeks

Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	2.0715*	1.1012	5.4250**	0.3902	2.5859*	3.4503**	4.6709**	4.8297**

* (P≤0.05)
** (P≤0.01)

Table 4.2.1 Blood glucose level (mg/dl) of female Japanese quails at fortnightly intervals

Age in weeks								
	2	4	6	8	10	12	14	16
	251.10	235.78	238.50	261.48	174.11	187.45	232.30	179.51
	252.94	191.81	247.00	170.08	184.71	170.04	218.14	213.92
	257.72	181.03	249.50	162.70	183.53	178.54	164.25	204.51
	250.48	200.86	210.50	162.70	184.71	153.85	167.26	174.18
	262.13	219.39	221.00	155.74	196.00	178.14	190.00	188.11
	261.97	210.10	239.00	179.92	167.90	142.11	193.88	274.59
	255.14	203.88	228.00	178.28	176.54	181.78	188.67	160.25
	255.14	208.80	206.00	179.10	151.85	166.80	209.29	164.39
	250.00	181.47	200.00	162.70	203.70	170.85	218.50	174.59
	122.20	208.62	213.00	217.21	150.62	202.83	187.61	178.29
	264.64	212.07	226.50	198.84	172.84	201.62	192.48	166.31
	250.36	215.09	201.20	260.24	134.24	193.93	-	140.57
	204.77	278.88	194.00	158.14	182.72	151.11	183.63	156.97
	233.80	180.60	223.00	210.24	149.38	201.21	213.72	158.61
	230.38	198.78	160.50	232.20	148.30	155.87	186.28	134.84
	560.66	204.31	211.00	184.24	190.54	179.76	212.83	173.36
	238.97	203.02	140.50	228.64	204.20	161.91	182.24	151.23
	235.29	231.03	159.00	170.00	206.36	672.06	188.14	179.51
	220.59	196.86	179.00	178.78	196.28	168.24	173.99	146.31
	263.60	190.00	139.98	168.84	170.36	210.53	168.58	144.26
Mean	241.308±	202.619±	206.959±	181.009±	176.444±	176.833±	193.250±	173.217±
±SE	7.221	3.575	6.513	5.326	4.678	4.120	9.184	6.996

Table 4.2.2 Comparison of blood glucose level of female quails between age groups at fortnightly intervals from zero to sixteen weeks

Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	0.4128	4.8014**	0.5842	3.0854**	0.6439	0.0623	2.4424*	2.4427*

* (P≤0.05)
** (P≤0.01)

Table 4.3 Mean blood glucose level in mg/dl (Mean ± S.E.) of Japanese quails at different ages (fortnightly intervals)

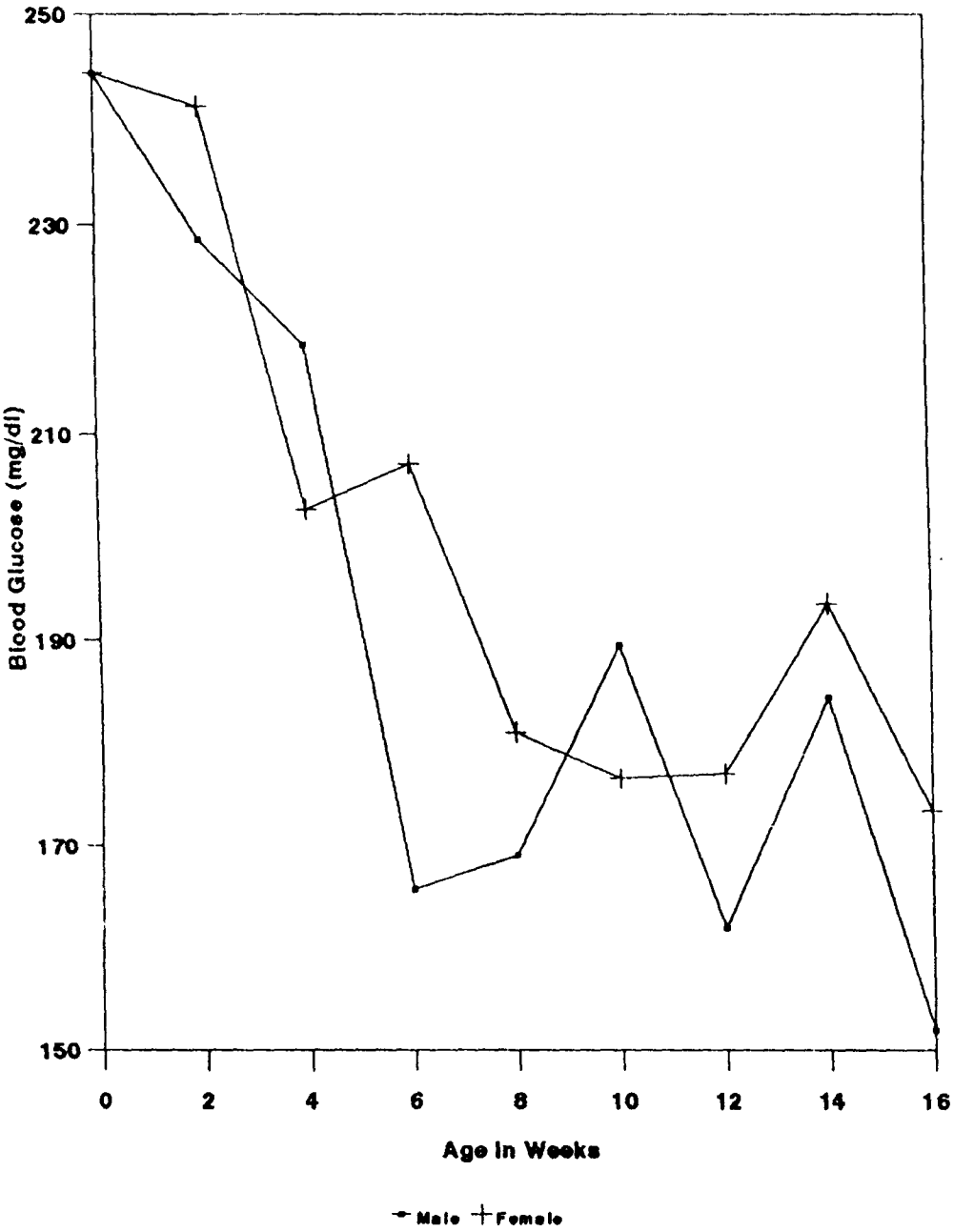
Age in weeks	Blood glucose level in mg/dl		
	Males	Females	Pooled (Males & Females)
0	244.425 ± 2.204 (unsexed)		
2	228.548 ± 7.241	241.308 ± 7.221	234.928 ± 0.219
4	218.372 ± 5.613	202.619 ± 3.575	210.496 ± 0.150
6	165.534 ± 7.959	206.959 ± 6.513	186.247 ± 0.191
8	168.934 ± 3.544	181.009 ± 5.326	174.972 ± 0.354
10	189.297 ± 7.032	176.444 ± 4.678	182.871 ± 0.148
12	161.826 ± 3.734	176.833 ± 4.120	169.330 ± 0.243
14	184.264 ± 3.023	193.250 ± 9.184	188.757 ± 0.643
16	151.851 ± 5.992	173.217 ± 6.996	162.534 ± 0.246

Table 5. Comparison of blood glucose, liver glycogen, liver weight and body weight between male and female Japanese quails at fortnightly intervals from zero to sixteen weeks

	Age in weeks							
	2	4	6	8	10	12	14	16
Blood glucose	1.2392	2.3671**	4.0279**	1.8875	1.5217	2.6990*	1.7742	2.3196*
Liver glycogen	3.3430**	0.1211	1.7792	0.3608	0.8427	0.4742	0.1078	0.4120
Liver weight	0.0824	1.8433	3.8985**	9.0065**	6.8394**	9.2839**	2.9477**	4.2708**
Body weight	0.3368	0.9036	2.3103*	7.0712**	13.5606**	5.3608**	6.6603**	2.6745*

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

Fig.1 BLOOD GLUCOSE LEVEL OF JAPANESE QUAIL (0 TO 16 WEEKS PERIOD)



difference ($P \leq 0.05$) was noticed (in females) between 12 and 14 weeks and 14 and 16 weeks of age too (Table 4.2.2). It was also observed that the blood glucose level was maintained above 200 mg/dl upto an age of fourth week in the case of males and sixth week in the case of females where after there was a lowering tendency for the blood glucose level (Table 4.3 and Fig.1). The mean blood glucose values in male and female Japanese quails for various age period (from the date of hatch to 16 weeks of age at fortnightly intervals) were recorded (Table 4.3 and Fig.1). Female quails had comparatively a higher blood glucose level than the male quails at all age levels except fourth and tenth week of age (Table 4.3 and Fig.1). Highly significant difference ($P \leq 0.01$) in blood glucose level between sexes was evident at fourth and sixth week of age (Table 5). Significant difference ($P \leq 0.05$) was noticed at 12 and 16 weeks of age (Table 5). Pooled blood glucose values for Japanese quail (both males and females put together) from day of hatch to 16-weeks of age were ranging from 244.425 ± 2.204 mg/dl (zero day) to 162.534 ± 0.246 mg/dl (16 weeks) vide Table 4.3.

4.2 Liver glycogen

Quail chicks on the day of hatch had a normal mean liver glycogen level of 2.039 ± 0.102% (Table 3). Liver glycogen content of both male and female quails from two to sixteen weeks of age was lower than that of the value on the day of

hatch (Table 6.3 and Fig.2). The mean glycogen content at two weeks of age in males and females were 1.953 ± 0.184% (Table 6.1.1) and 1.199 ± 0.131% (Table 6.2.1) respectively. Both males and females had a lowering tendency for the liver glycogen content. At sixteenth week of age the liver glycogen content for males and females were 1.016 ± 0.133% and 1.098 ± 0.152% respectively (Table 6.1.1 and Table 6.2.1). The values recorded at fortnightly intervals from two to sixteen weeks of age in males and females were represented in the Table 6.1.1 (males) and Table 6.2.1 (females). Highly significant difference ($P \leq 0.01$) in liver glycogen content of males was evident between four and six weeks of age (Table 6.1.2) whereas in females between zero and two weeks, four and six weeks and eight and ten weeks of age (Table 6.2.2). Significant difference ($P \leq 0.05$) in liver glycogen content was also noticed between 14 and 16 weeks of age in females. Significant difference ($P \leq 0.01$) due to sex on liver glycogen level was evident only at two weeks of age (Table 5). The mean liver glycogen content for male and female Japanese quails and the pooled value of both the sexes from the date of hatch to sixteen weeks of age at fortnightly intervals were recorded (Table 6.3). The liver glycogen content of Japanese quails on day of hatch and on sexual maturity (sixth week of age) were 2.039 ± 0.102% and 0.918 ± 0.144% (pooled value) respectively.

Table 6.1.1 Liver glycogen level (% of wet tissue) of male Japanese quails at fortnightly intervals

Age in weeks								
	2	4	6	8	10	12	14	16
	3.04	0.87	1.12	0.52	1.20	0.71	1.00	1.12
	1.15	3.30	1.12	0.51	0.59	0.65	1.10	0.55
	2.99	1.91	1.19	2.99	1.40	1.08	0.83	0.64
	2.47	1.84	2.30	0.72	0.79	2.10	1.81	2.10
	1.71	1.26	0.99	1.00	2.56	1.19	0.74	0.73
	1.34	0.82	1.16	2.66	3.24	1.15	0.94	0.97
	1.87	1.35	0.78	0.94	1.01	0.65	1.75	0.98
	3.94	3.58	0.64	0.63	0.79	2.22	1.27	0.70
	2.71	2.75	1.39	0.40	1.24	0.77	2.00	0.54
	2.46	1.91	1.14	1.20	0.85	0.77	1.63	1.35
	1.36	1.32	0.45	0.98	1.24	0.82	2.64	0.70
	2.83	0.46	1.20	1.00	0.73	0.79	2.78	0.50
	1.75	1.16	0.88	1.20	2.33	1.57	1.37	0.61
	1.00	1.26	1.44	0.72	0.68	0.87	1.34	1.01
	1.97	1.78	0.42	2.20	2.12	0.59	0.58	1.01
	1.22	1.66	0.65	0.96	0.68	1.23	0.66	0.43
	1.20	0.87	0.37	0.52	2.12	1.54	0.60	0.67
	1.56	1.40	1.33	0.66	2.60	1.17	2.41	0.99
	1.46	1.20	0.23	0.98	1.46	0.85	0.58	1.11
	1.03	2.24	1.99	1.20	1.20	0.65	1.12	2.22
Mean	1.953±	1.647±	1.040±	1.099±	1.441±	1.068±	1.363±	1.016±
±SE	0.184	0.182	0.117	0.159	0.174	0.105	0.153	0.133

Table 6.1.2 Comparison of liver glycogen level of male quails between age groups at fortnightly intervals from zero to sixteen weeks

Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	0.4091	1.1851	2.8140**	0.2995	1.4565	1.8337	1.5835	1.7140

** (P≤0.01)

Table 6.2.1 Liver glycogen level (% of wet tissue) of female Japanese quails at fortnightly intervals

Age in weeks								
	2	4	6	8	10	12	14	16
	0.34	2.76	0.57	0.86	0.69	0.92	1.23	1.40
	1.27	1.97	0.82	0.97	1.00	0.90	1.24	0.84
	1.85	0.58	0.31	0.77	0.57	1.30	0.62	0.61
	0.34	1.56	0.70	0.73	1.44	1.55	0.82	0.82
	1.36	0.76	0.71	1.00	0.81	1.24	0.77	3.21
	1.66	1.42	0.74	0.67	0.60	1.16	1.21	0.68
	0.59	3.85	0.49	0.95	2.10	0.84	0.85	0.76
	0.82	0.64	0.51	0.99	0.68	0.51	2.03	0.86
	0.36	0.73	0.48	1.36	1.02	1.01	2.79	1.76
	2.30	1.07	1.26	1.72	1.68	1.26	1.82	0.71
	2.15	0.38	0.96	1.32	0.56	0.54	1.88	0.58
	0.97	3.72	1.51	0.82	3.47	1.71	1.28	0.73
	0.89	0.55	0.50	0.76	0.32	0.65	0.79	0.91
	1.21	1.42	0.82	1.74	1.49	1.08	1.40	1.56
	1.79	1.28	0.66	2.00	0.41	1.08	1.96	0.86
	1.58	5.67	0.92	0.84	2.48	0.89	2.94	1.63
	1.02	0.57	0.72	2.42	1.91	0.45	5.75	2.02
	0.92	2.80	0.70	1.46	1.01	0.89	0.99	0.60
	0.91	2.00	1.21	0.98	0.92	0.79	1.43	1.11
	1.65	1.96	1.42	0.99	1.48	1.37	0.92	0.29
Mean	1.199±	1.684±	0.795±	1.168±	1.232±	1.007±	1.386±	1.098±
±SE	0.131	0.251	0.072	0.107	0.177	0.076	0.148	0.152

Table 6.2.2 Comparison of liver glycogen level of female quails between age groups at fortnightly intervals from zero to sixteen weeks

