THE EFFECT OF FEEDING MANAGEMENT DURING THE GROWING AND LAYING PERIODS ON PRODUCTIVITY AND THE CHARACTERISTICS OF ADIPOSE TISSUE OF THE BROILER BREEDERS

by

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ABSTRACT

The present experiment was undertaken to study the egg production and abdominal fat accumulation of broiler breeder female chickens which had been subjected to different feeding management procedures.

Broiler breeder female chicks (1022) were divided into two populations. One population was fed between 8 and 10 a.m. using conventional feeders. The other population was fed twice daily the same amount of feed as the feeder-fed population, but given feed broadcast on the litter between 8 a.m. and 10 p.m. and between 3:30 p.m. and 4:30 p.m. Physical activity and the extension of feeding time of the floor-fed population were therefore greater than was the case with the feeder-fed population.

The floor-fed brids were lighter in weight under *ad libitum* feeding from 2 to 4 weeks of age. Thereafter the floor-fed birds were heavier under quantitative feed restriction. At 18 weeks of age each population was divided into four groups, heaviest, upper medium, lower medium and lightest, based on body weight. The birds of the lighter groups subsequently grew faster than those of the heavier groups and by 47 weeks of age the weights were not significantly different.

The amount and proportion (% of body weight) of abdominal fat in the floor-fed pullets at 26-27 weeks of age were higher than in the feeder-fed pullets. Abdominal fat increased with increased body weight in those groups of pullets which gained up to 1200 g in body weight after the division at 18 weeks of age, but decreased in proportion to body weight in those groups of pullets which gained in excess of 1200 g. The data suggested that the more vital parts of the body, such as the muscle and skeletal tissues, developed at a faster rate than the abdominal fat pad in the lightest group of pullets.

Floor feeding did not affect the age at which the pullets reached sexual maturity. Egg production, calculated on hen-day basis, was similar in all groups. When egg production was calculated on a hen-housed basis, however, the feeder-fed pullets showed a higher rate of egg production than did the floor-fed pullets. Furthermore, the birds of the heavier groups within both feeding systems had a higher rate of production than did the birds in the lighter groups.

Floor-fed pullets laid significantly larger eggs than feeder-fed pullets. Egg weight was not significantly different among the four weight-groups of pullets in each feeding system.

Birds fed on the litter had lower mortality during the brooding period but thereafter had a higher mortality than did the birds fed from feeders. The major cause of death was gizzard impaction with litter material. Mortality was the highest in the lightest groups on both feeding systems during the laying period.

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INTRODUCTION

Since the Second World War, production of poultry meat in Canada has extensively expanded. The high productive efficiency and quality of the final product associated with rapidly advancing technology has sharply raised the productive volume of poultry commodities. Consequently, the cost of poultry production has declined and the share of poultry meat in the Canadian diet has risen.

According to a publication from the Economic Branch, Canada Department of Agriculture, by Emmery (1967), poultry meat consumption per capita in Canada rose from 16 pounds to 40 pounds, a 150 per cent increase, during the period from 1949 to 1966. While in the same period, consumption per capita of all other types of meats rose from 135 pounds to 148 pounds or only a 9.6 per cent increase.

The apparent domestic disappearance of broiler chickens from commercial supplies is continuously growing. The rate of growth was 13.2% for the first quarter of 1979 over the same period in 1978 (Elanco, 1979). Therefore, the demand for broiler hatching eggs is obviously increasing in Canada. D. Murray of the Statistics Section, Poultry Division of Agriculture Canada, announced last year in a profile of commercial broiler and roaster placements in Canada in 1977, that 25 per cent of broiler chicks hatched in Canada were from imported hatching eggs.

The broiler-type breeders are specifically bred for meat production. They possess the genetic potential for rapid growth, and they are very subject to obesity. Low egg production and infertility may be serious problems. Nutritionists have tried to resolve the above problems by modifying the broiler breeder diet in order to increase the egg production of the female breeders and the semen quality of the male breeders. Nevertheless, the reproductive performance of broiler-type breeders is not satisfactory. The present studies were undertaken in an attempt to increase our knowledge of the effects of feeding management on the reproductive performance of broiler breeders.

This thesis contains two chapters. Chapter One, which deals with the study of the effect of feeding management during the growing and laying periods on productivity and the characteristic of adipose tissue of the broiler breeders, serves as the major part of the thesis. Chapter Two, which deals with the study of the effect of prolonged feed restriction during the gorwing period on subsequent semen production, is a research note for record.

CHAPTER I.

THE EFFECT OF FEEDING MANAGEMENT DURING THE GROWING AND LAYING PERIODS ON PRODUCTIVITY AND THE CHARACTERISTICS OF ADIPOSE TISSUE OF THE BROILER BREEDERS.

1.0 INTRODUCTION

Obesity has undesirable effects on the reproductive performance of broiler breeder pullets. It is always associated with inactivity, high mortality, poor fertility and low egg production with high feed consumption per egg produced. There is a need for new management procedures to minimize obesity in broiler breeder chickens.

Scientists have used various methods to manipulate the composition of the diet or to increase the physical activity of the experimental animals in order to minimize obesity. Swimming, running and bicycle riding are commonly employed in experiments to increase the physical activity within the case of rats or men. There are no standard scientific procedures for testing the effects of physical activity on the biological responses of chickens.

In modern poultry farm management different methods of restricting feed consumption are used to control the overweight and obesity of broiler breeder pullets. The most common methods include quantitative feed restriction, restriction of feeding time, reduction in energy and/or protein content in the diet. Other methods, such as reduction in water intake, increase of temperature, alteration of the lighting pattern and debeaking have also been used to restrict feed intake. All the above methods retard growth and delay sexual maturity depending upon the severity of treatment.

However, the ontogenesis of each individual bird is not strictly controlled by the quality of the diet or the amount of the feed intake alone, but is also involved with many other prenatal and postnatal factors. The prenatal factors include genetic variation, nutritional environment for the developing embryo and conditions during the incubation. Postnatal factors include social peck order, stress, adaptivity, disease, humidity, light, temperature and altitude in addition to nutritional status.

The present experiment was undertaken on two populations of broiler breeder pullets. One population was fed between 8 and 10 a.m. using conventional feeders. The other population was fed twice daily the same amount of feed as the feeder-fed population, but given feed broadcast on the litter between 8 a.m. and 10 p.m. and between 3:30 p.m. and 4:30 p.m. Physical activity and the extension of feeding time of the floor-fed population were therefore greater than was the case with the feeder-fed population. At 18 weeks of age each population was equally divided into four groups on the basis of body weight. The abdominal fat accumulation at sexual maturity and the subsequent egg production and egg size among four groups of pullets in each population were studied.

1.1 LITERATURE REVIEW

1.1.1 Physical Activity

1.1.1.1 Physical activity and body conformation

Physical activity has profound effects on the course of ontogenesis and the subsequent body conformation. These effects have been thoroughly investigated in rats and humans, but not in domestic fowls.

According to the literature, pullets have been either raised in cages with a restriction of physical activity or have been raised on the floor with relative freedom to move around and agitate one another.

Over four decades ago, it was observed that birds reared on range had a higher percentage of breast muscle, leg muscle, and total edible portion than had those which were reared in confinement (Harshaw, 1936). Since then, the literature is in agreement that domestic fowl constrained in cages have a higher percent and total body fat deposition than those managed on floor, regardless of species and sex (White Leghorns: Jeffrey and Brith, 1941; Leo and Change, 1975) (broilers: Deaton et al., 1974) (turkeys: Andrews and Marrow, 1978).

By using radiographic techniques, it has been shown that there is a significantly higher bone density in men and women with increasing levels of physical activity (Emiola and O'Shes, 1978). Similarly, Wabeck and Littlefield (1972) showed that wing and leg breakage after processing was higher for broilers reared in cages than for those reared in floor pens. And Reece et al. (1971) demonstrated that leg weakness is significantly greater for constrained than for unconstrained birds.

Jeffrey and Britt (1941) further indicated that lack of exercise of pullets resulted in partial atrophy of the heart, liver, and gizzard when the confinement period was as long as one year. High liver fat in hens housed at high cage density was also reported by Leo and Change (1975). The fat content of eggs, on the other hand, was found to be similar whether hens were kept in cages or on the floor (Oluyemi and Roberts, 1975).

1.1.1.2 Obesity and egg production

Recently Chaney and Fuller (1975) brought two groups of broiler breeder pullets into production at the same time with widely different levels of carcass fat, by using different daylength and feeding regimes. There was a significantly higher per cent of carcass fat at sexual maturity for growing pullets under full feed and with decreasing daylength (26% carcass fat) than for those under restricted energy intake and with increasing daylength (19% carcass fat). The difference in carcass fat was not associated with egg production, and the egg production and carcass fat were roughly related to energy intake in their studies.

Studies by Singsen *et al*. (1959) suggested that meat-type pullets are not capable of adequately regulating energy intake when they are fed *ad libitum*. In the study, they became obese and suffered high mortality which appeared to be directly related to excessive caloric intake. However, obesity *per se* did not appear to reduce egg production.

Combs *et al*. (1961) reported a similar observation. When Columbian Plymouth Rock pullets were restricted to an energy intake of 87.0 per cent of the control the average per cent carcass ether extract and average blood serum cholesterol were lower than in the control, but no significant differences in egg production, mortality or Haugh Unit scores were found.

1.1.1.3 Physical activity and reproduction

Even though physical activity reduces obesity and obesity does not affect egg production, egg production may be affected by physical activity. Thus, physical activity *per se* rather than obesity may be directly altering the reproductive physiology of the laying hens.

There are controversial reports as to whether exercise has a beneficial or an adverse effect on egg production. Lowry *et al*. (1956) reported on a four-year study of cages versus floor management that the pullets kept on the floor were found to be superior in egg production than those kept in cages. Querner and Tuller (1966) and Christmas *et al*. (1972) reported that the birds on deep litter produced more eggs than those in cages. This substantiated the results of the annual California random sample tests for 1957 to 1960 inclusive in which layers on deep litter consistently laid more eggs than those in cages (Kosen, 1967).

Conversely, Miller and Quisenberry (1959), Bailey *et al*. (1959), Shupe and Quisenberry (1961), Thomason *et al*. (1972), Oluyemi and Roberts (1975), and Thomason *et al*. (1976) reported that mature pullets placed in cages appeared to have a significantly higher rate of egg production. Furthermore, the higher voluntary feed intake resulted in heavier body weights for the caged birds than for those maintained on litter-floor.

Andrews and Morrow (1978) subjected turkey poults to four feeding regimes: full-fed or 20 per cent restriction during rearing and/or laying periods. Birds from each feeding regime were placed in individual cages or floor pens, when they were 32 weeks of age. All caged hens were more persistent in egg production for the six 28-day periods of the study.

On the other hand, DeDortal (1966), Francis and Robertson (1963) and Andrews (1977) failed to find any significant difference between the caged and the deep litter held chickens in egg production.

1.1.2 Restricted Feeding

In the last few decades, it has been gradually recognized that proper restricted feeding of rapidly growing broiler-type pullets for breeding purposes is necessary in order to control adiposity and to maximize egg production.

