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Productive performance and fertility of broiler breeders maintained in commercial colony cages and on the conventional floors

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Productive Performance and Fertility of Broiler Breeders Maintained in Commercial Colony Cages and on the Conventional Floors

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(ABSTRACT)

A trial with four replicates was conducted to compare performance and fertility of naturally mated broiler breeders maintained on litter floor versus their counterparts maintained in two tiered colony cages. Cage maintained hens with restricted feeding weighed less ($P<0.05$) than those on the litter floors. No difference ($P>0.05$) was found in egg weights among treatments. No difference ($P>0.01$) was found in feed conversion ratio per dozen eggs produced by hens maintained in cages and those on the conventional floors. A higher ($P<0.05$) hen-day production was observed from 29 to 35 weeks of age in broilers maintained in cages than those on the conventional floors, but after this period no difference ($P>0.05$) occurred. There were more ($P<0.05$) eggs collected with cracks from cages than from the litter floors. The fertility rate was different ($P<0.05$) and it declined as the birds aged in both treatments. No significant ($P>0.05$) difference in mortality rate occurred between hens maintained on the litter floors versus those in cages. When the breeders were 41 weeks of age, eggs from each treatment group were randomly collected, weighed, and incubated. Offspring from these treatments were randomly allocated to litter floor pens. Progeny were spaced at 23 $cm.^2$ and were reared to 42 days. There was no significant ($P>0.05$) difference in growth rate and feed conversion ratio in offspring from hens maintained on the litter floors versus offspring from hens maintained in colony cages. No significant difference ($P>0.05$) in mortality rate was observed among chicks produced from eggs collected from both treatments. Broiler breeding in colony cages was economical up to 40 weeks of age.

Key words: Broiler breeders, Natural mating, Commercial colony cages, Litter floor, Fertility

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CHAPTER I. INTRODUCTION

The use of cages in commercial egg production has been widely accepted by the poultry industry. Cages eliminate eggs laid on the floor, as well as the need for litter, and laying nests. Eggs produced in cages are cleaner than those from conventional floor maintained hens. Feeding and care of birds maintained in cages require less labor, usually less feed, and culling of diseased, or non-productive birds is easier than with conventional floor reared chickens. Cages also allow for increased bird density in a given area (Petitte et al., 1983).

Past and recent problems in the broiler industry namely, increasing labor costs and diseases with birds maintained on the litter floors initiated interest in growing broilers in colony cages and coops (Rowland et al., 1971). Reed et al. (1966) listed high incidence of breast blisters as a major objection to rearing broilers in battery cages. Another problem was handling complications involved during` moving of birds in, or out of cages. However, interest in growing broilers in cages versus those reared on the conventional floor continues to grow. This growth is due to several factors such as, increased bird density per unit area, the growing shortage and increasing cost of litter material, reducing labor costs, and poultry zoning laws in some areas. Also, diseases and parasite incidences may be reduced when broilers are not in intimate contact with their fecal material (Reece et al., 1971).

Traditionally, broiler breeders have been maintained successfully on the conventional floor, and produce hatching eggs by natural mating (Fuquay and Renden, 1980). A major problem associated with this mating system is a decline in fertility after 40 weeks of age (Van Krey and Siegal, 1976). Infertility in overweight males may be related to the reduced frequency of successful matings (Parker and Arscott, 1964; Wilson et al., 1979).

Fuquay and Renden (1980) reported that reproductive inefficiency is the most costly item facing the broiler industry. Feed restriction and selection of healthy broiler breeders for use in cages may result in improved fertility and hatchability, hen-day production, feed conversion ratio, and the initial high body weight of the progeny (Van Wambekeke et al., 1979). In addition, the increase in broiler breeder density during the breeding phase accompanied by cage management advantages, represents a high potential in reducing production costs and maximizing profits. This study compared broiler breeders maintained in a two tiered commercial broiler breeder colony cages using natural mating with their counterparts maintained on the conventional (one third litter and two third slatted) floor system.

CHAPTER 2. REVIEW OF LITERATURE

2.1 Physiology and Reproduction

As hens and roosters age, egg production, fertility, and hatchability decrease (Atwood, 1929; Robinson et al., 1990). Fertility and hatchability also decline as hen weight increases (Fasenko et al. 1992). (Fasenko et al. (1992) demonstrated that embryos from first eggs of a sequence were not as viable, but were more developed than embryos of subsequent eggs. In summary, body weight and embryo development viability increased as hens and roosters aged, but eventually declined as hens grew older and were overweight. They also observed that embryos from eggs laid in the morning developed more rapidly than those from eggs laid later in the same day.

