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THE UNIVERSITY OF ALBERTA

INFLUENCE OF PARENT AGE AND MANAGEMENT AND NUTRITIONAL PROGRAMS ON BROILER CHICKEN PERFORMANCE

by

RICHARD W. SINCLAIR

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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IN

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled INFLUENCE OF PARENT AGE AND MANAGEMENT AND NUTRITIONAL PROGRAMS ON BROILER CHICKEN PERFORMANCE submitted by RICHARD W. SINCLAIR in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in POULTRY NUTRITION.

F. E. Robe..........................

Supervisor

Robert T. Hardin..........................

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....

Date July 15, 1988.

Dedication

To my wife Jacqueline

and in loving memory

of my father Dr. W. Sinclair

ABSTRACT

Three experiments were conducted with broiler chickens to study the relationship between parent age and chick quality as measured by percent weight loss (PWL) during incubation, and the efficacy of several management practices in improving growth performance and viability. In experiments 1 and 2, eggs were obtained from young and old breeder flocks of the same strain, individually weighed, incubated and candled 18 days after placement in the incubator. Chicks were placed on one of four treatments: 1) water and feed at time of placement; 2) water soluble Neo-Terramycin and feed at time of placement; 3) water at time of placement and feed four hours later; and 4) Neo-Terramycin at time of placement and feed four hours later. In experiment 1, chicks were grown in batteries while in experiment 2, chicks were grown in floor pens. Individual body weights were recorded daily for days 1 to 5 (Experiment 1) and days 1, 3 and 5 (Experiment 2) and then weekly to six weeks of age.

Chicks from old flocks were heavier and exhibited a significantly higher growth rate than chicks from young flocks at six weeks of age. A high correlation between chick hatch weight and egg weight was noted. The correlation between PWL and chick body weight was not significant.

In experiment 1, chicks receiving Neo-Terramycin were significantly heavier until day 4. Chicks allowed access to feed at time of placement were significantly heavier on days 2 through 5 and at weeks 2, 3 and 5. Body weight differences attributable to sex were significant with males being heaviest at weeks 3 through 6. Significant breeder age x medication and medication x sex interactions were noted as male chicks from the old flock receiving Neo-Terramycin and feed at time of placement had a significantly higher growth rate than males on any other treatment.

In experiment 2, no significant differences in body weight were observed that could be attributed to the treatments. Young flock males on water with feed four hours after placement had a significantly higher growth rate than males on any other treatment.

In experiment 3, chicks from a young breeder flock were sorted into two PWL groups and fed one of four starting diets: 1) 26% crude protein (C.P.) 3200 Kcal ME/kg; 2) 23% C.P. 2830 Kcal; 3) 23% C.P. 3200 Kcal; and 4) 26% C.P. 2830 Kcal. Chick weight (pen basis) was recorded weekly to six weeks of age, and carcass composition analysis was conducted at both three and six weeks of age. Chicks of low PWL were significantly heavier than chicks of high PWL until five weeks of age. Chicks on low energy or low C.P. diets were significantly heavier through three and six weeks respectively, than chicks on high energy or C.P. diets. Low C.P. diets had significantly lower overall feed conversions than high C.P. diets. Carcass analysis carried out at three and six weeks of age demonstrated that chicks on high energy starter diets had significantly lower crude protein but higher fat levels on a dry matter basis than chicks on low energy diets.

These findings demonstrate that antibiotics improved the growth rate of older flock chicks while young flock chicks show improved growth rate when allowed to rehydrate with water prior to the placement of feed. Dietary energy and C.P. levels significantly affect chick body weight. However, such diets failed to improve the growth performance of high PWL chicks.

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1: INTRODUCTION

1.1: General Introduction

Broiler chicken producers are currently faced with the problem of inconsistent quality of day-old chicks. Several factors, either directly or indirectly, influence chick quality and subsequent growth performance. Not all of these factors are within the control of the broiler producer. Chicks that arrive on the farm may be from breeder flocks differing in age, or they may have hatched from eggs of widely different setting weight, or they may have been held for different lengths of time in the hatcher, or they may have been sitting in chick boxes for extended periods of time due to sorting, processing and transport.

Management practices at time of chick placement and dietary manipulation are methods by which the broiler producer has the potential to assist chicks to overcome the initial stress at placement, so that maximum growth can be achieved.

The research reported here investigated the effects of breeder flock age, percent weight loss of the egg during incubation, various water and feed management programs, and protein and energy levels in the starter diet, on growth performance of broiler chickens to six weeks of age.

1.2: Factors Affecting Chick Quality

Chick quality is a subjective term used in an attempt to classify the status of a chick. It is manifested in initial body weight, appearance, and subsequently feed conversion, growth performance, livability, and health status during life. No standard or set of guidelines has yet been established to objectively evaluate chick quality. A method of systematically evaluating and classifying chick quality would be of benefit to the broiler chicken producer so that the appropriate chick placement management program could be implemented to maximize potential growth performance.

1.2.1: Egg Weight

The positive relationship between egg weight and chick weight has been well documented. Halbersleben and Mussehl (1922) noted a consistent relationship between hatching egg weight and subsequent chick weight at hatching. The chick weight averaged 64 percent of the egg weight. It was reported that any apparent advantage held by chicks that hatched from heavier eggs appeared to have been lost by 35 days of age. However, Godfrey and Williams (1952) reported that weight of egg, age at sexual maturity, and mature body weight accounted for 36 percent of the variation in body weight at 12 weeks of age. Goodwin (1961) stated that the initial effect of egg weight is to a considerable degree cumulative, and it can exert a major effect on the ranking of different strains at nine weeks of age. It was suggested that the weight of a chick at hatching does have an important effect on its growth, even though the correlation coefficients of nine week body weight with initial egg weight were small in comparison to the correlation coefficients of hatching chick weight with initial egg weight. Previous reports interpreted this small correlation as indicating the association to be nonsignificant. Upp (1928) also reported a high degree of association between egg weight and day old chick weight in Single Comb Rhode Island Red (S.C.R.I.R) birds at hatching.

Wiley (1950a) observed that both pre-hatching growth rate and chick weight were limited by the space in the shell during the last two or three days of incubation. Wiley also reported (1950b) that there was a high correlation between egg weight and chick weight which was highly significant at hatch time, showing that a heavier egg produced a heavier chick. This correlation was highly significant until the ninth week of age.

Kosin et al. (1952) recognized the practical implications of the relationship between egg weight and growth rate and concluded that egg weight frequently exercises a significant influence on the growth of the chick, but that the relationship was variable. Prominent sources of variability were breed and sex. The significance of the correlation between egg weight and body weight depends on r values and their interpretation. Chick weight at the start of the post-hatch growth period constitutes a greater percent of body weight than at subsequent weight stages. The initial chick body weight must be used as a covariate in the analysis so that it would not introduce a bias in favour of early stages of growth.

Egg weight can also significantly affect the length of incubation. Williams et al. (1951) reported that heavier eggs require a longer incubation period, as was previously reported by McNally and Byerly (1936). This is due to the longer time period required for the core temperature of a heavier egg to rise to the temperature of the incubator.

There is general agreement that egg weight influences broiler weight to six weeks of age in a positive, linear manner (Tindell and Morris, 1964; Merritt and Gowe, 1965; Morris et al., 1968; Gardner, 1973). The characteristic frequency distribution in egg weight seen when comparing eggs of young and old breeder flocks demonstrates that heavier eggs are associated with older flocks (McNaughton *et al*., 1978).

1.2.2: Parent Age

Hays and Spear (1952) found a highly significant relationship between age of parent and chick viability. Chicks from pullet dams exhibited significantly higher mortality than did chicks from hen dams. Skoglund *et al*. (1952) also reported higher mortality in chicks from light eggs than in chicks from heavy eggs, which was attributed to greater susceptibility to stress during shipping and the initial brooding period. Chicks from lighter eggs have lower body weights and yolk sac reserves to sustain them through the stress associated with hatching, processing, shipping, and placement. McNaughton *et al*. (1978) equalized egg weights between parent ages and found that parent age influenced offspring mortality with a more viable chick being produced from 58 week-old breeders than from 29 week-old breeders. However, no significant parent age-related differences in market weights were found when hatching egg weights were equalized. Shanawany (1987) summarized the available information concerning the relationship between initial egg weight and the corresponding chick weight at hatching for different species of domestic birds to try and solidify some general relationship which would be applicable across all species. The model generated indicated that hatching weight as a percentage of egg weight was similar for all species. The model is weak however, and would need to include such variables as incubation humidity and temperature, and a method to account for water loss during storage.

1.2.3: Weight Loss During Incubation

Day-old chick weight is also affected by the rate of moisture loss from the egg during incubation. The loss of weight during incubation depends primarily upon the relative humidity of the environment, although shell quality and thickness also affect weight loss during the incubation period. Weight loss decreases in direct proportion to the increase in the humidity. Incubator temperature also affects weight loss. Increasing the temperature from 37.2°C to 39.7°C results in increased weight loss of 33 percent (Pringle and Barott, 1937).

Hays and Spear (1951) found that weight loss during the first 17 days of incubation may vary from 6.5 to 12 percent without affecting hatchability. Weight losses greater than 12 percent were however, associated with significant reductions in hatchability. The rapid loss in weight during incubation has been associated with poor shell quality. O'Neil (1955) attributed heavier mortality in chicks with a hatch weight less than 65 percent of setting egg weight, to physiologically immature birds that could not adjust to their environment.

A relative humidity of 50 percent was recommended by Robertson (1961) as the optimum level for incubation. It was suggested that eggs of different weights may have different humidity requirements for optimum hatchability. Kirk _et_ _al_. (1980) recommended an optimum relative humidity of 53 percent for eggs from young chicken broiler breeders (28 to 44 weeks of age). An increase or decrease from this level depressed hatchability. For eggs from older broiler breeder flocks (48-60 weeks of age) a relative humidity of 44 percent was recommended for optimum hatchability.

Simkiss (1980) subjected chick embryos to severe water stress during incubation by removing allantoic fluid, or by drilling holes in the shell to increase water loss from the egg. While it was still possible to hatch chicks under these conditions, body weight of hatched chicks was reduced by an amount almost equivalent to the allantoic fluid removed, or the extra water loss through the drilled shell. When fresh egg weight and weight loss during incubation are taken together at the moment of escape from the shell, over 97 percent of the variation in chick weight can be explained by these two factors (Tullet and Burton, 1982). Differences in chick weight as a percentage of fresh egg weight during incubation resulted from differences in egg-shell porosities or incubation humidity.

1.2.4: Holding Time in the Hatcher

The duration of holding time in the hatcher after hatching also affects chick quality and performance. Early emerging chicks that were removed from the hatcher soon after hatching exhibited a slightly better rate of growth than did late emerging chicks (Williams _et al_., 1951). Misra and Fanguy (1978) reported an increased incidence of mortality and significant reductions in chick body weight at four weeks of age as a consequence of holding chicks for extended periods of time in the hatcher. To evaluate the effects of time of hatch and time held in the incubator post-hatch on subsequent growth rate, Hager and Beane (1983) devised a system of removing chicks from the hatcher or holding the chicks in the hatcher for various periods of time. They reported that the longer chicks were held in the hatcher, the greater was the body weight loss. At four weeks of age the body weight advantage of the early removal chicks was maintained, and was significantly greater than that of their hatch mates held in the hatcher.

Reinhart and Hurnik (1984) reported that breeder age, setter humidity, egg weight, egg location within the setter, and chick removal time from the hatcher significantly affected chick weight and hatching time. With increased sophistication in incubation technology and with close monitoring of hatch information, it was reported that these traits could be utilized to achieve optimum hatching performance.

Wyatt _et al_. (1985) attributed early chick mortality to dehydration [illegible] evidenced by urates in the urinary tract, with 70 percent of the total mortality occurring in the first week with light eggs (48 to 54 g) but only 33 percent occurring in the first week for the heavy eggs (58 to 64 g). Furthermore, higher total plasma protein and glucose concentrations, hematocrits, and heterophil:lymphocyte ratios were seen as a consequence of prolonged holding time in the hatcher. Wyatt _et al_. (1986) associated these findings with increased stress associated with the prolonged holding period which affected the chick's immune status.

Chick quality can be further reduced at the time of arrival on the farm due to the dehydration incurred through time spent in processing and transport (Moran and Reinhart, 1980). Chicks without water and feed for extended periods of time exhaust their yolk sac reserves. By improved incubation, processing, and distribution procedures, chicks would arrive on the farm in better condition.

Removing chicks from the hatcher at two different times through the hatching period, instead of all at one time, would help alleviate some of this stress.

1.2.5: Water and Feed Management at Placement

It has been recommended that when chicks are initially placed on the floor, water be provided three hours prior to the chicks being given feed, to reduce dehydration. This can be accomplished by placing additional waterers close to the brooding lamps at placement with chick feeders being placed in the same proximity three hours later. Bierer and Eleazer (1965) experimented with four treatment groups when chicks were initially placed in pens. These were: 1) water, no feed; 2) no water, feed; 3) no water, no feed; and 4) feed and water. By weighing the yolk sac of chicks at 0-5 and 7 days of age these researchers were able to estimate the portion of yolk sac that was utilized. They reported a large degree of variation in the size of the yolk sacs on gross examination in the groups of chicks receiving water but no feed, and those receiving neither feed nor water. Bierer et al. (1966b) reported that water consumption was decreased in day-old chicks when feed was withheld, but that initial feed consumption in the absence of water was normal. They suggested that the thirst mechanism in chicks is not efficiently stimulated until feed is first consumed.

Deprivation of water and feed can also cause increased mortality in day old-chicks (Marion et al., 1956) and can be associated with salmonella infections in poultry. The pathology of feed and water deprivation can include cheesy cecal cores due to salmonella infection, greenish gizzard mucous membranes, visceral gout, nephrosis and ulcerations of the proventriculus (Bierer and Eleazer, 1965; Bierer et al., 1966a,b). Erosion of the gizzard mucosa and lesions in the entire mucosa as well as around the entrance to the duodenum appeared 2 - 4 days after chicks were deprived of feed and/or water (Bierer et al., 1966a), possibly due to the destructive effects of the secretion of digestive enzymes on the mucosal tissue, and the invasion of infection.

Thaxton and Parkhurst (1976) reported that day old chicks given access to water, or water containing 10 percent sucrose for 12 hours prior to having access to feed, had significantly heavier body weights at eight weeks of age than chicks that received these same water treatments and feed, at time of placement. However, Twining et al. (1978b) found no significant effect on body weight or feed conversion at 28, 49, and 56 days of age in chicks that had access to water 12 hours prior to having access to feed. Chicks that were placed in pens four hours after removal from the hatcher were significantly heavier than those chicks that were held for 24 hours after removal from the hatcher before being placed in floor pens. No significant benefit was found by adding 10 percent sucrose to the drinking water. Moran (1988) reported that in turkey poults, a subcutaneous injection of a 50 percent glucose-saline solution administered at the base of the skull improved body weight at placement, while the oral intubation of the same treatment resulted in reduced weight at placement relative to controls.

Wilson and Dugan (1987) reported that the body weight of Bobwhite quail chicks at 24 hours was decreased by an eight hour delay in providing feed and also was decreased by a four hour delay in supplying feed or water. The chicks were unable to fully compensate in feed consumption after the initial treatment by 24 hours. It was found that water consumption was less when feed was not provided with the water. When feed or both feed and water were withheld for 24 hours, a reduction in body weight was noted at 21 days of age. Chicks held for 24 hours in chick boxes prior to receiving feed and water had lower mortality when compared to chicks held in brooder pens.

The inconsistency in response involving the various water and feed withholding treatments discussed in the previous experiments indicates that the mechanism for response has not been clearly identified, or that other factors not controlled in the experimental designs affected the results. Consideration of chick quality, as previously defined, would control additional factors which affect the growth response of day-old chicks.

1.2.6: Antibiotics as a Management Tool at Placement

Antibiotics in broiler feeding programs have been widely used and accepted by the industry for their growth stimulating characteristics. Eyssen and De Somer (1963) reported that the addition to the feed of penicillin or virginiamycin, (antibiotics active against Gram-positive microorganisms) resulted in improved intestinal absorption of nutrients and stimulated growth. In the control birds a growth depression was found after five days of age, which continued for an additional four days. Chickens receiving penicillin and virginiamycin exhibited improved growth through this period while chloramphenicol and chlortetracycline were ineffective.

Evangelisti et al. (1975) demonstrated that subtherapeutic levels of oxytetracycline significantly reduced the quantity of Salmonella typhimurium in chick feces when compared to feces of non-medicated control birds. However, drug resistant colonies were found in feces (21 of a total of 32 colonies isolated) from the medicated treatment group. Girard et al. (1976) reported that feeding sub-therapeutic levels of oxytetracycline combined with neomycin significantly reduced the shedding of S. typhimurium in the feces and the extent of colonization. No increase in the development of resistant S. typhimurium was found in the medicated birds since no resistant colonies among the 33 colonies isolated were found.