The nutritional methods adopted to restrict feed intake in order to achieve the above objectives include the following: (a) quantitative feed restriction, (b) restriction of the time allowed for feeding, (c) reduction of the energy level in the diet, (d) reduction of protein in the diet. In this review, the methods and their effects on maturity, final body weight, mortality and subsequent egg production will be discussed.

1.1.2.1 Quantitative feed restriction

1.1.2.1.1 Methods

Flocks of fully-fed control chickens are usually employed in this method. The weekly food consumption of the fully-fed control group is taken as a basis for predetermining the amount of feed allowed for the restricted fed groups in the following week. The quality of the diet is balanced with respect to all amino acids and other essential nutrients.

Most researchers have initiated restricted feeding of the pullets between 6 and 8 weeks of age and finished restriction between 21 and 24 weeks of age (Howes and Cottier, 1964; Schneider et al., 1955; Schumaier and McGinnis, 1969; Waldroup et al., 1966). Pullets also have been restricted in food consumption from 0 week by Leclercq et al. (1970), from 2 weeks by Ringrose (1958), from 3, 4 and 5 weeks by Strain et al. (1965) and from 5 weeks by MacIntyre and Gardiner (1964).

1.1.2.1.2 Effect on body weight

The reduction in growth rate of the restricted group depends on the degree of feed restriction. Lee et al.(1971) calculated, from the existing data in the literature, a regression line of food intake of restricted group as a percentage of food intake of fully-fed control (X) versus live-weight as percentage of fully-fed control (Y):$Y = 21.82 + 0.82X$. After termination of restricted feeding the subsequently body weight was affected. The above authors also reported that there were 78 comparisons of body weight at the end of the laying period, and in only 20 cases was the body weight of restricted-reared pullets equal to, or greater than, that of the fully fed controls. This resulted in a lower energy requirement for maintenance of the former birds and better feed efficiency for egg production.

1.1.2.1.3 Effect on egg production

The onset of laying was delayed in the restricted group. Bullock *et al.* (1963), based on the data of Ashcroft (1961), predicted that for every 1 percent drop in restricted feeding level from 90 percent to 70 per cent of the controls, there would be a delay in reaching 40 per cent egg production of 0.6 days.

According to studies of 87 cases by Lee *et al.* (1971), 52 cases showed equal or higher hen-day production for the restricted groups compared with the controls. Because the maturity of restricted-reared pullets is delayed and the whole productive curve displaced, there is an increase in average egg weight. Schneider *et al.* (1955) reported an increase of 19.1 per cent of settable eggs from heavy layer hens restricted to 21 per cent of feed intake from day old through the growing period to 28 weeks of age.

1.1.2.1.4 Effect on mortality

Unfortunately, however, quantitative feed restriction induced relatively high mortality during the rearing period. Isaacks *et al*. (1960) reported that 30 percent restriction of feed intake of meat-type replacement pullets resulted in 18.95 percent mortality, which was 12.36 percent higher than the mortality in the fully-fed control birds. One possible reason for this may be that the feed consumption of birds lower in the peck order is more severely restricted than that of birds higher in the order.

Lee *et al*. (1972) reported that during feed restriction, pullets might be more prone to disease. An outbreak of staphylococal arthritis in restricted pullets was reported by Berg and Bearse (1961); respiratory disease, by Bruckner and Hill (1959); coccidiosis, by Schneider *et al*. (1955) and by Proudfoot and Gowe (1967).

1.1.2.2 Restriction of the time allowed for feeding

1.1.2.2.1 Restricted for one or two hours daily

Pullets have been allowed 1 or 2 hours daily for feeding by Ringrose (1958), Schneider *et al*. (1955), Schumaier and McGinnis (1969), Lepkorsky *et al*. (1960) and Ballam (1978). By using this feeding system, enough feeding space must be provided in order to reduce the competition for food among birds and allow uniform consumption. The restricted pullets are inclined to eat more quickly and hence develop a capacity to store larger amounts of food in their crops than do the fully-fed controls. Lepkovsky et al. (1960) observed that the crops of chickens, trained to eat during 2 hours daily, were consistently heavier in order to store more food, but that there was no similar adaptation in the gizzard, intestine and pancreas. Schumaier and McGinnis (1969) reported that when heavy-type pullets were restricted in daily feeding from 1 to 3 hours between 8 to 55 weeks of age, the egg production, per cent fertility and hatchability of eggs, and growth of chicks hatched were unaffected.

1.1.2.2.2 Skip-a-day feeding

Alternate day and skip-one or two-days-per-week feeding systems have also become popular for growing meat-type breeder replacement pullets. Harms et al. (1968) fed meat-type pullets on a alternate day feeding regime with a 16% crude protein diet from 8 to 24 weeks of age. The feed consumption during the restricted period was 7.13 kg of feed per pullet for the restricted group and 12.95 kg of feed per pullets for the full-fed control group. On the skipped day regimen 910 gm of whole oats was given on the restricted day per 100 birds in the litter. Sexual maturity, defined as age at 30 per cent production, was at 197.6 days and 173.6 days for the restricted group and control group respectively.

Mortality during the growing period was higher in the restricted group (23.7%) than in the control group (15.7%). During the laying phase, from 25 weeks to 56 weeks of age the numbers of eggs weighing over 52 gm per hen were 117.9 and 111.5 for pullets fed on the alternate day program and pullets fed ad libitum respectively.

Yates and Schaible (1963) reared Leghorn-type pullets on a skip-one-day-per-week feeding program. They found that the reduction in food consumption, compared with fully-fed controls, ranged from nil, when the dietary energy level was 3.15 kcal/g, to 10 per cent when it was 1.48 kcal/g. The maturity of the group receiving the diet containing 1.48 kcal/g was markedly delayed.

1.1.2.3 Reduction in the energy level in the diet

1.1.2.3.1 Methods

Nutritionally inert materials, such as oat hulls, cellulose, vermiculite, kaolin and sand have been included in the diet in attempt to lower the dietary energy concentration. However, unless substantial amounts of inert materials are added to the diet, the bird is able, within limits, to adjust feed intake accordingly and a significant reduction in caloric intake cannot be obtained. Lee et al. (1971) estimated that at metabolisable energy levels below 2.0 kcal/g of feed, growth rate is progressively reduced.

1.1.2.3.2 Effects on body weight, age at sexual maturity and egg production

Isaacks *et al*. (1960) restricted caloric intake of broiler-type pullets from 9 weeks to 21 weeks of age by adding to diets either 15 or 25 per cent fibre from ground oat hulls. Accordingly, the productive energy of the diets was decreased to 1.07 kcal/g, or 0.74 kcal/g. The control diet contained 2.15 kcal M.E. per kg of feed. The body weights of the treated birds were 15.4 per cent or 23.9 per cent respectively lower than those of the controls by the end of 21 weeks of age. Restriction had no significant effect on egg production in this experiment.

Summers, *et al*. (1967) fed birds with a ration containing 80 per cent wheat bran from 8 to 23 weeks of age. Feed intake of the bran-fed birds was approximately 50 per cent greater than that of the controls. The body weight of the bran-fed birds was 2.27 kg and the control birds was 2.66 kg at 23 weeks of age. However, only slight differences in age at sexual maturity, egg production and egg weight were noted between the bran-fed group and the control group.

1.1.2.3.3 Economic

A high percentage of inert material, about 30 to 40 per cent, is required to dilute the diet sufficiently to delay maturity. It is claimed to be inconvenient to transport a large volume of low energy diet and consequently the practice of dietary dilution would probably be uneconomic (Lee *et al.*, 1972).

1.1.2.4 Reduction in protein content in the diet

1.1.2.4.1 Protein and energy levels

Reduction of protein alone, and not energy, in the diet is not an appropriate method of restricting feeding. Davidson (1964) showed that carcass fat level was greater in birds fed diets in which the ratios of crude protein to metabolisable energy had been lowered considerably below that corresponding to 20 per cent protein and 2.9 kcal metabolisable energy per gram of diet. Birds fed on such low protein diets tended to overeat in order to compensate for inadequate concentration of amino acids in the diet. The excess metabolisable energy intake resulted in a greater loss of this energy, mainly as heat, per unit of live body weight. Consequently, the feed efficiency was lower in the birds fed with the lower protein diets.

Bullock and Morris (1963) decreased energy or protein to 70% of the control (M.E. 2.6 kcal/g, protein 15%). Restricting energy alone retarded growth and delayed age at 50 per cent production by 7 days. A 30 per cent reduction of protein caused 4.5 days delay. Restricting both energy and protein delayed maturity by 10-11 days. Thus, the effects of energy and protein restriction on maturity appeared to be additive. In general practice, both energy and protein levels should be decreased in the diet.

1.1.2.4.2 Deprivation of essential amino acid

Deprivation of any essential amino acid from the diet, if severe enough, can markedly depress the growth of developing chicks. Several experiments have successfully delayed sexual maturity of growing pullets with a diet low in lysine (Berg and Bearse, 1958; Berg, 1959; Waldroup and Harms, 1962; Lillie and Denton, 1966; Gous, 1977 and 1978). Lee *et al*. (1971) stated that maximum live-weight gain can be attained in growing pullets at lysine intakes of about 0.55 to 0.60 gm per bird per day, depending on the breed of bird. When lysine intakes drop below 0.40 gm per bird per day, the decline in the live-weight gain is rapid and the increase of voluntary feed intake is no longer enough to compensate for the lower lysine level in the diet.

Severe protein and lysine restriction in growing pullets induces feather pecking, cannibalism, mortality, leg weakness and rupture of the gastrocnemius tendon. These adverse effects have been fully reported by Carnaghan and Hanson (1958) and Lee et al. (1971).

An apparently satisfactory feeding management procedure for growing broiler breeder pullets by using low protein and lysine in diet was suggested by Singsen et al. (1964, 1965). After a series of experiments of feeding low lysine and protein diets to broiler breeder pullets at different ages. Singsen et al. recommended that 0.57 per cent lysine and 20 per cent protein be fed from 0 to 8 weeks, and 0.47 per cent lysine and 16 per cent crude protein be fed from 9 to 21 weeks of age. Gous (1978) suggested that the most favourable method of restriction appeared to be the feeding of a low lysine or low protein diet, since rearing costs were low and the performance of the pullets on these treatments was good.

1.2 MATERIALS AND METHODS

1.2.1 Source of Birds

One thousand and twenty-two female and 155 male day-old broiler breeder chicks from Heisdorf and Nelson stock, inoculated with Marek's disease vaccine, were delivered by air from the State of Washington, U.S.A., to Vancouver International Airport on October 12th, 1978. The chicks were immediately transported to the poultry experimental farm at the University of British Columbia and were held in chick-boxes until the following day.

1.2.2 Brooding Period (0-4 weeks)

All chicks were randomly distributed into 16 groups each with either 73 or 74 females and 9 or 10 males. They were subjected to two feeding management programs. Half of them served as feeder-fed groups fed *ad libitum* on the conventional long metal feed toughs. The remaining groups, which served as floor-fed groups, were given feed *ad libitum* on paper (empty feed bags) and as such they were trained to pick up feed from the ground. The floor-fed groups were agitated daily during feeding in order to increase their activity. The feeder-fed and floor-fed managements are showed in Figures 1.1 and 1.2 respectively.