Bilgilli and Renden (1985) studied the relationships among body weight, body fat, oviduct fat and fertility in dwarf broiler breeders. They reported that body weight was positively correlated with body fat and oviduct fat. Although body weight and body fat were negatively correlated with fertility, oviduct fat was not significantly correlated with this variable. This study concluded that the adverse effects of increased percentage of body fat and decreased fertility involved mechanism(s) other than increased fat deposition in the oviduct area. Broiler breeder males maintained in cages produce more volume and concentrated semen than those maintained on litter floor (Renden and Pierson, 1982a, b). They showed that viable semen can be collected from cage maintained broiler breeder males from 34 to 105 weeks of age with no significant differences in semen volume, sperm concentration, and total sperm ejaculate or fertility. Wilson et al. (1979) reported that fertility with natural mating is poorly correlated with the physical characteristics of the male broiler breeder. They also reported that correlation between a male broiler breeder's quality of semen and fertility are not significant in natural mating. However, Harris et al. (1984) observed a linear regression on broiler breeder's body weight with the volume of semen production, and it was positively correlated with fertility.

Crawford (1962) compared the performance of meat type roosters raised in cages to those maintained on conventional floor. Roosters placed in individual cages were compared to all male flocks and unisexual flock (roosters mixed with hens) maintained on the floor. At 239 days of age, roosters in cages weighed significantly more than unisexual, and male flocks on the floor. The unisexual flock had a significantly higher mortality rate than the male flock and individually caged roosters, respectively. Fertility among the three treatments was not different.

White leghorns roosters were caged individually and in pairs to study their semen characteristics. Sperm motility, semen volume, fertility, and hatchability were measured after 147 days old. There were no significant differences between individual and paired roosters in cages in all parameters measured, except semen volume. There was significantly higher semen volume from roosters in single cages than those in pairs per cage. It was evident that subordinate members from paired cages produced less semen than the dominate members (Crawford and Proudfoot, 1967).

In another study to determine the influence of maintaining roosters in cages versus litter floors, Parker and McClurskey (1959) reported that the semen volume per ejaculate was not significantly different between cages and the floor reared birds. Semen fertility capability did not differ significantly, although percent fertility of semen from cage males was higher than males maintained on littered floor.

Bramwell et al. (1996) used artificially inseminated and naturally mated flock in experiments to determine the effect of age on sperm penetration into the perivitelline layer overlying the germinal disc. They found out that in artificial insemination, sperm penetration into the perivitelline layer was lower in older hens than in younger hens regardless of the age of the male roosters used. They also observed that there was an increase in sperm penetration into the perivitelline layer and the germinal disc of younger hens when they used sperm donated by older male broiler breeders as compared to younger broiler males. These authors also reported that younger broiler male's ejaculate contained a higher percentage of dead sperm. Also, in this study they found that during natural mating, sperm penetration into the germinal disc and fertility decreased with the aging of the flock due to physiological conditions of individual hens. It was concluded that sperm penetration into the perivitelline layer and fertility declined with the male's senescence due to physical problems. These problems included rooster mating competition, physical injuries, and decreased libido, but not necessarily due to physiological limitations of the male gamete.

2.2 Slatted versus Litter Floors

Egg production and fertility drops when hens are reared on slatted floors as compared to litter floors, although egg production is increased per unit of space (Nordskog and Schierman, 1965). Newcombe et al. (1991) compared effects of dietary energy sources on growth and productivity of broiler breeders reared in slats and litter floors. They reported that there was no significant effect of flooring on growth, fertility and hatchability when different sources of dietary energy were used.

2.3 Cage Maintained Broiler Breeders

Robinson et al. (1996) used photo period to stimulate broiler breeders at 120, 130, 140, 150 and 160 days of age in cages. As age at photo stimulation increased, the age at sexual maturity decreased. This study showed no significant difference among treatments on first egg weight, average hatchability, and fertility. Egg production was higher in 140, 150, and 160 day old photo stimulated broiler breeders than 120 to 130 day old birds. Birds photo stimulated after 140 days of age reached sexual maturity with a better flock uniformity than those photo stimulated between 120 and 130 day old.

McDaniel et al. (1981) determined that body weight was negatively correlated with egg hatchability and shell quality (specific gravity), and hen-day production of broiler breeder hens, but not egg weight. The authors also observed that egg shell quality had a significant positive correlation with fertility. They found that fertility was positively correlated with hatchability and hen-day production, and that hatchability was positively correlated with hen-day production.

Egg fertility and hen body weight were inversely related to each other when the hen's average body weight is surpassed (Yu et al., 1992). In two simultaneous studies, Goerzen et al. (1996) maintained broiler breeder hens on *ad libitum* feeding and restricted feeding in cages to compare feeding effects on body weight. In study 1, there were no differences in the duration of fertility between restricted and *ad libitum* feeding. In study 2, *ad libitum* fed broiler breeder hens had a significantly lower duration of fertility than restricted fed hens. These results demonstrated that increased body weight for full-fed mature hens reduced egg fertility, hatchability and embryonic viability.