Twining et al. (1978a) reported that the addition of a water soluble vitamin and antibiotic mixture containing vitamin A, vitamin D_3, vitamin E, vitamin B_{12}, pyridoxine hydrochloride, menadione sodium bisulfite, folic acid, choline chloride, penicillin and streptomycin to the drinking water of day old chicks for 72 hours, resulted in a significantly higher rate of gain to 28 days of age than those birds that received no supplementation. The same response could not be obtained in a later trial and hence, there remains uncertainty as to the nature of the response.

Seuna and Nurmi (1979) reported that the combination of oxytetracycline hydrochloride and neomycin sulphate was effective in broiler chicks as an antimicrobial treatment against Salmonella infantis, when administered through the drinking water for a period of four days. But, seven days after the withdrawal of the drugs, S. infantis was again detected in the chicks indicating that infection had reoccurred. Migaki and Hargis (1981) established enteric and respiratory disease models in chicks caused by <u>Salmonella typhimurium</u> and <u>Escherichia coli</u>. They found that water medicated with Neo-Terramycin (Pfizer Canada Inc., Montreal) resulted in improved weight gain and decreased mortality in the enteric disease model, and reduced lesion scores in the respiratory model, when compared to the individual antibiotics. Williams (1985) also reported that the combination of oxytetracycline and neomycin significantly improved average daily gain and feed efficiency to 16 days of age when compared to either antibiotic fed separately. It also appeared that the combination of both drugs was more effective in reducing the stress associated with subclinical infection of <u>S. typhimurium</u> in chickens.

1.2.7: Summary

Many factors affect chick quality and growth performance. Parent flock age, initial egg weight, incubation conditions, weight loss during incubation, holding, processing and transport times have been indicated to affect chick quality prior to the chick arriving on the chicken producers farm. The management approach the producer then takes to start the chicks upon placement in the barn has also been indicated to have a significant effect on the performance of the chicks to market weight. Many of these factors have been studied in isolation and may lose their significance when incorporated into a total program. The variability in some of the research reported may be caused by not taking into consideration factors affecting chick quality, and management procedures advantageous in achieving optimum and consistant performance results.

1.3: Dietary Factors Affecting Broiler Chick Performance

The recognition of the influence of nutritional factors on growth and efficiency of feed utilization has long been an area of intense investigation. Carcass composition can be altered by dietary manipulation. In general, increasing the calorie:protein ratio (C:P) increases growth rate and carcass fat deposition, while decreasing the ratio has the opposite effect (Kubena _et al_., 1974; Griffiths _et al_., 1977; Summers and Leeson, 1979; Jackson _et al_., 1982a,b). When dietary protein or energy levels are inadequate, growth rate is depressed (Jackson _et al_., 1982c). Nutritional factors that influence performance and the level of fatness in broiler chickens include: 1) dietary C:P ratio, 2) dietary amino acid balance, 3) dietary fat, and 4) the effects of dietary energy levels (Mabray and Waldroup, 1981).

1.3.1: Calorie:Protein Ratio

The C:P ratio was initially recognized as a simple method to balance the protein and energy content of poultry diets. Manipulation of the C:P ratio alters the growth performance of chicks and body composition. Fraps (1943) demonstrated that narrowing the C:P ratio prevented excessive fat deposition. However, in this report, the dietary energy level was not consistent, resulting in variable body weights. While increasing the dietary protein level has no effect on gain but decreased body fat content, increasing the dietary energy level results in increased weight gain and body fat deposition (Spring and Wilkinson, 1957). Total energy intake is directly related to carcass fat, but only when protein consumption is constant (Rand _et al_., 1957).

A series of experiments have been conducted by Leong et al. (1955) involving New Hampshire-White Leghorn cross-bred chicks fed diets ranging from 12 to 42 percent protein with energy levels of 1543-3196 Kcal/kg. Optimal growth and feed efficiency were obtained with wide C:P ratios. These researchers reported that as dietary energy level increases, the percentage of dietary protein required for optimum growth of chicks also increases. These results indicate a need for a rising level of the C:P ratio. A diet properly supplemented with amino acids permits a wider, and more nearly constant C:P ratio than do diets deficient in limiting amino acids. Carcass fat content in this study was influenced more by the source and amount of energy, than by the C:P ratio.

Donaldson et al. (1955, 1956, 1957) used diets of widely different C:P ratios but of constant amino acid quality to demonstrate a highly significant correlation between the C:P ratio and the amount of carcass fat in chickens and turkeys. As the C:P ratio increased, the energy intake and carcass fat deposition were increased and the water content in the carcass decreased. As the C:P ratio was increased, less dietary protein and more dietary energy were required per unit of gain.

The reduction of the C:P ratio in broiler diets from optimum levels by the addition of feather meal, a nonspecific nitrogen source, was as effective in reducing fat pad size as was a high quality protein, but was much more cost effective (Deaton et al., 1974; Griffiths et al., 1977; Cabel et al., 1988). Neither energy level nor C:P ratio significantly influenced body weight gains or feed efficiency. These results indicate that a C:P ratio which optimizes feed efficiency and carcass finish at one level of dietary energy may not be optimum at alternate levels. Compensatory growth was demonstrated since chicks that were of significantly lower body weight at three weeks of age, as a result of low energy starter diets with feed intake being similar to the control birds, did not differ in body weight and abdominal fat pad size at eight weeks of age (Griffiths et al., 1977).

Mabray and Waldroup (1981) observed that varying the amino acid levels from 70 to 120 percent of NRC recommendations with energy levels of 2970 to 3410 Kcal/kg, influenced abdominal fat pad size at 57 days of age. The amino acid requirements were adjusted in accordance with the energy levels to maintain constant energy to amino acid ratios. Total fat pad weight was directly influenced by the dietary energy level and could be significantly reduced, producing a leaner carcass by increasing the dietary amino acid levels within a given energy level. These results support research reported by Kubena et al. (1972) and Bartov et al. (1974) which demonstrated that the amount of carcass fat in chickens could be influenced by feeding isocaloric diets formulated with protein levels slightly above or below an accepted optimum level.

The effect of dietary protein concentration on carcass fat is both rapid and reversible. Chicks changed from lipolytic diets (narrow C:P ratio) to lipogenic type diets (wide C:P ratio) have a gradual increase in carcass fat to an equilibrium level by 12 days. The reverse treatment reduced carcass fat to an equilibrium level in seven days (Yoshida and Morimoto 1970; Bartov et al., 1974).

The "extra caloric" effect of dietary fat, as reported by Jensen et al. (1970) is influenced by C:P ratio in diets fed to turkeys of 8-24 weeks of age. By using two C:P ratios and four dietary fat levels (0, 4, 8, and 12 percent) they reported that at 24 weeks of age average body weight was progressively greater for each increment of fat in the low protein series, but that in the high protein series, the growth response appeared to plateau at the 8 percent fat level. The addition of fat to the diet improved the feed efficiency by approximately 32 percent, which was more than would be expected from the calories supplied in the ration by the fat. Supplementary fat in turkey rations improves the utilization of metabolizable energy calories supplied by the carbohydrates in other ingredients in the rations.

Broiler age, breed and sex have been shown to be non-nutritional factors which significantly affect body weight and carcass composition. Robbins (1981) reported that increasing body fat content of male broilers appeared to be dependent upon dietary energy level and that fat deposition was independent of the C:P ratio, since increased body fat was found with both a constant C:P ratio and a variable C:P ratio. However, in females, body fat content failed to respond to varying dietary energy levels with a constant C:P ratio, but body fat content increased with a widening C:P ratio.

Pesti and Fletcher (1983) used various models to predict the fat content of the dressed chicken carcass and determined whether it could be adequately described in terms of dietary protein and energy content as well as by the C:P ratio of the diet. The inclusion of the C:P ratio in the model did not increase the r^2 value by more than 0.001; therefore, it didn't necessarily follow that carcass fat was a function of the C:P ratio. They concluded that since growth, feed consumption and body composition are dependent on dietary protein and energy levels, it seems appropriate to consider the protein and energy levels in diets independently so that maximum returns in weight gain can be obtained for the investment. They suggested that optimum levels of protein, energy and the C:P ratio should be made on economic, not biological criteria.

1.3.2: Dietary Energy Levels

Increasing the productive energy levels in the diet increases carcass fat in chickens when crude protein levels remain constant (Hill and Dansky, 1954; Kubena _et_ _al_., 1972, 1974; Farrell, 1974). Chicks fed low energy diets have demonstrated marked increases in feed consumption, while total energy consumption decreased progressively as dietary energy decreased (Deaton _et_ _al_., 1973). Feed consumption is determined primarily by energy level while protein level has little or no effect on feed consumption. Scott _et_ _al_. (1947) were some of the first to report the merits of various sources of energy and their effects on growth and feed efficiency. These researchers suggested that chickens do not adjust their energy intake exactly, but consume somewhat more energy as the energy concentration of the diet increases. This results in the deposition of large amounts of fat, a considerable amount of which is deposited in the abdominal area. In selecting for maximum growth rate, we may actually be selecting for appetite, such that the finishing period occurs at a very early age. An increasingly greater portion of this gain, relative to age, is associated with fat deposition (Essary _et_ al., 1960a,b; Summers and Leeson, 1979).

The fat content of broiler chickens has been reported as total carcass fat, ether extract, and as abdominal fat pad weight. Becker et al. (1979) reported that the abdominal fat in broilers is highly correlated to total carcass fat.

Differences in broiler body composition have been attributed to breed, sex and age (Farrell, 1974; Nordstrom et al., 1978; Coon et al., 1981; Deaton and Lott, 1985). Male broilers have significantly less carcass fat than female broilers (Farrell, 1974). Farrell (1974) noted that as the energy concentration in the diet increases, birds grow faster, and feed intake declines, resulting in an improved feed conversion ratio. Deaton and Lott (1985) noted that the abdominal fat, as a percent of body weight increased as age and dietary energy level increased. Summers and Leeson (1986) reported increased weight gain in broilers fed diets containing equal C:P ratios but with dietary fat levels of 0, 3, 6, and 9 percent. The increased body weight was attributed to the higher fat levels and increasing energy and protein levels.

Kubena et al. (1974) reported that broilers fed various starter and finisher combinations exhibited significant differences in percentage abdominal fat. The energy level of the starter diet appeared to influence the quantity of abdominal fat in both sexes, with low energy starters (3141 Kcal/kg) producing carcasses with reduced abdominal fat at seven and eight weeks of age than broilers fed higher energy starters (3306 Kcal/kg). Fatter broilers generally had heavier body weights than those with low fat content.

The work of Kubena _et al_. (1974) supported the results reported by Deaton _et al_. (1973) which demonstrated that compensatory growth occurred in broilers when a low energy starting diet was followed by a high energy finishing diet. At four weeks of age, birds on the low energy starting diets were four percent lighter in body weight than broilers on higher energy starting diets, but at eight weeks of age all birds were of similar weight. Birds that demonstrated compensatory growth following having been fed first the low energy starter and then the high energy finisher, had higher ether extract levels than did the control birds, indicating higher fat levels in the carcass.

Birds that were initially subjected to a severe energy restriction demonstrated compensatory gain in body weight for weight gain lost during the restriction period. Improved feed efficiency and a reduction in abdominal fat were found at eight weeks of age (Plavnik and Hurwitz, 1985).

These findings are of interest to the research reported here since a compensatory response in weight gain to a dietary treatment may have significant application in management practices used by broiler chicken producers. Day-old chicks received on the farm that are small in body weight due to parent age or percent weight loss throught incubation, could also demonstrate a compensatory growth response to dietary treatments. Manipulation of the energy or crude protein levels in the diet may assist chicks that are sub-standard to improve their growth and feed efficiency performance.

However, Griffiths et al. (1977) showed that no differences in abdominal fat pad weight existed between eight week old broilers reared on either 2970 or 3190 Kcal ME/kg diets. Both diets contained identical dietary fat and C:P ratios. Coon et al. (1981) also failed to observe a significant difference in fat pad weight or 56-day weight gain attributable to energy level and combinations in the starter and grower diets when sexes were combined. The weight gain of the males and females was not affected by diet to 28 days of age, but the feed conversions of the males and females fed the high energy starter (3410 Kcal ME/kg) were significantly better than the broilers fed the low energy starter (3190 Kcal ME/kg). Deaton et al. (1983) reported that growth rate and abdominal fat deposition as a percent of body weight, did not change in male broilers from 40 to 53 days of age. Nordstrom et al. (1978) also reported that energy level had no significant effect on the abdominal fat of broilers, either as a percent of the whole carcass or eviscerated carcass. However, whole carcass and eviscerated carcass weights were significantly greater for broilers fed the high energy diets.

Deaton et al. (1974) noted that broilers in cages, when compared to broilers in floor pens, had increased quantities of abdominal fat when expressed as a percent of body weight for each sex, at each age. These findings were significant only for males at nine weeks of age. This increase in abdominal fat could be attributed to the close proximity of feed and water in cages and the reduced amount of energy required to feed. Reduced space also restricts movement and promotes fat deposition.

The growth performance and ratio of protein to fat in the carcass of broiler chickens can be influenced by diet composition, environmental temperature, type of housing, age, strain and sex (Kubena et al., 1972, 1974; Edwards et al., 1973; Deaton et al., 1974; Evans et al., 1976; Nordstrom et al., 1978). Energy intake rather than dietary energy level, appears to be the main factor influencing abdominal fat deposition and growth performance.

1.3.3: Dietary Protein Levels

Dietary protein is the main source of amino acids which alter plasma amino acid levels and regulate energy balance in animals. If specific amino acids are deficient in the diet, other amino acids will accumulate in the blood which may impair appetite. This has been shown in the chick for tryptophan, methionine, lysine, arginine, isoleucine, leucine, and valine (Fisher and Shapiro, 1961; Hill and Olsen, 1963; Maurice, 1981). Diets low in energy and protein have been shown to increase voluntary feed intake (Hill and Dansky, 1954; Combs et al., 1964). This is of interest to the research reported here as a dietary management treatment in assisting chicks of high percent weight loss through incubation, with resulting lower initial body weight, compensate and improve growth response.

It is important to consider the influence of strain, age, sex and environmental temperature when evaluating protein supplementation in broiler diets. Differences in amino acid requirements between strains, amino acid availability based on the type of protein used, as well as the vitamin and mineral levels in the diet, can influence net protein utilization.

Protein level of the diet has been shown to affect weight gain, feed intake, and feed efficiency of broiler chicks (Hill and Dansky, 1950; Summers et al., 1964, 1965; Summers and Leeson, 1984). As the dietary crude protein level increases, weight gain and feed efficiency improves, to an optimum level of 20 percent (Hill and Dansky, 1950; Summers et al., 1965; Summers and Leeson, 1984). When graded levels of a crystalline amino acid diet or graded levels of isoleucine or lysine were fed to broiler chicks, the body protein retention, weight gain, feed efficiency and liver protein levels increased linearly when evaluated as a function of protein intake (Velu et al., 1971, 1972). This suggested that the amino acid balance could improve performance of high protein, low energy diets, and that the protein level was related to the energy level through its influence on feed intake. Diambra and McCartney (1985) reported that broiler finisher diets that had adequate levels of lysine and the sulphur amino acids produced body weight gains that were directly proportional to the dietary protein level. Broilers fed an 18 percent crude protein diet had significantly improved feed efficiency.

High dietary protein levels were reported to be detrimental to growth during the starter period from 0 - 14 days of age (Hargis and Creger, 1980) and to reduce feed efficiency (Sunde, 1956). However, as the energy increased, improved gain and feed efficiency were obtained, indicating that when protein levels are altered the optimal energy to protein ratio should be adjusted to insure that sufficient energy is supplied.

Jackson <u>et al</u>. (1982a,b) demonstrated that body weight and feed efficiency improved with increasing dietary protein and energy. A significant interaction was found between protein and energy, indicating the importance of a balanced C:P ratio to obtain maximum performance.

Dietary crude protein levels have been demonstrated to affect carcass composition of broilers. Increasing dietary crude protein levels results in an increase in protein retention and moisture content of the carcass and a reduction in carcass fat content (Rand <u>et al</u>., 1957; Spring and Wilkinson, 1957; Yoshida and Morimoto, 1970; Lipstein <u>et al</u>., 1975; Seaton <u>et al</u>., 1978). Summers <u>et al</u>. (1965) reported that with increasing dietary protein levels, carcass protein levels increase and carcass fat levels decrease, with greater effect in female than in male broilers. By shifting the level of protein in the diet by replacing energy with protein on a straight substitution basis, Yoshida and Morimoto (1970) demonstrated the inter-relationship between dietary protein and carcass fat composition in chicks. Fat content of the chick carcass decreased exponentially with the increase in dietary protein. Carcass protein levels increased linearly reaching a maximum of 20.6 percent. They stated that the upper and lower limits of carcass fat content were suspected to be 17 percent and 0.9 percent, respectively.

Jackson <u>et al</u>. (1982c) reported that maximum carcass protein deposition resulted with diets containing 20 percent crude protein. The percent carcass protein and moisture decreased as energy increased, while absolute carcass protein remained constant. Carcass fat decreased as dietary protein increased. Protein utilization decreased with each increment of dietary protein. In contrast, Jackson et al. (1982a) reported that absolute carcass protein content was not affected by dietary protein level.