Figure 1.1 Feeder-fed chicks during the brooding period.

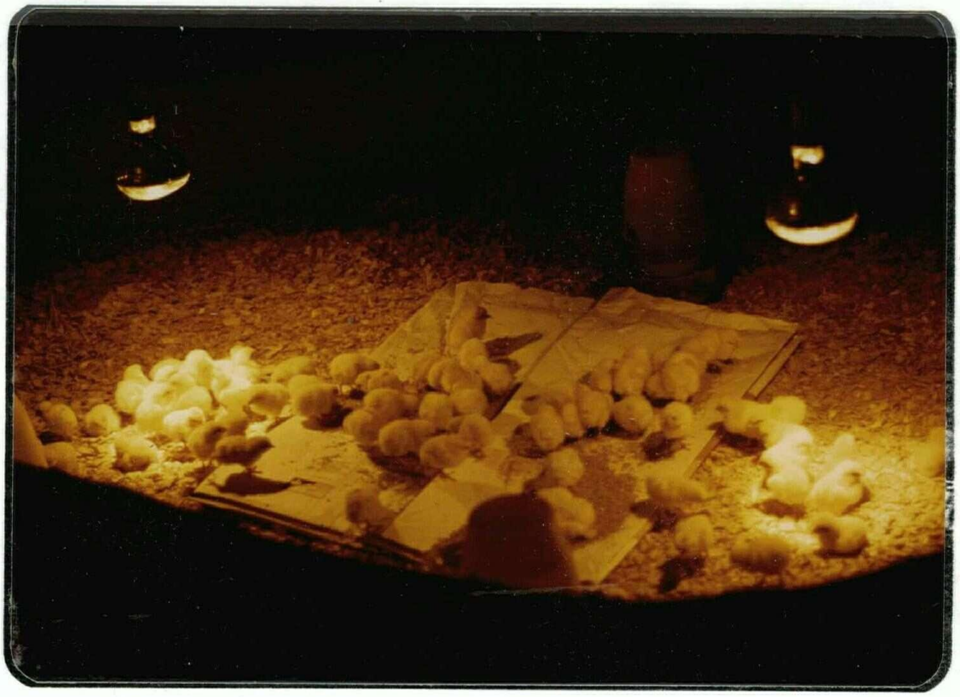

Figure 1.2 Floor-fed chicks during the brooding period.

The composition of the diet fed from hatching to sexual maturity is shown in Table 1.1. It contained 15.35% crude protein and 2686 kcal metabolizable energy/kg. During the brooding period the diet was provided in crumble form. Heat was provided by two 500 watt heat lamps (2 feet above floor) per pen through the brooding period.

Chicks were weighed, wing-banded, and vaccinated intraocularly against Newcastle disease and infectious bronchitis, when they were 12 days old. Chicks were weighed again at 26 days of age.

1.2.3 Rearing Period (5-18 weeks)

On the first day of the rearing period, the average feed consumption of the birds was 79.0 g per bird per day. Thereafter, the amount of feed given was gradually reduced to finally provide by 6 weeks of age 60 g per bird per day. Beginning at 7 weeks of age all birds were restricted in feed intake, so that they grew to the target body weight of 1.64 kg (3.60 lb) by the end of the rearing period (18 weeks), as recommended by the Pfizer Heisdorf and Nelson broiler breeder management program. The modified formula used to control, on a daily basis, the body weight gain was: $\Delta E = 5.90 (e^{0.9W_1} - e^{0.9W_2})$ (Eden, 1977), W_1 = initial body weight (kg), W_2 = final body weight (kg), ΔE = amount of metabolizable energy

Table 1.1 Composition of diet 1.

Ingredients	G/kg
Ground wheat	746*
Ground corn	100
Soybean meal	80
Rapeseed meal	40
Limestone	10
Dicalcium phosphate	20
Iodized salt	4
Microingredients	**

**add microingredients	per kg
zinc oxide	50 mg
manganese oxide	25 mg
choline 50%	1,000 mg
calcium pantothenate	3 mg
riboflavin	3 mg
vitamin B_{12}	0.01 mg
vitamin A	5,000 units
vitamin D_3	500 units
vitamin E	12 units
ethoxyquin	150 mg
amprol (coccidiostat)	500 mg
lincomycin	2 mg

* 15 kg of ground wheat was replaced by 15 kg of alfalfa meal after 10 weeks of age.

(Mcal) required for increasing body weight from W_1 to W_2 of heavy type bird. Cumulative feed consumption on bi-weekly basis for the feeder-fed birds through the restricted period is listed in Table 1.2. Feed was changed from crumble form to pellet form at the beginning of the rearing period. Water was given ad libitum through the whole experiment except over 15 to 18 weeks period, when water was restricted for 14.5 hr daily (from 5:30 pm. to 8:00 a.m.).

Feeder-fed groups were fed between 8 and 10 a.m. every day from hanging tube feeders. At 9 weeks of age, the wood shavings used as litter were replaced with coarser oat straw in the pens containing the floor-fed birds to enhance the scratching behavior of the birds associated with looking for the pelleted feed. The floor-fed groups were fed twice daily the same amount of feed as the feeder-fed group. The pellets were broadcast on the litter between 8 a.m. and 10 p.m. and between 3:30 p.m. and 4:30 p.m. Figures 1.3 & 1.4 show the feeder-fed and floor-fed managements during the rearing period.

Since the feed requirement for males was higher than for females, some of the males did not grow or even lost body weight. Therefore, all males were removed from the experiment at 9 weeks of age. In order to make pen space for the newly grouped males, one group of females was equally and randomly redistributed into the other seven groups for both the feeder-fed and floor-fed populations.

Table 1.2 Cumulative feed consumption of the feeder-fed pullets.

Age-Weeks	Gm. of Feed Consumed Per Pullet
2	217
4	897
6	1,855
8	2,488
10	3,235
12	4,076
14	4,973
16	6,033
18	7.044
20	8,575

After 20 weeks of age, 130 gm of feed given per pullet per day until the termination of the experiment.

Figure 1.3 Feeder-fed pullets during the rearing period.

Figure 1.4 Floor-fed pullets during the rearing period.

All heat lamps were raised to 5 feet above the floor at 5 weeks of age. One heat lamp was removed from each pen at 13 weeks. The remaining heat lamp was replaced with a 60 watt light bulb in the following week. The light bulbs gave light from 7 a.m. to 4 p.m. An extended hour of dim light was given by the lights in the corridor outside the pens to avoid frightening the birds with sudden complete darkness. All pullets were revaccinated against Newcastle disease and bronchitis at 16 weeks of age. Birds were weighed bi-weekly through the rearing period, and they were weighed approximately 15 hours after feeding.

1.2.4. Holding Period (19-25 weeks)

Based on the body weight at the end of the rearing period (18 weeks), each of the feeder-fed and floor-fed populations was equally divided into four groups, heaviest, upper medium, lower medium and lightest, each with two replicates. They were transferred from the rearing house and held in the laying house. A minimum photoperiod extending from 7 a.m. to 8 p.m. was provided with the aid of artificial lights. Over the course of the holding period and at the beginning of the laying period there was an increase in natural daylength which extended the birds' photoperiod. The amount of daily feed provided per bird was gradually increased to 130 g per bird by 20 weeks of age, then maintained at 130 g until the end of the experiment.

1.2.5 Laying Period (26-47 weeks)

Between 26 and 27 weeks of age at sexual maturity, 5 birds closest to the mean body weight were selected from each group for examination of the abdominal fat pad. A commercial broiler breeder diet replaced the grower diet at 27 weeks of age. The diet contained 16 per cent protein 2860 M.E. kcal/kg. Daily egg production was recorded. The eggs laid on one day at 34, 38 and 47 weeks of age from all groups were weighed. Body weights were recorded at 41 and 47 weeks of age. Figures 1.5 and 1.6 show the feeder-fed and floor-fed managements at 45 weeks of age.

Figure 1.5 Feeder-fed pullets during the laying period.

Figure 1.6 Floor-fed pullets during the laying period.

1.3 RESULTS AND DISCUSSION

1.3.1 Body Weight

1.3.1.1 Comparison of the feeding management procedure

The average body weight of the feeder-fed and floor-fed pullets from 2 weeks to 47 weeks of age is presented in Table 1.3. The average *ad libitum* feed consumption of the feeder-fed groups by 4 weeks of age (27 days) was 897 g per bird. The floor-fed groups during the same period were given 1039 g of feed per bird to ensure they were fed to appetite. Under *ad libitum* feeding, the floor-fed birds were significantly ($P < 0.05$) lighter than the feeder-fed birds by 7.9 g and 37.7 g at 2 and 4 weeks respectively.

Reduction in body weight gain has also been observed in rats which received physical exercise. Oscai *et al*. (1972), found that rats subjected to an exercising program of swimming from 15 to 360 min daily over a period of 14-16 weeks of age gained weight more slowly than the sedentary control rats when they were both provided with food and water *ad libitum*. Jones *et al*. (1964), Holloszy (1967), Crews *et al*. (1969) and Oscae *et al*. (1971) reported similar observations.

Table 1.3 The effect of feeder-fed and floor-fed feeding managements on body weights during the brooding, rearing, holding and laying periods.

Age in weeks	Averages of Body Weights - gm. Feeder-fed Pullets		Floor-fed Pullets	
2	125	a	117	b
4	405	a	367	b
6	739	b	767	a
8	847	b	914	a
10	1005	b	1075	a
12	1173	b	1253	a
14	1238	b	1367	a
16	1493	b	1584	a
18	1574	b	1656	a
20	1957	b	2058	a
25	2494	a	2520	a
41	3267	b	3352	a
47	3341	b	3404	a

a, b, In the analysis of variance, the averages of body weights at the same age which carry the same letter are not significantly different ($P > 0.05$).

After 5 weeks of age the amount of feed given daily was gradually restricted to both feeder-fed and floor-fed pullets. The average body weight of the floor-fed pullets shifted to be heavier than the feeder-fed birds at 6 weeks of age. This might be because the former picked up some extra feed left over in the litter from the *ad libitum* feeding period. From 6 weeks of age onward, the body weights of the floor-fed birds were consistently heavier than the feeder-fed birds. It suggested that the floor-fed birds were able to pick up almost all the feed among the straw and they were also observed to engage coprophagy. The feeder-fed bird weighed 1.57 kg and the floor-fed bird weighed 1.66 kg at 18 weeks of age. They were thus close to the target weight of 1.64 kg as was recommended by Heisdorf and Nelson broiler breeder management program.

After the rearing period, daily feed intake rapidly increased from 75 g to 130 g per bird per day by the end of 20 weeks of age, and maintained on 130 g per bird until the end of the experiment. During this feeding period the feeder-fed birds gained body weight faster than the floor-fed birds. By 25 weeks of age, the floor-fed pullets were slightly but not significantly heavier than the feeder-fed pullets.

During the laying period, even though feed consumption was maintained at 130 g per day, both populations of birds increased in weight. However, the floor-fed birds again became significantly heavier than the feeder-fed birds at 41 and 47 weeks of age.