Sexton et al. (1989) collected broiler breeder's semen to determine the effect of five energy levels (1600, 2000, 2400, 2800, and 3200 Kcal. M.E. kg^{-1}) in broiler breeder males maintained in cages from 30 to 60 weeks old. Males that received the lower (1,600 and 2,000 Kcal. M.E. kg^{-1}) had reduced semen volume with advancing age than those which received higher energy. Sperm count decreased in all groups as age advanced. Fertility and testosterone decreased as the male's age increased, but was more significant in groups receiving 1,600 to 2,400 Kcal. M.E.kg^{-1}. Parker and

Arscott (1964) reported that decreasing caloric content to less than 2,000 M.E. kg^{-1} in a diet for white leghorns males reduced their semen volume and its fertilizing capability, and this finding supports Sexton et al. (1989) observations.

Brown and McCartney (1986) used 4 levels (115, 85, 70, and 55%) and compared them to National Research Council (NRC) requirements as a 100% standard guide of restricted feeding in 2 experiments to examine the reproductive performance of individually caged broiler breeder males. Total body weight decreased significantly as feed intake was reduced from the recommended NRC percentages. Feed restriction levels of 85, and 70% did not significantly affect semen volume. However, dietary 55% restriction reduced semen volume in the first experiment. The dietary level also caused significant reduction in testicle weight. There were no significant differences with luteinizing hormone level due to variations in fed restriction percentages.

2.4 Cage versus Litter Floor Management

Fuquay and Renden (1980) studied the performance of broiler breeders maintained in cages and litter floor in 2 experiments. Semen samples were collected weekly between 36 and 60 weeks of age. In the first experiment, broiler breeder hens were placed individually, or in pairs per cage. Broiler breeder males were assigned individually to similar cages and semen was collected 3, 5, and 10 times per week from 30 to 60 weeks of age. Broiler females were inseminated with semen from known male breeders. No significant differences were observed in semen volume and concentration among breeder roosters up to 59 weeks old. Total sperm count per ejaculate was more from broiler breeders ejaculated 5 times per week. The fertility rate and hatchability were not different among the male breeder treatment groups.

In the second experiment, female broiler breeders were assigned to floor pens with male to female ratio of 1:25, 2:25, and 3:25 for natural mating. Eggs were collected for 7 days. The study found no significant differences in fertility and hatchability among eggs from the different male to female broiler breeder ratio. Comparison of the two studies revealed more eggs were laid per day by birds maintained on the floor than those in cages throughout the production cycle. The results from this study contradict McDaniel (1974) who reported that broiler breeder hens produced more eggs when in cages than on the floor. Fuquay and Renden (1980) found that the body weights of caged female broiler breeders were significantly higher than females maintained on the floor. The study found better fertility and hatchability for broiler breeders maintained in cages with artificial insemination than naturally mated broiler breeders maintained on the floor. The flock weight uniformity was not significantly different among broiler breeder hens maintained on the floor, but there was a flock weight difference among cage maintained broiler breeder hens.

Broiler breeders housed in cages lay heavier eggs than their litter floor managed counterparts (Petitte et al., 1982). In three trials Petitte et al. (1983) evaluated production efficiency of cage maintained broiler chicks versus floor maintained broiler breeders. Fertility of artificially inseminated caged broiler breeders was significantly lower than that of naturally mated breeders on the litter floor. Early embryonic mortality difference was not significant among eggs from caged, or litter floor housed broilers. Egg hatchability in trial 1 was not different among housing arrangement, but there was a significant lower fertility in eggs from caged broilers. Hatchability for eggs in trials 2 and 3 was significantly lower for caged than floor managed broiler breeder hens. Offspring from caged broiler breeders in trial 2 were significantly heavier at 42 days of age (slaughter time) than their counterparts on the litter floor. However, the same result was not observed in trial 3 which were slaughtered at 49 days of age. No significant effect on broiler feed efficiency and mortality occurred among the maternal pen management in these studies.

Lessen and Summers (1985) trials on rearing performance of cage versus floor rearing of dwarf broiler breeders showed no significant differences on egg production among these housing treatments. Renden and Pierson (1982a) reported that caged hens were significantly heavier than floor managed broiler breeder hens at 26 weeks of age. They observed that mortality, hen-day production, and feed conversion (kg. feed per dozen eggs) between cage and floor managed hens were insignificant. Fertility of broiler hens naturally mated on the floor was significantly better than that of artificially inseminated cage maintained dwarf broiler breeders. Carter et al. (1970) reported that there was no significant difference in egg production, egg size, and hatchability of fertile eggs from natural mating of broiler breeders maintained in sloppy wire floor versus litter floor. However, there was significantly lower egg fertility in wire managed broiler breeders than floor managed broiler breeders.