Velu et al. (1972) noted a five-fold increase in the amount of carcass fat in chicks fed ad libitum, diets containing graded levels of isoleucine or lysine from 0 - 21 days of age. When feed intake was equalized to reduce variation between treatments, the amount of carcass fat decreased as the limiting amino acid was increased, and body protein content increased quadratically.

In studies concerned with performance of broilers during the finishing period, Lipstein et al. (1975) reported that the increase in carcass fat associated with reducing the protein content of a balanced finisher diet, could be reversed by supplementing the diet with methionine and lysine. The increase in fat in the carcass was attributed to a compensatory increase in feed intake by the broilers in an attempt to consume additional protein so that growth could be maximized. Velu et al. (1971) reported a reduction in feed intake in broilers fed an amino acid deficient diet. Lipstein et al. (1975) suggested that differences in feed intake could be explained by the distinction between an amino acid deficiency and an amino acid imbalance. Mabray and Waldroup (1981) also reported that the degree of fatness in the broiler chick as measured by abdominal fat pad size could be significantly reduced by increasing the dietary amino acid levels within a specific energy level in the diet.

The addition of feathermeal to the diet has been used to increase the non-specific dietary protein level in an attempt to reduce abdominal fat pad size (Griffiths et al., 1977; Cabel et al., 1987, 1988). No significant differences in rate of gain, feed efficiency or dressing percentage were reported, but the amount of abdominal fat was significantly reduced.

It has been suggested that the composition and volume of the diet broilers are fed during the first few days of feeding may affect body weight and abdominal fat pad development (Griffiths et al., 1977; Hargis and Creger, 1980; Plavnik and Hurwitz, 1985). Jensen et al. (1987) altered the level of dietary protein and fat in isocaloric starter diets to study the effect of these parameters on early nutrition and subsequent body weight and abdominal fat at four and seven weeks of age. No significant differences in body weight were observed but extreme variability was noted. In one experiment chicks fed 28 percent crude protein starter diets had a significantly reduced growth rate at seven days. Under certain conditions the composition of the diet fed during the first seven days did influence abdominal fat deposition at market age. Chicks fed the high protein starter diets (28 percent crude protein), regardless of fat content, had significantly more abdominal fat than those fed the low protein starter diets (18 percent crude protein).

1.4: Summary

The growth performance and carcass composition of chicks has been shown to be affected by the C:P ratio, energy and protein levels in the diet. The manipulation of the levels of these components in the diet of chicks has been demonstrated to alter the amount of carcass fat, protein and moisture in the carcass. The use of dietary manipulation to assist chicks of poorer quality at placement in the barn get of to a good start is of interest as a mangement tool by the producer. The relationship between energy and protein levels in the starter diet, and the percent weight loss during incubation may be of significance when management treatments are needed to optimize the performance of chicks of variable quality.

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2: THE EFFECT OF PARENT AGE AND SEVERAL POST-HATCH TREATMENTS ON BROILER CHICK PERFORMANCE

2.1: INTRODUCTION

Broiler chicken producers are currently faced with the problem of inconsistent quality of day-old chicks. Several factors, either directly or indirectly, influence chick quality and subsequent growth performance.

There is general agreement that egg size influences six-week broiler weight in a positive, linear manner (Tindell and Morris, 1964; Merritt and Gowe, 1965; Morris et al., 1968; Gardner, 1973). The characteristic frequency distribution of eggs of young and old breeders reported by McNaughton et al. (1978), demonstrates that heavier eggs are associated with older flocks. Hays and Spear (1952) found a highly significant relationship between age of parent and chick viability. Chicks from pullet dams exhibited significantly higher mortality than did chicks from hen dams. McNaughton et al. (1978) equalized egg weights between parent ages and found that parent age influenced offspring mortality with a more viable chick being produced from 58 week-old breeders than from 29 week-old breeders. However, no significant parent age related differences in market weights were found when hatching egg weights were equalized.

Day-old chick quality is also affected by the rate of moisture loss through the shell during incubation (Tullet and Burton, 1982) and by the duration of the holding time after hatching. O'Neil (1955) attributed heavier mortality in chicks with a hatch weight less than 65 percent of setting egg weight, to physiologically immature birds that could not adjust to their environment. Misra and

Fanguy (1978) reported increased mortality and significant reductions in chick body weight at four weeks of age when chicks were held for extended periods of time in the hatcher. Wyatt et al. (1985) attributed early chick mortality to dehydration as evidenced by urates in the urinary tract. Higher total plasma protein and glucose concentrations, hematocrits, and heterophil:lymphocyte ratios were seen as a consequence of prolonged holding in the hatcher. Wyatt et al. (1986) attributed these findings to a stress reaction due to the prolonged holding period which affected the chick's immune status.

Chick quality can be further reduced at the time of arrival on the farm due to the dehydration losses incurred through time spent in processing and transport (Moran and Reinhart, 1980).

The objectives of the research reported here were to examine the relationship between broiler parent age and chick quality as measured by the rate of moisture loss during incubation, and the efficacy of several management treatments currently employed by broiler producers to assist in chick rehydration and growth.

2.2: MATERIALS AND METHODS

2.2.1: Pre and Post-Hatch Processing and Chick Allocation

Two experiments were conducted using hatching eggs obtained from young (30 and 31 weeks of age) and old (51 and 53 weeks of age) breeder flocks of the same strain (Arbor Acre and Hubbard). All eggs were obtained from the same commercial hatching egg source and had been stored for a maximum of one week. Eggs were set in a forced air incubator and standard hatchery protocol was followed. On the 18th day of incubation the non-viable (infertile or early dead germ) eggs were detected by candling and removed. Viable embryo's were transferred to pedigree baskets for hatching. Eggs of a common initial weight for each flock were hatched together to facilitate measurement of shell weight.

The chicks were removed at a pre-determined length of incubation. At the time of chick removal, chicks were sexed, weighed, wing-banded and vaccinated with Marek's vaccine. The weight of the remaining egg shells and hatch debris from each pedigree basket was recorded.

2.2.2: Management and Experimental Design

Chicks from each breeder flock were randomly assigned to each of the following four treatments: 1) water and feed at time of placement, (control); 2) water soluble Neo-Terramycin (Pfizer Canada Inc. 1g/3L; each 100g contains 20 g of oxytetracycline hydrochloride and 20 g of neomycin sulphate in a water soluble base) for three days after placement and feed at time of placement; 3) water at placement and feed four hours after placement, and 4) water soluble Neo-Terramycin for three days after placement and feed four hours after placement. Hence, for each of the two flock ages each of the four treatments were replicated four times. All birds were held in chick boxes for 30 hours at 20^{0}C to simulate industry processing and transport conditions before being placed in either chick batteries or floor pens. A standard photoperiod of 23L:1D was used throughout the growing period. The chicks were fed standard broiler starter ration (23 percent crude protein) ad lib. for three weeks followed by broiler grower ration (20 percent crude protein) to six weeks of age (Table 2.1).

Individual body weights were recorded daily for the first five days and then weekly to six weeks of age. Feed consumption was determined on a per pen basis for each weigh period.

The percent weight loss (PWL) of each egg during incubation was calculated as follows:

$$\text{PWL} = \frac{\text{Egg weight(g)} - \text{chick weight(g)} - \text{x shell weight(g)}}{\text{Egg weight (g)}} \times 100$$

2.2.2.1: Experiment 1. Growth Trial in Batteries

Arbor Acres hatching eggs were obtained from flocks that were 30 and 51 weeks of age. A total of 908 eggs were set. The hatch was removed at 21 days of incubation.

The experiment was conducted using 32 battery cages, each of which contained six male and six female chicks providing 550 cm^2/bird for three weeks, at which time they were moved to grower cages providing 500 cm^2/bird. At five weeks of age, the 12 birds were equally divided between two grower cages, with three males and three females in each pen, providing 1000 cm^2/bird until they reached six weeks of age.

2.2.2.2: Experiment 2. Growth Trials in Floor Pens

Hatching eggs were obtained from Hubbard strain flocks that were 31 and 53 weeks of age. A total of 2520 eggs were set. The hatch was removed at 21 days 12 hours of incubation.

The experiment was conducted using 32 floor pens, each of which contained 15 male and 15 female chicks providing 2500 cm^2/bird.

A representative sample of 50 eggs from each breeder flock was used to characterize the mean egg weight, yolk weight, shell weight, albumen weight, Haugh units and specific gravity of each flock.

2.2.3: Statistical Analyses

Means, correlation coefficients, regression estimates and analysis of variance were calculated using the Statistical Analysis System (SAS) for Personal Computers Version 6 (Joyner _et al_., 1985).

All percentage data were transformed to their $\log_{10}$ values prior to statistical analysis. In the analysis of variance of the regression coefficients, the intercept was used as a covariate to correct for significant differences in the intercept.

A 2 x 2 x 2 factorial design was used. The general linear model contained the fixed effects of breeder flock age, medication withholding feed, as well as all interactions and a random error term. The model was as follows:

$$Y_{ijkl} = u + B_i + M + (BM)_{ij} + H_k + (BH)_{ik} + (MH)_{jk} + (BMH)_{ijk} + e_{ijkl}$$

Where:

Y_{ijkl} = an observation on the l^{th} chick in the ijk^{th} subclass.

u = overall mean

B_i = effect of the i^{th} breeder flock age ($i = 1,2$)

M_j = effect of the j^{th} medication ($j = 1,2$)

H_k = effect of the k^{th} withholding feed ($k = 1,2$)

$(BM)_{ij}$, $(BH)_{ik}$, $(MH)_{jk}$ and $(BMH)_{ijk}$ are the interactions among the main effects.

e_{ijkl} = random error term.

Statistical significance was assessed at the .05 level.

2.3: RESULTS

2.3.1: Experiment 1

Breeder flock age significantly (P<.05) affected chick weight with chicks from the old flock being heavier than chicks from the young flock at each weighing (Table 2.2). Egg weight and percent weight loss (PWL) increased significantly (P<.05) with breeder flock age (Figures 2.1 and 2.2). Correlation coefficients (Table 2.3) indicate a high correlation between chick hatch weight and egg weight. There was a reduced correlation between egg weight and chick weight from placement to six weeks of age. A low correlation between PWL, hatch weight and day one chick body weight was observed.

Chicks receiving Neo-Terramycin-medicated water were significantly heavier (P<.05) on Days 2, 3 and 4. No significant differences attributable to medication were found later in the growing period (Table 2.2).

Chicks which were allowed access to feed at the time of placement were significantly heavier (P<.05) on Days 2, 3, 4 and 5, and at weeks 2, 3 and 5 (Table 2.2) than chicks which received feed four hours after placement. Weight differences attributable to sex were significant (P<.05) at weeks 3, 4, 5 and 6 with male chicks being heaviest.

A significant breeder age x medication interaction (P<.05) was seen at days 4 and 5 and at weeks 2 and 3 (Table 2.2). Chicks from the old flock responded to medication supplementation as evidenced by significantly increased chick weight (Table 2.2). However, chicks from the young flock which received medication were lighter than chicks which did not receive medication. A significant (P<.05) medication x sex interaction was found at weeks 3, 4, 5 and 6. Neo-Terramycin supplementation increased body weight in male chicks but decreased body weight in female chicks.

Growth rate from day 1 to 42 , as measured by the slope of the best fitting linear equation describing the growth curve (Table 2.4) was significantly higher (P<.05) in chicks from the old flock compared to chicks from the young flock. Female chicks from the old flock on treatment 2 (Neo-Terramycin and feed at time of placement) had a significantly higher growth rate than female chicks on any other treatment. Male chicks on treatment 2 had a significantly higher growth rate than male chicks on treatment 3 (water at placement and feed four hours after placement).

Male chicks from the young flock on treatment 1 (water and feed at time of placement) had significantly higher growth rates than chickens on treatments 3 and 4 (Neo-Terranmycin at time of placement and feed four hours later). Male chicks on treatment 2 had a significantly higher growth rate than chicks on treatment 4.

No significant differences in overall feed efficiency were observed but significant differences (P<.05) were noted for flock age at four and five days of age and at three weeks of age, with young flock chicks having a lower feed efficiency than old flock chicks. Significant interactions between flock age and medication were observed at four days and two weeks of age, with old flock chicks without medication having lower feed efficiency (Table 2.5).

Feed intake was significantly (P<.05) affected by flock age from day three through to week four, and for overall feed intake; with old flock chicks consuming more feed than young flock chicks (Table

2.6). Feed at time of placement significantly (P<.05) affected feed intake, with chicks that did not receive feed until four hours after placement consuming less feed until three weeks of age. A significant (P<.05) flock age x medication interaction at two weeks of age indicated that old flock chicks with no medication consumed less feed.

Overall mortality was unaffected by any of the treatments under study (Table 2.5).

2.3.2: **Experiment 2**

Breeder flock age significantly (P<.05) affected chick weight with chicks from the old flock being heavier than chicks from the young flock at Days 0, 1, 3 and 5, and at weeks 2, 3, 4 and 6 (Table 2.7). Egg weight and PWL significantly (P<.05) increased with breeder age (Figures 2.3 and 2.4).

As in Experiment 1, correlation coefficients (Table 2.6) indicate a high correlation between chick hatch weight and egg weight, and a reduction in correlation coefficients between egg weight and chick weight from time of placement to six weeks of age. Correlation coefficients between PWL and other listed parameters (Table 2.8) were not significant after day 5.

Neither medication nor feed placement time significantly affected chick body weight at any weighing. Male chicks were significantly heavier than female chicks on days 3 and 5, and weeks 2, 3, 4, 5 and 6 (P<.05). Several significant interactions were noted between breeder age and medication, and between breeder age, medication, feed placement time, and sex (Table 2.7).

Growth rate of chicks from the older flock was significantly higher ($P<.05$) than of chicks from the younger flock (Table 2.4). In regards to growth rate, no significant effects attributable to any of the chick management treatments were observed with chicks from the old flock (Table 2.4). Male chicks from the young flock subjected to treatment 3 had a significantly higher growth rate than males on treatments 1, 2 and 4. No significant differences were found for young flock female chick treatments.

Feed efficiency was significantly ($P<.05$) affected by flock age at three days of age, three weeks of age and in overall feed efficiency, with chicks from the young flock having higher feed efficiency (Table 2.9). Chicks allowed access to feed at time of placement had significantly ($P<.05$) lower feed efficiency at day three. A significant ($P<.05$) flock age x feed at time of placement interaction indicated that chicks from the old flock who did not receive feed at placement had lower feed efficiency.

Flock age significantly ($P<.05$) affected feed intake with chicks from old flocks consuming more feed through four weeks of age, at six weeks of age and in overall feed intake for the trial, than chicks from young flocks (Table 2.10). Medication significantly ($P<.05$) affected feed intake, with chicks who received no medication having higher feed intake at five days of age. Chicks who received feed at placement had higher feed intake at three days of age than chicks who did not receive feed until four hours after placement. A significant ($P<.05$) flock age x medication interaction was observed at five days and two weeks of age, indicating that chicks from old flocks who did not receive medication had lower feed intake. A significant ($P<.05$) medication x feed at time of placement interaction was observed at weeks two and three, with chicks that had no medication or feed at placement having higher feed intake.

Egg weight and yolk weight were observed to be significantly heavier ($P<.05$) in the old flock than in the young flock (Table 2.11). Haugh units and specific gravities were significantly higher ($P<.05$) in eggs from the young flock compared to eggs from the old flock.

No significant effect attributable to flock age, medication or feed at time of placement was found on overall mortality (Table 2.9). However, a significant ($P<.05$) flock age x medication interaction was found, indicating that old flock chicks who received no medication had lower mortality.

2.4: DISCUSSION

In both experiments, breeder flock age was found to significantly affect chick weight, with heavier chicks being associated with older breeder flocks. Breeder flock age is specified since no equalization of egg weight was done between breeder flocks. Egg weight differences between flocks may influence the growth response attributable to breeder flock age (Figures 2.1 and 2.3). However, the normal range of day-old chick weights seen under industry conditions was represented.

Correlation coefficients reported in Tables 2.3 and 2.4 are in agreement with those reported previously (O'Neil, 1955; McNaughton <u>et al</u>., 1978; Wyatt <u>et al</u>., 1985) indicating a high correlation between chick hatch weight and egg weight. Furthermore, correlation between egg weight and chick weight is considerably reduced during the span from 0 to 6 weeks as previously reported (Halbersleben and Mussehl, 1922; Upp, 1928; Wiley, 1950; Godfrey and Williams, 1952; Goodwin, 1961; Gardner, 1973).

Percent weight loss during incubation significantly ($P<.05$) increased with breeder flock age. It has been suggested that increased dehydration of the chick is a consequence of reduced shell thickness and increased porosity (Hays and Spear 1951). The increased PWL seen in experiment 2 may be attributed to the increased length of time (12 h) the chicks were kept in the incubator after hatching (Hager and Beane, 1983).