1.3.1.2 Comparison of the four weight-groups

At the end of the rearing period the birds were equally divided into four different weight-groups based on the body weight at 18 weeks of age. The growth history of individual birds was studied. The mean body weight of each group before 18 weeks of age was calculated and the subsequent body weights are reported in Table 1.4. It was found that even at 2 weeks of age the lightest group was already significantly ($P < 0.05$) lighter than the heaviest and the upper medium groups in the feeder-fed management. There was, however, no significant difference between the heaviest and the lightest groups of birds managed on the floor throughout the entire brooding period.

Feed restriction was begun at the beginning of the rearing period (5 weeks). The mean of body weights of the four weight-groups of birds showed significant difference from each other in both populations of birds by 8 weeks of age. The difference was accounted for by at least two factors, the genetic variation and social peck order.

Table 1.4 The body weight in gram of all weight-groups of feeder-fed and floor-fed pullets at each weighing period (only pullets surviving to 18 weeks were considered in the calculation).

Average of Body Weights of Feeder-Fed Pullets

Age in Weeks	Heaviest	Upper Medium	Lower Medium	Lightest
2	128 a	128 a	125 ab	123 bc
4	420 a	413 ab	400 bc	394 c
6	772 a	750 ab	734 bc	714 c
8	923 c	871 d	840 e	777 f
10	1122 c	1043 c	988 f	897 h
12	1339 b	1223 c	1149 d	1027 f
14	1439 b	1302 c	1205 d	1045 f
16	1739 b	1575 d	1451 f	1235 g
18	1831 b	1645 d	1532 f	1312 g
20	2152 b	2043 c	1923 d	1728 e
25	2583 ab	2579 ab	2460 bc	2361 c
41	3293 ab	3325 ab	3245 ab	3294 b
47	3367 a	3368 a	3331 a	3296 a

Continued.....

Table 1.4 (continued)

Average of Body Weights of Floor-fed Pullets

Age in Weeks	Heaviest	Upper Medium	Lower Medium	Lightest
2	119 cd	117 d	116 d	116 d
4	372 d	364 d	364 d	366 d
6	785 a	764 ab	760 ab	761 ab
8	1045 a	957 b	901 c	852 de
10	1306 a	1165 b	1086 d	974 g
12	1537 a	1350 b	1241 c	1077 e
14	1689 a	1439 b	1330 c	1114 e
16	1943 a	1694 c	1526 e	1231 g
18	1874 a	1778 c	1596 e	1289 g
20	2304 a	2137 b	2014 c	1776 e
25	2691 a	2602 a	2413 c	2361 c
41	3401 a	3345 ab	3358 ab	3295 ab
47	3417 a	3416 a	3416 a	3361 a

a, b, c, d, e, f, g — In the student Newman-Keuls multiple range test, the body weights of feeder-fed and floor-fed pullets at each weighing period followed with the same letter are not significant different (P > .05).

The stronger birds probably consumed more feed, gained weight faster and therefore suffered a lesser degree of feed restriction than the lighter birds during the rearing period (5-18 weeks).

After the rearing period, daily feed consumption rapidly increased from 75 g to 130 g per bird per day in two weeks as mentioned before. The lighter birds grew faster than the heavier birds. By 41 weeks of age there was no significant difference ($P > 0.05$) in body weight among weight-groups from each feeder-fed and floor-fed management (Table 1.4). The analysis of variance (Table 1.5) showed that the difference of body weight among weight-groups decreased to be not significant by 47 weeks of age. Therefore, the birds in the lightest group was almost able to fully compensate for their previous slower growth relative to the heaviest groups by 47 weeks of age.

Differences of mean body weights among weight groups in the floor-fed birds were consistently larger than that in the feeder-fed birds (Table 1.4). It suggested that competition for feed was probably more rigorous among floor-fed birds than the feeder-fed birds. Observation of the body weight difference among four weight-groups from different feeding managements indicated that the interaction between feeding management and weight-group was brought about by the

Table 1.5 Summary of mean squares of the analysis of variance of body weights of all groups of pullets from 2 to 47 weeks of ages (only pullets surviving to 18 weeks were considered in the calculation).

Source of Variation	d.f.	Time of Weighing (week)							
		Brooding and Rearing Periods							
		2	4	6	8	10	12	14	16
Feeder-fed vs.Floor-fed (F)	1	16377 *	340433 *	135162 *	1523350 *	3007266 *	2679112 *	4140837 *	1770785 *
Weight groups (G)	3	904 *	11378 *	65417 *	1067862 *	2744816 *	5500158 *	8575806 *	13822886 *
F X G	3	169 n.s.	5314 n.s.	12843 n.s.	30827 *	149363 *	223802 *	333281 *	432076 *
Error	832	213	2453	6899	9317	16033	17452	19620	12835

Continued.....

Table 1.5 (continued)

Source of Variation	Time of Weighing (week)									
	Holding Period						Laying Period			
	d.f.	18	d.f.	20	d.f.	25	d.f.	41	d.f.	47
Feeder-fed vs. Floor-fed (F)	1	1245814 *	1	2237537 *	1	194294 n.s.	1	1268280 *	1	670620 *
Weight groups (G)	3	12646915 *	3	8062554 *	3	3055125 *	3	367173 *	3	153979 n.s.
F X G	3	215446 *	3	22952 n.s.	3	194150 n.s.	3	53516 n.s.	3	5956 n.s.
Error	813	21541	804	80755	777	142918	692	127339	675	160929

At 2 and 4 weeks of ages the sedentary feeder-fed birds were heavier than the exercised floor-fed pullets, thereafter, the exercised floor-fed pullets were heavier.

* Significant ($P < .05$) n.s. Not significant

more rapid response in body weight increase in the heavier groups managed on the floor-fed system (Table 1.4, Table 1.5). This interaction was only observed during the rearing period when the pullets were under restricted feeding.

1.3.2 Abdominal Fat

Between 26 and 27 weeks of age, 5 birds close to the mean body weight of each group from the feeder-fed and floor-fed populations were killed for abdominal fat studies. The mean body weight and the abdominal fat weight are listed in Table 1.6. The average body weight of each 20 birds selected from the feeder-fed and floor-fed pullets were 2.83 kg and 2.78 kg respectively, and were not significantly different ($P > 0.05$). However, the abdominal fat of the feeder-fed birds weighed 126.0 g which was significantly ($P > 0.05$) higher than the fat content of the floor-fed birds which weighed 102.2 g. The proportion of abdominal fat per body weight was also significantly higher ($P < 0.05$) in the feeder-fed (4.44%) than in the floor-fed (3.69%) birds. Thus, broiler breeder pullets subjected to exercise program by feeding on litter in this experiment showed less abdominal fat deposition both quantitatively and proportionally than those pullets raised on conventional feeder-fed management.

Johnson *et al*. (1956) in a study of obesity in high school girls reported that inactivity was even more important than overeating in association with obesity, on a statistical

Table 1.6 Body weight on the day of autopsy (at 26-27 weeks), total body weight gain after 18 weeks of age to the day of autopsy, total body weight gain minus abdominal fat weight, abdominal fat weight and the percentage of abdominal fat per body weight of the heaviest, upper medium, lower medium and lightest groups of pullets managed on feeder-fed or floor-fed system.

	Body Weight		Total Gain Minus abdominal fat	Abdominal Fat	
	Kg.	Total Gain in gm.	in gm.	Gm.	% Body Weight
Feeder-fed					
Heaviest	2.93 a	1098 cd	980 cd	118 ab	4.04 ab
Upper medium	2.88 a	1192 bc	1048 bc	145 a	5.02 a
Lower medium	2.79 abc	1248 bc	1123 bc	125 ab	4.45 ab
Lightest	2.73 bc	1282 ab	1165 b	117 ab	4.24 ab
Mean	2.83	1205	1079	126	4.44
Floor-fed					
Heaviest	2.84 ab	845 e	751 e	94 b	3.30 b
Upper medium	2.79 abc	981 de	876 de	105 ab	3.72 ab
Lower medium	2.81 abc	1168 bc	1049 bc	119 ab	4.27 ab
Lightest	2.66 c	1411 a	1320 a	92 b	3.45 ab
Mean	2.78	1101*	999*	102*	3.69*

a,b,c,d,e All values in each column followed by the same letter are not significantly different (P < .05), according to Duncan multiple range test.

* Significant difference (P < .05) with the mean in the feeder-fed management.

Table 1.7 Mean squares from the analysis of variance of body weights on the day of autopsy (at 26-27 weeks), body weight gain after 18 weeks of age to the day of autopsy, body weight gain minus abdominal fat, abdominal fat weight and the percentage of abdominal fat per body weight of the heaviest, upper medium, lower medium and lightest groups of pullets managed on feeder-fed or floor-fed system.

		Mean Squares				
Source of Variation	d.f.	Body Weight	Body Weight Gain	Body Weight Gain Minus Abdominal Fat	Abdominal Fat Weight	% Abdominal Fat Body Weight
Feeder-Fed vs. Floor-fed (F)	1	31,584	107,537*	63,853*	5,666*	5.66*
Weight Groups (G)	3	64,031*	259,414*	265,323*	1,126	1.29
F X G	3	6,201	74,111*	71,374*	479	0.52
Error	32	14,491	14,087	13,725	1,017	1.21

* Significant ($P < 0.05$)

basis. The obese subjects had a lower caloric intake; thus, their relatively greater energy balance resulted from a relatively lesser activity. Mayer et al. (1954) also made a similar conclusion based on a study of caged and exercised mice.

Deaton et al. (1974) reared male and female broilers in cages and litter-floor pens under feed and water ad libitum conditions up to 7, 8 and 9 weeks of age. Caged broilers consistently had more abdominal fat and ether extract percentage of body weight than the broilers reared in litter-floor pens.

After the segregation of pullets into four groups by weight at 18 weeks of age, the lighter groups gained weight faster than the heavier groups (Tables 1.6, 1.7, Figure 1.7). The amount and proportion of the abdominal fat pad (% of body weight) at sexual maturity of the feeder-fed pullets were higher ($P < 0.05$) than of the floor-fed pullets. Abdominal fat increased with increased body weight in those groups of pullets which gained up to 1200 g in body weight after the segregation, but decreased in proportion to body weight in those groups of pullets which gained in excess of 1200 g (Figure 1.7). The lightest group had higher body weight than any of the other groups but these lighter pullets contained the least amount of abdominal fat. It should be noted that the lightest group, which suffered the severest feed restriction prior to segregation, was subjected to the least feed restriction after segregation.