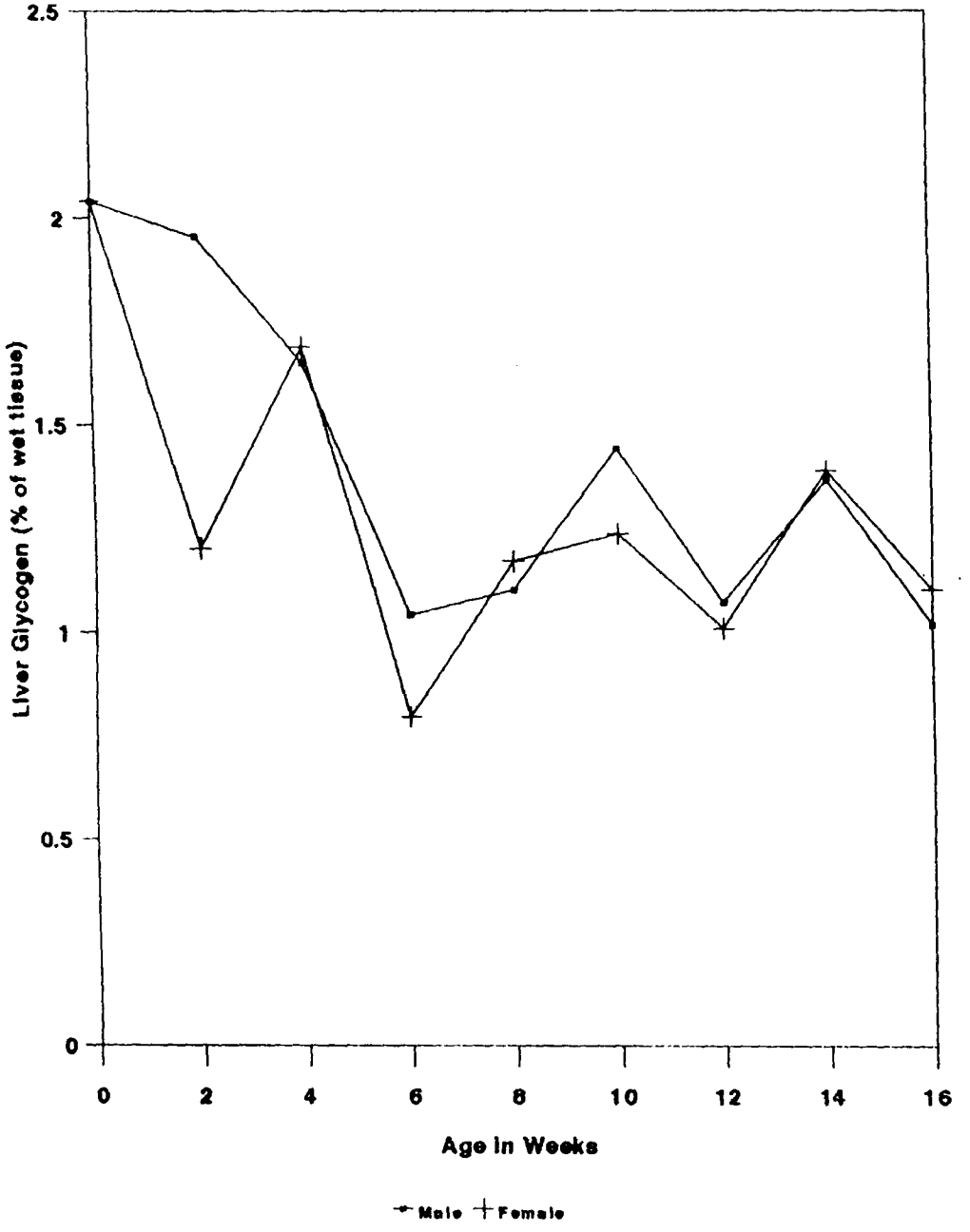
Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	5.0539**	7.7191	3.4080**	2.8894	0.3113**	1.1659	2.2753	1.3533*

* (P≤0.05)
** (P≤0.01)

Table 6.3 Mean liver glycogen level in percentage of wet tissue (Mean ± S.E.) of Japanese quails at different ages (fortnightly intervals)

Age in weeks	Liver glycogen level in percentage of wet tissue		
	Males	Females	Pooled (Males & Females)
0	2.039 ± 0.102 (unsexed)		
2	1.953 ± 0.184	1.199 ± 0.131	1.576 ± 0.160
4	1.647 ± 0.182	1.684 ± 0.251	1.666 ± 0.317
6	1.040 ± 0.117	0.795 ± 0.072	0.918 ± 0.144
8	1.099 ± 0.159	1.168 ± 0.107	1.134 ± 0.156
10	1.441 ± 0.174	1.232 ± 0.177	1.337 ± 0.213
12	1.068 ± 0.105	1.007 ± 0.076	1.038 ± 0.166
14	1.363 ± 0.153	1.386 ± 0.148	1.375 ± 0.228
16	1.016 ± 0.133	1.098 ± 0.152	1.057 ± 0.260

Fig.2 LIVER GLYCOGEN LEVEL OF JAPANESE QUAIL (0 TO 16 WEEKS PERIOD)



4.3 Liver weight

The mean liver weight of Japanese quails was 0.190 ± 0.005 g on the day of hatch (Table 3). The weight of liver in Japanese quails both males and females from two to sixteen weeks of age (fortnightly intervals) showed a steady increase ranging from 1.527 ± 0.074 g to 5.068 ± 0.283 g (males) and 1.535 ± 0.067 g to 6.960 ± 0.341 g (females) vide Table 7.1.1, 7.2.1 and Fig.3. Liver weight showed highly significant difference ($P \leq 0.01$) between zero and two weeks, two and four weeks and also twelve and fourteen weeks of age (Table 7.1.2) in males. Males showed a significant increase ($P \leq 0.05$) in liver weight between four and six weeks, six and eight weeks and also eight and ten weeks of age (Table 7.1.2). In females highly significant increase ($P \leq 0.01$) in liver weight was noticed upto eight weeks of age (Table 7.2.2). Significant difference ($P \leq 0.05$) between 14 and 16 weeks of age was also noticed in the liver weight of females (Table 7.2.2). It was also observed that the liver weight was higher in female quails at all age levels and highly significant ($P \leq 0.01$) from sixth week onwards (Table 7.3, 5 and Fig.3). The mean liver weight for male and female Japanese quails and the pooled values (both males and females put together) were recorded from the day of hatch to sixteen weeks of age (Table 7.3).

Table 7.1.1 Liver weight (g) of male Japanese quails at fortnightly intervals

	Age in weeks							
	2	4	6	8	10	12	14	16
	1.5510	2.7871	3.4084	3.0378	4.2291	3.7648	4.8695	4.9210
	1.2980	2.9596	4.3010	3.6995	4.1562	4.2231	4.6222	4.0476
	2.0734	2.8203	4.6742	3.9786	3.3229	4.0659	4.5658	5.0561
	1.8193	2.8035	3.3944	3.6857	3.4759	4.5384	4.4942	4.5456
	1.6533	3.1923	3.3753	3.8846	5.3668	3.0124	3.7139	4.5701
	1.4317	2.9081	2.8227	4.3372	5.5895	3.7811	3.0309	6.9262
	1.2556	2.5034	2.5644	4.0822	4.0118	3.3175	3.4383	3.4312
	1.8116	3.0616	2.7436	2.9424	4.5938	4.9587	4.5955	3.4095
	1.8010	3.7490	3.3414	3.9310	3.7647	3.7783	6.9534	5.2803
	1.3693	2.5038	3.2873	3.2378	4.1074	3.0740	4.8033	3.0122
	1.8296	3.5159	3.8545	3.9848	4.6249	3.3444	3.4255	3.6563
	1.9186	2.5676	2.4609	4.6464	2.7352	3.6895	4.9480	4.3813
	1.1213	3.1120	3.5679	3.1624	4.5831	4.5839	6.0529	6.4519
	1.4994	2.9251	3.6905	3.9696	2.5642	3.3148	5.7774	6.8714
	1.8420	2.9482	3.0497	4.0224	3.5831	2.9533	4.5027	5.6543
	1.3782	2.9651	0.1859	3.7646	3.5642	4.8294	4.5254	6.8612
	1.1697	2.7871	3.5612	3.8678	3.5229	4.8034	4.6208	4.2527
	1.0296	2.3424	5.2145	4.0222	4.1230	3.1350	5.7069	6.8262
	1.7876	2.4834	2.7162	4.2232	3.6238	4.8711	3.4174	5.8874
	0.8942	3.6690	2.5355	4.3246	3.0026	3.4383	5.6217	5.3609
Mean	1.527±	2.930±	3.387±	3.840±	3.927±	3.879±	4.684±	5.068±
±SE	0.074	0.086	0.161	0.100	0.175	0.153	0.222	0.283

Table 7.1.2 Comparison of liver weight of male quails between age groups at fortnightly intervals from zero to sixteen weeks

Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	17.9843**	12.3796**	2.5112*	2.3927*	0.4316*	0.2082	2.9841**	1.0669

* (P≤0.05)
** (P≤0.01)

Table 7.2.1 Liver weight (g) of female Japanese quails at fortnightly intervals

Age in weeks								
	2	4	6	8	10	12	14	16
	1.8495	3.5997	5.1500	5.2096	5.1758	6.4685	6.2492	7.2942
	2.2740	2.9767	4.3207	5.3609	7.6479	6.4907	9.9989	5.7643
	1.1309	2.7699	3.2451	5.3253	5.9204	7.3969	7.9872	9.5632
	1.4599	3.1580	5.7540	5.2424	7.6558	7.6556	4.9450	5.6774
	1.3266	3.2915	5.5172	4.9833	6.1400	5.5892	5.4202	7.7936
	1.7146	4.2853	3.6988	4.7102	6.1814	7.1122	6.2646	5.5824
	1.4519	3.3011	4.1592	6.1646	7.9905	6.0289	6.6884	5.9230
	1.6079	3.4569	4.1176	5.2835	7.0595	8.7441	7.2514	5.9773
	1.8213	4.5649	3.7739	6.5339	7.1996	6.1282	3.6093	5.2520
	1.5276	2.6033	5.3290	6.1673	4.9689	4.8212	4.0199	6.4906
	1.8929	3.2366	6.2971	4.7226	5.2716	5.9420	5.1530	6.1130
	1.8544	3.1883	7.4997	5.5374	5.6081	6.4879	5.8796	9.8809
	1.2652	2.4653	4.1343	5.3232	6.3406	6.9464	7.0683	6.0697
	1.3108	2.4484	4.6802	5.9484	9.6963	6.8657	5.6746	7.2374
	1.4772	3.1695	5.8900	6.5667	5.7467	5.8066	4.2118	6.6722
	1.5528	2.4399	3.1670	5.2454	4.6618	5.3110	5.4648	9.6360
	1.2270	3.7429	4.1005	4.1422	5.3676	5.9979	4.2862	5.7376
	1.5991	2.9697	3.7082	7.2432	6.4678	4.6221	5.3373	6.2366
	1.1174	2.6834	3.3027	5.9646	4.4834	6.4011	5.8484	5.7116
	1.2422	4.2424	3.7042	6.2434	5.5638	5.8879	5.8494	7.5810
Mean	1.535±	3.230±	4.577±	5.594±	6.251±	6.335±	5.860±	6.960±
±SE	0.067	0.138	0.260	0.167	0.291	0.261	0.331	0.341

Table 7.2.2 Comparison of liver weight of female quails between age groups at fortnightly intervals from zero to sixteen weeks

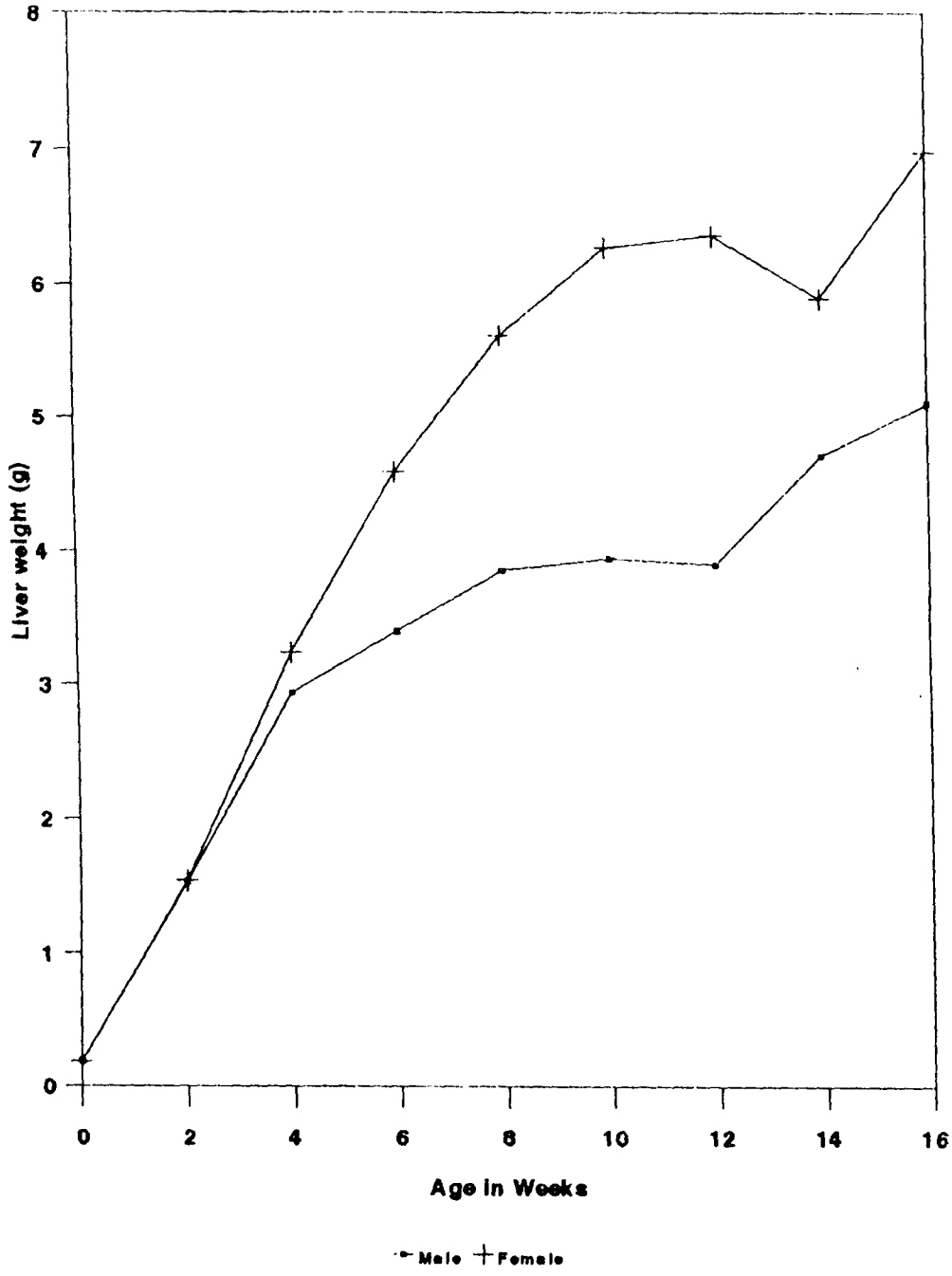
Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	20.0645**	11.0439**	4.5848**	3.2941**	1.9565	0.2312	1.2008	2.3138*

* (P≤0.05)
** (P≤0.01)

Table 7.3 Mean liver weight in g (Mean ± S.E.) of Japanese quails at different ages (fortnightly intervals)

Age in weeks	Liver weight in g		
	Males	Females	Pooled (Males & Females)
0	0.190 ± 0.005 (unsexed)		
2	1.527 ± 0.074	1.535 ± 0.067	1.531 ± 0.212
4	2.930 ± 0.086	3.230 ± 0.138	3.080 ± 0.329
6	3.387 ± 0.161	4.577 ± 0.260	3.982 ± 0.374
8	3.840 ± 0.100	5.594 ± 0.167	4.717 ± 0.389
10	3.927 ± 0.175	6.251 ± 0.291	5.089 ± 0.388
12	3.879 ± 0.153	6.335 ± 0.261	5.107 ± 0.280
14	4.684 ± 0.222	5.860 ± 0.331	5.272 ± 0.346
16	5.068 ± 0.283	6.960 ± 0.341	6.014 ± 0.279

Fig.3 LIVER WEIGHT OF JAPANESE QUAIL (0 TO 16 WEEKS PERIOD)



4.4 Body weight

Body weight of Japanese quails both males and females had an increasing tendency from the date of hatch (zero day) to sixteenth week of age (Table 8.3). Body weight on date of hatch for Japanese quail chicks was 6.525 ± 0.129 g (Table 3). Mean body weight of Japanese quails from second to sixteenth week of age ranged from 35.300 ± 1.008 g (second week) to 170.500 ± 2.244 g (16th week) in males (Table 8.1.1) and from 34.800 ± 1.090 g (second week) to 184.000 ± 4.542 g (16th week) in females (Table 8.2.1). Highly significant increase ($P \leq 0.01$) in body weight was recorded upto an age of eight weeks in males (Table 8.1.2) and ten weeks in the case of females (Table 8.2.2). There was an increase ($P \leq 0.05$) in body weight of males between eight and ten weeks of age and highly significant ($P \leq 0.01$) increase in body weight between 14 and 16 weeks of age (Table 8.1.2). Significant difference ($P \leq 0.05$) in body weight was noticed between 10 and 12 weeks and 12 and 14 weeks in females (Table 8.2.2). In the case of male quails the increase in body weight was steady throughout the age period whereas in female quails the increase in body weight was steady upto 10th week of age, thereafter a decrease and further increase in body weight from 14th to 16th week of age (Table 8.3, Fig.4). It was also evident from the study that the body weight of females was significantly higher ($P \leq 0.05$) than that of males from sixth week of age onwards