The efficacy of Neo-Terramycin in the drinking water as a short-term antimicrobial therapy produced variable results. Although not quantitatively assessed, by personal observation it was noted that chick vitality seemed poorer in experiment 1 than in experiment 2, when assessed visually. In the first experiment chicks from the old flock were just starting to emerge from the shell or were wet. Chicks from the young flock had completed the hatching process. Reinhart and Hurnik (1984) reported that hatching time is strongly influenced by parent age, setter humidity, egg weight and egg location within the setter. The growth rate of male chicks from the old flock with Neo-Terramycin supplementation and with feed provided at time of placement was superior to all other treatments. Neo-Terramycin may assist the chick in resisting enteric and respiratory disease challenges from various etiologic agents (Migaki and Hargis, 1981). The short-term response to oxytetracyline hydrochloride and neomycin sulphate may be attributable to the short period of treatment (3 days), since in experiment 1, increased weight attributable to medication was significant only until Day 4. After medication withdrawal, the chick is again susceptible to disease challenge which may account for our results (Seuna and Nurmi, 1979). It is suggested that the medication may have benefitted the late hatching chicks from old flocks by reducing subclinical yolk sac infection due to a greater incidence of unhealed navels. Chicks from the young flock did not exhibit the same response, possibly attributable to superior chick quality and maturity at the time of removal from the hatcher.

In experiment 2, incubation time was extended to 21 days 12 hours. No response was found to the Neo-Terramycin treatments, seemingly reflecting improved health status associated with more physiologically mature chicks. Withholding feed at time of placement for four hours did not assist day-old chicks in rehydration and subsequent performance. In fact, body weights were seen to be significantly lower in chicks withheld feed in experiment 1, but no significant response was noted in experiment 2. The inconsistency of this report may be explained by the improved quality of chicks in experiment 2 at time of placement. Furthermore, the use of battery cages with wire floors may inhibit easy access to water and feeders compared to rearing chicks in floor pens.

Withholding feed at time of placement with young flock male chicks in experiment 2 significantly improved growth rate. The increased dehydration due to prolonged time in the hatcher (Wyatt <u>et al</u>., 1986) was effectively alleviated by allowing the chick to rehydrate before filling on feed. It has been suggested that allowing rehydration to take place prior to feed access prevents the occurrence of a dry feed bolus in the crop, inhibiting optimum feed and water intake.

In conclusion, it has been documented that variation in chick quality seen in current broiler chicken production is considerable. These studies indicate that chicks from an old breeder flock have significantly higher body weight at six weeks of age (7.2 and 4.2 percent for experiments 1 and 2 respectively) than chicks from young breeder flocks. Further research is required to characterize the cost effectiveness of egg production and chick growth from young and old broiler breeders. Specific management practices can be used to improve growth performance of sub-standard quality chicks. If the broiler producer is aware of the breeder age of the day-old chicks, the growth rate of older breeder flock chicks would seem to be improved by medication with water soluble antibiotics. Chicks from young flocks which are allowed to rehydrate with water prior to the placement of feed showed improved growth performance. It would seem that chicks which are of a superior quality do not benefit from the use of these management techniques.

Table 2.1. Experiments 1 and 2: Composition of starter and grower diets.

Ingredients:	Type of ration Starter (0-3 wks)	 Grower (3-6 wks)
Ground wheat	583.2	684.5
Stabilized fat	30.0	30.0
Dehydrated alfalfa meal	10.0	10.0
Meat meal (50% C.P.)	30.0	30.0
Soybean meal (46.5 C.P.)	280.0	180.0
Canola meal (36% C.P.)	30.0	30.0
Limestone	12.0	[illegible]
Dicalcium phosphate	10.0	[illegible]
Iodized salt	3.0	3.0
D.L. methionine	1.3	.5
Selenium premix	.5	—
Micronutrients[1]	10.0	10.0
Total	1000 kg	1000 kg
Chemical analysis:		
Metabolizable energy	2862 kcal/kg	2925 kcal/kg
Protein	23%	20.3%
Calcium	1.04%	1.03%
Available phosphorus	.45%	.45%
Lysine	1.2%	.94%
Methionine	.45%	.35%

[1] The micronutrients supplied the following levels per kg of ration: manganese sulphate, 400 mg; zinc oxide, 100 mg; Vitamin A, 6000 IU; Vitamin D_3, 600 ICU; Vitamin E, 10 IU; menadione, 1 mg; riboflavin, 5 mg; calcium pantothenate, 10 mg; niacin, 20 mg; choline chloride, 100 mg; folic acid, 1 mg; Vitamin B_{12}, 10 mcg; biotin, 100 mg.

Table 2.2 Experiment 1. Influence of flock age, medication and feed holding period on the growth performance of broiler chickens through six weeks of age.

		Body Weight (g)										
		Day						Week				
Variable	% Weight Loss	0	1	2	3	4	5	2	3	4	5	6
Flock age (A)	*	***	***	***	***	***	***	***	***	***	***	**
30 wks	20.9	39.2	36.1	41.4	48.1	55.6	64.5	213	423	732	1112	1561
51 wks	21.6	46.9	43.3	51.4	60.0	70.6	80.5	259	476	814	1220	1673
SEM		.3	.3	.8	.6	.9	1.2	3.1	5.5	10.0	12.5	19.1
Medication (M)				*	*	**	NS	NS	NS	NS	NS	NS
No				45.6	53.1	62.2	71.0	232	445	774	1160	1613
Yes				46.9	54.9	64.0	73.9	240	454	772	1172	1621
SEM				.8	.6	.9	1.2	3.1	5.5	10.0	12.5	19.1
Feed at time of placement (P)				***	**	***	**	**	**	NS	*	NS
No				44.3	52.3	60.8	69.6	229	439	760	1148	1596
Yes				48.2	55.8	65.5	75.3	243	461	787	1184	1638
SEM				.8	.6	.9	1.2	3.1	5.5	10.0	12.5	19.1
Sex (S)		NS	NS	NS	NS	NS	NS	NS	***	***	***	***
Females		43.1	39.9	46.3	54.0	63.3	72.9	233	438	744	1108	1517
Males		42.9	39.6	46.2	54.1	63.0	72.0	238	463	807	1228	1723
SEM		.3	.3	.8	.6	.9	1.2	3.1	5.5	10.0	12.5	19.1
AxM				NS	NS	***	*	**	**	NS	NS	NS
AxF				NS	NS	NS	NS	NS	NS	NS	NS	NS
AxS				NS	NS	NS	NS	NS	NS	NS	NS	NS
MxF				NS	NS	NS	NS	NS	NS	NS	NS	NS
FxS				NS	NS	NS	NS	NS	NS	NS	NS	NS
MxS				NS	NS	NS	NS	NS	**	*	*	*
AxMxS				NS	NS	NS	NS	NS	NS	NS	NS	NS
AxFxS				NS	NS	NS	NS	NS	NS	NS	NS	NS
MxFxS				NS	NS	NS	NS	NS	NS	NS	NS	NS
AxMxF				NS	NS	NS	NS	NS	NS	NS	NS	NS
AxMxFxS				NS	NS	NS	NS	NS	NS	NS	NS	NS

Sex and its interactions were tested using the residual error term from the full model.

*$P<.05$

**$P<.01$

***$P<.001$

Table 2.3. Experiment 1. Correlation coefficients of egg weight, hatch weight and percent weight loss with chick body weight to six weeks of age.

	Egg Weight	Hatch Weight[1]	Percent Weight Loss
Egg weight	-	.94***	-.02
Hatch weight	.94***	-	-.36***
Day 1	.92***	.97***	-.33***
2	.69***	.67***	-.09***
3	.77***	.77***	-.13*
4	.78***	.76***	-.08
5	.71***	.70***	-.10
Week 2	.61***	.60***	-.09
3	.46***	.48***	-.15**
4	.44***	.46***	-.14**
5	.39***	.41***	-.15**
6	.29**	.31***	-.13*

*P<.05
**P<.01
***P<.001

[1] Hatch weight - chick weight when removed from the hatcher.

Table 2.4. Experiments 1 and 2. Mean linear regression coefficients of broiler body weight on broiler age (g/day).

Treatment	Experiment 1		Experiment 2	
	Males	Females	Males	Females
Young Flock				
1	36.6c[1]	35.8a	38.6a	38.0a
2	35.8bc	35.8a	38.8a	37.8a
3	35.3ab	34.8a	39.9b	38.4a
4	34.8a	34.4a	38.1a	37.6a
Old Flock				
1	39.2de	38.1b	41.3c	40.3b
2	40.7e	40.2c	41.6c	40.8b
3	38.1d	38.1b	41.5c	40.6b
4	39.2de	38.8b	41.7c	41.0b
	n = 345		n = 920	

[1] Means within a column with different superscripts are significantly different ($P<.05$).

Table 2.5 Experiment 1. Influence of flock age, medication, and feed holding time on feed efficiency and mortality of broiler chickens through six weeks of age.

	Feed Efficiency[1]										
	Age										
	Days				Weeks						
Variable	2	3	4	5	2	3	4	5	6	Overall	Mortality[2]
Flock Age (A)	NS	NS	***	**	NS	**	NS	NS	NS	NS	NS
30 wks	1.10	1.73	1.87	1.75	1.38	1.78	1.76	2.42	2.27	2.05	4.39
51 wks	.93	1.63	1.54	2.02	1.40	1.86	1.82	2.42	2.29	2.04	3.43
SEM	1.43	.11	.05	.06	.02	.02	.03	.05	.02	.02	1.94
Medication (M)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
No	.44	1.65	1.69	1.93	1.39	1.81	1.78	2.43	2.27	2.04	3.75
Yes	1.59	1.72	1.73	1.85	1.39	1.83	1.81	2.41	2.28	2.05	4.02
SEM	1.43	.11	.05	.06	.02	.02	.03	.05	.02	.02	1.94
Feed at time (F) of placement	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
No	.55	1.64	1.73	1.87	1.38	1.81	1.80	2.45	2.25	2.05	4.02
Yes	1.47	1.72	1.68	1.91	1.40	1.82	1.78	2.40	2.30	2.04	3.75
SEM	1.43	.11	.05	.06	.02	.02	.03	.05	.02	.02	1.94
AxM	NS	NS	**	NS	*	NS	NS	NS	NS	NS	NS
AxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AxMxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] (g) Feed/(g) body weight

* P<.05

**P<.01

***P<.001

NS - Non-significant

[2] Data analyzed as the $\log_{10}$ percent of mortality. Data presented as actual values.

Table 2.6 Experiment 1. Influence of flock age, medication, and feed holding on feed intake of broiler chickens through six weeks of age.

Variable	Feed Intake (g)									
	Age									
	Day				Weeks					
	2	3	4	5	2	3	4	5	6	Overall
Flock Age (A)	NS	•••	•••	•••	•••	•••	•	NS	NS	•••
30 wks	10.5	11.2	13.3	15.4	208	372	561	918	1020	3130
51 wks	11.3	13.2	16.3	19.1	244	402	590	968	1032	3297
SEM	.9	.3	.4	.4	2.2	4.5	7.5	18.8	12.0	31.4
Medication (M)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
No	10.5	11.9	14.5	16.8	224	384	582	937	1033	3214
Yes	11.3	12.6	15.1	17.8	228	390	570	949	1018	3212
SEM	.9	.3	.4	.4	2.2	4.5	7.5	18.8	12.0	31.4
Feed at time (F) of placement	••	•	••	••	•••	•	NS	NS	NS	NS
No	8.8	11.7	14.0	16.4	219	380	576	945	1012	3183
Yes	13.0	12.7	15.6	18.1	233	394	576	941	1040	3244
SEM	.9	.3	.4	.4	2.2	4.5	7.5	18.8	12.0	31.4
AxM	NS	NS	NS	NS	•	NS	NS	NS	NS	NS
AxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AxMxF	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

• P<.05
••P<.01
•••P<.001
NS · Non significant

Table 2.7 Experiment 2. Influence of flock age, medication and feed holding period on the growth performance of broiler chickens through six weeks of age.

Variable	% Weight Loss	Body Weight (g) Day 0	Day 1	Day 3	Day 5	Week 2	Week 3	Week 4	Week 5	Week 6
Flock age (A)	•••	•••	•••	•••	•••	•••	•••	••	NS	•
31 wks	22.5	38.3	35.4	51.8	72.0	249	492	834	1252	1672
53 wks	25.0	44.6	41.5	61.8	86.3	287	534	896	1318	1742
SEM		.2	.2	.3	.8	3.6	4.4	7.4	9.9	7.8
Medication (M)				NS	NS	NS	NS	NS	NS	NS
No				56.8	80.4	267	516	862	1277	1708
Yes				56.7	77.9	269	510	867	1292	1706
SEM				.3	.8	3.6	4.4	7.4	9.9	7.8
Feed at time of placement (P)				NS	NS	NS	NS	NS	NS	NS
No				56.9	79.7	270	515	864	1277	1707
Yes				56.7	78.5	267	511	866	1293	1707
SEM				.3	.8	3.6	4.4	7.4	9.9	7.8
Sex (S)		NS	NS	•	•••	•••	•••	•••	•••	•••
Females		41.4	38.5	56.4	78.1	260	490	813	1193	1567
Males		41.4	38.5	57.1	80.1	284	536	9[illegible]6	1375	1847
SEM		.2	.2	.3	.8	3.6	4.4	7.4	9.9	7.8
AxM				NS	NS	NS	•	NS	NS	NS
AxF				NS	NS	NS	NS	NS	NS	NS
AxS				NS	NS	NS	NS	NS	NS	NS
MxF				NS	NS	NS	NS	NS	NS	NS
FxS				NS	NS	NS	NS	NS	NS	NS
MxS				NS	NS	NS	NS	NS	NS	NS
AxMxS				NS	NS	NS	NS	NS	NS	NS
AxFxS				NS	NS	NS	NS	NS	NS	NS
MxFxS				NS	NS	NS	NS	NS	NS	NS
AxMxF				NS	NS	NS	NS	NS	NS	NS
AxMxFxS				NS	NS	NS	••	NS	•	••

Sex and its interactions were tested using the residual error term from the full model.

•$P < .05$

••$P < .01$

•••$P < .001$

Table 2.8. Experiment 2. Correlation coefficients of egg weight, hatch weight and percent weight loss with chick body weight to six weeks of age.

	Egg Weight	Hatch Weight[1]	Percent Weight Loss
Egg weight	-	.92***	.27***
Hatch weight	.92***	-	-.13***
Day 1	.91***	.98***	-.11***
3	.85***	.83***	.08*
5	.72***	.72***	.07*
Week 2	.51***	.51***	.03
3	.37***	.39***	-.02
4	.34***	.37***	-.03
5	.27***	.28***	-.01
6	.21***	.22***	-.01

*P<.05
***P<.001

[1] Hatch weight = chick weight when removed from the hatcher.

Table 2.9 Experiment 2. Influence of flock age, medication, and feed holding period on feed efficiency and mortality of broiler chickens through six weeks of age.

Variable	Feed Efficiency[1]								Mortality (%)[2]
	Age								
	Days		Weeks						
	3	5	2	3	4	5	6	Overall	
Flock Age (A)	***	NS	NS	**	NS	NS	NS	*	NS
31 wks	1.19	1.49	1.59	1.74	1.97	2.11	2.47	2.04	3.64
53 wks	1.07	1.43	1.55	1.83	1.99	2.15	2.52	2.06	2.97
SEM	.01	.04	.02	.02	.02	.03	.04	.01	.85
Medication (M)	NS	NS	NS	NS	NS	NS	NS	NS	NS
No	1.13	1.42	1.57	1.79	2.00	2.15	2.45	2.05	3.33
Yes	1.14	1.50	1.57	1.78	1.96	2.11	2.53	2.05	3.23
SEM	.01	.04	.02	.02	.02	.03	.04	.01	.85
Feed at time (F) of placement	***	NS	NS	NS	NS	NS	NS	NS	NS
No	1.09	1.44	1.58	1.79	1.98	2.15	2.45	2.05	3.20
Yes	1.18	1.48	1.57	1.78	1.99	2.11	2.53	2.06	3.38
SEM	.01	.04	.02	.02	.02	.03	.04	.01	.85
AxM	NS	NS	NS	NS	NS	NS	NS	NS	*
AxF	NS	NS	NS	NS	*	NS	NS	NS	NS
MxF	NS	NS	NS	NS	NS	NS	NS	NS	NS
AxMxF	NS	NS	NS	NS	NS	NS	NS	NS	NS

*$P<.05$

**$P<.01$

***$P<.001$

NS - Non-significant

[1] (g) Feed/(g) body weight

[2] Data analyzed as the $\log_{10}$ percent of mortality. Data presented are actual values.

Table 2.10. Experiment 2. Influence of percent weight loss and dietary starter energy and protein levels, on feed intake of broiler chickens through six weeks of age.