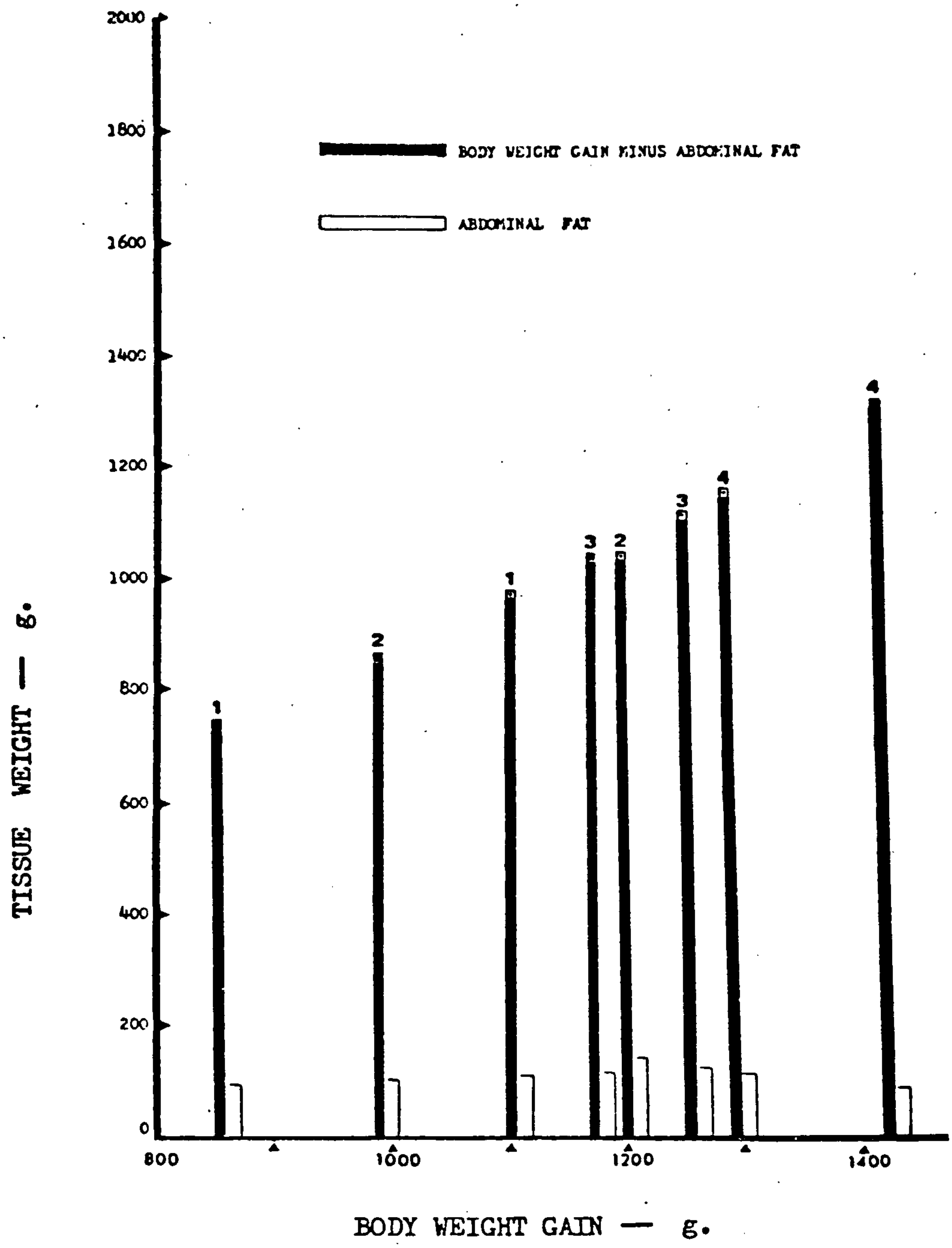

Figure 1.7 Amount of abdominal fat and the body weight gain minus abdominal fat weight in feeder-fed pullets (⊡), and floor-fed pullets (■) with different body weight gains after the pullets were separated into four groups, heaviest (1), upper medium (2), lower medium (3) and lightest (4), by weight at 18 weeks of age to 27 weeks of age.

The data suggest that the more vital parts of the body, such as muscle and skeletal tissues developed at a faster rate than did the abdominal fat in the lightest group of pullets.

1.3.3 Egg Production

1.3.3.1 Sexual maturity

Sexual maturity is shown in Table 1.8 which shows the mean number of days to the first egg, 30 and 50 percent production for different weight-groups in each feeding management. The mean days to first egg laid, 30% and 50% egg production were 194, 208 and 214 for the feeder-fed pullets and 192, 207 and 213 for the floor-fed pullets respectively. Thus, pullets managed on floor-fed system showed no effect on age at sexual development according to the three parameters. Sexual maturity of the lighter groups tended to be delayed, however, the difference was not significant.

1.3.3.2 Rate of lay

Accumulated egg production per hen per day on hen day basis is shown in Table 1.9 for different weight-groups of pullets from feeder-fed and floor-fed

Table 1.8 The effect of feeder-fed and floor-fed managements on three estimates of age at sexual maturity.

Weight-Groups	Days to First Egg	Days to 30% Production	Days to 50% Production
Feeder-fed			
Heaviest	193	207	213
Upper medium	193	205	213
Lower medium	194	209	213
Lightest	197	210	214
Means	194	208	214
Floor-fed			
Heaviest	190	207	214
Upper medium	192	206	213
Lower medium	194	207	214
Lightest	192	207	213
Means	192	207	213

Table 1.9 The effect of feeder-fed and floor-fed feeding managements on cumulative percentage of egg production calculated on a hen-day bases to various ages for different weight-groups of broiler breeder pullets.

	To 30 wks.	To 33 wks.	To 36 wks.	To 39 wks.	To 42 wks.	To 45 wks.	To 47 wks.
<u>Feeder-fed</u>							
Heaviest	10.4	36.2	48.9	53.5	55.9	56.7	57.5
Upper medium	12.4	39.6	50.9	54.2	56.6	57.7	59.2
Lower medium	7.7	32.1	46.7	51.9	54.2	56.0	56.5
Lightest	7.0	30.3	45.3	51.4	54.6	56.3	57.1
Mean	9.4	34.6	48.0	52.8	55.3	56.6	57.6
<u>Floor-fed</u>							
Heaviest	12.2	36.6	49.1	54.9	58.1	60.1	60.6
Upper medium	12.7	34.6	45.8	50.4	53.0	55.0	55.1
Lower medium	10.5	32.8	45.3	51.8	54.8	57.0	57.2
Lightest	8.8	33.0	44.6	50.3	54.6	57.4	57.9
Mean	11.1	34.3	46.2	51.9	55.1	57.4	57.7

feeding managements. Up to 30 weeks of age, the birds from the floor-fed groups produced higher number of eggs than the feeder-fed groups. The early high accumulated egg production was related to earlier maturity of the floor-fed groups. The feeder-fed groups overcame this early advantage of the floor-fed groups with a higher rate of lay subsequent to 33 weeks of age. To verify this point, the hen-day percent egg production by three-week periods over a period of twenty weeks was analyzed (Table 1.10). The analysis indicated that the mean egg production of the feeder-fed groups was slightly higher but not significantly so ($P > 0.05$), than of the floor-fed groups during 31 to 36 week period.

As shown in Table 1.11, the floor-fed groups had higher cumulative egg production on a hen-housed basis than those from the feeder-fed groups at up to 30 weeks of age. Thereafter, the feeder-fed groups consistently had higher cumulative egg production on a hen-housed basis than those from the floor-fed groups. This pattern of production was accounted for by two factors: the feeder-fed groups increased hen-day production at a faster rate after 30 weeks of age, and the floor-fed groups had higher mortality.

The lightest groups laid fewer eggs per hen-day and per hen-housed than the heaviest groups under each feeding management. This was due to both the lower rate of lay and higher mortality of the lightest pullets compared with the heaviest pullets.

Table 1.10. The effect of feeder-fed and floor-fed feeding managements on hen-day percent production by three-week periods over a period of twenty weeks for different weight-groups of broiler breeder pullets.

	27-30* wks.	31-33 wks.	34-36 wks.	37-39 wks.	40-42 wks.	43-45 wks.	46-47** wks.
Feeder-fed							
Heaviest	10.4	62.1	74.1	67.4	65.7	60.3	62.8
Upper medium	12.4	66.7	73.5	64.0	66.3	63.2	68.1
Lower medium	7.7	56.5	76.0	67.5	63.5	64.7	59.5
Lightest	7.0	53.6	75.3	69.9	67.4	64.5	61.8
Mean	9.4	59.7	74.7	67.2	65.7	63.2	63.1
Floor-fed							
Heaviest	12.2	61.1	73.9	72.6	70.9	70.1	63.5
Upper medium	12.7	56.6	68.3	64.1	63.5	64.7	55.7
Lower medium	10.5	55.2	70.3	71.1	66.7	67.9	58.9
Lightest	8.8	57.1	68.0	67.4	71.6	71.6	60.6
Mean	11.1	57.5	70.1	68.8	68.2	68.6	59.7

* this period included four weeks.

** this period included two weeks.

Table 1.11 The effect of feeder-fed and floor-fed feeding management on cumulative percentage of egg production calculated on a hen-housed basis to various ages for different weight-groups of broiler breeder pullets.

	To 30 wks.	To 33 wks.	To 36 wks.	To 39 wks.	To 42 wks.	To 45 wks.	To 47 wks.
Feeder-fed							
Heaviest	10.4	36.2	48.9	53.5	55.9	56.7	57.5
Upper medium	12.1	38.4	49.2	52.2	54.5	55.7	55.8
Lower medium	7.7	31.8	46.0	51.1	53.3	54.7	54.8
Lightest	6.7	29.1	43.2	49.0	52.0	53.5	54.0
Mean	9.2	33.9	46.8	51.5	53.9	55.2	55.5
Floor-fed							
Heaviest	12.0	35.7	47.8	53.3	56.3	58.1	58.4
Upper medium	12.5	33.8	44.3	48.2	50.4	51.8	51.7
Lower medium	10.2	31.3	41.9	47.5	50.1	51.7	51.7
Lightest	8.5	30.3	40.0	44.6	48.1	50.3	50.6
Mean	10.8	32.8	43.5	48.4	51.2	53.0	53.1

1.3.3.3 Egg weight

Egg weights and the analysis of variance of the effect of feeding management on egg weight are shown in Table 1.12 and Table 1.13 respectively. There was a significant effect due to the feeding managements on egg weight. The birds of the floor-fed groups consistently laid heavier eggs than did those of the feeder-fed groups. The difference in egg weight was statistically significant ($P < 0.05$) at 38 and 47 weeks of ages. The eggs laid by pullets in the different weight-groups were not significantly different.

The distribution of egg weights of the heaviest, upper medium, lower medium and lightest groups of pullets from feeder and floor feeding managements at 34, 38 and 47 weeks of ages were shown in Figure 1.8. The production of larger eggs increased as the age of the pullets increased. The floor-fed groups laid larger proportion of eggs over 65 g than those of the feeder-fed groups.

Although the floor-fed groups had less abdominal fat at the onset of lay (as shown in Table 1.6) and consistently laid heavier eggs, it should not be concluded that the floor-fed groups had a better feed efficiency for egg production. The hen-day egg production was not superior and the cumulative number of eggs per hen-housed per day was consistently lower in the floor-fed groups than in the feeder-fed groups. These two factors were probably accounted for the heavier eggs laid by the floor-fed groups.

Table 1.12 The effect of feeder-fed and floor-fed feeding managements on mean egg weights in grams ±s.d. at several ages among different weight-groups of broiler breeder pullets.