Table 8.1.1 Body weight (g) of male Japanese quails at fortnightly intervals

Age in weeks							
2	4	6	8	10	12	14	16
32	60	100	120	160	160	150	180
30	76	112	140	148	160	150	170
42	90	116	146	160	160	162	180
40	80	120	148	144	152	160	177
38	80	120	120	150	150	162	175
36	72	118	146	160	140	160	180
32	72	122	166	156	180	158	170
36	88	132	120	160	160	154	152
38	90	138	146	140	140	180	170
36	80	114	134	158	140	166	150
38	82	142	146	148	144	148	160
44	80	124	158	146	142	166	170
30	98	108	138	160	160	180	180
32	88	126	150	150	133	178	180
36	90	114	152	150	182	150	174
30	88	112	146	150	176	154	180
30	60	120	148	150	158	160	150
30	70	140	160	152	146	156	170
42	72	110	158	156	160	152	170
34	90	118	164	158	140	174	172
Mean 35.300±	80.300±	120.300±	145.300±	152.800±	154.150±	159.800±	170.500±
±SE 1.008	2.039	2.446	3.048	1.364	3.132	2.122	2.244

Table 8.1.2 Comparison of body weight of male quails between age groups at fortnightly intervals from zero to sixteen weeks

Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	28.3121**	77.8599**	11.8904**	6.3967**	2.2460*	0.3951	1.4933	3.4647**

* (P≤0.05)
** (P≤0.01)

Table 8.2.1 Body weight (g) of female Japanese quails at fortnightly intervals

Age in weeks								
	2	4	6	8	10	12	14	16
	42	80	140	170	180	168	190	185
	44	78	130	170	190	168	192	176
	32	70	120	172	180	178	182	222
	32	70	150	176	190	182	158	170
	30	80	120	158	180	168	178	180
	42	108	115	166	186	182	194	160
	40	80	130	172	180	170	158	180
	38	104	120	164	174	194	196	180
	32	96	120	174	190	162	172	220
	30	90	120	170	168	158	168	162
	40	90	150	162	170	174	178	182
	38	80	166	168	172	180	178	230
	30	78	100	174	182	186	194	180
	32	76	150	170	182	185	178	182
	30	96	156	174	188	174	198	170
	34	72	110	164	172	178	182	210
	30	82	132	162	184	168	168	162
	38	80	114	172	190	164	198	178
	30	76	130	162	178	176	186	170
	32	80	132	174	186	168	166	182
Mean	34.800±	83.300±	130.600±	168.200±	181.100±	174.100±	182.500±	184.000±
±SE	1.090	2.385	3.753	1.094	1.579	2.027	2.667	4.542

Table 8.2.2 Comparison of body weight of female quails between age groups at fortnightly intervals from zero to sixteen weeks

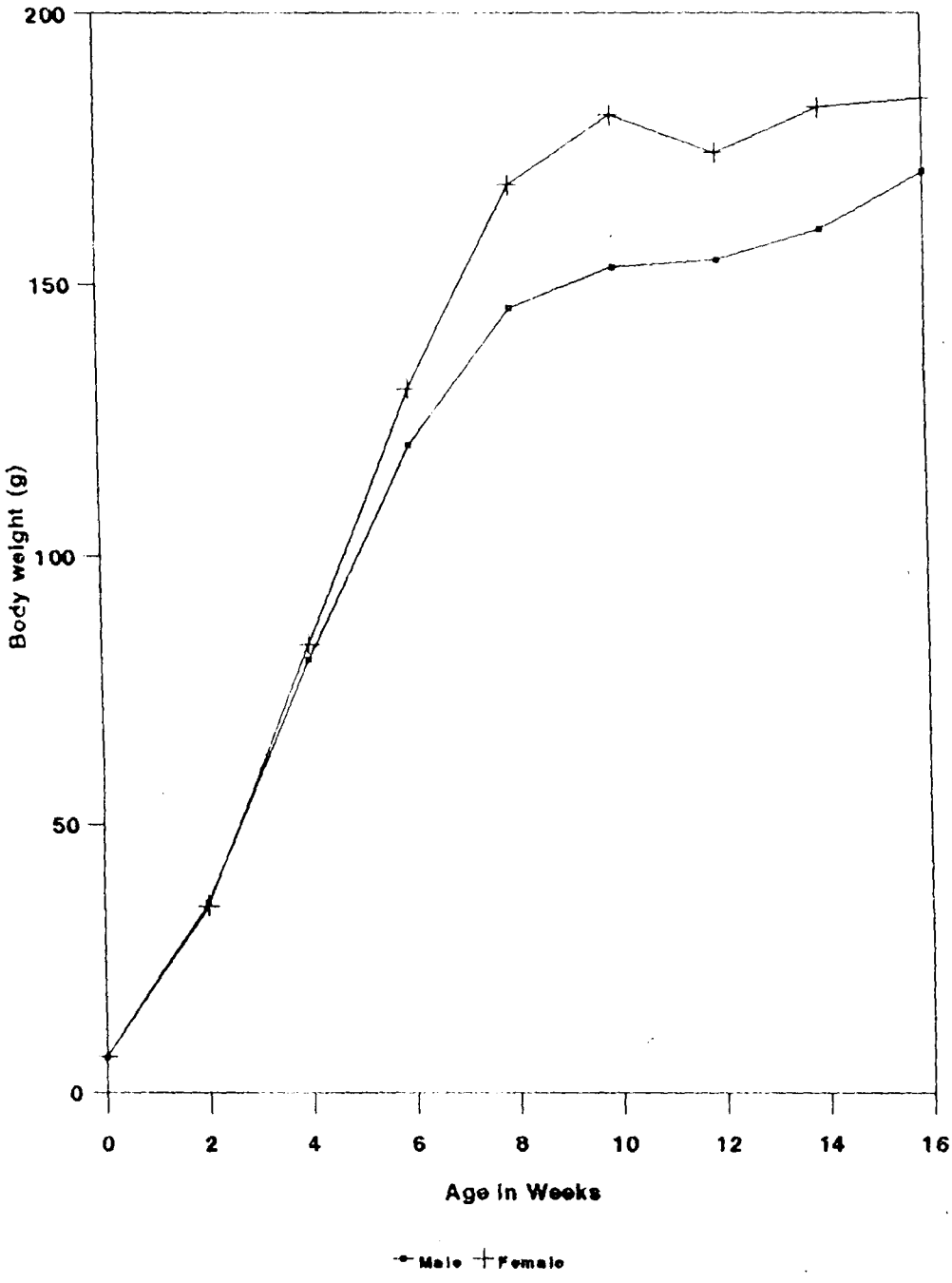
Weeks	0 Vs 2	2 Vs 4	4 Vs 6	6 Vs 8	8 Vs 10	10 Vs 12	12 Vs 14	14 Vs 16
t value	25.7683 **	18.4940 **	10.6477 **	9.6050 **	6.7136 **	2.7051 *	2.4958 *	0.2943

* (P≤0.05)
** (P≤0.01)

Table 8.3 Mean body weight in g (Mean ± S.E.) of Japanese quails at different ages (fortnightly interals)

Age in weeks	Body weight in g		
	Males	Females	Pooled (Males & Females)
0	6.525 ± 0.129 (unsexed)		
2	35.300 ± 1.008	34.800 ± 1.090	35.050 ± 0.250
4	80.300 ± 2.309	83.300 ± 2.385	81.800 ± 0.243
6	120.300 ± 2.446	130.600 ± 3.753	125.450 ± 0.359
8	145.300 ± 3.048	168.200 ± 1.094	156.750 ± 0.080
10	152.800 ± 1.364	181.100 ± 1.579	166.950 ± 0.264
12	154.150 ± 3.132	174.100 ± 2.027	164.125 ± 0.152
14	159.800 ± 2.122	182.500 ± 2.667	171.150 ± 0.277
16	170.500 ± 2.244	184.000 ± 4.542	177.250 ± 0.456

Fig.4 BODY WEIGHT OF JAPANESE QUAIL (0 TO 16 WEEKS PERIOD)



(Table 5 and Fig.4) at which age the birds started laying. The difference in body weight between male and female birds was highly significant ($P \leq 0.01$) at eighth, tenth, twelveth and fourteenth week of age (Table 5). Maximum body weight of males and females at 16th week of age were 170.500 ± 2.244 g (males) and 184.000 ± 4.542 g (females) vide Table 8.3. The pooled values of body weight of both sexes from the day of hatch to 16 weeks of age at fortnightly intervals were ranging from 6.525 ± 0.129 g to 177.250 ± 0.456 g.

4.5 Effect of feed restriction on blood glucose, liver glycogen, liver weight and body weight

4.5.1 Two weeks feed restriction (sixth to eighth week of age)

The effect of two weeks feed restriction (from sixth to eighth week) on blood glucose level, liver glycogen content, liver weight and body weight for both male and female Japanese quails was recorded (Table 9.1 and 9.2.1). There was no significant reduction in blood glucose level and liver glycogen content due to two weeks feed restriction in both sexes of quails (Table 9.2.2 and Fig.5 and 7). The control male and female Japanese quails (normally fed birds) had a blood glucose level of 168.934 ± 3.544 mg/dl and 181.009 ± 5.326 mg/dl respectively and liver glycogen content of 1.099 ± 0.159% and 1.168 ± 0.107% respectively. The feed restricted birds had the blood glucose level of 176.681 ± 3.215 mg/dl

Table 9.1 Blood glucose, liver glycogen, liver weight and body weight of two weeks feed restricted birds at eighth week of age

Blood glucose (mg/dl)		Liver glycogen (% of wet tissue)		Liver weight (g)		Body weight (g)	
Males	Females	Males	Females	Males	Females	Males	Females
167.13	206.15	0.65	0.88	2.6742	4.5424	144	160
153.61	195.08	0.46	1.45	3.4906	4.5431	136	140
162.26	141.80	1.05	0.35	4.3302	2.9470	136	160
166.39	168.40	0.32	1.43	3.6428	6.0264	120	160
173.36	172.20	0.81	0.96	2.6766	4.1342	120	138
170.90	215.16	0.72	1.89	3.0848	4.5088	146	150
202.46	165.98	1.66	1.26	2.7905	4.0428	118	140
201.80	186.23	1.34	1.17	3.1414	3.2241	120	120
158.11	161.88	1.11	1.21	2.5071	5.0886	130	160
188.52	163.11	0.57	0.88	2.8250	3.7584	120	156
193.85	188.52	1.14	0.57	3.8701	5.0549	120	162
168.36	182.24	0.56	1.12	2.9945	4.3116	130	152
156.36	198.77	0.53	1.10	2.2242	2.9438	132	140
203.36	156.66	1.29	0.80	2.7707	4.3443	120	150
130.36	178.24	1.02	1.12	2.1340	3.3940	116	124
195.08	160.29	1.99	0.79	2.2321	4.8548	130	134
172.23	162.29	1.30	1.52	2.5721	3.0319	128	146
154.32	154.10	0.72	0.81	3.0848	5.2234	130	146
187.70	151.23	0.42	1.17	3.2828	3.9426	128	156
177.46	184.02	1.42	1.51	3.6058	3.1608	130	130
Mean ±SE 176.681± 3.215	174.618± 4.373	0.954± 0.101	1.099± 0.081	2.997± 0.129	4.154± 0.193	127.700± 1.899	147.200± 2.777

Table 9.2.1 Effect of two weeks feed restriction (from six to eight weeks) on blood glucose, liver glycogen, liver weight and body weight of Japanese quails

	Control		Feed restricted	
	Males	Females	Males	Females
Blood glucose (mg/dl) Mean±SE	168.934 ± 3.544	181.009 ± 5.326	176.681 ± 3.215	174.618 ± 4.373
Liver glycogen (% of wet tissue) Mean±SE	1.099 ± 0.159	1.168 ± 0.107	0.954 ± 0.101	1.099 ± 0.081
Liver weight (g) Mean±SE	3.840 ± 0.100	5.594 ± 0.167	2.997 ± 0.129	4.154 ± 0.193
Body weight (g) Mean±SE	145.300 ± 3.048	168.200 ± 1.094	127.700 ± 1.899	147.200 ± 2.777

Table 9.2.2 Comparison of control and two weeks feed restricted Japanese quails on blood glucose, liver glycogen, liver weight and body weight

	t value	
	Males	Females
Blood glucose	1.5089	0.9274
Liver glycogen	0.7684	0.5077
Liver weight	5.1589**	5.6432**
Body weight	4.9010**	7.0346**

** ($P \leq 0.01$)

(males) and 174.618 ± 4.373 mg/dl (females). The liver glycogen levels of two weeks feed restricted birds were 0.954 ± 0.101% (males) and 1.099 ± 0.081% (females) vide Table 9.2.1. The body weight and liver weight of two weeks feed restricted male quails were 127.700 ± 1.899 g and 2.997 ± 0.129 g respectively and the values for feed restricted female quails were 147.200 ± 2.777 g and 4.154 ± 0.193 g respectively. The body weight and liver weight of control birds for corresponding feed restriction period were 145.300 ± 3.048 g and 3.840 ± 0.100 g respectively (males) and 168.200 ± 1.094 g and 5.594 ± 0.167 g respectively (females) vide Table 9.2.1. From these data, it was evident that there was significant ($P \leq 0.01$) reduction in body weight and liver weight due to two weeks feed restriction in both sexes of quails (Table 9.2.2 and Fig.9 and 11). In two weeks feed restricted birds the distention of gall bladder with bile was also noticed. Egg production was not seriously affected by two weeks feed restriction in female quails.

4.5.2 Four weeks feed restriction (Sixth to tenth week of age)

Feed restriction for four weeks (sixth to tenth week of age) showed a significant ($P \leq 0.01$) lowering effect on the blood glucose level, liver glycogen content, liver weight as well as body weight in males whereas in females only on the

liver weight and body weight (Table 10.2.1 and 10.2.2, Fig.6, 8, 10 and 12). The blood glucose levels of male and female quails at 10th week of age after four weeks feed restriction were 157.185 ± 7.840 mg/dl and 155.981 ± 9.680 mg/dl respectively (Table 10.1). The blood glucose levels of control birds during the corresponding period were 189.297 ± 7.032 mg/dl (males) and 176.444 ± 4.678 mg/dl (females). The liver glycogen contents for feed restricted males and females were 0.716 ± 0.092% and 0.892 ± 0.064% respectively (Table 10.1). The liver glycogen levels for control males and females were 1.441 ± 0.174% and 1.232 ± 0.177% respectively (Table 10.2.1). Feed restricted males and females had the mean liver weight of 2.134 ± 0.070 g and 4.697 ± 0.182 g respectively (Table 10.1) whereas the control males and females had the liver weight of 3.927 ± 0.175 g and 6.251 ± 0.291 g respectively (Table 10.2.1). The body weight was significantly ($P \leq 0.01$) lower in feed restricted birds, the mean body weight in males and females were 112.450 ± 2.578 g and 141.200 ± 2.129 g respectively (Table 10.1, 10.2.1 and 10.2.2). Control males and females had the body weight of 152.800 ± 1.364 g and 181.100 ± 1.579 g respectively during this period (Table 10.2.1). It was observed that the gall bladder of feed restricted male and female quails were found to be fully filled with bile. The egg production in quails was found to be significantly reduced during third and fourth week of four weeks feed restriction.