	Feed Intake (g)							
	Age							
	Days		Weeks					
	3	5	2	3	4	5	6	Overall
Flock Age (A)	•••	•••	•••	•••	••	NS	•	•••
31 wks	19.7	29.6	284	424	682	887	1033	3359
53 wks	21.7	34.8	312	452	720	906	1063	3510
SEM	.25	.29	3.3	4.8	8.0	7.3	9.8	22.8
Medication (M)	NS	•••	NS	NS	NS	NS	NS	NS
No	20.6	33.2	299	444	701	896	1057	3451
Yes	20.8	31.2	297	432	701	897	1039	3418
SEM	.25	.29	3.3	4.8	8.0	7.3	9.8	22.8
Feed at time (F) of placement	••	NS	NS	NS	NS	NS	NS	NS
No	20.0	32.6	302	441	697	[illegible]92	1052	3437
Yes	21.4	31.8	294	434	706	901	1043	3432
SEM	.25	.29	3.3	4.8	7.8	7.3	9.8	22.8
AxM	NS	[illegible]	•	NS	NS	NS	NS	NS
AxF	NS	NS	NS	NS	NS	NS	NS	NS
MxF	NS	NS	•	•	NS	NS	NS	NS
AxMxF	NS	NS	NS	NS	NS	NS	NS	NS

•(P<.05)
••(P<.01)
•••(P<.001)
NS - Non-significant

Table 2.11. Experiment 2. Means of egg weight, yolk weight, shell weight, albumen weight, Haugh units and egg specific gravity for eggs from 31 and 53 week old broiler breeders.

Flock age	Egg weight (g)	Yolk[1] weight (g)	Shell[1] weight (g)	Albumen[1] weight (g)	Haugh units	Egg specific gravity
31 wks	56.2 A[2]	18.3 A	5.2 A	32.7 A	79.0 A	1074.4 A
53 wks	66.5 B	22.8 B	5.8 A	37.8 A	70.0 B	1070.5 B

n = 100

[1] Data analysed as the $\log_{10}$ % of total egg weight. Data presented are actual values.

[2] Those numbers in a column without a common superscript are significantly different ($P<.05$).

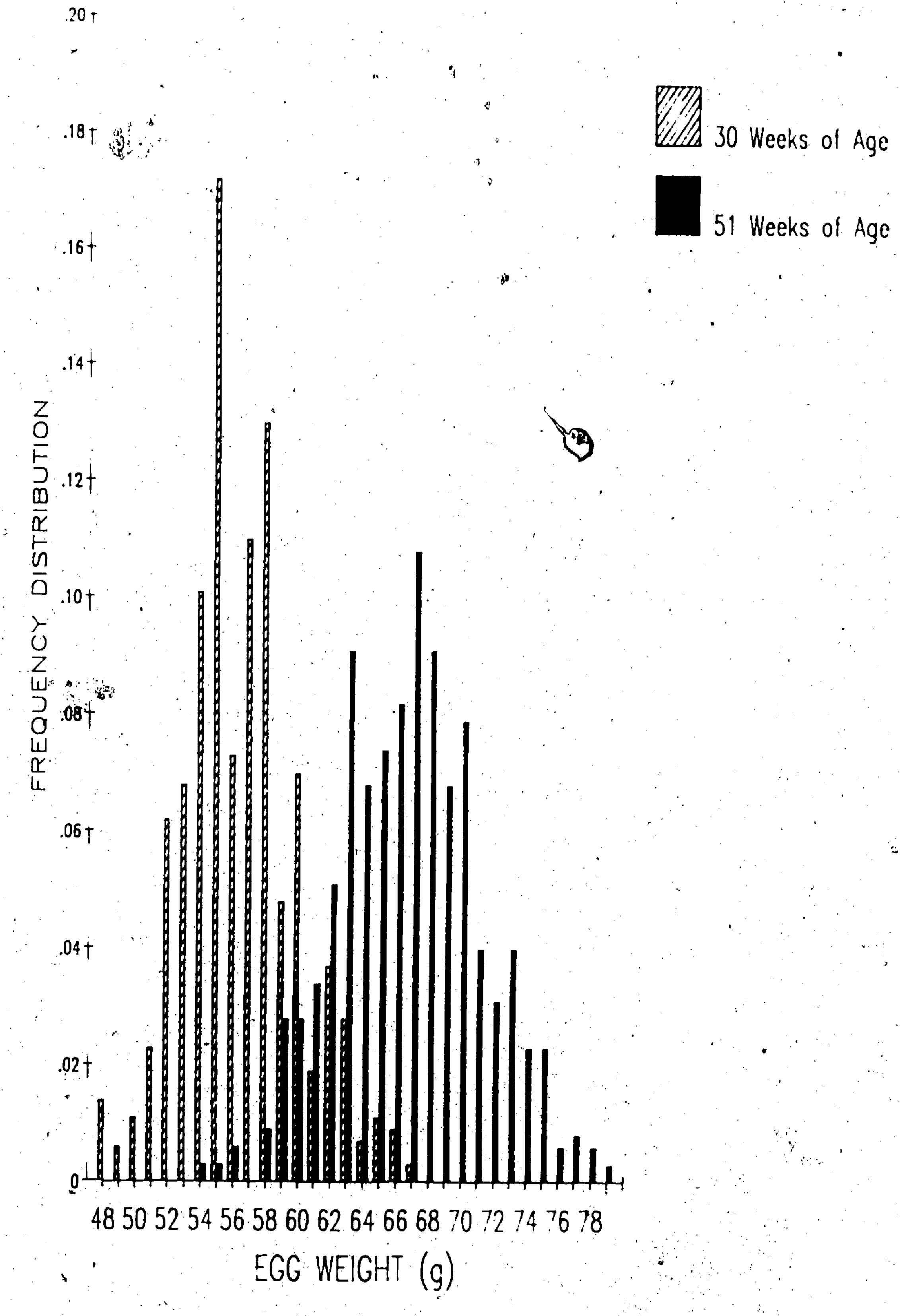

Figure 2.1 Experiment 1. Egg weight frequency distribution

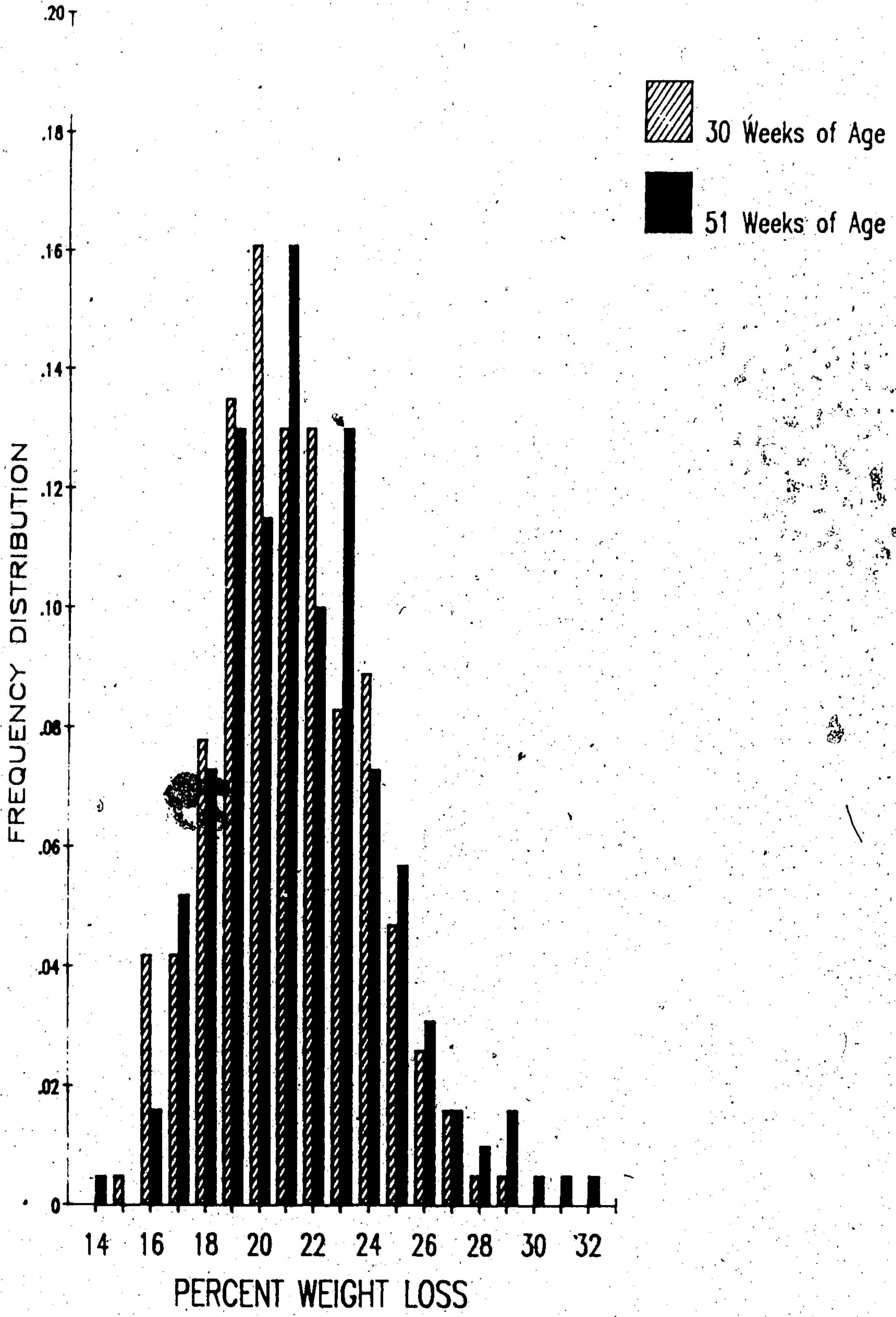

Figure 2.2 Experiment 1. Percent weight loss frequency distribution.

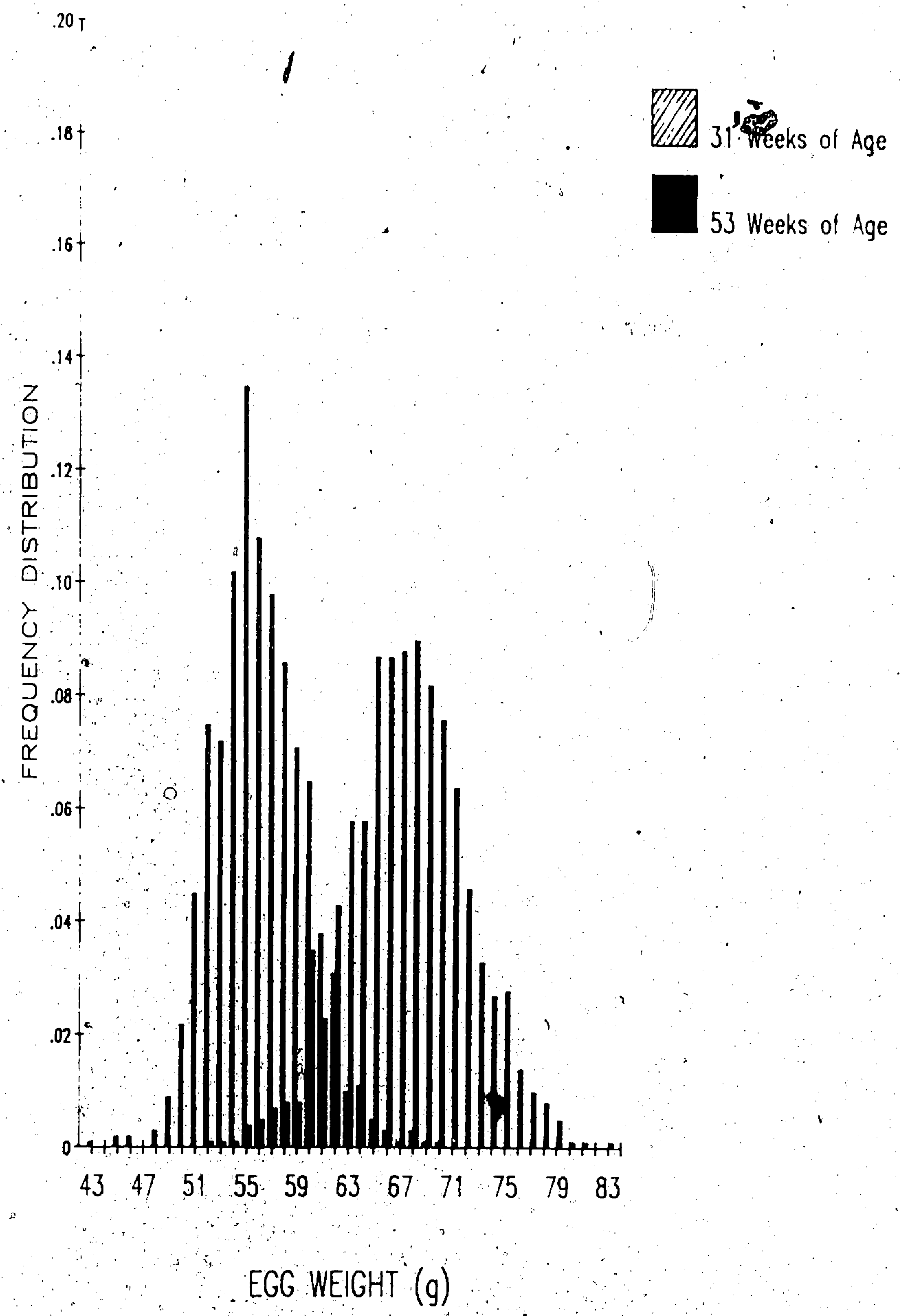

Figure 2.3 Experiment 2. Egg weight frequency distribution.

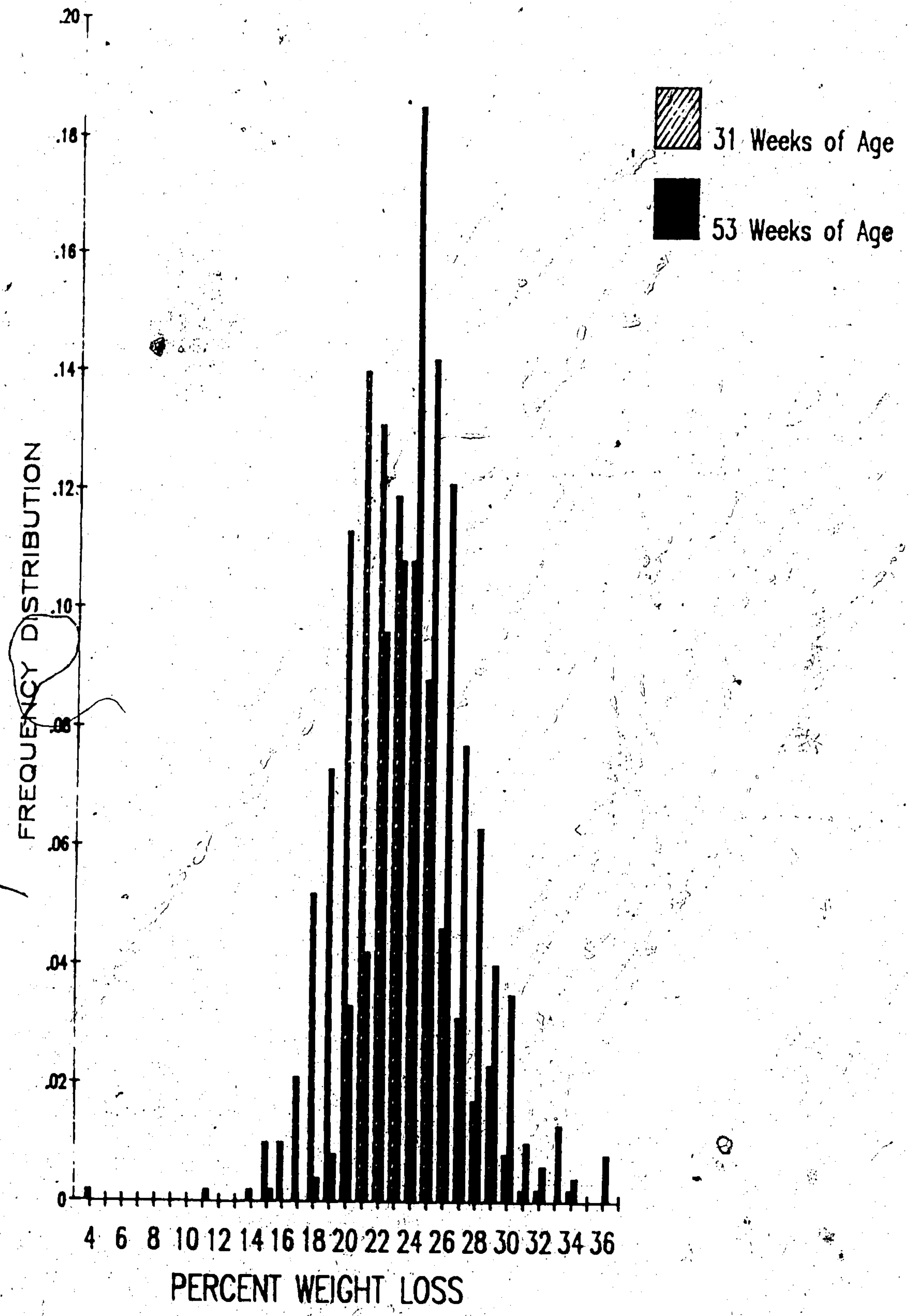

Figure 2.4 Experiment 2. Percent weight loss frequency distribution.