	First 10 Eggs at the Onset of Lay	34 wks.	38 wks.	47 wks.
Feeder-fed				
Heaviest	55.1±10.3	64.3±4.0	66.5±7.1	68.4±5.0
Upper medium	52.2±6.5	64.7±5.4	66.6±4.4	69.9±4.2
Lower medium	49.7±5.6	65.5±7.5	65.9±5.2	68.8±4.9
Lightest	52.3±10.9	63.7±7.4	64.9±5.3	69.6±7.7
Mean	52.3±8.4	64.6±6.4	65.9±4.9	69.2±5.6
Floor-fed				
Heaviest	55.0±10.8	65.1±5.3	67.5±7.1	71.4±6.0
Upper medium	51.3±5.8	65.8±6.7	66.6±8.8	71.8±7.7
Lower medium	51.7±5.1	64.1±3.3	67.5±6.3	69.9±4.5
Lightest	55.3±12.5	66.2±8.7	67.5±5.0	71.3±4.2
Mean	53.3±9.0	65.3±6.4	67.3±6.8	71.0±6.0

Table 1.13 The analysis of variance of the effect of feeder-fed and floor-fed feeding managements on mean egg weight at 34, 38 and 47 weeks of ages among different weight-groups of broiler breeder pullets.

Source of Variation	34-weeks		38-weeks		47-weeks	
	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
Feeder-fed vs. Floor-fed (F)	1	69.4	1	230.2*	1	291.7*
Weight-groups (G)	3	7.4	3	10.7	3	45.3
F X G	3	75.8	3	23.9	3	18.4
Error	514	40.6	420	34.8	364	33.4

* Significant ($P < 0.05$)

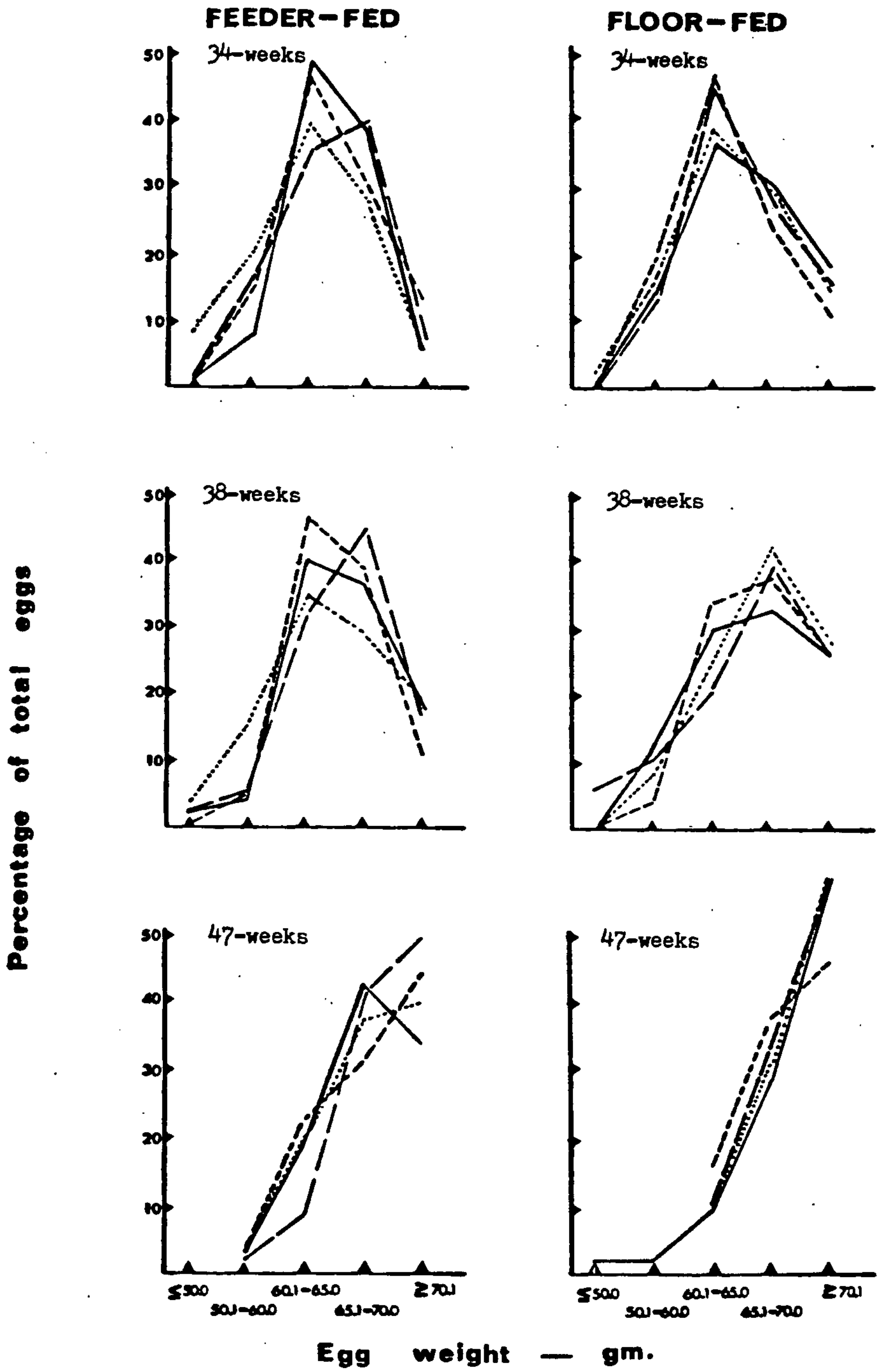

Figure 1.8 The distribution of egg weights of the heaviest (————), Upper medium (— — —), lower medium (--------), and lightest (··············) groups of pullets from feeder-fed and floor-fed feeding managements at 34, 38 and 47 weeks of ages.

1.3.4 Mortality

Twenty-four (4.7%) chicks from the feeder-fed groups and only two (0.4%) from the other groups died at 12 days of age, on the day when all chicks were weighed, vaccinated and wing-banded. This suggested that birds subjected to a greater activity probably had developed higher resistance to stress than those that were less active. The total mortality of the feeder-fed birds was 6.85% and of the floor-fed birds was 1.76% at the end of the brooding period.

The cumulative mortality and the mortality during brooding, rearing, holding and laying periods of the feeder-fed and floor-fed pullets are shown in Table 1.14. The floor-fed birds consistently had a higher mortality than the feeder-fed birds through the rearing to laying period. The major cause of death of the floor-fed birds was gizzard impaction or intestinal blockage with litter material.

At about 30 weeks of age numerous pullets were discovered to have visual problems. One or both of their eyes were grey and some of them were apparently enlarged. The problem was identified to be bluish discoloration of the lens. In tracing back the history of mortality, there was found 1 bird killed with serious tremor of the head and neck at 5 weeks of age, and seven birds (0.6% of all chicks)

Table 1.14 The cumulative mortality and the mortality during the brooding, rearing, holding and laying periods of the feeder-fed and floor-fed pullets.

To the End of Each Period		% Cumulative Mortality	
		Feeder-Fed	Floor-Fed
Brooding		6.85	1.76
Rearing		11.94	20.55
Holding		15.50	27.79
Laying		17.40	33.23

		% Mortality in Each Period	
Brooding		6.85	1.76
Rearing		5.45	19.13
Holding:	heaviest	3.96	1.05
	upper medium	2.73	4.12
	lower medium	1.79	2.11
	lightest	6.31	13.13
Laying:	heaviest	0.00	4.55
	upper medium	2.94	6.82
	lower medium	1.90	11.36
	lightest	5.05	13.58

sitting on their backs with ataxia during the rearing period. Serum samples therefore were collected from pullets with opaque lenses, and were examined in the Abbotsford Veterinary Research Station. Five out of eight samples of serum were reported to contain Avian encephalomyelitis antibodies.

During the laying period the lightest groups had higher mortality than the heaviest groups. Most of the birds that died had fatty livers.

1.4 SUMMARY

Two populations of broiler breeder chicks from Heisdorf and Nelson stock with 511 chicks each were subjected to two feeding management regimes. One population was fed once daily using conventional feeder. The other population was fed twice daily the same amount of feed as the feeder-fed population, but given feed broadcast on the litter. Physical activity, and the extension of feeding time of the floor-fed population was therefore greater than was the case with the feeder-fed population.

Both populations were given feed and water *ad libitum* from 1 to 4 weeks of age. Thereafter the birds in both treatments were given the same weight of feed each day. The amount of feed intake was adjusted daily to restrict growth to a target body weight of 1.65 kg at 18 weeks of age. Water was given *ad libitum* throughout the whole experiment except during the period from 15 to 18 weeks, when water was restricted for 14.5 hours daily (from 5:30 p.m. to 8:00 a.m.).

At 18 weeks of age, each population was divided into four groups, heaviest, upper medium, lower medium and lightest, based on body weight. Body weight, abdominal fat weight at sexual maturity, egg production and mortality of each group of birds from the two populations under different feeding managements were studied.

The feeder-fed birds were heavier than the floor-fed birds under *ad libitum* feeding from 2 to 4 weeks of age. Thereafter, the floor-fed birds were heavier than the feeder-fed birds when they were under quantitative feed restriction. After the segregation of four groups based on body weight, the lighter groups grew faster than the heavier groups. By 47 weeks of age, body weight were not statistically different ($P > 0.05$) among the four groups.

The amount and proportion (% of body weight) of the abdominal fat pad in the feeder-fed pullets at 26-27 weeks of age were higher than in the floor-fed pullets. Abdominal fat increased with increased body weight in those groups of pullets which gained up to 1200 g in body weight after the segregation at 18 weeks of age, but decreased in proportion to body weight in those groups of pullets which gained in excess of 1200 g. The lightest group of pullets had greater body weight gains than any of the other groups, but these lighter pullets contained the least abdominal fat. The data suggested that the more vital parts of the body, such as the muscle and skeletal tissues, developed at a faster rate than the abdominal fat pad in the lightest group of pullets.

Floor feeding did not affect the age at which the pullet reached sexual maturity. Egg production, calculated on hen-day basis, was similar in all groups. When egg production was calculated on a hen-housed basis, however, the feeder-fed pullets showed a higher rate of egg production than did the floor-fed pullets. Furthermore, the heavier pullets within both feeding systems had a higher rate production than did the lighter birds.

Eggs laid by the floor-fed pullets were significantly ($P < 0.05$) heavier than those laid by the feeder-fed pullets. Average egg weights were 67.3 g and 71.0 g for the floor-fed pullets and 65.9 g and 69.2 g for the feeder-fed pullets at 38 and 47 weeks of ages respectively.

CHAPTER II.

THE EFFECT OF PROLONGED FEED RESTRICTION DURING THE GROWING PERIOD ON SUBSEQUENT SEMEN PRODUCTION.

2.0 INTRODUCTION

The reproductive physiology of the male fowl is influenced by different postnatal environmental factors, such as nutrition, photoperiodism, temperature, disease, drugs and behavior. Of these factors, nutrition is still of the most concern to the practising farmer raising domestic male fowls. This is particularly important for heavy-type birds, because proper body size, is associated with low mortality, high fertility and sexual activity.