Table 10.1 Blood glucose, liver glycogen, liver weight and body weight of four weeks feed restricted birds at 10th week of age

Blood glucose (mg/dl)		Liver glycogen (% of wet tissue)		Liver weight (g)		Body weight (g)	
Males	Females	Males	Females	Males	Females	Males	Females
202.21	148.89	0.86	1.07	2.4449	5.4802	130	140
126.27	130.97	1.28	0.90	2.3732	5.6475	110	160
181.74	121.16	0.71	1.37	2.0262	5.1214	100	130
168.51	130.55	0.33	0.67	1.9596	4.6708	113	148
140.78	102.39	0.46	0.87	2.3079	4.9061	122	132
150.17	122.01	1.28	0.99	2.2916	5.3231	130	154
157.42	139.51	0.76	0.92	1.9643	3.6675	120	138
151.45	130.97	0.39	0.60	1.9012	5.5134	122	150
134.81	143.20	1.06	0.72	1.7722	6.0323	102	146
134.39	120.73	0.34	0.89	2.5101	3.3517	118	130
206.48	133.53	0.37	1.40	1.9408	4.1513	108	146
197.09	169.41	1.04	0.75	1.6372	3.9325	116	150
160.41	276.47	0.48	1.13	2.3335	5.4442	104	140
118.60	167.06	0.39	0.44	2.3915	3.9003	100	144
251.71	202.35	0.34	0.74	2.2643	4.9104	90	140
137.79	157.65	1.26	1.39	1.5702	4.4749	102	144
128.84	247.05	0.30	1.14	2.6595	5.6948	100	144
144.62	180.00	0.37	0.62	2.3582	3.8044	130	130
110.49	159.25	0.67	0.70	2.2547	3.9176	118	138
139.93	136.47	1.64	0.53	1.7124	3.9013	114	120
Mean ±SE	157.185± 7.840	155.981± 9.680	0.716± 0.092	0.892± 0.064	2.134± 0.070	4.697± 0.182	112.450± 2.578	141.200± 2.129

Table 10.2.1 Effect of four weeks feed restriction (from six to ten weeks) on blood glucose, liver glycogen, liver weight and body weight of Japanese quails

	Control		Feed restricted	
	Male	Female	Male	Female
Blood glucose (mg/dl) Mean±SE	189.297 ± 7.032	176.444 ± 4.678	157.185 ± 7.840	155.981 ± 9.680
Liver glycogen (% of wet tissue) Mean±SE	1.441 ± 0.174	1.232 ± 0.177	0.716 ± 0.092	0.892 ± 0.064
Liver weight (g) Mean±SE	3.927 ± 0.175	6.251 ± 0.291	2.134 ± 0.070	4.697 ± 0.182
Body weight (g) Mean±SE	152.800 ± 1.364	181.100 ± 1.579	112.450 ± 2.578	141.200 ± 2.129

Table 10.2.2 Comparison of control and four weeks feed restricted Japanese quails on blood glucose, liver glycogen, liver weight and body weight

	t value	
	Males	Females
Blood glucose	3.0490**	1.9035
Liver glycogen	3.6829**	1.8026
Liver weight	9.5147**	4.5270**
Body weight	13.8353**	15.0497**