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3: THE INFLUENCE OF WEIGHT LOSS OF EGGS DURING INCUBATION, AND DIETARY ENERGY AND PROTEIN INTAKE ON GROWTH, FEED EFFICIENCY, AND CARCASS CHARACTERISTICS IN BROILER CHICKENS

3.1: INTRODUCTION

Variable chick quality at time of placement on the farm has led to the development of various placement management programs. Breeder flock age, setter humidity, egg weight, egg location within the setter, and chick removal time from the hatcher significantly affect chick weight, hatching time, and subsequent performance (Misra and Fanguy, 1978; Tullet and Burton, 1982; Hager and Beane, 1983; Reinhart and Hurnik, 1984). Percent weight loss through incubation may be an indicator of the condition of the chick upon removal from the hatcher and be a measure of chick quality when the day-old chick is placed in a growing facility.

Early nutrition may affect growth rate and carcass composition. Deaton _et al_. (1973) reported that compensatory growth occurs in broilers fed a low energy starter diet followed by a high energy finisher diet. Birds that were four percent lighter in body weight at four weeks of age compensated to the point that they weighed almost the same as the control birds by eight weeks of age. Birds demonstrating compensatory growth had higher fat levels than did the control birds fed the high energy starter diet.

Kubena _et al_. (1974) reported significant differences in abdominal fat when expressed as a percentage of body weight in broilers fed various starter and finisher diets. Low energy starter diets produced carcasses with lower abdominal fat than high energy starter diets in broilers at seven and eight weeks of age, contradicting Deaton et al. (1973). However, broilers with higher fat content generally had heavier body weights than those with lower fat content. Griffiths et al. (1977) reported that chicks fed low energy starter diets were smaller at three weeks of age, but, by eight weeks of age, body weight, abdominal fat pad and feed intake were unaffected by the three week restriction, demonstrating a compensatory growth effect.

Seaton et al. (1978) reported that carcass fat decreased and moisture content increased as the amount of protein and lysine in the diet was increased. The content of carcass fat was positively correlated with the C:P ratio. The amino acid balance and dietary energy level significantly affected weight gain and feed efficiency.

Jackson et al. (1982a,b) demonstrated that body weight and feed efficiency improved with increased amounts of dietary protein and energy indicating the importance of a balanced C:P ratio to obtain maximum performance.

Early nutrition studies in broilers have indicated the importance of what and how broilers are fed during the first few days of placement and the effect they exert on body weight and abdominal fat pad development. Protein levels of 30 percent crude protein in the starter diets were found to have detrimental effects on growth rate during the starter period from 0 to 14 days of age (Hargis and Cregor, 1980). Plavnik and Hurwitz (1985) restricted energy intake to 1.5 kcal/day x $BW^{2/3}$ with the intention of supporting maintenance requirements only. This feeding level represents approximately 60 percent of the normal caloric intake under ad lib. feeding conditions. After refeeding commenced at control levels the weight gain of the restricted birds exceeded that of the control birds. Feed efficiency improved by two to nine percent. Abdominal fat at eight weeks of age was reduced by the early restriction period.

Jensen et al. (1987) reported extreme variability among body weight of broilers fed various levels of dietary protein and fat in isocaloric diets. The variability could not be attributed to the treatments under study since significance was not obtained, but the effect of poor initial chick quality was not taken into consideration. However, in one study a low fat starter diet containing 28 percent crude protein fed to chicks for seven days followed by a low fat 23 percent crude protein starter diet significantly reduced growth rate when compared to high and low fat starter diets containing 23 percent crude protein at 26 days of age.

The objectives of this research [illegible] examine the relationship between dietary energy and protein [illegible] and chick quality as measured by the percent weight loss during incubation, and to assess if the use of these treatments by broiler producers could improve body weight and carcass composition at six weeks of age.

3.2: MATERIALS AND METHODS

3.2.1: Pre and Post-Hatch Processing and Chick Allocation

Broiler hatching eggs were obtained from a young Indian River breeder flock which was 34 weeks of age. All eggs had been stored for a maximum of one week. A total of 1207 eggs were set in a forced air incubator representing a normal egg weight frequency distribution (Figure 3.1). Standard hatchery protocol was followed. On the 18th day of incubation the nonviable eggs were detected by candling and removed. Viable embryos were transferred to pedigree baskets for hatching. Eggs of a common initial weight were hatched together to facilitate measurement of shell weight.

The hatch was removed at 21 days and 12 hours of incubation. At the time of chick removal, chicks were sexed, weighed, wing-banded and vaccinated with Marek's vaccine. The weight of the remaining egg shells and hatch debris from each pedigree basket was recorded.

The percent weight loss (PWL) of each chick throughout incubation was calculated and chicks were sorted into two groups, high and low (29.57 ± .31 and 24.32 ± .28 percent respectively), based on the PWL frequency distribution (Figure 3.2).

3.2.2: Management and Experimental Design

Four hundred and sixteen chicks were assigned to each of the following four starter dietary treatments within each PWL group, and fed for 21 days: 1) 26 percent crude protein, 3200 Kcal ME/kg; 2) 23 percent crude protein, 2830 Kcal ME/kg; 3) 23 percent crude protein, 3200 Kcal ME/kg; and 4) 20 percent crude protein, 2830 Kcal ME/kg (Table 3.1). Hence, for each of the two PWL groups, each of the four treatments were replicated four times. All were practical type diets representative of commercially prepared rations with similar ingredient profiles. At 21 days of age all treatments were fed a 20 percent crude protein 3200 Kcal ME/kg grower ration which was fed to 42 days of age (Table 3.1). All chicks were held in chick boxes for 30 hours at 20° C to simulate industry processing and transport conditions before being placed in floor pens. Thirteen male and thirteen female chicks were placed in each of 32 floor pens providing 2885 cm^2/bird. All pens were allowed access to water at placement

and feed four hours after placement. A standard photoperiod of 23L:1D was used throughout the growing period.
Group pen weights and feed consumption were recorded weekly to six weeks of age.

The percent weight loss (PWL) of each egg during incubation was calculated as follows:

$$\text{PWL} - \frac{\text{Egg weight(g)-chick weight(g) - x shell weight(g)}}{\text{egg weight(g)}} \text{x } 100$$

At three weeks of age two males and two females were selected at random from each replicate, fasted for 24 hours, and killed by cervical dislocation. Measurements were taken to obtain empty gizzard weight and the length of the duodenum, small intestine, and two ceca combined using the technique described by Freehling and Moore (1987) to provide consistent tension to the intestine for gut length measurement. Carcasses were stored at -20°C until analyzed for body composition. Carcasses containing the gizzard and intestines were prepared for chemical analyses using a modified variation of the technique described by Bailey (1985). The entire carcass was placed in a 4" x 10" aluminum pan and autoclaved at 124°C for a minimum of five hours in a Sylron/Barnstead Steam Sterilizer 3122. Sterilization and processing were achieved while maintaining 18 psi pressure in both the jacket and chamber. The contents were then transferred to a Polytron PCU-2 homogenizer where the contents were reduced to the consistency of a puree within 2 minutes. A subsample of the homogeneous sample was frozen (-30°C) and dried in a freeze-drier for a minimum of two days. The water content of each sample was calculated by weighing duplicate 1 g samples of the freeze dried material and drying these samples to constant weight for four hours at 110°C.

Duplicate freeze-dried tissue samples were analyzed to determine the nitrogen content by Kjeldahl procedure AOAC (1975). Total fat content of duplicate aliquots of freeze-dried tissue was obtained by solvent extraction using petroleum ether in conjunction with the Goldfish apparatus according to the AOAC (1980) method. The procedure involved extracting a 2 g sample for four hours with petroleum ether, collecting the extract in a tared beaker, evaporating the solvent and weighing the residual.

At the conclusion of the experiment two male and two female chickens were selected at random from each replicate for body composition analysis. Birds were fasted for 24 hours and killed by cervical dislocation. The birds were scalded, plucked and stored at -20°C until analyzed for body composition. Sample preparation and analysis were as previously described.

3.2.3: Statistical Analyses

Means and analysis of variance were calculated using the Statistical Analysis System (SAS) for Personal Computers Version 6 (Joyner _et al._, 1985). A 2 x 2 x 2 factorial design was employed. The general linear model contained the fixed effects of percent weight loss, protein level, and energy level, as well as all interactions and a random error term. All percentage data were transformed to their $\log_{10}$ values prior to statistical analysis.

The model was as follows:

$$Y_{ijkl} = u + W_i + P_j + (WP)_{ij} + E_k + (WE)_{ik} + (PE)_{jk} + (WPE)_{ijk} + e_{ijkl}$$

Where:

Y_{ijkl} = an observation on the l^{th} chick in the ijk^{th} subclass

u = overall mean

W_i = effect of the i^{th} weight loss group ($i = 1,2$)

P_j = effect of the j^{th} protein level ($j = 1,2$)

E_k = effect of the k^{th} energy level ($k = 1,2$)

$(WP)_{ij}$, $(WE)_{ik}$, $(PE)_{jk}$ and $(WPE)_{ijk}$ are the interactions among the main effects.

e_{ijkl} = random error term.

Statistical significance was assessed at the .05 level.

3.3: RESULTS

3.3.1: Body Gr[illegible] Feed Efficiency

The PWL o[illegible]e chick through incubation had a significant effect on body weight through five weeks of age ($P<.05$). Chicks in the low PWL treatments were heavier at each weighing through five weeks of age than chicks in the high PWL treatment (Table 3.2).

Chicks on treatments receiving low energy starter diets (2830 Kcal/kg) were significantly heavier ($P<.05$) at 1, 2 and 3 weeks of age than chicks on high energy starter diets (3200 Kcal/kg). After the chicks were changed from starter diets to a common grower diet at three weeks of age, no significant differences were observed in body weight between treatments. The chicks fed the high energy starter diet, which were 4.02 percent lighter at three weeks of age, and those chicks that were on the low energy starter diet, had similar body weights at six weeks of age. A significant interaction (P<.05) between PWL and energy level in the starter diet was noted in chicks at the one week body weight period. High PWL chicks fed high energy starter diets had significantly heavier body weights.

Chicks fed low protein starter diets were significantly heavier in body weight through six weeks of age (P<.05) than those chicks receiving high protein starter diets.

The efficiency of feed utilization was significantly higher (P<.05) in chicks fed the low dietary protein treatments than in chicks fed the high crude protein diets (Table 3.3) at two and three weeks of age. Chicks fed high energy starter diets had significantly improved feed efficiency at three and four weeks of age (P<.05) than did chicks fed low energy starter diets. A significant PWL x energy interaction (P<.05) was found at two weeks of age with chicks of high PWL fed high energy diets having a higher feed efficiency.

In regard to overall feed efficiency for the trial, significant differences (P<.05) were attributable to protein levels in the starter diet, with chicks fed low crude protein starter diets having a higher feed efficiency than chicks fed high crude protein starter diets (Table 3.3).

Feed intake (Table 3.4) was significantly affected by PWL group at 2, 4 and 5 weeks of age and for the overall feeding period, with chicks in the low PWL group consuming more feed. The energy level in starter diet significantly (P<.05) affected feed intake through three weeks of age, with chicks consuming more of the low energy starter diet. Dietary protein level in the starter diet had a significant effect (P<.05) on feed intake through all periods with higher intake attributed to the starter diets containing the lower crude protein level. A significant PWL x energy interaction was observed at one week of age with chicks of high PWL having higher feed intake on high energy starter diets.

3.3.2: Carcass Composition at Three and Six Weeks of Age

Body composition analysis was carried out on chicks at three and six weeks of age (Table 3.5). At three weeks of age chicks in the high PWL group had significantly higher crude protein and fat levels on [illegible] matter basis (P<.05) than did chicks of the low PWL group. Chick[illegible] high energy starter diets had significantly less crude protein, but more carcass fat on a dry matter basis, than chicks fed low energy starter diets (P<.05). No significant differences in carcass composition were observed due to die[illegible] protein levels or sex at three weeks of age. However, a significant (P<.05) energy x protein interaction was found indicating that chicks fed high energy, high protein starter diets had higher carcass crude protein levels. Furthermore, a significant protein x sex interaction (P<.05) indicated that female chicks fed high dietary protein rations had lower carcass fat levels.

In the six-week carcass composition analysis no significant differences in composition attributable to PWL were found in either crude protein or fat levels. However, a significant (P<.05) effect attributable to dietary crude protein levels was found, with chicks fed high crude protein diets having lower carcass fat levels, and chicks fed low crude protein diets having higher fat levels (Table 3.5).

Differences attributable to sex were found with male chicks having significantly higher levels of carcass crude protein (P<.05) than female chicks, but female chicks had significantly (P<.05) higher levels of carcass fat than male chicks.

3.3.3: Gut Characteristics at Three Weeks of Age

Gut measurements are reported as absolute weights or lengths, as a percent of body weight, or as cm/100g of body weight (Table 3.6). Percent weight loss of the chick had no significant effect on absolute gizzard weight or gizzard weight as a percent of body weight. Duodenum and cecum length, whether absolute or in cm/100g of body weight, were unaffected by PWL. A significant effect on the absolute small intestine length (P<.05) attributed to PWL was noted, with chicks from the low PWL group having longer small intestine measurements than those from the high PWL group. When reported on a cm/100g of body weight basis this difference was not found to be significant.

Dietary energy levels in the starter significantly (P<.05) affected gizzard weight with low energy starter diets producing heavier gizzard weights than high energy starter diets. This effect was non-significant on a percent of body weight basis. The energy level of the diet had no significant effect on the absolute lengths of the duodenum, small intestine, cecum and the cm/100g of body weight cecum measurement. However, on a cm/100g of body weight basis high energy starter diets produced significantly longer duodenum and small intestine lengths (P<.05) than did low energy starter diets.

Dietary crude protein levels in the starter significantly (P<.05) affected gizzard weight with gizzards from chicks fed low crude protein diets being heavier than gizzards from chicks fed high crude protein diets. No significant effect was noted on a percent of body weight basis. Crude protein levels had no effect on the absolute length of the duodenum, small intestine and cecum. However, when analyzed on a cm/100g of body weight basis, high crude protein starter diets produced significantly (P<.05) longer duodenum, small intestine and cecum in chicks at three weeks of age, than did low crude protein starter diets.

Sex had a significant effect on gut characteristics. Absolute gizzard weight was significantly (P<.05) heavier for male than female chicks but this was not significant on a percent of body weight basis. Duodenum and small intestine absolute length were significantly longer (P<.05) in male than in female chicks but no effect was noted in cecum length. When analyzed on a cm/100g of body weight basis, significant differences were found, with female chicks having longer duodenum, small intestine and cecum lengths per 100g of body weight (P<.05) than male chicks.

A significant (P<.05) PWL x crude protein interaction was noted for duodenum and cecum length on a cm/100g of body weight basis. High PWL chicks fed high crude protein starter diets had longer intestinal measurements. Also, a significant (P<.05) PWL x energy x sex interaction was noted for the small intestine and cecum measurements on a cm/100g of body weight basis. High PWL female chicks fed high energy starter diets had significantly longer gut measurements on a cm/100g of body weight basis.

3.3.4: Livability

Mortality was unaffected by PWL and dietary starter energy or protein level (Table 3.5). A significant PWL x crude protein interaction ($P<.05$) was observed, indicating that chicks of high PWL fed high crude protein starter had lower mortality. Livability was unaffected by PWL and starter diet energy levels. However, chicks fed high crude protein starter diets had significantly lower ($P<.05$) livability than chicks fed low protein starter diets.

3.4: DISCUSSION

3.4.1: Body Growth and Feed Efficiency

The percent weight loss through incubation significantly affected growth performance with chicks of low PWL being heavier than those of high PWL until five weeks of age. Chicks of high PWL were found to be significantly lower in initial body weight, as was demonstrated in experiments 1 and 2 and by others, (O'Neil, 1955; McNaughton, 1978; Wyatt _et al_., 1985) confirming that initial chick weight is highly correlated with pre-incubation egg weight. Chicks from lighter eggs will hatch earlier than chicks from heavier eggs and will be held longer in the hatcher, resulting in increased dehydration and subsequent weight loss (Hager and Beane, 1983). As reported here, chicks from within the same flock will undergo varying degrees of dehydration based upon egg weight and the subsequent length of time that the chick is held in the hatcher. To improve chick quality, it would be beneficial to sort eggs prior to setting such that eggs of similar weights would be set together. This would result in a more uniform hatch and improved chick quality at placement.

Starter dietary treatments had a significant effect on performance. High PWL chicks responded to high energy starter diets, with improvements in body weight and feed efficiency through the first two weeks of the growing period. The higher energy density in the starter diet may have been more readily utilized since the chicks in the high PWL group would have been hatched for a longer period of time and may have absorbed a higher percentage of their yolk sacs. Moran (1988) reported that a subcutaneous injection of glucose in poults was more readily utilized than an oral administration in improving body weight, which he attributed to an immature gut in the initial post-hatch period. The higher fat content of the high energy starter diet (Diets 1 and 3; 8 percent versus 4.5 percent in the low energy starter), may also contribute to the improved weight gain and feed efficiency. Summers and Leeson (1986) attributed increased body weight to higher dietary fat levels and rising energy and protein levels when the C:P ratio remained constant. Jensen et al. (1970) also identified the "extra caloric" effect of dietary fat on weight gain.