According to a survey of fertility and hatchability of 63 flocks of broiler-breeders in the lower Fraser Valley (Chu and March, 1976) hatchability reached a peak at some time between 31 to 40 weeks of age, after which it declined. During the decline period fertility dropped more rapidly than hatchability. It was obvious that the fertilizing capacity of the aged breeder flocks showed a decline which might be due to poor semen quality of males. The present experiment was undertaken to determine if there is any association in aged broiler breeder males, of semen volume and sperm concentration with early dietary feed restriction.

2.1 LITERATURE REVIEW

2.1.1 Overfeeding and Male Fowl Reproductive Performance

Obesity induced by overfeeding as it adversely affects male reproductive performance was discussed by Ingle (1950). He observed that atrophy of the testes was found in obese male animals, when the obesity was induced by overfeeding. Kennedy (1926) in a review noted that obesity in the male may be associated with decreased fertility through oligospermia.

Poultry breeders also have long been aware that obesity is associated with reduced fertility and libido of the male fowls. Nir *et al*. (1975) force-fed 20 week old White Leghorn cockerels. By the end of 25 weeks of age, there was an increase in the mean body weight of 827 gm in the case of the force-fed birds, and of only 77 gm in the control birds. The average abdominal adipose tissue weighed 96.7 gm in the force-fed birds and 36 gm in the control birds. Obesity was followed by testicular regression, an eight-fold reduction in the number of spermatozoa in the vasa deferentia and a depression in sperm motility. The blood plasma testosterone was reduced and luteinising hormone showed an increase. Comb surface and blood packed cell volume both increased. A disturbance of body temperature regulation was shown with an increase in rectal temperature but a decrease in skin and comb temperatures.

It has been reported that quail, in which obesity was induced by overfeeding, showed a 30 per cent reduction in testicular weight and a 50 per cent reduction in the spermatozoa concentration in the testis and ducti deferentes. Plasma testosterone and sexual maturity also decreased with obesity (Nir, 1977).

Lane and Dickie (1954) and Lidell and Hellmen (1966) however indicated that the endocrine function of mice with hereditary obesity was impaired. Food restriction did not cause improvement of the hormonal production of the testes, indicating that overeating per se was not the cause of the impairment. Lidell and Hellman (1966) stated that, "it should furthermore be pointed out that our data in mice do not exclude the possibility of a common denominator for the obesity and the reduced testicular activity nor that the latter function in some cases might be a primary cause of obesity". The common denominator may be located in the hypothalamus, which plays a central role in gonadal development: the release of gonadotrophic hormones, termoregulation and food and water intake (Pandsepp, 1975). The mechanism by which obesity and fertility may be regulated by the hypothalamus are still, however, poorly understood.

2.1.2 Inanition and Male Reproductive Performance

The generative organs of male domestic animals are fairly resistant to caloric deficiency. Restricted feeding of boars and bulls up to 40 per cent of *ad libitum* causes a distinct retardation in growth, but the fertility and total semen volume produced by these animals are not significantly affected (Nalbandov, 1976).

Similarly, King (1972) studied the energetics of reproduction in wild birds and concluded that a negligible fraction of the males energy budget used for seasonal growth of the testes. Testicular function is highly resistant to caloric shortage. Sperm production and vitality are not impaired until the loss of body weight approaches 30 per cent of normal weight.

Boone (1969) reported that complete starvation of adult fowl for 4 to 6 days caused a significant decrease in semen volume. However, semen volume returned to normal within 8 to 16 days after returning birds to feed and water.

In fact, a moderate energy and protein restriction of growing male domestic fowls, particularly the heavy-type birds, has no adverse effect on subsequent reproductive performance, even though sexual maturity may be delayed. Testes weight, semen concentration and fertility have been reported to increase more in moderately restricted-birds than in full-fed controls (Arscotl and Parker, 1963; Jones *et al.*, 1967; Wilson et al., 1965, 1971; Voitle et al., 1971, 1972).

However, too severe and prolonged inanition may stop gonadal function entirely, and may permanently impair male reproductive performance. Parker and Arscotl (1963) reported that prolonged energy restriction to 40 per cent of control adult White Leghorn male for 13 weeks decreased subsequent volume and fertilizing capacity of semen, and testicular and body weight. Wilson et al. (1972) substantiated that broiler breeder males fed a low protein (9.3%) diet from 4 to 18 weeks of age, showed a decrease in fertility but that the hatchability of fertile eggs was not affected.

2.2 MATERIAL AND METHODS

2.2.1 Source of Birds

A group of 27 54-week old broiler-type male chickens was placed in individual cages on the 30th of May, 1978. Previously, all chickens were subjected to feed restriction programs of different lengths, which are listed on Table 2.1.

Each treatment was tested with 8 to 10 bird except the control group which contained 12 birds. All birds were fed the diet listed on Table 2.2, from day old to 54 weeks. The diet was then changed to a layer diet until the end of the experiment.

2.2.2 Collection of Semen

A chicken holder developed by Burrow and Quinn (1937) was used for collecting semen. The birds had been conditioned in cages for one week, then they were trained on alternative days for 2 weeks to give semen. Five semen collections were obtained during the age of 57 to 58 weeks of age. Samples were taken in individual test tubes and examined within 2 hours after collection. The whole semen volume, including the transparent fluid from the swollen lymphfold, was measured by micropipettes graduated to 25 microliter. Spermatozoa concentration in the whole semen sample was estimated by

Table 2.1 Restricted feeding programs during the growing period.

Treatment No.	No Feed	Free Access to Feed	Feeding Restricted to ½ hr.daily	Start of Feeding ad libitum	Length of Feed Restriction (wks)
	Feeding Programs (Age-Dates)				
1 (control)	1st-2nd			3rd	0
2	1st-3rd	4th	5th-11th	12th	1
3	1st-3rd	4th	5th-18th	19th	2
4	1st-3rd	4th	5th-33rd	34th	4
5	1st-3rd	4th	5th-54th	55th	7
6	1st-3rd	4th	5th-68th	69th	9
7	1st-3rd	4th	5th-82nd	83rd	11
8	1st-3rd	4th	5th-96th	97th	13

Table 2.2 Composition of diet 2.1.

Ingredients	%
Ground wheat	31.0
Ground corn	31.0
Ground oats	20.0
Soybean meal	12.8
Dehydrated cereal grass	2.0
Iodized salt	0.5
Limestone	1.2
Calciumphosphate	1.5
Micronutrients	**

Crude protein ---------------------15.2%
Metabolizable energy---------------2861 kcal/kg

**Micronutrients	per kg of diet
manganese sulfate (5 H_2O)	150 mg
zinc oxide	62 mg
choline chloride	1320 mg
riboflavin	3 mg
vitamin B_{12}	13.2 mg
vitamin A	4400 I.U.
vitamin D_3	440 I.C.U.
amprol*	125 mg

* Amprol (coccidiostat) supplied courtesy of Marck, Sharp and Dohme Canada Ltd.

optical density technique, which has been fully described by McCartney and Brown (1959). Only those samples with more than 0.1 c.c. were subjected to the measurement of spermatozoa concentration. A standard curve (Appendix Figure 2.1) was established, as described by McCartney and Brown (1959), and was used in this experiment.

2.2.3 Post-Mortem Studies

All birds were killed by cervical dislocation at 60 weeks of age. They were weighed immediately after death. Testes were excised and weighed.

2.3 RESULTS AND DISCUSSION

2.3.1 Treatment Effect

Based on the number of birds examined in this experiment, feed restriction of one to thirteen weeks during the growing period appeared to have no effect on body weight at 60 weeks of age compared with the control (Table 2.3). Even though prolonged feed restriction retarded body weight gain until 33 weeks of age, as reported by Ballam (1978), the surviving birds had fully compensated for the earlier slower growth by 60 weeks of age.

The mean testes weight and percent testes weight per body weight of each treatment groups was not significantly different from the control group (Table 2.3), even though there was a slight negative correlation between the length of feed restriction and testicular weight (Table 2.5).

The average testicular weight and percent testicular weight per body weight of all experimental birds were 36.58 gm and 0.76 per cent respectively. Two control birds had testes weighing 85.42 gm and 58.96 gm (1.68% and 1.18% of body at respectively) which were the two biggest testes pairs among all the birds, of which testes weights were listed on Appendix Table 2.2. These two birds appeared healthy, but they aggressively refused to give any semen throughout the experiment.

Table 2.3 Treatments effect on mortality, body weight at 60 weeks of age, testes weight and testes weight per body weight.

Treatment No.	Length of Feed Restriction (wks)	No. of Birds at 54 wks.	No. of Birds Died Between 55-60 wks.	Body Weight at 60-wks. (kg)	Testes Weight (gm)	% Testes Wt. / Body Wt.
1 (control)	0	6	0	4.93±0.15	48.12±8.85	0.97±0.16
2	1	3	1	4.85±0.02	55.63±0.86	1.14±0.04
3	2	3	0	5.14±0.36	40.03±8.99	0.76±0.14
4	4	6	0	4.59±0.20	24.73±2.54	0.55±0.07
5	7	2	1	4.55	32.86	0.72
6	9	4	2	4.57±0.05	25.09±13.10	0.56±0.30
7	11	1	0	4.43	14.43	0.33
8	13	2	1	5.60	38.89	0.52
		Average:		4.82±0.10	36.58±3.77	0.76±0.07

Semen volume, spermatozoa concentration and number of spermatozoa per ejaculation were not found to affected by the experimental treatments (Table 2.4, Table 2.5). The average semen volume in c.c. ± SE per ejaculation among all birds was 0.83 ± 0.15 and millions of spermatozoa per c.c. of semen was 0.610 ± 0.140. Siegel et al. (1969) reported that White Rock cockerels given 6 to 14 hours of light per day produced 0.34 and 0.32 c.c. semen volume, and 1.00 and 1.57 millions spermatozoa per c.c. of semen respectively. The semen characteristics, from their report, appeared lower in volume and higher in spermatozoa concentration than in the present experiment. The discrepancy might be because more transparent fluid (produced by the swollen lymphfold) was collected in our experiment. However, the total number of spermatozoa per ejaculation was similar in cocks from this experiment and cocks receiving 14 hours of light in the experiment of Siegel et al.

Mortality in the control birds was 38% and in the restricted birds was 51% by 38 weeks of age. Total mortality increased to 51% and 66% respectively by 54 weeks. No control birds died subsequently; but meanwhile, five birds died from the treatment groups (Table 2.3). The effect of early feed restriction may also extend to affect the viability of those surviving cocks even up to one year of age.

Table 2.4 Length of feed restriction of broiler breeder males during the growing period on subsequent volume of semen per ejaculation, spermatozoa concentration and millions of spermatozoa per ejaculation.