** ($P \leq 0.01$)

Fig.5 EFFECT OF TWO WEEKS FEED RESTRICTION (SIX TO EIGHT WEEKS) ON BLOOD GLUCOSE LEVEL OF JAPANESE QUAIL

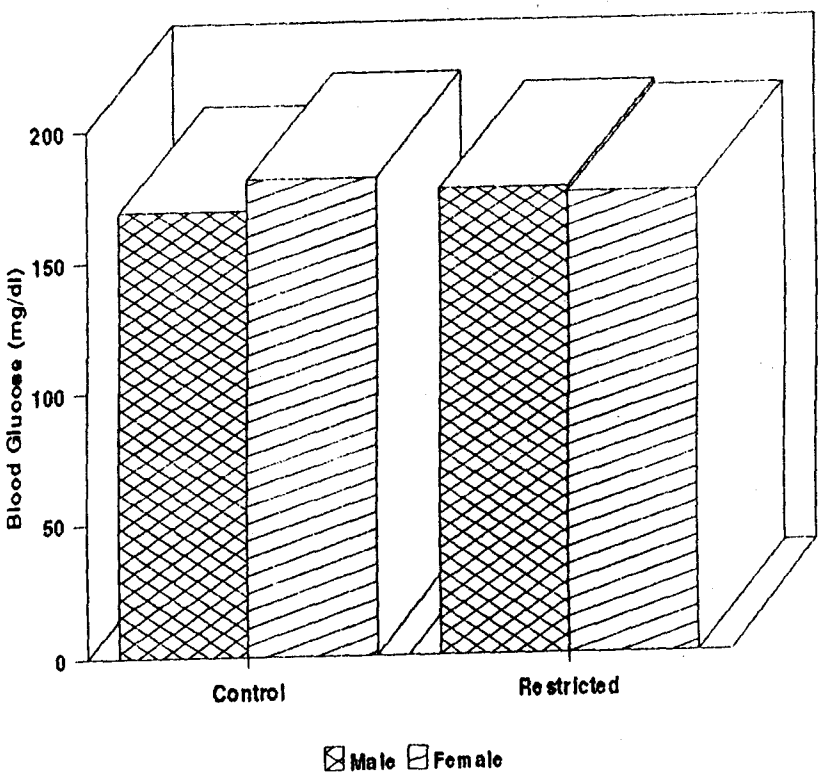


Fig.6 EFFECT OF FOUR WEEKS FEED RESTRICTION (SIX TO TEN WEEKS) ON BLOOD GLUCOSE LEVEL OF JAPANESE QUAIL

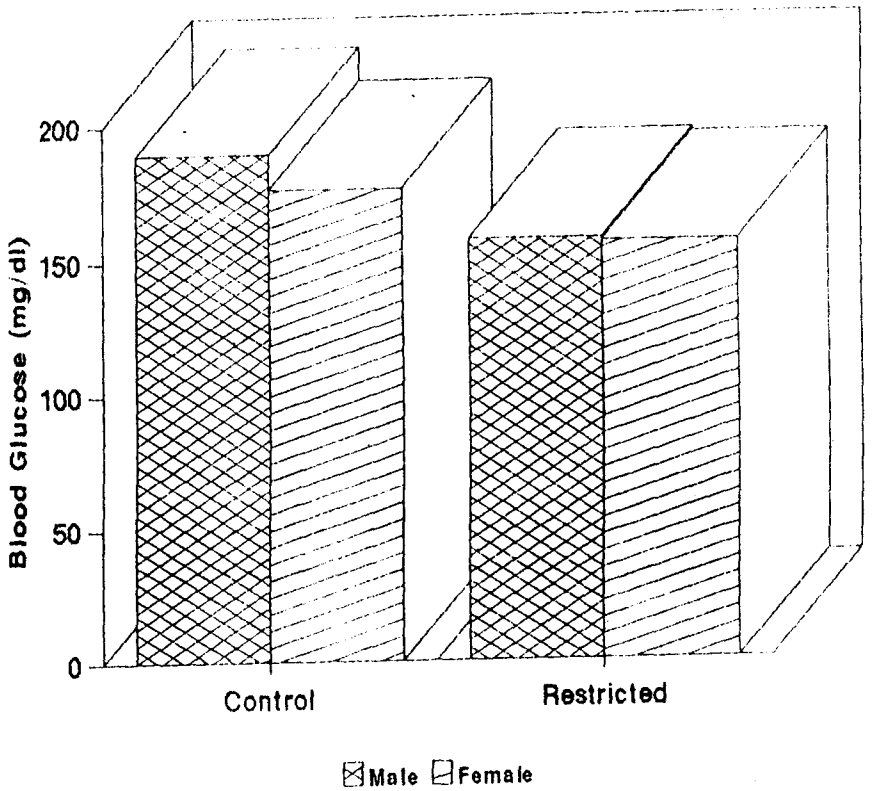


Fig.7 EFFECT OF TWO WEEKS FEED RESTRICTION (SIX TO EIGHT WEEKS) ON LIVER GLYCOGEN LEVEL OF JAPANESE QUAIL

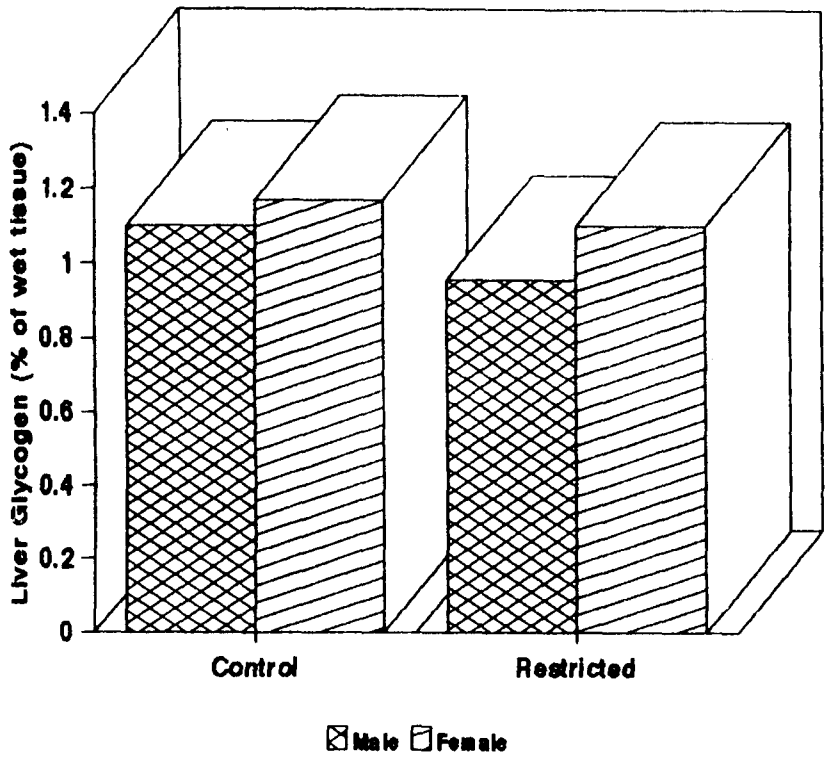


Fig.8 EFFECT OF FOUR WEEKS FEED RESTRICTION (SIX TO TEN WEEKS) ON LIVER GLYCOGEN LEVEL OF JAPANESE QUAIL

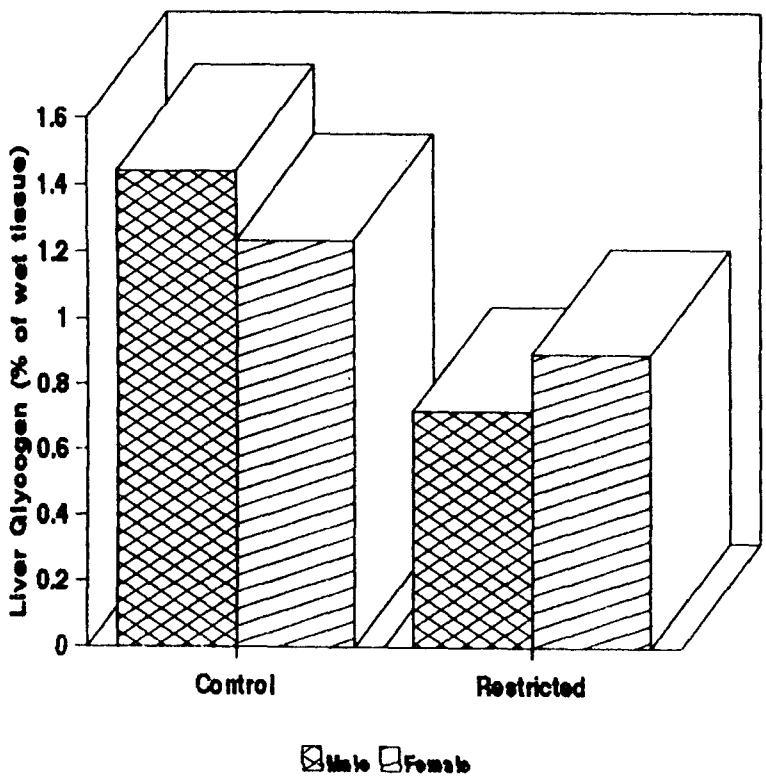


Fig.9 EFFECT OF TWO WEEKS FEED RESTRICTION (SIX TO EIGHT WEEKS) ON LIVER WEIGHT OF JAPANESE QUAIL

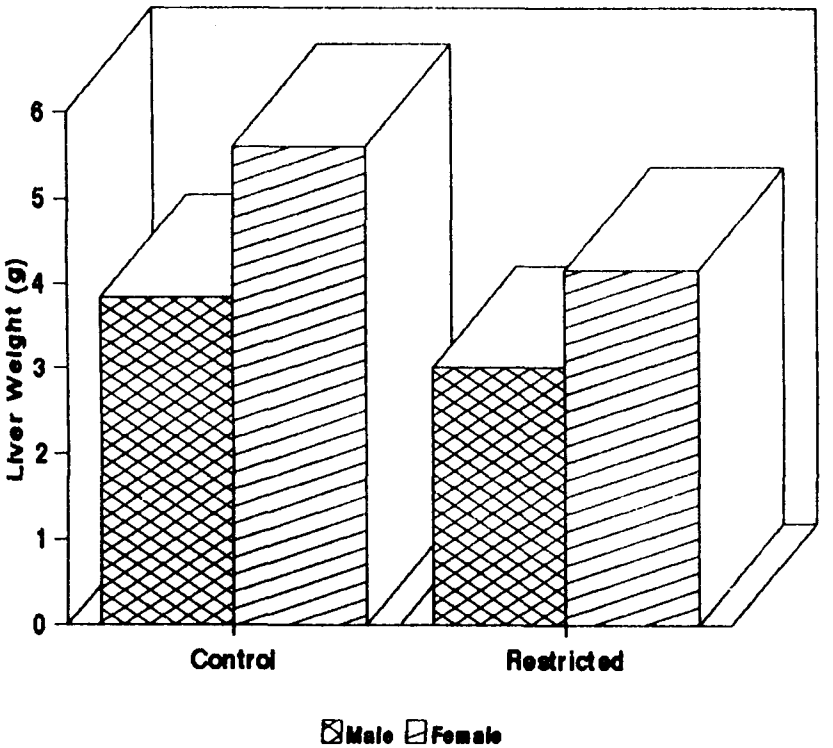


Fig.10 EFFECT OF FOUR WEEKS FEED RESTRICTION (SIX TO TEN WEEKS) ON LIVER WEIGHT OF JAPANESE QUAIL

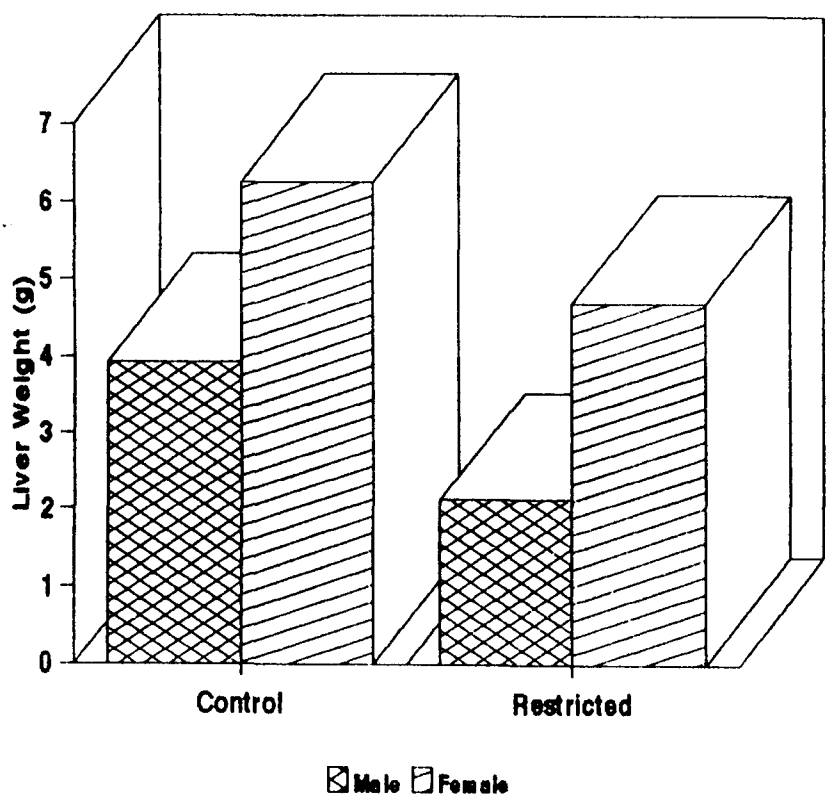


Fig.11 EFFECT OF TWO WEEKS FEED RESTRICTION (SIX TO EIGHT WEEKS) ON BODY WEIGHT OF JAPANESE QUAIL

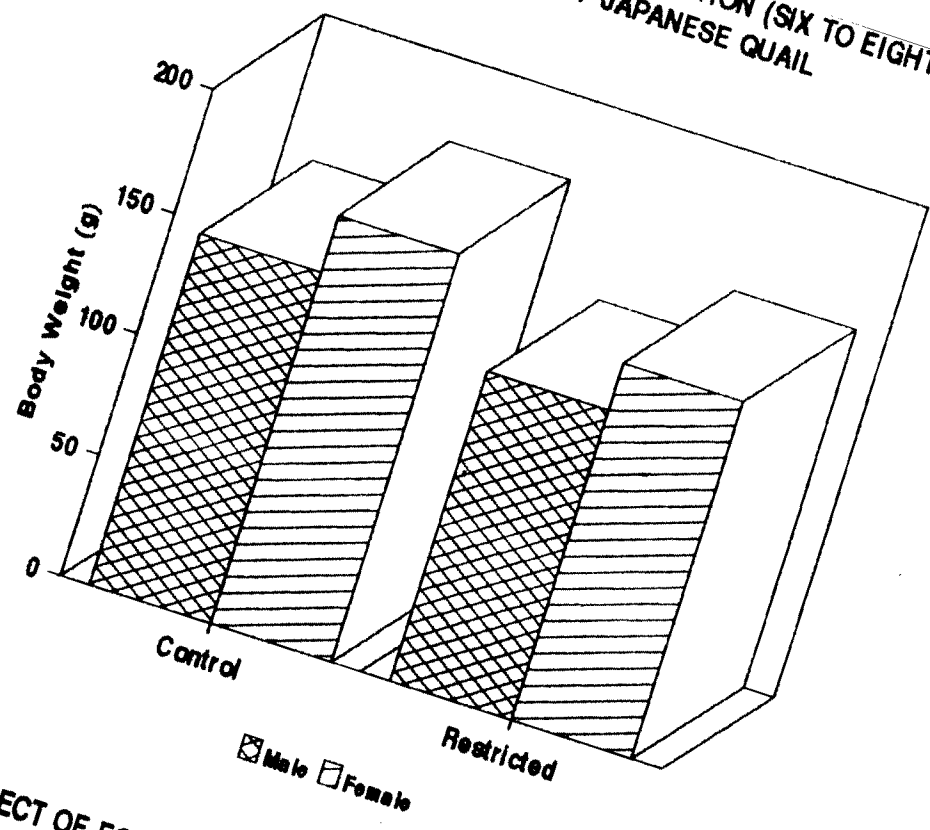
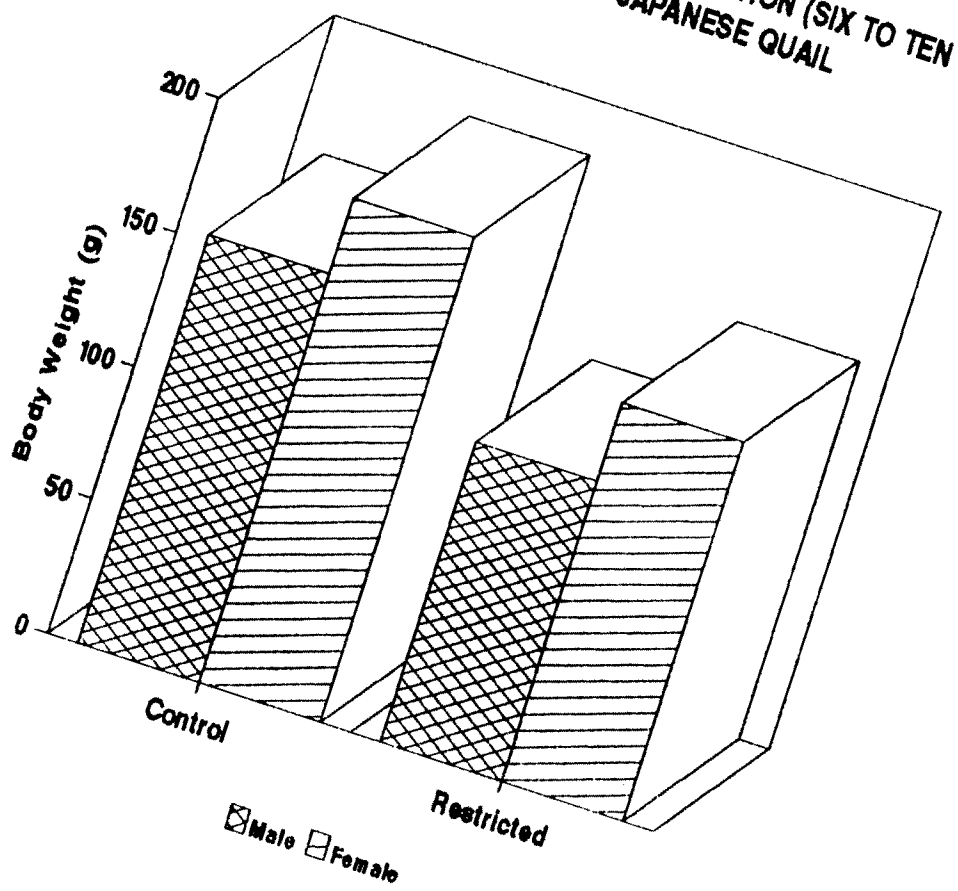


Fig.12 EFFECT OF FOUR WEEKS FEED RESTRICTION (SIX TO TEN WEEKS) ON BODY WEIGHT OF JAPANESE QUAIL



4.6 Correlation between blood glucose concentration, liver glycogen content, liver weight and body weight

Correlation between the different parameters as blood glucose concentration, liver glycogen content, liver weight and body weight in normally fed birds (control) was analysed and presented in Tables 11.1, 11.2 and 11.3. It was observed that in both male and female quails blood glucose level and liver glycogen content were positively correlated (Table 11.3), the correlation values being 0.987 for males and 0.526 for females. A negative correlation was recorded at four (-0.372), six (-0.133) and twelve (-0.320) weeks of age in the case of male birds (Table 11.1). Female birds exhibited a negative correlation between blood glucose and liver glycogen content at two (-0.250), six (-0.117), ten (-0.221) and sixteen (-0.021) weeks of age (Table 11.2). A highly significant ($P \leq 0.01$) positive correlation was observed at an age of eight weeks in female quails (Table 11.2).

Both males and females showed a negative correlation between liver weight and liver glycogen content with a correlation value of -0.849 in males and -0.652 in females (Table 11.3). Male birds exhibited a positive correlation through out their growth period beginning from two to sixteen weeks, the correlation being highly significant ($P \leq 0.01$) at

two, ten and twelve weeks of age (Table 11.1). Females showed the positive correlation only at sixth (0.360), eighth (0.148) and sixteenth (0.231) week of age (Table 11.2). Liver weight was found to be positively correlated with body weight in both male and female Japanese quails from the date of hatch to 16th week of age (Table 11.1, 11.2 and 11.3). The correlation was highly significant ($P \leq 0.01$) at two, eight, fourteen and sixteen weeks in male quails and two, six, eight, twelve and sixteen weeks in female quails.

Male quails exhibited the positive correlation (0.584), which was highly significant ($P \leq 0.01$), between blood glucose level and liver glycogen content after two weeks feed restriction. But four weeks feed restriction in male birds produced a negative correlation (-0.177) between blood glucose concentration and liver glycogen content (Table 11.1). Female quails maintained a positive correlation even after two and four weeks feed restriction (Table 11.2). Correlation values at two weeks and four weeks feed restriction were 0.457 and 0.090 respectively (Table 11.2). Feed restriction for two weeks and four weeks in male birds produced a negative correlation between liver weight and liver glycogen content (Table 11.1). The correlation was significant ($P \leq 0.01$) in four weeks feed restricted male birds. Two weeks feed restricted females exhibited a negative correlation (-0.001)

Table 11.1 Correlation among blood glucose, liver glycogen, liver weight and body weight in male Japanese quail during 0-16 weeks period and feed restricted periods

	Weeks								2 weeks feed restriction	4 weeks feed restriction
	2	4	6	8	10	12	14	16		
Blood glucose and liver glycogen	0.161	-0.372	-0.133	0.117	0.243	-0.320	0.282	0.344	** 0.584	-0.177
Liver weight and liver glycogen	** 0.576	0.380	0.106	0.298	** 0.574	** 0.617	0.244	0.051	-0.196	** -0.483
Body weight and liver weight	** 0.800	* 0.519	0.224	** 0.763	0.300	0.269	** 0.586	** 0.682	0.125	0.110

* P≤ 0.05
** P≤ 0.01

Table 11.2 Correlation among blood glucose, liver glycogen, liver weight and body weight in female Japanese quail during 0-16 weeks period and feed restricted periods

	Weeks								2 weeks feed restriction	4 weeks feed restriction
	2	4	6	8	10	12	14	16		
Blood glucose and liver glycogen	-0.250	0.173	-0.117	** 0.843	-0.221	0.195	0.211	-0.021	* 0.457	0.090
Liver weight and liver glycogen	-0.074	-0.060	0.360	0.148	-0.039	-0.029	-0.348	0.231	-0.001	0.255
Body weight and liver weight	** 0.769	* 0.553	** 0.775	** 0.650	0.441	** 0.793	* 0.465	** 0.884	* 0.528	* 0.471

* P≤ 0.05
** P≤ 0.01

Table 11.3 Correlation among blood glucose, liver glycogen, liver weight and body weight in male and female Japanese quails

	Correlation	
	Male	Female
Blood glucose and liver glycogen	0.987*	0.526
Liver weight and liver glycogen	-0.849*	-0.652
Body weight and liver weight	0.974*	0.991*

* $P \leq 0.05$

between liver weight and liver glycogen content whereas four weeks feed restriction in them resulted in a positive correlation with a correlation value of 0.255 (Table 11.2). Positive correlation between liver weight and body weight was maintained in both sexes even after two weeks and four weeks feed restriction period (Table 11.1 and 11.2). The correlation was not significant in male quails. But the female quails exhibited significant correlation ($P \leq 0.05$) after feed restriction for both two and four weeks period.

4.7 Feed consumption

Feed consumption of male and female Japanese quails from two to sixteen weeks of age (at fortnightly intervals) was recorded (Table 12). Daily feed consumption in both sexes was 11.11 g/bird during two to four weeks of age period whereas the feed consumption during 14 to 16 weeks of age period was 23.96 g/bird (male) and 25.93 g/bird (female). Female quails consumed more feed when compared with male quails at all age period (Table 12). The maximum daily feed consumption was recorded at the age of 14 to 16 weeks of age in male quails (23.96 g/bird) whereas 12 to 14 weeks age period in female quails (26.13 g/bird) vide Table 12.

Table 12. Feed consumption (g) of individual Japanese quails from two to sixteen weeks of age

Weeks	Male		Female	
	Daily feed consumption (g)	Feed consumption/ 2 weeks (g)	Daily feed consumption (g)	Feed consumption/ 2 weeks (g)
2-4	11.11	155.54	11.11	155.54
4-6	17.64	246.96	18.78	262.92
6-8	18.68	260.40	22.75	318.50
8-10	18.80	263.20	25.13	351.82
10-12	19.20	268.80	25.40	355.60
12-14	20.40	285.60	26.13	365.82
14-16	23.96	355.44	25.93	363.02

Discussion

Chapter 5

DISCUSSION

5.1 Blood glucose

The mean blood glucose level recorded in quail chicks on the day of hatch (zero day) was 244.425 ± 2.204 mg/dl (Table 3). Shibata and Watanabe (1981) observed a lower blood glucose level of 179.7 mg/dl in the embryo which increased gradually after hatch to 188.7 mg/dl in male quails and 192.3 mg/dl in female quails. The value observed in the present study was higher than that reported by Shibata and Watanabe (1981).

There was significant ($P \leq 0.05$) difference in blood glucose level of male quails between zero and two weeks and eight and ten weeks of age. The difference was highly significant ($P \leq 0.01$) between four and six weeks, ten and twelve weeks, twelve and fourteen weeks and fourteen and sixteen weeks of age (Table 4.1.2). In the case of females there was significant difference ($P \leq 0.05$) between 12 and 14 weeks and 14 and 16 weeks of age. Highly significant ($P \leq 0.01$) difference was observed between two and four weeks and six and eight weeks of age (Table 4.2.2). There are many factors influencing the blood glucose concentration in avian species. The environmental factors cause variations in the blood

glucose concentration. The circadian rhythm is also regulating the normal blood glucose concentration. Rodbard and Goldstein (1950) reported that blood glucose level in birds was highly sensitive to environmental temperature. According to them hypothermia resulted in a reduction of blood glucose concentration of chicken. However, Bhattacharya (1990) observed a higher blood sugar level in the cold exposed Japanese quails.

The blood glucose level in Japanese quail recorded after sexual maturity ranged from 151.851 ± 5.992 mg/dl (16 weeks of age) to 189.297 ± 7.032 mg/dl (10 weeks of age) in males (Table 4.1.1) and 173.217 ± 6.996 mg/dl (16 weeks of age) to 206.959 ± 6.513 mg/dl (six weeks of age) in females (Table 4.2.1). However, Shibata and Watanabe (1981) recorded the blood sugar level of adult male Japanese quail as 354.4 mg/dl. Genetic factors can influence the blood glucose concentration. Blood glucose concentration in different lines, strains and breeds of poultry is different. Darshan *et al.* (1987) reported that the glucose in blood is a trait. They recorded higher glucose values for desi chicken than the exotic breeds. Leelercq *et al.* (1987) observed that two lines of broiler chicken exhibited different levels of glucose concentration in blood. They observed low glucose level in fatter lines of broilers. In the present study Japanese quails of egg type

was utilised where adult bird had the blood glucose level ranging from 162.534 ± 0.246 mg/dl to 188.757 ± 0.643 mg/dl (Table 4.3).

It was observed in the present study that the blood glucose level was maintained above 200 mg/dl upto an age of fourth week in the case of males and sixth week in the case of females (Table 4.3). A decreasing tendency was noticed in blood glucose level of both sexes with the advancement of age. A similar trend was reported by Ducci *et al.* (1992). Heller and Pursell (1937) estimated most of the chemical constitutents in blood of chicken and observed a decreasing tendency for the blood glucose level after one year of age. Kundu *et al.* (1993b) reported that young quails had a lower erythrocyte count than the adult quails. The glucose content of red blood cells is low. As the number of erythrocytes increased with the advancement of age the glucose concentration in whole blood also got decreased. Blood glucose level in this experiment was estimated in whole blood. The increase in red blood cell count (Kundu *et al.*, 1993b) may be the reason for the decreasing tendency of blood glucose level observed in Japanese quail with the advancement of age.

Significant ($P \leq 0.05$) difference was noticed in the blood glucose level of male and female quails at 12th and 16th week (Table 5). The difference was highly significant ($P \leq 0.01$) at

fourth and sixth week of age (Table 5). In general female quails had a higher blood glucose level than the male quails at all age levels except fourth and tenth week of age (Table 4.3). Higher blood glucose level in female birds was also reported by Nirmalan and Aravindan, 1963 (in chicken), Surendranathan, 1966 (in ducks) and Poyraz, 1988 (in quails). However, Kathe and Gadgil (1965) and Olowookorun *et al.* (1980) could not observe any significant difference in blood glucose level between male and female chicken. The higher values observed in present study for blood glucose concentration in female quails may be due to the low red cell count in the females in comparison to that of males of the same age group. Greenman and Zarrow (1961) reported that testosterone appeared to lower the blood glucose level as a result of increase in red cell count in domestic fowl. In male quails the influence of testosterone and increased erythrocyte count may be the reason for low blood glucose concentration when compared with female quails.

According to Dukes (1947) the blood glucose level in avian species had a wide range from 161 to 280 mg% in chicken and 175 to 210 mg% in turkey. Surendranathan (1966) reported that the blood glucose value in ducks was low, ranging from 129 to 152 mg%. The blood glucose values observed in Japanese quails were comparable to that of chicken. According to Scheer (1954) the blood sugar values were higher in flying birds,

lower in cursorial species and lowest in aquatic forms. The blood glucose concentration of Japanese quail observed in this study indicated that Japanese quail can be considered as a cursorial species in their habitat.