Except for the interaction just mentioned however, lower energy starter diets gave heavier body weights for the first three weeks of growth. These results are in contrast to work by Deaton et al. (1973) and Kubena et al. (1974) who reported that chicks fed a low energy starter diet were four percent lighter at four weeks of age than chicks fed a high energy diet. The increased body weight is attributed to the significantly higher feed intake levels of the chicks on the low energy diet through three weeks of age (Table 3.4)

The dietary protein level in the starter diet had a significant effect on growth performance. Chicks consuming starter diets containing 26 percent crude protein had significantly lower body weights throughout the six week growing period than chicks fed starter diets containing 23 percent crude protein. Feed efficiency was lower for chicks fed high crude protein diets at weeks two and three, and over the whole feeding period. Similar results were reported by Sunde (1956) and by Hargis and Cregor (1980) who found that 30 percent crude protein in starter diets had detrimental effects on growth rate from 0 - 14 days of age. Jensen et al. (1987) reported that starter diets containing 28 percent crude protein significantly reduced growth rate at seven days of age.

No interaction between dietary protein and energy levels was noted, in contrast to reports by Jackson et al. (1982a,b). This would indicate that the reduced body weight of birds on high crude protein starter diets was due to the crude protein level of the diet and the subsequent C:P ratio. The high crude protein starter diets had no beneficial management effect in assisting chicks of high PWL get off to a better start. Summers and Leeson (1984) reported that the response in weight gain, feed intake and feed to gain ratio, attributable to crude protein levels on isocaloric diets, plateaued at the 20 percent crude protein level. However, it has been reported that chicks fed diets higher in crude protein have elevated carcass moisture levels attributed to the dietary crude protein (Seaton et al., 1978; Jackson et al., 1982a). It was hypothesized that this elevated carcass moisture would be a beneficial effect to chicks that had undergone a high PWL during incubation.

3.4.2: Carcass Composition at Three and Six Weeks of Age

Dietary treatments had a significant effect on the carcass composition of chicks at three weeks of age. Chicks on the high energy starter diet had significantly higher carcass fat, and significantly lower carcass crude protein levels. These results are in agreement with those reported previously (Kubena et al.,1972, 1974; Farrell, 1974; Summers and Leeson, 1979; and Deaton and Lott, 1985).

Chicks from the high PWL group had significantly lower carcass fat and higher crude protein levels than chicks from the low PWL group. This may indicate that the high PWL chicks were more efficient in converting dietary intake into carcass protein on a relative basis but at three weeks of age had not been able to fully compensate for their lower initial starting weight.

Carcass composition analysis at six weeks of age indicated a significant effect of starter dietary protein on carcass fat levels. High dietary crude protein resulted in a significant reduction in the carcass fat levels while low dietary crude protein levels resulted in significantly higher fat levels. These results are in general agreement with work reported previously (Yoshida and Morimoto, 1970; Lipstein et al., 1975; Mabray and Waldroup, 1981; Jackson et al., 1982c; and Cabel et al., 1988).

3.4.3: Gut Characteristics at Three Weeks of Age

Changes in the length of the duodenum, small intestine and cecum of a variety of birds have been attributed to differences in the fibre content of the diet (Leopold, 1953; Moss, 1972). Mean size of the gizzard, intestine, liver and ceca of wood ducks increased in response to high dietary fibre and conversely were reduced in size when dietary fibre was decreased (Drobney, 1984). Gross et al. (1985) reported that with reduced energy availability, cecal length, mass with contents, wet tissue mass and dry tissue mass increased significantly in Microtus ochrogaster. No significant differences in the length of the gastrointestinal tract were noted in animals held at room temperature.

Gut measurements have been reported to be affected by the separate effects of dietary fibre, sex and age, with longer intestinal measurements attributed to higher fibre levels in diets fed to older female birds (Savory and Gentle, 1976a). Differences in gut size between dietary treatments were more a reflection of variations in food intake than the effects of fibre level, sex, and age. Savory and Gentle (1976b) reported that it took 8-10 days for Japanese quail to adjust to changes in diet composition and three to four weeks for their guts to adjust to such changes.

Summers and Leeson (1986) reported that as dietary fibre increased, gizzard weight increased in a linear manner, whether expressed in absolute terms or on a relative basis. Intestinal absolute length decreased as fibre increased, but relative intestinal length (cm/100g of body weight) increased with fibre in the diet. As dietary fat level was increased, absolute intestinal length increased in a significant linear manner. These diets used by Summers and Leeson (1986) maintained a constant C:P ratio (118 Kcal:1 percent crude protein). As the fat levels were increased from 0 : 9 percent, the crude protein levels ranged from 24 to 27 percent and the energy levels ranged from 2807 to 3204 Kcal/kg, to maintain the C:P ratio.

Measurements of gastrointestinal tract length in previous reported research was carried out by stretching the gut in a subjective manner. Freehling and Moore (1987) compared two methods for measuring intestinal length. They reported a new method of measuring intestinal length that reduced surface adhesion and provided consistent tension to the intestine when it was being measured. The coefficients of variation were reduced in comparison to the previously used technique.

Gizzard weight on a percent of body weight basis was unaffected by PWL, sex or dietary energy and protein levels. The relative weight of the gizzard was proportionate to body weight. Duodenum and small intestine length (cm/100g of body weight) were significantly longer for starter diets high in energy and crude protein. This was attributed to the high energy starter diets containing higher fat levels than the low energy starter diets (8 and 4.5 percent respectively). Fibre levels in the high and low energy and crude [illegible] diets were similar (3 and 5 percent respectively), and thus [illegible] have little effect on intestinal length. This would account [illegible] non-significant effect of energy on cecum length since the [illegible] thought to have a function in fibre digestion. However, [illegible] cecum length was significantly increased by high crude protein diets. These findings are in agreement with Summers and Leeson (1986) who reported that higher dietary fat levels associated with higher energy and crude protein levels, increased absolute intestinal length. Diets of higher nutrient density have longer transit times, and this is reflected in increased intestinal length.

Male chicks at three weeks of age had significantly longer relative duodenum and cecum measurements. This is in contrast to work reported by Savory _et al_. (1976a) indicating that female birds had longer intestinal measurements than male birds. These researchers stated however, that feed intake was a greater factor in influencing differences in gut characteristics.. Male chicks have higher feed intake levels than female chicks which equates to longer intestinal length as reported in this research. Relative small intestine and cecum length were significantly longer for high PWL female chicks on high energy diets. This,. in conjunction with the significant interaction between high PWL chicks fed high energy starter diets, on one week body weight (Table 3.2), and two week feed efficiency (Table 3.3), indicates that high PWL chicks can adapt by increasing intestinal length to more efficiently absorb and utilize dietary energy. However, increased relative duodenum and cecum length, indicated by the interaction between high PWL chicks and high crude protein starter, did not result in improved body weight or feed efficiency, but the converse. Increased duodenum length may reflect decreased digestability of the higher crude protein starter diets, resulting in decreased body weights and poorer feed efficiency (Tables 3.2 and 3.3).

The variability in the reported research reflects the inconsistent methodology of measuring gut dimensions. The gastointestinal tract is very flexible and easily stretched, thus providing room for variation between researchers. A common methodology is needed.

In conclusion, it has been reported that variation in chick quality is considerable between chicks obtained from the same breeder flock. This study indicates that chicks of low PWL had significantly higher body weights at five weeks of age than did chicks of high PWL. No significant differences were noted at six weeks of age. Further research is required to assess the cost effectiveness of sorting eggs prior to incubation such that chicks of more consistent quality could be placed by the broiler producer. If the broiler producer was aware of the PWL level of the chicks, the body weight, feed efficiency, and resulting carcass composition could be improved by the specific starter diet implemented. This would improve the performance of sub-standard chicks. Chicks of high PWL fed high energy starter diets showed improved performance. High protein starter diets had a negative effect on growth performance regardless of chick quality, however, lower carcass fat levels were obtained, indicating a leaner carcass for market.

Table 3.1. Experiment 3. Composition of starter treatments and grower diets.

Ingredients:	Type of ration (kg)				
	Starter 1	Starter 2	Starter 3	Starter 4	Grower
Oat Hulls	-	71.0	-	73.0	
Ground Corn	484.3	495.5	543.6	442.6	613.8
Canola Oil	25.0	10.0	25.0	7.5	23.4
Stabilized fat	25.0	10.0	25.0	9.3	23.0
Meat meal (50% C.P.)	75.0	75.0	75.0	75.0	75.0
Canola meal (36% C.P.)	75.0	75.0	75.0	75.0	75.0
Soybean meal (46.5% C.P.)	136.0	140.0	119.0	140.0	100.0
Corn gluten meal (62% C.P.)	128.0	75.0	88.0	126.0	49.0
Limestone	3.0	3.5	3.3	2.9	1.4
Dicalcium Phosphate	2.7	2.6	2.6	2.8	1.0
Iodized salt	1.0	1.0	1.0	1.0	1.0
D.L. Methionine	4.9	3.5	3.8	4.9	1.7
L-Lysine	6.1	3.9	4.7	6.0	2.7
Potassium chloride	1.0	1.0	1.0	1.0	1.0
Selenium premix	1.0	1.0	1.0	1.0	[illegible]
Coban	.75	.75	.75	.75	.75
Lincomix	.25	.25	.25	.25	.25
Micronutrients[1]	21.0	21.0	21.0	21.0	21.0
Lignosol	10.0	10.0	10.0	10.0	10.0
Total	1000.0	1000.0	1000.0	1000.0	1000.0
Chemical analysis: (%)					
Metabolizable energy (kcal/kg)	3200	2830	3200	2830	3200
Protein	26	23	23	26	20
Calcium	1.00	1.00	1.00	1.00	.90
Available Phosphorus	.45	.45	.45	.45	.42
Lysine	1.35	1.20	1.20	1.35	1.00
Methionine	[illegible]	.66	.67	.79	.46
T.S.A.A.	1.05	.93	.93	1.05	.72
Crude Fibre	3.00	5.00	3.00	5.00	3.20
Fat	8.00	4.50	8.00	4.50	8.00

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[1] The micronutrients supplied the following levels per kg of ration: manganese sulphate, 400 mg; zinc oxide, 100 mg; Vitamin A, 6000 IU; Vitamin D_3, 600 ICU; Vitamin E, 10 IU; menadione, 1 mg; riboflavin, 5 mg; calcium pantothenate, 10 mg; niacin, 20 mg; choline chloride, 100 mg; folic acid, 1 mg; Vitamin B_{12}, 10 mcg; biotin, 100 mg.

Table 3.2. Experiment 3. Influence of percent weight loss and dietary starter energy and protein levels, on the growth performance of broiler chickens through six weeks of age.

	Body Weight (g)						
	Age (Weeks)						
Variable	0	1	2	3	4	5	6
Percent Weight Loss (PWL)	***	*	**	**	**	**	NS
High	36.4	101	250	505	860	1264	1722
Low	39.8	104	259	520	890	1317	1738
SEM	.2	.8	2.0	3.4	7.3	12.7	17.8
Energy (E) (Kcal/kg)	NS	[illegible]	***	***	NS	NS	NS
High	38.0	101	248	502	869	1290	1725
Low	38.1	105	261	523	882	1292	1735
SEM	.2	.8	2.0	3.4	7.3	12.7	17.8
Protein (P) (% C.P.)	NS	**	***	***	***	**	**
High	38.2	101	245	495	849	1263	1690
Low	38.0	104	263	530	901	1319	1770
SEM	.2	.8	2.0	3.4	7.3	12.7	17.8
PWLxE	NS	*	NS	NS	NS	NS	NS
PWLxP	NS	NS	NS	NS	NS	NS	NS
ExP	NS	NS	NS	NS	NS	NS	NS
PWLxExP	NS	NS	NS	NS	NS	NS	NS

*P<.05
**P<.01
***P<.001
NS - Non-significant

Table 3.3. Experiment 3. Influence of percent weight loss and dietary starter energy and protein levels, on feed efficiency of broiler chickens through six weeks of age.

Variable	Feed Efficiency[1]					
	Age (Weeks)					
	2	3	4	5	6	Overall
Percent Weight Loss (PWL)	NS	NS	NS	NS	NS	NS
High	1.40	1.45	2.54	1.84	2.19	1.81
Low	1.41	1.45	2.49	1.80	2.25	1.80
SEM	.01	.01	.06	.03	.09	.02
Energy (E) (Kcal/kg)	NS	***	*	NS	NS	NS
High	1.40	1.41	2.42	1.81	2.27	1.80
Low	1.40	1.49	2.61	1.83	2.16	1.80
SEM	.01	.01	.06	.03	.09	.02
Protein (P) (% C.P.)	***	**	NS	NS	NS	*
High	1.43	1.48	2.54	1.84	2.33	1.84
Low	1.38	1.42	2.49	1.80	2.10	1.77
SEM	.01	.01	.06	.03	.09	.02
PWLxE	*	NS	NS	NS	NS	NS
PWLxP	NS	NS	NS	NS	NS	NS
ExP	NS	NS	NS	NS	NS	NS
PWLxExP	NS	NS	NS	NS	NS	NS

[1] (g) feed/(g) body weight
*P<.05
**P<.01
***P<.001
NS - Non-significant

Table 3.4. Experiment 3. Influence of percent weight loss and dietary starter energy and protein levels, on feed intake of broiler chickens through six weeks of age.

	Feed Intake (g)						
	Age (Weeks)						
Variable	1	2	3	4	5	6	Overall
Percent Weight Loss (PWL)	NS	**	NS	*	*	NS	*
High	84.0	207	363	595	724	867	2839
Low	84.4	217	370	618	750	875	2915
SEM	.8	1.7	3.3	6.2	7.7	11.7	25.4
Energy (E) (Kcal/kg)	*	***	***	NS	NS	NS	NS
High	82.4	206	353	606	742	873	2863
Low	85.9	218	380	607	732	869	2890
SEM	.8	1.7	3.3	6.2	7.7	11.7	25.4
Protein (P) (% C.P.)	*	***	**	**	*	*	**
High	82.7	206	357	594	726	851	2817
Low	85.6	218	376	619	748	890	2936
SEM	.8	1.7	3.3	6.2	7.7	11.7	25.4
PWLxE	*	NS	NS	NS	NS	NS	NS
PWLxP	NS	NS	NS	NS	NS	NS	NS
ExP	NS	NS	NS	NS	NS	NS	NS
PWLxExP	NS	NS	NS	NS	NS	NS	NS

*P<.05
**P<.01
***P<.001
NS - Non-significant

Table 3.5. Experiment 3. Influence of percent weight loss and dietary starter energy and protein levels, on carcass composition at three and six weeks of age, and overall mortality and livability.

Variable	Crude Protein (%)[1]		Crude Fat (%)[1]		Mortality (%)[1]	Livability (%)[1]
	Weeks					
	3	6	3	6		
Percent Weight Loss (PWL)	•	NS	•	NS	•	NS
High	57.06	46.26	31.21	45.96	5.53	93.75
Low	55.75	46.06	32.46	46.57	2.40	95.67
SEM	.37	.34	.43	.46	.98	1.02
Energy (E) (Kcal/kg)	•••	NS	•••	NS	NS	NS
High	55.23	46.11	33.24	46.33	3.85	94.95
Low	57.58	46.21	30.43	46.19	4.10	94.47
SEM	.38	.34	.43	.46	.98	1.02
Protein (P) (% C.P.)	NS	NS	NS	••	NS	•
High	56.82	46.55	31.27	45.34	4.57	92.79
Low	55.99	45.76	32.40	47.19	3.37	96.63
SEM	.36	.34	.43	.46	.98	1.02
Sex (S)	NS	•••	NS	•••		
Female	56.22	44.80	32.08	48.14		
Male	56.59	47.51	31.59	44.39		
SEM	.38	.34	.43	.46		
PWLxE	NS	NS	NS	NS	NS	NS
PWLxP	NS	NS	NS	NS	•	NS
PWLxS	NS	NS	NS	NS	NS	NS
ExP	•	NS	NS	NS	NS	NS
ExS	NS	NS	NS	NS		
PxS	NS	NS	NS	NS		
PWLxExP	NS	NS	NS	NS	NS	NS
PWLxExS	NS	NS	NS	NS		
PWLxPxS	NS	NS	NS	NS		
ExPxS	NS	NS	NS	NS		
PWLxExPxS	NS	NS	NS	NS		

•$P < .05$

••$P < .01$

•••$P < .001$

NS - Non-significant

[1] Data analyzed as the $\log_{10}$. Data presented are actual values.

Table 3.6. Experiment 3. Influence of percent weight loss, dietary starter energy and protein levels and sex on the gut measurements of three week old broiler chickens.