Treatment No.	Length of Feed Restriction (wks.)	Volume (c.c.) of Spermatozoa Per Ejaculation		Spermatozoa Concentration Millions/c.mm.	Millions of Spermatozoa Per Ejaculation
1 (control)	0	1.14±0.52	(4)*	1.067±0.480	710±228
2	1	0.82±0.10	(2)	0.353±0.213	268±139
3	2	1.34±0.57	(3)	0.430±0.150	413±179
4	4	0.55±0.18	(6)	0.413±0.130	160±050
5	7	0.31	(1)	0.097	030
6	9	0.60±0.03	(2)	0.593±0.510	341±288
7	11		(0)		
8	13	1.07	(1)	1.658	1774
	Average:	0.83±0.15	(19)	0.610±0.140	424±107

* number of birds.

Table 2.5 Correlation coefficient of body weight at 60 weeks, testes weight, percentage of testes weight over body, semen volume, semen concentration and number of spermatozoa per ejaculation.

	Kg of Body+ Weight at 60 weeks	Gm. of Testes Weight	% Testes Wt. / Body Wt.+	c.c. of Semen Volume Per Ejaculation	Millions of sperm per c.c. of Semen	Millions of sperm per Ejaculation
Weeks of feed restriction	0.03 n.s.	-0.22 n.s.	-0.24 n.s.	-0.18 n.s.	0.08 n.s.	0.22 n.s.
Kg. of body weight+ at 60 weeks		0.49 *	0.22 n.s.	0.62 *	0.12 n.s.	0.60 *
Gm. of testes weight			0.96 *	0.50 *	-0.12 n.s.	0.30 n.s.
% Testes Weight / Body Weight+				0.35 n.s.	-0.17 n.s.	0.14 n.s.
c.c. of semen volume per ejaculation					-0.21 n.s.	0.50 *
Millions of sperm per c.c. of semen						0.55 *

n.s. not significant * significant ($P < .05$)

\+ not including testes weight

2.3.2 Body Weight Testes Weight and Semen Characteristics

Regardless of the treatment effects, body weight (excluding testes weight) was positively correlated with the testes weight ($P < 0.05$), semen volume ($P < 0.05$) and number of spermatozoa per ejaculation ($P < 0.05$) (Table 2.5).

The observation reported by Burger *et al*. (1962) and Payne *et al*. (1960) is thereby substantiated. It is suggested that a bigger bird has a larger genital organ which is capable of producing a larger volume of semen and a greater number of spermatozoa, when they are under voluntary feed intake.

On the other hand, birds in which obesity is induced by force-feeding may show testicular regression. Nir *et al*. (1975) force-fed White Leghorn cockerels twice as much feed as the *ad libitum* intake for 5 weeks. Testis weight was 17.5% less, even though the body weight gain was more than ten-fold of the control group. An even more pronounced effect on testicular regression was found in force-fed male Japanese quail (Nir, 1971).

Brobick (1946) showed that the obesity observed in rats with hypothalamic lesion was consequent to overfeeding. In the case of fowl, rendered obese by forced-feeding, the hypothalamal-hypophyseal complex might be damaged and the normal secretion of gonadotrophic hormones disturbed. The testes therefore regressed. Furthermore, forced-feeding has also been found to be able to alter several physiological phenomena of the male domestic fowl. Nir and Shapina (1974) showed that force-feeding of young chicks for 15 days increased kidney arginase activity and liver exanthime dehydrogenase activity, and also increased overall secretion of digestive enzymes. Nir _et al_. (1975) reported that increase of the rectal temperature and decrease of the skin and comb temperature, a reduction in the blood packed cell volume and a decrease of testosterone and an increase of luteinising hormone concentrations in the blood plasma were observed in adult male fowls after 5 weeks of receiving feed two fold more than the _ad libitum_ intake. Recently, Nir (1977) studied male Japanese quail and reported that obesity induced by forced-feeding was accompanied by increases in colonic temperature (about .3^{o}C), and peripheral leg temperature (about 3^{o}C) and by a decrease of the mid-scapular skin temperature (about .6^{o}C).

The testis weight of the surviving cocks in the present experiment was positively correlated ($P < .05$) with body weight (Table 1.5) in contrast to the effect reported by other investigators who studied force-fed animals. The adverse effect caused by prolonged dietary feed restriction during the growing period was evidenced by increased mortality. However, as long as the previously restricted birds survived, their testicular size was relative to their body weights as in the normal situation (Burger _et al_., 1962).

2.4 SUMMARY

Seven groups of day-old broiler-type males with 8 to 10 birds each were restricted to half an hour feeding from 0 weeks to 1, 2, 4, 7, 9, 11 or 13 weeks of ages during the growing period. All groups of birds were given water and feed *ad libitum* after the feed restriction. The effects of dietary feed restriction on body weight, testes weight, and semen characteristics were studied when the birds were 57 to 58 weeks old.

No significant effect of the different period of dietary feed restriction on body weight, testes weight, semen volume, spermatozoa concentration and number of spermatozoa per ejaculation was found compared with the control group which had free access to feed throughout the experiment.

The averages of semen volume per ejaculation, spermatozoa concentration, number of spermatozoa per ejaculation of all birds examined in this studies were 0.83 c.c./ejac., 0.610 millions/c.mm. and 424 millions/ejac. respectively.

Testes weight was positively correlated with the body weight (not including testes weight) ($P < .05$), semen volume ($P < .05$) and number of spermatozoa per ejaculation ($P < .05$). Birds subjected to dietary feed restriction had higher mortality during the restriction period and during the subsequent period when feed was given *ad libitum* than had the control birds.

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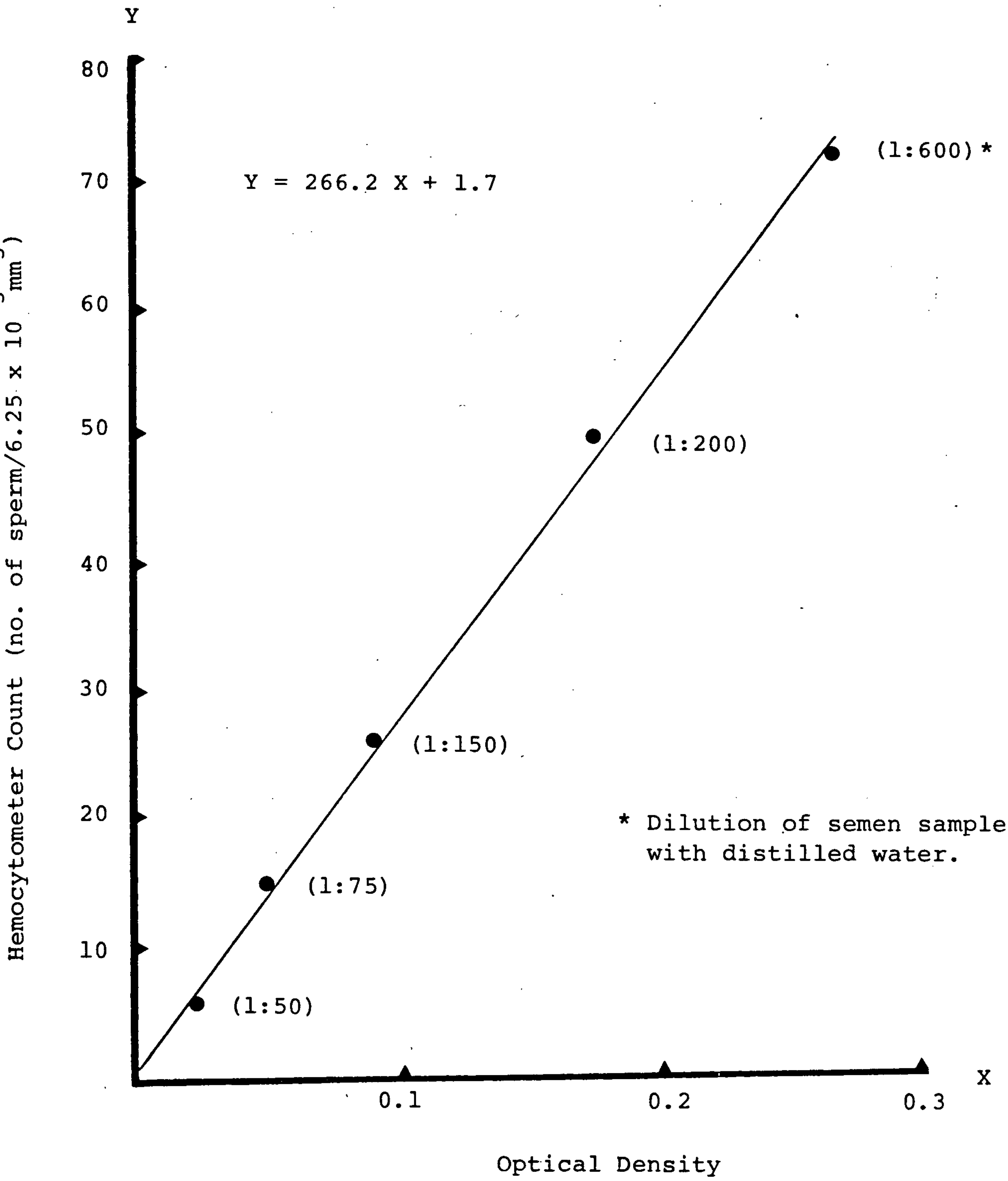
APPENDIX

Appendix Figure 2.1. Regression line for spermatozoa counts on the basis of optical density reading (660 millimicrons).



Appendix Table 2.2. Body weight at 60 weeks of age, testes weight, percentage of testes weight per body weight, semen volume, sperm concentration and number of spermatozoa per ejaculation of individual broiler male studied in this experiment.

Bird No.	Weeks of Feed Restriction	Kg. of Body Weight at 60 wks.	Gm. of Testes Weight	% Testes Weight / Body Weight	c.c.of semen Volume per Ejaculation	Millions of sperm per c.c. of semen	Billions of Sperm per Ejaculation
8029	0	4.59	27.11	0.59	0.23	2.468	0.568
8016	0	5.01	58.96	1.18			
8020	0	5.08	85.42	1.68			
8021	0	4.94	39.32	0.80	2.54	0.496	1.260
8034	0	4.45	30.22	0.68	0.46	0.384	0.177
8018	0	5.48	47.70	0.87	0.91	0.921	0.838
8005	1	4.97	54.77	1.10	0.72	0.566	0.407
8008	1	4.82	56.49	1.17	0.92	0.140	0.129
8096	2	4.46	22.36	0.50	0.21	0.682	0.143
8098	2	5.67	46.00	0.81	2.11	0.164	0.345
7949	2	5.29	51.72	0.98	1.69	0.444	0.751
8067	4	3.69	27.06	0.73	0.10	0.685	0.069
8184	4	4.63	13.50	0.29	0.43	0.082	0.035
8074	4	4.53	26.63	0.59	0.49	0.314	0.154
8051	4	4.87	26.65	0.55	1.44	0.102	0.147
8167	4	4.64	31.80	0.69	0.41	0.419	0.172
8054	4	5.18	22.73	0.44	0.44	0.097	0.030
8140	7	4.55	32.86	0.72	0.31	0.097	0.030
8038	9	4.62	25.76	0.56	0.57	1.102	0.628
8144	9	4.52	38.22	0.85	0.63	0.836	0.053
8177	11	4.43	14.43	0.33			
8152	13	5.60	38.89	0.52	1.07	1.658	1.774