5.2 Liver glycogen

The highest level of liver glycogen (2.039 ± 0.102%) was found on the zero day (day of hatch) in Japanese quail (Table 3). The glycogen content for day old chicks reported by Sturkie (1965) and Deb and Chakravarthi (1967) ranges from 250-500 mg%. Garcia *et al.* (1986) reported that the glycogen stores in muscle and liver got increased before hatching to attain the adult values. In the present study also a high liver glycogen value was recorded on the zero day.

Liver glycogen content of both male and female quails from two to sixteen weeks of age were in the range of 1.953 ± 0.184 per cent to 1.016 ± 0.133 per cent in males and 1.199 ± 0.131 per cent to 1.098 ± 0.152 per cent in females (Table 6.1.1 and 6.2.1), the values were lower than that of the values observed on the day of hatch. The level of liver glycogen was having a lowering tendency from zero day to 16 weeks of age. Golden and Long (1942), Hazelwood and Lorenz (1959) and Sturkie (1965) also observed a lowered

concentration of glycogen in the adult chicken (around 180 mg%) in comparison to day old chicks (250-500 mg%). According to Golden and Long (1942) adult chicken had a lower liver glycogen content than young birds. The lowered liver glycogen content with advancement of age may be due to the increased utilization of this energy fuel to cope with the increased demand during the growing period. Moreover a positive correlation was observed between the levels of blood glucose and liver glycogen with advancement of age. Blood glucose concentration also showed a decreasing tendency as age advanced. No significant difference was noticed in the liver glycogen content because of sex except for the second week of age (Table 5). Narasimhan (1971) also reported that there was no influence of sex in the liver glycogen content of ducks as well as chicken. He observed a liver glycogen value of 4.10 ± 0.29 per cent in male ducks and 4.02 ± 0.29 per cent in female ducks. According to him, values in chicken were 4.32 ± 0.42 per cent in males and 3.32 ± 0.49 per cent in females.

In the present study the liver glycogen content of Japanese quail ranged from 0.918 ± 0.144 per cent (6 weeks) to 1.666 ± 0.317 per cent (4 weeks) of wet tissue (Table 6.3). Narasimhan (1971) recorded the liver glycogen content of ducks (4.06 ± 0.29) and chicken (3.82 ± 0.45%). The values observed in the present study in Japanese quails were lower than those reported in chicken and ducks which may be due to species

variation. Deb and Chakravarthi (1967) reported that different breeds of chicken had different levels of liver glycogen. Even the diurnal variation can influence the liver glycogen content.

5.3 Liver weight

The liver weight of Japanese quails on the day of hatch (zero day) was 0.190 ± 0.005 g (Table 3). The weight of liver of both male and female quails from two to sixteen weeks of age showed a steady increase, ranging from 1.527 ± 0.074 g to 5.068 ± 0.283 g (males) and 1.535 ± 0.067 g to 6.960 ± 0.341 g (females). Matsuzawa (1981) recorded an increase in the liver weight of growing White Leghorn birds between one and twenty weeks of age. The increase in liver weight in quails (both sexes) observed in the present study may be due to increase in size and number of liver cells during the growing period and also may be due to the deposition of fat in the liver.

Liver weight showed a significant ($P \leq 0.05$) increase (0.190 ± 0.005 g to 3.927 ± 0.175 g) from zero to ten weeks of age in males (vide Table 7.1.1 and 7.1.2) and zero to eight weeks in females (0.190 ± 0.005 g to 5.594 ± 0.167 g) vide Table 7.2.1 and 7.2.2 which indicated that the development of liver was undergoing in the early growing periods in quails.

Lilja (1983) reported that the geese and some wild birds had a rapid early development of digestive tract and liver. According to them growth pattern of turkeys and quails was characterised by an early rapid development of breast muscles and feathers. In the present study in Japanese quail an early rapid development of liver was observed. Moreover the liver weight showed a positive correlation ($P \leq 0.05$) with body weight (Table 11.3). Body weight also showed a significant increase upto ten weeks of age in both sexes (Table 8.1.1 and 8.2.1).

Significantly higher liver weight as well as body weight were recorded in female quails from sixth week onwards (Table 7.3, 8.3 and 5). Liver weight was found to be positively correlated with body weight (Table 11.3). According to Wilson *et al.* (1961) larger body weight of female Japanese quail was primarily due to the heavier gonads, liver and intestine.

5.4 Body weight

The mean body weight of Japanese quail recorded on the day of hatch was 6.525 ± 0.129 g (Table 3). Mean body weight from second to sixteenth week of age ranged from 35.300 ± 1.008 g to 170.500 ± 2.244 g in males (Table 8.1.1) and 34.800 ± 1.090 g to 184.000 ± 4.542 g in females (Table 8.2.1). Tiwari and Panda (1978) recorded the average body weight of quail at 30, 50, 100, 150 and 200 days of age as 87.8, 110.6,

129.5, 136.5 and 136.9 g respectively. Thomas *et al.* (1993) recorded the body weight of Japanese quail at 1, 6, 9 and 12 weeks of age as 7.12 ± 4.16, 121.07 ± 14.95, 147.00 ± 12.64 and 157.66 ± 14.52 g in males and 7.16 ± 0.18 g, 123.38 ± 12.30 g, 154.33 ± 14.22 g and 179.20 ± 19.80 g in females. In the present study the body weight recorded at six weeks and twelve weeks were 120.300 ± 2.446 g and 154.150 ± 3.132 g respectively in males and 130.600 ± 3.753 g and 174.100 ± 2.027 g respectively in females (Table 8.1.1 and 8.2.1). The data observed were comparable with the values reported by other workers.

Body weight in both male and female quails had a tendency to increase from the date of hatch to 16th week of age. Significant ($P \leq 0.01$) increase in body weight was recorded upto eighth week of age in males and tenth week of age in females (Table 8.1.2 and 8.2.2).

Philomina (1994) observed that the body weight gain in Japanese quail was steadily on increase upto sixteenth week of age. Wilson *et al.* (1961) reported that mature body size was attained at about eight weeks in male Japanese quails and nine to ten weeks in female quails.

In the present study it was evident that the body weight of females was significantly higher than that of males from sixth week of age onwards (Table 5). Sato *et al.* (1981)

observed that the influence of sex on body weight gain was evident at significant levels from three weeks of age onwards. Growth comparison in Japanese quail done by Thomas *et al.* (1993) revealed that the difference in body weight between sexes was significant from ninth week of age onwards. In the present study the influence of sex on body weight was significantly evident from sixth week of age onwards.

It was observed that the sexual maturity was attained at an age of six weeks in females (started egg production) with an average body weight of 130.600 ± 3.753 g. Philomina (1994) also observed that quails attained sexual maturity at sixth week of age with an average body weight of 131.800 ± 0.600 g. Ahuja *et al.* (1978) and Sato *et al.* (1981) recorded the age of sexual maturity in quails at sixth week with an average body weight of 90.55 g and 109 g respectively. Jues and Houghes (1978) reported that Coturnix quail attained mature body weight of 162 g at six weeks of age. Sachedev and Ahuja (1986) recommended that 200 g body weight was the optimum level to be attained at sexual maturity for high egg production.

5.5 Effect of feed restriction on blood glucose, liver glycogen, liver weight and body weight

5.5.1 Two weeks feed restriction (sixth to eighth week of age)

There was no significant reduction in blood glucose level of male and female quails due to the feed restriction for two weeks period. The blood glucose level recorded were 176.681 ± 3.215 mg/dl in males and 174.618 ± 4.373 mg/dl in females. Houpt (1958) and Hazelwood and Lorenz (1959) had reported that the birds were able to maintain their normal blood glucose level during starvation. Brady *et al.* (1978) found that the total body protein and fat were significantly decreased, whereas blood glucose level remained constant with fasting in the case of chicken. Riesenfeld *et al.* (1981) observed that the glucose oxidation contributed 31 per cent of total heat production in normally fed chicken whereas it was only 21% in feed deprived chicken. According Rayo *et al.* (1992) acute and intermittent starvation caused increase in the intestinal absorption of glucose. In the present study distention of gall bladder with bile was also noticed in feed restricted birds. This may be an evidence for increased rate of digestion in feed restricted birds. Therefore the reduced rate of glucose oxidation or increased intestinal absorption of glucose may be responsible for maintaining the normal blood glucose level in fasting birds. Reduction in liver weight was also noticed

during two weeks feed restriction. As a result there was reduction in total glycogen content of whole liver which might have been utilised for maintenance of blood glucose level.

There was no significant reduction in the liver glycogen level of both male and female quails due to two weeks feed restriction. The liver glycogen levels were 0.954 ± 0.101 per cent in males and 1.099 ± 0.081 per cent in females (Table 9.1). There was no reduction in blood glucose level also. The compensatory mechanisms may be sufficient to cope with two weeks feed restriction i.e. to maintain normal blood glucose and liver glycogen levels in both male and female quails.

Two weeks feed restriction resulted in a reduction of liver weight in both sexes. The liver weight of feed restricted quails were 2.997 ± 0.129 g in males and 4.154 ± 0.193 g in females as against the control (normally fed) birds, 3.840 ± 0.100 g in males and 5.594 ± 0.167 g in females. Palo *et al.* (1995) reported about the decrease in relative weight of liver as a result of fourteen days feed restriction in chicken. He observed that feed restriction reduced the number and size of liver cells. In the present study there was no reduction in the liver glycogen level. Therefore it can be assumed that the reduction in liver weight may be due to the reduction in number and size of liver cells.

Liver weight exhibited a positive correlation with body weight (Table 11.3). Due to two weeks feed restriction there was a reduction in the liver weight as well as body weight.

The body weight of Japanese quails recorded in two weeks feed restriction (at the eighth week of age) were 127.700 ± 1.899 g in males and 147.200 ± 2.777 g in females (Table 9.1). The control (normally fed) birds had a body weight of 145.300 ± 3.048 g (males) and 168.200 ± 1.094 g (females) vide Table 9.2.1. There was significant ($P \leq 0.01$) reduction in body weight of both male and female quails (Table 9.2.2). Gildersleeve *et al.* (1980) reported that quails on restricted feed had reduced body weight gain and final body weights. Robblee *et al.* (1979) and Santaso *et al.* (1995) had reported about the reduction in body weight due to the restricted feed intake in chicken. According to Van (1980) exposure of chickens to heat stress and feed restriction during fourth and fifth week retarded growth by 19 per cent. In the present study also reduction in body weight was observed due to two weeks feed restriction. Reduction in the body weight may be due to reduction in organ weight and deposition of fat. Reduction in liver weight was also observed during this period.

5.5.2 Four weeks feed restriction (sixth to tenth week of age)

Feed restriction for four weeks period resulted in a significant reduction in blood glucose level of male quails (157.185 ± 7.840 mg/dl), where control male quails had a blood glucose level of 189.297 ± 7.032 mg/dl (Table 10.2.1). Warris *et al.* (1988 and 1993) reported that longer periods of feed deprivation reduced circulating glucose concentration by about eight percentage. In female quails the reduction in blood glucose level due to four weeks feed restriction was not significant (Table 10.2.1 and 10.2.2). It was observed in female quails that they adjusted the situation by reducing the egg production. A drastic reduction in egg production was noticed during the third and fourth week of feed restriction. There were compensatory mechanisms operating during the early stages of restriction, like increased intestinal absorption (Rayo *et al.*, 1992) and reduced oxidation of glucose (Riesenfeld *et al.*, 1981) which may not be sufficient to maintain the normal blood glucose level in male quails during four weeks feed restriction.

Four weeks feed restriction in male quails resulted in a significant reduction of liver glycogen content. The liver glycogen content in four weeks feed restricted male quails was 0.716 ± 0.092 per cent as against 1.441 ± 0.174 per cent in the control birds (Table 10.2.1). Matsumoto and Hamada (1981)

reported that chicken maintained on the restricted feed had the lowest amount of liver glycogen than that of birds maintained on the carbohydrate free diet. Warriss *et al.* (1988) observed that liver glycogen in chicken was reduced to less than 1 mg/g within six hours of feed deprivation. According to Warriss*et al.* (1993) fasting for 10 h in broilers reduced the concentration of glycogen in the liver by 40 per cent. The reduced liver glycogen content observed in male quails due to four weeks feed restriction may be due to the insufficient compensatory mechanism in males to maintain the normal blood glucose level. Therefore in later stages the mobilisation of liver glycogen might have occurred to meet the energy requirements of the body. But in females there was no significant reduction in the liver glycogen content due to four weeks feed restriction. The reduction in egg production observed in females might be a compensatory mechanism to maintain the normal level of blood glucose and liver glycogen. Thus female quails in contrast to male quails were efficient in maintaining normal level of blood glucose and liver glycogen.

There was significant reduction in liver weight due to four weeks feed restriction in both sexes of Japanese quail (Table 10.2.2). There was highly significant ($P \leq 0.01$) reduction in liver weight in four weeks feed restricted birds than that of two weeks feed restricted birds. The liver

weight recorded in males was 2.134 ± 0.070 g and in females was 4.697 ± 0.182 g. Feed restriction might have resulted in reduction in the number and size of cells as well as deposition of fat in the liver.

Body weight was found to be significantly lowered in both male and female quails due to four weeks feed restriction. The body weight recorded were 112.450 ± 2.578 g for males and 141.200 ± 2.129 g for females. In male quails reduced organ weight and deposition of glycogen were observed due to four weeks feed restriction, may be responsible for the reduction in body weight. As the period of feed restriction increased from two to four weeks its influence on body weight was more pronounced. Body weight of four weeks feed restricted birds was significantly ($P \leq 0.01$) lower when compared with two weeks feed restricted and normally fed birds (Table 10.2.2).

5.6 Correlation between blood glucose level, liver glycogen content, liver weight and body weight

In general the levels of blood glucose and liver glycogen were found to be positively correlated in normally fed male and female quails (Table 11.3), the correlation values being 0.987 for males and 0.526 for females. According to Ganong (1991) there was net uptake of glucose by the liver when the plasma glucose was high and net discharge occurred when the plasma glucose was low. Thus liver functions as a sort of

glucostat. But this positive correlation was not maintained at all age groups. A negative correlation was observed at four weeks, six weeks and twelve weeks of age in male quails (Table 11.1). Female quails exhibited a negative correlation at the age of two weeks, six weeks, 10 weeks and 16 weeks (Table 11.2). Female quails maintained the positive correlation even after two and four weeks feed restriction. But the male quails exhibited a negative correlation after four weeks feed restriction (Table 11.1 and 11.2). According to Narasimhan (1971) chicken depended mainly on gluconeogenesis for maintaining the normal blood sugar level. Watford *et al.* (1981) proposed that in chicken, kidney had a major role in net gluconeogenesis. Thus in addition to liver, kidney also plays a major role in controlling the normal blood glucose level in birds. This may be the reason for an indefinite relation observed in the present study between blood glucose and liver glycogen.

There was a negative correlation between liver weight and liver glycogen (Table 11.3) in both sexes of quails. The correlation values were -0.849 in males and -0.652 in females. This was also found to be changed at different age periods and during feed restriction period (Table 11.1 and 11.2). A definite correlation between liver weight and liver glycogen could not be recorded. Male quails showed a positive correlation in majority of cases whereas the female quails

exhibited a positive correlation at the age of six, eight and sixteen weeks of age. Feed restricted (both two and four weeks) male birds exhibited a negative correlation, whereas feed restricted females had a positive correlation between liver weight and liver glycogen due to four weeks feed restriction. Palo *et al.* (1995) reported that there was reduction in the liver weight in feed restricted birds due to reduction in liver cell number and size. From the results recorded in the present study it can be concluded that liver glycogen may not be the only factor responsible for the changes observed in the liver weight but reduction in number and size of liver cells may also be responsible.

Liver weight was found to be positively correlated with body weight. This positive correlation was exhibited in both sexes of quails at all age periods (Table 11.1 and 11.2). This positive correlation was observed even in feed restricted quails (two weeks as well as four weeks feed restriction) vide Table 11.1 and 11.2. Burger *et al.* (1962) studied the relationship of organ weight to body weight. He proposed that certain biological factors control the organ growth. One is 'step wise control' in which organ growth is stimulated by a factor, the production rate of which is related to body size. The present study proposed a 'step wise control' on the liver growth. Kawahara and Satto (1976) reported that liver weight showed highest correlation with body weight and muscle

weight. Here also a significant correlation was observed between the liver weight and body weight in both sexes of quails.