	Gizzard Weight		Duodenum Length		Small Intestine Length		Cecum Length	
Treatment	(g)	% of Bwt¹	cm	cm/100 g Bwt	cm	cm/100 g Bwt	cm	cm/100 g Bwt
Percent Weight Loss (PWL)	NS	NS	NS	NS	*	NS	NS	NS
High	13.0	2.9	62.5	14.1	42.7	9.6	42.7	4.6
Low	13.5	2.9	64.1	13.8	44.3	9.6	44.3	4.5
SEM	.2	.1	.6	.2	.5	.1	.2	.1
Energy (E) (Kcal/kg)	***	NS	NS	**	NS	***	NS	NS
High	12.8	2.9	63.4	14.3	43.9	9.9	20.4	4.6
Low	13.8	3.0	63.3	13.6	43.1	9.3	20.9	4.5
SEM	.2	.1	.6	.2	.5	.1	.2	.1
Protein (P) (% C.P.)	***	NS	NS	***	NS	***	NS	***
High	12.8	2.9	63.8	14.5	43.9	10.0	20.6	4.7
Low	13.8	2.9	62.8	13.4	43.1	9.2	20.6	4.4
SEM	.2	.1	.6	.2	.5	.1	.2	.1
Sex (S)	*	NS	*	**	***	NS	NS	**
Female	12.9	3.0	61.9	14.3	41.9	9.7	20.3	4.7
Male	13.7	2.9	64.7	13.6	45.1	9.5	20.9	4.4
SEM	.2	.1	.6	.2	.5	.1	.2	.1
PWLxE	NS	NS	NS	NS	NS	NS	NS	NS
PWLxP	NS	NS	NS	*	NS	NS	NS	*
PWLxS	NS	NS	NS	NS	NS	NS	NS	NS
ExP	NS	NS	NS	NS	NS	NS	NS	NS
ExS	NS	NS	NS	NS	NS	NS	NS	NS
PxS	NS	NS	NS	NS	NS	NS	NS	NS
PWLxExP	NS	NS	NS	NS	NS	NS	NS	NS
PWLxExS	NS	NS	NS	NS	NS	*	NS	*
PWLxPxS	NS	NS	NS	NS	NS	NS	NS	NS
ExPxS	NS	NS	NS	NS	NS	NS	NS	NS
PWLxExPxS	NS	NS	NS	NS	NS	NS	NS	NS

¹Body Weight
*P<.05
**P<.01
***P<.001
NS - Non-significant

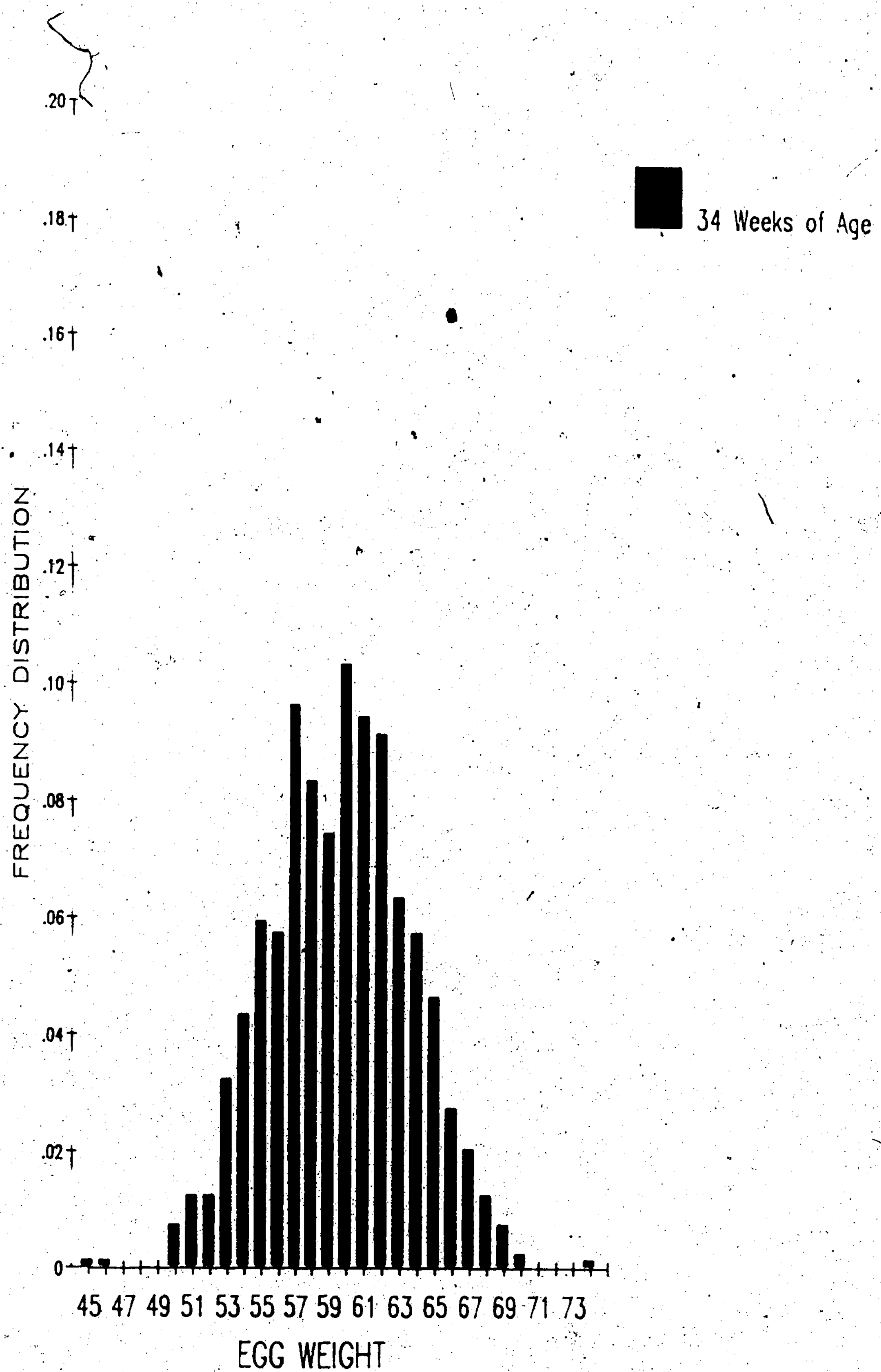

Figure 3.1 Experiment 3. Egg weight frequency distribution.

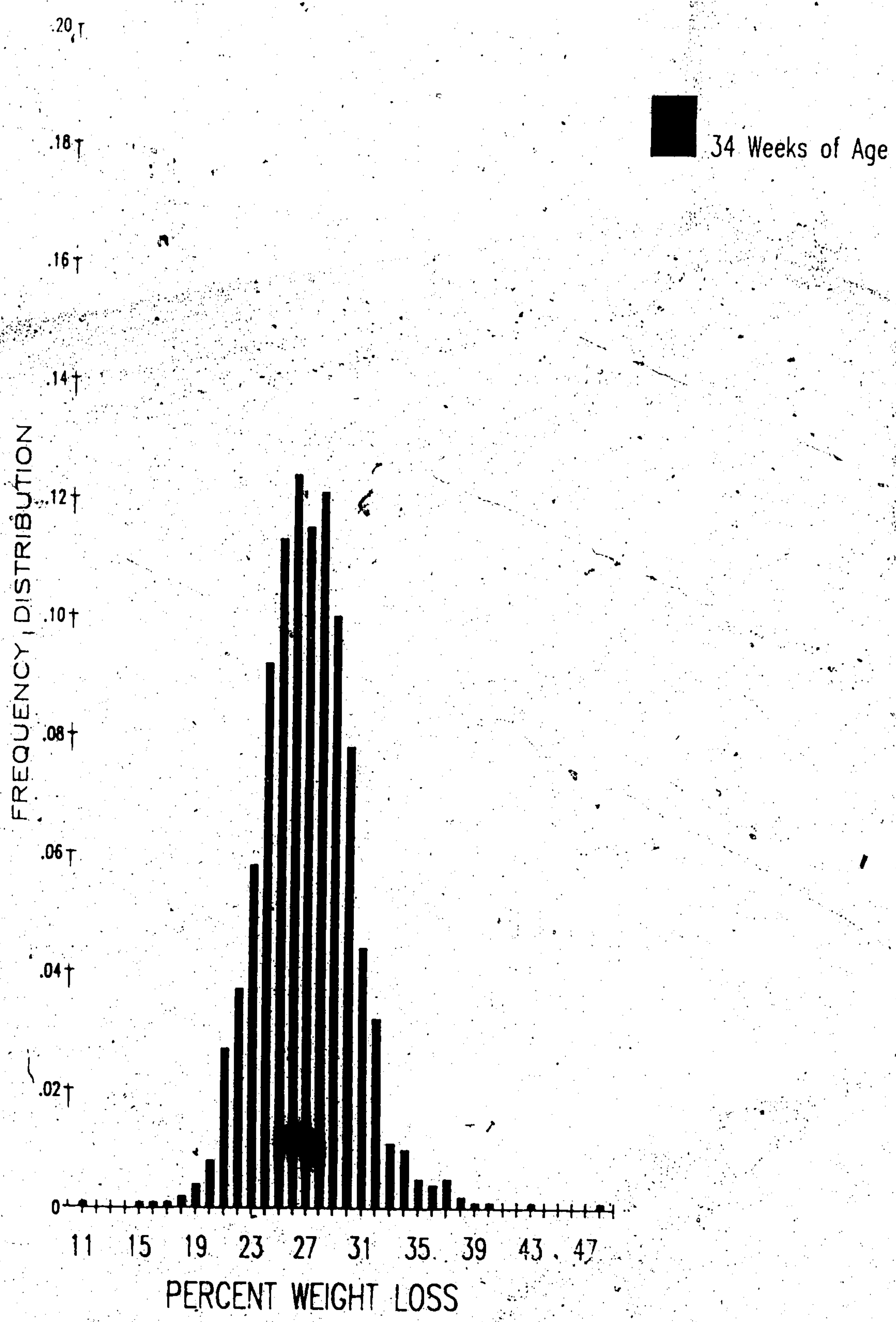

Figure 3.2 Experiment 3. Percent weight loss frequency distribution.

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4: GENERAL DISCUSSION AND CONCLUSIONS

4.1: GENERAL DISCUSSION

The purpose of this research was to investigate factors affecting broiler chick quality as defined by percent weight loss (PWL). The influence of the broiler breeder parent flock age, the effectiveness of various management treatments attempting to rehydrate day-old chicks, and the utilization of various dietary management treatments, were studied as to their influence on chick weight, performance parameters, and broiler carcass composition.

Broiler breeder parent flock age had a significant effect on egg weight, chick weight, yolk weight, Haugh units, and egg specific gravity (Table 2.9). Egg weight frequency distributions were in agreement with those reported by McNaughton _et al_. (1978). Percent weight loss was significantly higher in old flocks than in young flocks (Tables 2.2 and 2.6). However, its influence on chick body weight to six weeks of age, as reflected in the correlation coefficient (Tables 2.4 and 2.8), was minimal. In Experiment 3 the PWL within a flock had a significant influence on chick body weight to five weeks of age (Table 3.2). This data demonstrates the variability in chick quality that can be found not only between parent breeder flocks of different age, but also between chicks within the same flock.

The high correlation between egg weight and chick weight and the significant influence of initial chick weight on subsequent growth, as previously reported (Tindell and Morris, 1964; Merritt and Gowe, 1965; Morris _et al_.,1968), present useful information for hatchery management and flock performance expectations of broiler producers. A more consistent emergent time and chick weight can be obtained by sorting eggs by weight prior to incubation. Eggs set for incubation in pre-determined weight groups hatch in a shorter period of time, and thus the resulting chicks do not need to be held for extended periods in the hatcher. This reduces the extremes in dehydration reflected in PWL, and results in a higher quality chick with more consistent growth performance results (Hager and Beane, 1983; Misra and Fanguy, 1978).

In the past, the quality of chicks from old flocks has been a subjective term, at times being described as having a "mushy" conformation, of less than ideal firmness. Chicks of this consistency were thought to be of poorer quality and thus were considered to be poorer performers. However, chicks from old flocks, which include a higher proportion of these "mushy" chicks, were superior in performance to chicks from young breeder flocks (Table 2.5). When individual body weights were analyzed utilizing linear regression analysis, chicks from old breeder flocks, whether male or female, had significantly superior body weight gains (g/day) than did chicks from young breeder flocks. Uneven growth in broiler chicks when placed in industry could be attributed to differences in breeder flock age. It would be economically advantageous to obtain chicks from older flocks due to their superior growth potential.

Placement management treatments in particular housing conditions had differing effects on growth performance. In Experiment 1, chicks reared in batteries on wire floors exhibited a greater response to the medication and time of feed placement treatments than did the chicks in Experiment 2 that were raised in floor pens with straw bedding. The effect of the type of flooring on performance was not included in the experimental model and may have had an influence on the results by inhibiting or encouraging access to the feeders and waterers (Deaton et al., 1974). With the increasing pressure on producers to reduce costs and improve efficiency however, considerable attention is being paid to raising broilers in tiered cages instead of on open floors. This would increase space utilization and would make the research reported here beneficial. Optimum performance may be achieved by different management methods than presently used for floor pen conditions.

Water soluble Neo-Terramycin significantly improved body weights in chicks in batteries to four days of age. Significant interactions indicated that old flock chicks and male chicks had improved performance attributable to Neo-Terramycin. Withholding feed so that chicks could rehydrate prior to the initial feeding did not improve body weight but rather reduced body weights until five weeks of age. Plavnik and Hurwitz (1985) reported that the restriction of feed intake resulted in compensatory growth and improved feed efficiency, whereas short-term feed deprivation, as reported here and previously by Wilson and Dugan (1987), did not significantly improve overall performance.

Neither medication nor withholding feed however, had any significant effect on body weight in chicks raised in floor pens in Experiment 2. This could be attributed to the housing conditions, overall improved health status of the chicks at hatch due to a lower level of disease challenge (Williams, 1985), or improved quality of chick due to a higher PWL caused by being held in the hatcher for an additional 12 hours.

Dietary protein and energy treatments were designed in Experiment 3 to explore the effect of altering the protein and energy levels in practical diets characteristic of current commercial rations. All rations contained similar ingredient profiles (Table 3.1). High crude protein levels in diets fed to chicks have been shown to increase the carcass moisture content (Seaton et al., 1978; Jackson et al., 1982a). However, extremely high crude protein levels in the diet have also been reported to decrease growth performance (Sunde, 1956; Hargis and Cregor, 1980; Jensen et al., 1987). A dietary crude protein level which would assist the chick in rehydration but not negatively affect growth performance, was sought as a dietary starter treatment for high PWL chicks. High crude protein starter diets did not assist in the rehydration of chicks but significantly reduced body weight to six weeks of age. Chicks had higher carcass crude protein levels and lower fat levels, in agreement with previous reports (Mabray and Waldroup, 1981; Jackson et al., 1982c; Cabel et al., 1988).

Some amino acids may have a regulatory function, with the specific ability to act as regulators of synthesis or degradation of lipogenic enzymes and to have a role in the rate of lipatic lipogenesis (Maurice, 1986). The mechanism of this regulation could be of significant importance in obtaining the optimum growth performance and carcass composition of chicks through dietary manipulation.

Low energy starter diets resulted in significantly heavier body weights until four weeks of age, which is in disagreement with previous reports (Deaton et al., 1973; Kubena et al., 1974). The significantly lower feed efficiency at three and four weeks indicates that the chicks were able to compensate for the lower energy level in the diet by increasing feed consumption. A significantly heavier gizzard weight, and shorter duodenum and small intestine lengths (cm/100g of body weight) indicate a shorter feed retention time and a faster rate of passage through the gut.

A significant PWL by energy interaction at one week of age indicates that high PWL chicks did respond to a diet which contained the higher energy level. This same interaction was nonsignificant (P<.057) at two weeks of age, but indicated a treatment response trend.

Starter diet crude protein and energy levels were found to have an effect on growth performance, but have limited use as a management tool to assist day-old chicks in improved growth performance.

4.2: CONCLUSION

The research reported has demonstrated that breeder parent flock age, initial egg and chick weight, and PWL through incubation are factors significantly affecting chick quality and the subsequent growth performance of day-old chicks. The variation in chick quality is considerable. These studies indicate that chicks from old breeder flocks have significantly higher body weight at six weeks of age than chicks from young breeder flocks. Variation also exists within a breeder flock, with chicks of low PWL through incubation being significantly heavier at five weeks of age than chicks of high PWL.

The use of water soluble antibiotics and the withholding of feed for four hours after placement as management tools have been shown to have a significant effect in specific circumstances. The broiler producer can better manage the day-old chicks he receives on the farm by obtaining as much information as possible about the age of breeder flock the chicks came from and the incubation conditions under which they were hatched. In this way he can manage their initial placement to best assist the chicks in rehydration and optimum growth.

Dietary crude protein and energy levels in starter rations were found to have little specific effect in assisting chicks to rehydrate and obtain optimum growth performance.

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