5.7 Feed consumption

Daily feed consumption of Japanese quail from two to sixteen weeks age period ranged from 11.11 g/bird to 23.96 g/bird in males and 11.11 g/bird to 25.93 g/bird in females. Wilson *et al.* (1961) reported that to put on 122 g of body weight, a quail consumed 496 g of feed. Panda *et al.* (1977) recorded the average daily feed consumption of quail as 24.3 g/bird/day. Sreenivasaiah *et al.* (1980) also reported that the daily feed consumption at 40 and 120 days of age in quails averaged 19.94 g and 27.59 g respectively with the corresponding body weight of 125.31 g and 139.59 g. The data observed in the present study were comparable with that reported by these workers.

Summary

Chapter 6

SUMMARY

An investigation of correlation between blood glucose and liver glycogen in Japanese quail (*Coturnix coturnix japonica*) was carried out in the Department of Physiology and Biochemistry, College of Veterinary and Animal Sciences (Kerala Agricultural University), Mannuthy.

In the first phase of study, the levels of blood glucose and liver glycogen were estimated in 40, zero day-old (on the day of hatch) Japanese quails. In the second phase 400 quail chicks of two weeks of age were maintained on standard quail ration and managemental conditions upto an age of 16 weeks. The male and female quails were separated at four weeks of age and grouped into G_1 and G_2. They were housed in separate cages comprising of 20 birds in each subgroup. Feed consumption was recorded at fortnightly intervals. From second to 16th week, at fortnightly intervals, twenty birds each from G_1 (males) and G_2 (females) groups were sacrificed and the estimations on blood glucose, liver glycogen levels, liver weight and body weight were conducted. At the sixth week of age, two subgroups each from G_1 and G_2 were selected and reared on half the quantity of ration, upto tenth week of age. Twenty birds each from feed restricted G_1 and G_2 groups were sacrificed along with control birds (normally fed) at

eighth (two weeks feed restriction) and tenth (four weeks feed restriction) week of age.

The concentration of blood glucose, liver glycogen level, liver weight, body weight and feed consumption were recorded at fortnightly intervals from the day of hatch to 16th week of age.

The data collected from the above studies were statistically analysed.

The highest level of blood glucose in Japanese quail was recorded on the day of hatch as 244.425 + 2.204 mg/dl. A decreasing tendency was noticed in the blood sugar level with the advancement of age. The blood sugar level was maintained above 200 mg/dl upto an age of fourth week in males, whereas in females upto sixth week of age. There was variation in blood glucose level of both male and female quails at different age levels. In general female quails exhibited a higher blood glucose level than the male quails. The blood glucose level recorded at 16 weeks of age were 151.851 ± 5.992 mg/dl in males and 173.217 ± 6.996 mg/dl in females. The blood glucose values observed in Japanese quails were comparable to cursorial species of birds.

The highest level of liver glycogen in Japanese quail was found on the day of hatch (2.039 ± 0.102%). Liver glycogen

content of both male and female quails from two to sixteen weeks of age were lower than that of the value observed on the day of hatch. The liver glycogen content recorded at 16 weeks of age were 1.016 ± 0.133% for males and 1.098 ± 0.152% in females. Variation in liver glycogen level was noticed at different age levels in both male and female quails, however there was no significant variation in liver glycogen level due to sex.

The liver weight showed a steady increase upto 16th week of age in both male and female quails. Liver weight was significantly increased upto 10th week of age in male quails whereas upto eighth week of age in female quails. The female quails showed a higher liver weight than male quails, the difference in liver weight was significantly evident from sixth week onwards.

Body weight was increased upto an age of 16 weeks in both sexes. Female quails showed a higher body weight than male quails at all age periods. The influence of sex was significantly noticed from sixth week of age onwards. Females attained sexual maturity (started egg production) at an age of six weeks, with a body weight of 130.600 ± 3.753 g.

Feed restriction for two weeks period resulted in a significant reduction of liver weight and body weight in both sexes. But blood glucose of both males and females did not

show any significant variation due to the feed restriction for two weeks. However feed restriction for four weeks resulted in the reduction of blood glucose level, liver glycogen content, liver weight and body weight in the male quails. Female quails had significant reduction in liver weight as well as body weight whereas reduction of blood glucose concentration and liver glycogen level was not significant.

In general, blood glucose level as well as glycogen content was found to be positively correlated. But this positive correlation was not maintained at all age levels and in feed restricted birds. A definite correlation was not obtained between blood glucose level and liver glycogen content. Liver weight and liver glycogen exhibited an indefinite relation at different stages of growth, whereas liver weight and body weight were positively correlated in both male and female quails. The positive correlation between liver weight and body weight was maintained even in feed restricted birds.

The daily feed consumption is Japanese quails was increased as age advanced. Female quails consumed more feed and put on more weight at the same age when compared with the male quails. The maximum daily feed consumption recorded for male quails and female quails were 23.96 g (14 to 16 weeks of age) and 26.13 g (12 to 14 weeks of age) respectively.

References

REFERENCES

Ahuja, R., Gulati, D.P., Agarwal, S.K. and Prakashbabu, M. (1978). Inheritance of growth and some of the reproductive traits in Japanese quail. *Indian Poult. Gaz.* **62** (3): 98-104.

Allen, P.C. and Ruff, M.D. (1981). Analysis of liver glycogen in chicks. *Poult. Sci.* **60**: 2697-2700.

Bhattacharya, B. (1990). Short term thermal stress on some haematobiochemical constituents in Japanese quail. *J. Vet. Anim. Sci.* **21** (2): 136-138.

*Boztepe, S. and Ozturk, A. (1993). Effects of diets with different levels of protein in performance of Japanese quail. *Poult. Abstr.* **20** (7): 219.

Brady, L.H., Romsos, D.R., Brady, P.S., Bergen, W.G. and Leveille, G.A. (1978). The effects of fasting in body composition, glucose turn over enzymes and metabolites in chicken. *J. Nutr.* **108** (4): 648-657.

Burger, R.E., Lorenz, F.W. and Gates, C.E. (1962). Relationships of organ weight to body weight. *Poult. Sci.* **41**: 1762-1773.

Casirola, G., Petronio, L. and Bignotti, G. (1956). Cited by Narasimhan, T.R. (1971). A comparative study of the chemical composition and some of the enzymes in the liver of ducks and chicken. M.Sc. thesis submitted to the Calicut University.

Chatterjee, C.C. (1992). Human Physiology, 11th edn. Medical Allied Agency, 82/1 Mahathma Gandhi Road. Calcutta-9.

Chopra, S.K. and Aggrawal, C.K. (1994). Effect of quantitative feed restriction on body weight, feed consumption and feed conversion ratios of turkeys. *Indian J. Poult. Sci.* **29** (1): 68.

Christensen, V.L. and Donaldson, W.E. (1991). Effect of oxygen and maternal dietary iodine in embryonic metabolism and hatchability of turkey eggs. *Poult. Sci.* **71** (4): 747-753.

Claude Bernard (1813-1878). Cited by West, E.S., Todd, W.R., Mason, H.S. and Brugger, J.T.V. (1966). Textbook of biochemistry 4th edn. MacMillan Publishing Company, New York.

Clawson, R.C. and Domer, L.V. (1961). The effect of cortisol on growth and liver glycogen in the embryo of domestic fowl. *Anat. Rec.* 139:217.

Costa, P.T., Miles, R.D. and Harms, R.H. (1980). Influence of laying hen body weight at 28 weeks of age in daily feed intake. *Poult. Sci.* **59** (7): 1596.

Darshan, N., Panda, J.N. and Singh, D.P. (1987). Study of the biochemical parameters of the blood of Desi domestic fowl. *Indian J. Poult. Sci.* **22** (4): 339-343.

*Deb, R.N. and Chakravarthy, C.H. (1967). Effects of breeds on the hepatic glucose-6-phosphatase activity and glycogenesis in liver and muscle. The *Indian J. Physiol. All. Sci.* **21**: 79-83.

Delphia, J.M., Singh, S. and Baskin, H. (1967). A relationship of hyperthermia to liver growth and liver glycogen in the chick embryo. *Poult. Sci.* **46** (6): 1454-1459.

*Didier, R., Remesy, C. and Demigne, C. (1981). Effect of starvation on the main plasma and liver metabolites of gluconeogenesis and ketogenesis in the adult domestic quail (*Coturnix coturnix japonica*). *Reproduction, Nutrition, Development.* **21** (3): 421-428.

Donaldson, W.E., Brewer, C.E., Ferket, P.R. and Christensen, V.L. (1992). Post hatch carbohydrate feeding and subsequent performance of turkey poults. *Poult. Sci.* **71** (1): 128-132.

Donaldson, W.E. and Christensen, V.L. (1993). Effects of L alanine injection and post-hatch deprivation of feed and water on glycogen reserves in turkey poults. *Comp. Biochem. Physiol.* **104** (2): 345-347.

*Ducci, M., Sighieri, C., Gazzano, A., Paci, G., Frateschi, T.L. and Martelli, F. (1992). Physiological blood analytes in growing Muscovy duck. *Poult. Abstr.* **21** (1): 49-51.

Dukes, H.H. (1947). Cited by Sturkie, P.D. (1954). Avian Physiology, 1st edn. Comstock Publishing Associates, Ithaca, New York. pp. 185-203.

*Dukes, H.H. (1955). The Physiology of Domestic Animals, 7th edn. Bailliere, Tindall and Cox, London.

*Dutton, G.J. (1963). Comparison of glucoronide synthesis in developing mammalian and avian liver. *Ann. N. y. Acad. Sci.* **113**: 259.

Elfin, L.G., Petren, T. and Sollberger, A. (1955). Influence of some endogenous and exogenous factors on diurnal glycogen rhythm in chicken. *Acta. anat.* 25: 286.

Freeman, B.M., Manning, A.C.C. and Flack, I.H. (1980). Short term stressor effects of food withdrawal in immature fowl. *Comp. Biochem. Physiol. A. Comp. Physiol.* **67** (4): 569-571.

Freeman, B.M., Manning, A.C.C. and Flack, I.H. (1983). Adrenal cortical activity in the domestic fowl (*Gallus domesticus*) following withdrawal of water and feed. *Comp. Biochem. Physiol.* **74** (3): 639-641.

Ganong, W.F. (1991). Review of Medical Physiology. 15th edn. Prentice-Hall International Inc. New Jersey. p. 271.

Garcia, F.J., Pons, A., Alemany, M. and Palou, A. (1986). Tissue glycogen and lactate handling by the developing domestic fowl. *Comp. Biochem. Physiol. B. Comp. Biochem.* **85** (4): 727-731.

Gildersleeve, R.P., Scott, T.R. and Satterlie, D. (1980). Effect of feed restriction on daily rhythm of plasma corticosterone in coturnix. *Poult. Sci.* **59** (7): 1614.

Golden, W.R.C. and Long, C.N.H. (1942). The influence of certain hormones on the carbohydrate levels of chicks. *Endocrinology* **30**: 675.

Grande, F. (1968). Effect of glucagon in plasma free fatty acids and blood sugar in birds. *Proc. Soc. exp. Biol. Med.* **128**: 532-536.

Grande, F. (1970). Effect of glucagon and insulin in plasma free fatty acids and blood sugar in owls. *Proc. Soc. exp. Biol. Med.* **133**: 540-543.

Greenman, D.L. and Zarrow, M.X. (1961). steroids and carbohydrate metabolism in the domestic bird. *Proc. Soc. Exp. Biol. Med.* **106** (3): 459-462.

Guyton, A.C. and Hall, J.E. (1996). Textbook of Medical Physiology. 9th edn. W.B. Saunders Company, U.S.A. p. 857.

Hammouda, Y.A.F., Bacon, W.L. and Kurima, K. (1992). Dynamic effects of insulin infusion on plasma growth homone (GH), non esterified fatty acids (NEFA), glucose and triacylglycerol (TG) in growing female turkeys. *Poult. Sci.* **71**. Suppl. 1: 82.

Hazelwood, R.L. and Lorenz, F.W. (1957). Responses of the domestic fowl to hyper and hypoglycaemic agents. *Endocrinology* **61**: 520.

Hazelwood, R.L. and Lorenz, F.W. (1959). Effect of fasting and insulin on carbohydrate metabolism of the domestic fowl. *Am. J. Physiol.* **197** (1): 47-51.

Heald, P.J., Mclachlan, P.M. and Rookledge, K.A. (1965). The effect of insulin, glucagon and adreno corticotropic hormone in the plasma glucose and free fatty acids of domestic fowl. *J. Endocr.* 33: 83.

Heller, V.G. and Pursell, L. (1937). Chemical composition of blood of the hen during its life cycle. *J. Biol. Chem.* **118**: 549.

*Hohtola, E., Hissa, R., Pyornila, A., Rintamaki, H. and Saarela, S. (1991). Nocturnal hypothermia in fasting Japanese quail: The effect of ambient temperature. *Physiology & Behaviour.* **49** (3): 563-567.

Houpt, T.R. (1958). Effects of fasting on blood sugar levels in baby chicks of varying ages. *Poult. Sci.* 37 (6): 1452-1459.

Hyravinen, A. and Nikila, E.A. (1962). Cited by Henry, R.J., Cannon, D.C. and Winkelman, J.W. (1974). Clinical Chemistry: principles and technics. 2nd edn. Harper and Row publishers, Maryland. pp. 1285-1289.

Joseph, J. and Ramachandran, A.V. (1992). Alterations in carbohydrate metabolism by exogenous dexamethasone and corticosterone in post hatched White Leghorn chicks. *Br. Poult. Sci.* 33 (5): 1085-1093.

*Jouglar, J.Y., Antoine, J., Benard, G., Kolchack, S. and Labie, C. (1992). Establishing some growth parameters for force feeding Mullard ducks. *Poult. Abstr.* 20 (2): 49.

Jues, J.E. and Houghes, B.L. (1978). Comparison of growth rate, body weight and feed conversion between Coturnix quail and Bob white quail. *Poult. Sci.* **57** (5): 1471-1472.

Kathe, S.T. and Gadgil, Y.G. (1965). Fasting blood sugar levels in adult male and female Rhode Island Red chickens. *Indian Vet. J.* **42** (7): 498-501.

Kawahara, T. and Satto, K. (1976). Genetic parameters of organ and body weights in the Japanese quail. *Poult. Sci.* **55**: 1247-1252.

*Kohler, D. (1984). Phenotypic parameters of Japanese quail. *Poult. Abstr.* **10** (9): 1906.

Krebs, H.A. and Yoshida, M. (1963). Renal gluconeogenesis, 2. The gluconeogenic capacity of the renal cortex of various species. *Biochem. J.* **89**: 398-400.

Kumar, K.M.A., Kumar, K.S.P., Ramappa, B.S. and Manjunath, V. (1990). Influence of parental age, fertility, hatchability, body weight and survivability of Japanese quail. *Poult. Adviser.* **23** (9): 43-47.

Kumar, A. and Rawat, J.S. (1975). Distribution of blood glucose and cholesterol levels in White Leghorn birds in relation to age, sex and reproduction. *Indian Vet. J.* **52** (10): 775-778.

Kundu, S.N., Gupta, D. and Karmakar, R. (1993a). Differential sensitivity towards glycogen metabolism in the liver and muscle of White Leghorn after prednisolone treatment. *Indian J. Poult. Sci.* 28 (2): 160-161.

Kundu, A.K., Misra, C.S. and Misra, M.S. (1993b). Haematological study of different age groups of Japanese quail. *Indian Vet. J.* **70** (5): 417-421.

Lee, W.A. (1951). The glycogen content of various tissues of the chick embryo. *Anat. Rec.* **110**: 465.

Leelercq, B., Simon, J. and Ricard, F.A. (1987). Effects of selection for high and low plasma glucose concentration in chickens. *Br. Poult. Sci.* **28** (40): 557-565.

Lilja, C. (1983). A comparative study of post-natal growth and organ development in some species of birds. *Growth.* **47**: 317-339.

Majumdar, S. and Panda, J.N. (1991). Intestinal glucose absorption ability of high, medium and non laying birds. Proceedings of 7th conference of SAPI, Madras:2.

Matsumoto, M. and Hamada, T. (1981). Changes in heart, skeletal muscle and liver glycogen in fed and starved chicks adapted to a carbohydrate-free or a glucose - containing diet. *Jap. J. Zootech. Sci.* 52 (8): 622-624.

Matsuzawa, T. (1981). Changes in blood components and organ weights in growing White Leghorn chicks. *Growth*. 45 (3): 188-197.

McLeod, M.G., Savory, C.J., McCorquodale, C.C. and Boyd, A. (1993). Effects of long term food restriction in energy expenditure and thermoregulation in broiler breeder fowl. (*Gallus domesticus*). *Com. Biochem. Physiol*. **106** (2): 221-225.

Misra, S.M., Murti, T.L., Panda, J.N. and Mishra, A. (1977). A note on the effect of epinephrine and propranalol in blood glucose and plasma cholestrol in poultry. *Indian J. Poult. Sci*. **12** (2): 53-54.

Moudgil, K.D. and Narang, B.S. (1989). The liver and biliary system. Cited in Textbook of Biochemistry and Human Biology (Thalwar, G.P., Srivasthava, L.M. and Moudgil, K.D.. eds.) 2nd edn. Prentice Hall of India Private Ltd., New Delhi. pp. 253-275.

Narasimhan, T.R. (1971). A comparative study of the chemical composition and some of the enzymes in the liver of ducks and chicken. M.Sc. thesis, submitted to Calicut University.

*Nirmalan, G. and Aravindan, M. (1963). A study of the chemical constituent of the blood of desi fowls. *Kerala Vet*. 2: 1.

Nobukuni, K., Koga, O. and Nishiyama, H. (1989). The effects of thyroid hormone in liver glycogen, muscle glycogen and liver lipid in chicks. *Jap. J. Zootech. Sci*. **60** (4): 346-350.

*Olowookorun, M.O., Ayeni, J.S. and Aire, T.A. (1980). Plasma glucose and alkaline phosphatase levels in guinea fowl (*Numida meleagris*) and Nigerian domestic fowls. (*Gallus domesticus*). *Poult. Abstr.* 7 (8): 259.

Palo, P.E., Sell, J.L., Piquer, F.J., Vilascca, L. and Sotosalanova, M.F. (1995). Effect of early nutrient restriction in broiler chickens. 2. performance and digestive enzyme activities. *Poult. Sci.* **74** (9): 1470-1483.

Panda, B. (1990). A decade of research and development on quails (1979-1989). ICAR, Central Avian Research Institute, Izatnagar, U.P.

Panda, B., Ahuja, S.D., Prakashbabu, M. and Gulati, D.P. (1980). Evaluation of a quail line for some important economic traits. *Indian J. Poult. Sci.* 50 (6): 518-520.

Panda, B., Reddy, V.R. and Sadagopan, V.R. (1977). Nutrient requirements and feeding of Japanese quail. *Indian Poult. Gaz.* **61** (4): 151-172.

Parkes, J.L., Cardell, E.L., Grieninger, G. and Cardell, R.R. (1990). Glycogen metabolism in cultured chick hepatocytes. A morphological study. *Anat. Rec.* 227 (20) 321-333.

Philomina, P.T. (1994). The structure and function of the shell gland in Japanese quail under different levels of dietary calcium. Ph.D. thesis submitted to Kerala Agricultural University.

Plavnik, I. and Hurwitz, S. (1985). The performance of broiler chicks during and following a severe feed restriction at an early age. *Poult. Sci.* **64** (2): 348-355.

Plavnik, I. and Hurwitz, S. (1987). Early feed restriction in chicks: Effect of age, duration and sex. *Poult. Sci.* **67** (3): 384-390.

*Poyraz, O. (1988). Study of plasma glucose, cholesterol and protein values in chickens, quail and their hybrids. *Poult. Abstr.* **17** (10): 351.

Rajini, R.A., Narahari, D. and Rukmangadhan, S. (1988). Metabolizable energy requirement of growing Japanese quail in humid tropics. *Indian J. Poult. Sci.* 23 (1): 35-39.

*Rayo, J.M., Esteban, S. and Tur, J.A. (1992). Effect of starvation on the in vivo intestinal absorption of sugars and amino acids in young chickens. (*Gallus domesticus*). Archives internationales de physiologie, de Biochemic et de Biophysique. **100** (1): 155-158.

Riesenfeld, G., Berman, A. and Hurwitz, S. (1981). Glucose kinetics and respiratory metabolism in fed and fasted chicken. *Comp. Biochem. Physiol. A. Comp. Physiol.* **70** (2): 223-227.

Riesenfeld, G., Geva, A. and Hurwitz, S. (1982). Glucose homeostasis in the chicken. *J. Nutr.* **112** (12): 2261-2266.

Robblee, A.R., Clandinin, D.R., Darlington, K. and Milni, G.R. (1979). The effects of restricted feeding and energy content of the ration on the performance of broiler breeding chickens. *Can. J. Anim. Sci.* 59 (3): 539-544.

Rodbard, S. and Goldstein, M.S. (1950). Neurogenic control of the blood sugar decided by induced variations in the body of the chick. *Am. J. Physiol.* 162: 175.

Sachedev, A.K. and Ahuja, S.D. (1986). Studies on the influence of body weight at sexual maturity on production traits in Japanese quail. *Indian J. Poult. Sci.* 21 (1): 66-68.

Sadhu, D.P. and Chaudhari, S. (1961). Tissue respiration and glycogenolysis in birds and young mammals. *Comp. Biochem. Physiol.* 4: 72.

Santaso, U., Tanaka, K. and Ohtani, S. (1995). Does feed restriction, refeeding programme improve growth characteristics and body composition of broiler chicken. *Anim. Sci. Technol.* (Jpn). 66 (1): 27-35.

*Sato, K., Agiko, M. and Ino, T. (1981). Genetic parameter of body weight in Japanese quail. Scientific reports of the faculty of Agriculture. Okayana University Japan. 58: 31-41.

Savory, C.J. (1987). How closely do circulating blood glucose levels reflect feeding state in fowls! *Comp. Physiol. Biochem., A. Comp. Physiol.* 88 (1): 101-106.

*Scheer, B.I. (1954). Comparative Physiology. John Wiley and Sons, Inc., NewYork.

Schulz, P. and Mistry, S.P. (1981). A technique for the isolation of chicken hepatocytes and their use in a study of gluconeogenesis. *Poult. Sci.* **60** (3): 643-652.

Seaton, K.W., Thomas, O.P., Gous, R.M. and Bossard, E.H. (1978). The effect of diet on liver glycogen and body composition in the chick. *Poult. Sci.* **57**: 692-692.

Sefton, A.E. and Siegel, P.B. (1974). Inheritance of body weight in Japanese quail. *Poult. Sci.* **53**: 1597-1603.

Seifter, S., Dayton, S., Novic, B. and Muntwyler, E. (1950). Cited by Narasimhan, T.R. (1971). A comparative study of the chemical composition and some of the enzymes in the liver of ducks and chicken. M.Sc. thesis, submitted to Calicut University.

Sharma, G.L. and Panda, B. (1978). Studies on some production traits in Japanese quail. *Indian Poult. Gaz.* 62 (1): 24-30.

Shen, C.S. and Mistry, S.P. (1979). Effect of fasting and fasting and refeeding on hepatic and renal gluconeogenic enzymes in the chicken. *Poult. Sci.* **58** (4): 890-895.

Shibata, T. and Watanabe, S. (1981). Change of blood sugar level with growth in Japanese quail and its components. *Jap. J. Zootech. Sci.* **52** (12): 869-873.

Shukla, P.K., Srivastav, A.K. and Raju, M.V.L.N. (1994). Evaluation of different feeding schedules during the onset of laying in Japanese quails. *Indian J. Poult. Sci.* **29** (3): 272-273.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. 6th edn. Oxford and IBH Publishing Company, Calcutta.

Sreenivasaiah, P.V., Joshi, H.B. and Garg, R.C. (1980). Performance efficiency index during different periods of egg formation in Japanese quail. *Kerala J. Vet. Sci.* **11** (1): 147-150.

Sturkie, P.D. (1954). Avian Physiology 1st edn. Comstock publishing Associates, Ithaca, New York.

Sturkie, P.D. (1965). Avian Physiology. 2nd edn. Cornell University Press, Ithaca, New York.

Surendranathan, K.P. (1966). Studies on the haematological constituents of duck (*Anas platyrhynchos*). M.Sc. thesis submitted to the University of Kerala.

Susbilla, J.P., Frankel, T.L., Parkinson, G. and Gow, C.B. (1994). Weight of internal organs and carcass yield of early food restricted broilers. *Br. Poult. Sci.* **35** (5): 677-685.

Thomas, M.J., George, K.C., Thomas, M.J. and Nair, G.R. (1993). Growth comparison method in Japanese quails. *J. Vet. Anim. Sci.* **24** (1): 58-59.

*Thommes, R.C. and Tambornino (1962). Effects of insulin administration upon blood glucose levels of the chick embryo. *Physiol. Zool.* **35**: 256.

Thurston, R.J., Bryant, C.C. and Korn, N.N. (1993). The effects of corticosterone and catecholamine infusion on plasma glucose levels in chicken (*Gallus domesticus*) and turkeys (*Meleagris gallapavo*). *Comp. Biochem. Physiol.* **106**(1): 59-62.

Tiwari, K.S. and Panda, B. (1978). Production and quality characteristics of quail eggs. *Indian J. Poult. Sci.* **13** (1): 27-32.

*Van, K.M. (1980). The effect of short term heat stress or feed restriction on body weight subsequent laying performance and body composition of pullets. *Arch* Geflugelk **44** (3): 124-128.

Verma, D. and Panda, J.N. (1991). Serum biochemical parameters in the laying quail during egg formation. Proceedings of 7th conference of SAPI, Madras:5.

Warriss, P.D., Kestin, S.C., Brown, S.N. and Bevis, E.A. (1988). Depletion of glycogen reserves in fasting broiler chickens. *Br. Poult. Sci.* **29** (1): 149-154.

Warriss, P.D., Kestin, S.C., Brown, S.N., Knowless, T.G., Wilkins, J., Edwards, J.E., Austin, S.D. and Nicol, C.J. (1993). The depletion of glycogen stores and indices of dehydration in transported broilers. *Br. Vet. J.* **149** (4): 391-398.

Watford, M., Hod, Y., Chiao, Y., Utter, M.F. and Hanson, R.W. (1981). The unique role of the kidney in gluconeogenesis in the chicken: The significane of a cytosolic form of phosphoenol pyruvate carboxykinase. *J. Biol. Chem.* **256** (19): 10023-10027.

*Watterson, R.L., Veneziano, P. and Brown, D.A. (1958). Development of the glycogen body of the chicks spinal cord. V. Effects of hypophysectomy in its glycogen content. *Physiol. Zool.* **31**: 49.

West, E.S., Todd, W.R., Mason, H.S. and Brugger, J.T.V. (1966). Textbook of Biochemistry 4th edn., MacMillan Publishing Company, New York.

Wilson, W.O., Abott, U.K. and Applanolp, H. (1961). Evaluation of Coturnix (Japanese quail) as pilot animal for poultry. *Poult. Sci.* **40**: 651-657.

Yamane, T., Ono, K. and Tanaka, T. (1980). Energy requirement of laying Japanese quail. *Br. Poult. Sci.* **21** (6): 451-455.

Zulkifle, I., Dunnington, E.A., Gross, W.B., Larsen, A.S., Martin, A. and Siegel, P.B. (1993). Responses of dwarf and normal chickens to feed restriction, *Eimeria tenella* infection and sheep red blood cell antigen. *Poult. Sci.* **72** (9): 1630-1640.

* Originals not consulted

CORRELATION BETWEEN BLOOD GLUCOSE LEVEL AND LIVER GLYCOGEN STORAGE IN JAPANESE QUAIL *(Coturnix coturnix japonica)*

BY

K. RAJI

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR

1997

ABSTRACT

Literature available on the physiology of Japanese quail is scanty. It is only in the recent years that any concentrated attempt has been made to study the various aspects of metabolism in domestic fowl. The present study was undertaken to probe into some fundamental areas of carbohydrate metabolism in Japanese quail with special reference to the normal blood glucose level and liver glycogen content of both sexes at various ages and physiological conditions.

The study was carried out in four hundred and forty Japanese quails (both sexes) of the same strain (egg type) procured from Kerala Agricultural University Poultry Farm, Mannuthy. In the first phase of study the estimations were conducted in 40, zero day old (on the day of hatch) Japanese quail chicks. In the second phase, 400, two week old quail chicks were utilized. The males and females were separated at four weeks of age and grouped into G_1 (males) and G_2 (females) comprising of 20 birds in each subgroup. The birds were maintained on standard quail rations in separate compartments of the cage. Feed consumption was recorded at fortnightly intervals. Twenty birds each from G_1 (males) and G_2 (females) groups were sacrificed at fortnightly intervals from the

second to 16th week of age for the estimations. At the sixth week of age two sets of males from G_1 group (20+20) and females from G_2 group (20+20) were maintained on 50 per cent feed restriction for a period of four weeks. At eighth (two weeks feed restriction) and tenth (four weeks feed restriction) week of age twenty birds each from control and 50 per cent feed restricted birds of G_1 and G_2 groups were sacrificed for the different estimations as blood glucose concentration, liver glycogen content, liver weight and body weight.

The results from the study revealed that the highest level of blood glucose was recorded at an age of zero day in Japanese quail (244.425 ± 2.204) mg/dl). A decreasing tendency in blood glucose level was observed as age advanced, may be due to an increase in the erythrocyte count of adult birds. In general female quails exhibited higher blood glucose level than the male quails. The highest content of liver glycogen (2.039 ± 0.102%) was recorded in the zero day old quail chicks (on the day of hatch). The level of glycogen showed a decreasing tendency as age advanced, may be due to the utilisation of liver glycogen for the energy requirements of growing birds. There was no significant variation in liver glycogen level due to sex. However there was higher liver glycogen content in male quails at the age of two weeks.

Liver weight and body weight showed a tendency of steady increase from the day of hatch to sixteenth week of age in both sexes. The females had higher liver weight as well as body weight than the males. The increase in liver weight may be due to the increase in the number and size of liver cells and also by excess deposits of energy required for growth. The maximum body weight recorded at the age of 16 weeks in both males and females were 170.500 ± 2.244 g and 184.000 ± 4.542 g respectively. Female quails had a higher body weight than the male quails especially from sixth week of age onwards, when they attained sexual maturity.

Two weeks feed restriction, did not influence the blood glucose concentration and liver glycogen content in both sexes of quails, whereas a significant reduction was noticed in the liver weight and body weight of both male and female quails. Four weeks feed restriction in male quails resulted in a reduction in blood glucose level, liver glycogen content, liver weight as well as body weight. However, in female quails the blood glucose level and liver glycogen content were not significantly altered, whereas body weight and liver weight showed a significant reduction. The female quails were able to withstand the situation by lowering the rate of egg production.

Blood glucose concentration and liver glycogen content exhibited a positive correlation in control as well as feed

restricted (Two weeks and four weeks) birds. However, there was variation at different age levels in both male and female quails. The mean liver weight and liver glycogen content in both sexes of quails exhibited a negative correlation. However, there was variation in the correlation due to sex and age. Body weight and liver weight were found to be positively correlated in both sexes of quails at all age periods and even in feed restricted periods.

It was also observed that the daily feed consumption in both male and female quails increased with the advancement of age and female quails consumed more than the male quails.

Over and above the information obtained from the present study on certain aspects of avian carbohydrate metabolism, further studies are required to investigate the factors influencing the regulation of normal levels of blood glucose and liver glycogen in birds. The indefinite relation at different age periods observed in Japanese quails between blood glucose concentration and liver glycogen content and the ability to withstand the changes in the levels of blood glucose and liver glycogen, due to feed restriction, attract further investigations. The factors involved may be either the predominance of alpha cells in avian pancreas or role of kidney in gluconeogenesis. It will also be interesting to investigate the compensatory mechanisms that operate at the time of feed restriction in the regulation of normal blood glucose level and liver glycogen content.