In a study to test uniformity of body weight in broiler breeders maintained on the litter floor versus cages, Petitte et al. (1982) observed no significant differences in productive performance among flocks of 80% and 89% of body weight uniformity. They also observed that caged broiler breeders produced significantly more eggs than floor maintained breeders during peak egg production, but cumulative egg production was not significantly different. Caged broiler breeders laid significantly heavier eggs than their floor counterparts with similar mortality rates. These authors also reported that naturally mated broiler breeders on the floor exhibited a significant higher fertility than artificial inseminated breeders in cages. Their study revealed that cage maintained broiler breeders were significantly heavier than floor maintained hens throughout their reproductive cycle. Reece et al. (1971) reported that male and female broilers raised in cages were significantly heavier and had a higher feed consumption per gain at 8 weeks old than their counterparts raised on the floor. Andrews and Goodwin (1973) compared the performance of growing day old broilers on cages versus litter floor. At 8 weeks of age, they found that cage raised broilers were heavier than floor raised birds, but the difference was not significant. However, at 9 weeks of age, cage reared broilers were significantly heavier than floor grown broilers. They found no significant difference in feed efficiency.

2.5 Leg Weakness

Deaton et al. (1970) raised broilers in cages and compared their leg problems with those raised on the litter floor. At 8 weeks of age cage raised broilers had more leg weaknesses than floor reared broilers. In both treatment groups male broilers had more leg weaknesses than their female counterparts. Stake et al. (1978) found battery cage reared broilers had more incidences of curled toes than broilers raised on the floor. Reece et al. (1971) reported that leg weaknesses were significantly higher in cage raised broilers than for those raised on the floor. This study showed that leg problems were significantly increased in cage raised broilers during summer than those raised in winter season. Fuquay and Renden (1980) observed more leg problems in male breeders raised in cages than those on the floor, but females were unaffected. They found no association between broiler breeder males body weight with leg problems.

In an evaluation for leg abnormalities in broilers, Petitte et al. (1983) reported that male broilers were more susceptible to these damages than female broilers. May and Cox (1970), and Reece et al., (1971) observed higher incidences of leg weaknesses in broiler males than females reared in cages than those managed on the litter floor.

2.6 Effects of Egg Size

Skoglund et al. (1952) studied the growth of broiler chicks hatched from various sized eggs (43 to 71 gm. each) when reared in competition with each other. The initial weight of a day old chick increased as the egg weight from which they hatched increased. The weight difference decreased as chicks grew older, but at 12 weeks of age chicks from eggs weighing over 59 gm. were significantly heavier than chicks from eggs weighing less than 52 gm. After 12 weeks of age, the chicks growth rate weights were not significantly different. They also found that the initial mortality rate was higher in chicks from egg sizes lower than 52 gm. as compared to chicks from eggs weighing more than 59 gm. Goodwin (1961) reported that as the weight of an egg increased, the weight of the chick increased up to 9 weeks of age. In a similar experiment, Skoglund and Tomhave (1949) reported that chicks produced from eggs weighing 63.8 to 71 gm., weighed heaviest at 12 weeks of age than chicks from eggs weighing 43 to 52 gm. In experiments to determine the effects of wire and litter floor broiler breeder management on egg weight and specific gravity, Harms et al. (1984) reported higher egg weight from broilers managed on wire floors than hens on the litter floor. There was a significant higher specific gravity in eggs from litter floor than those from cages.

In an experiment to determine the effects of egg weight (18-19.99, 20-21.99, 22-23.99, 24-25.99) on subsequent broiler performance, Tindell and Morris (1964) reported that egg fertility increased with its size. In addition the larger the egg the higher the initial weight of the chick. In a similar experiment Proudfoot and Hullan (1981) observed that there was no significant difference in fertility and hatchability between large (53.0 grams) eggs and small size (47.98 grams) eggs. Egg size had a significant effect on chick's body size at 48 days of age. Feed conversion efficiency was slightly better for chicks hatched from larger eggs (53.0 grams). This study concluded that the size of hatching eggs could influence the subsequent growth of broiler chicks up to slaughter age.

2.8 Conclusion of Literature Review

Semen fertilization capability is not affected by increased broiler breeder males body weight and age. Roosters senescence and over weight reduces their libido and natural mating competition with other roosters in the same flock. As broiler breeders age they increase in body weight. This weight increment is associated with a decline in egg fertility and hatchability, hen-day production, and egg shell quality. Fertility in chickens is negatively correlated with body weight and fat deposition. Broiler breeders maintained in cages with *ad libitum* feed lay larger and increased number of eggs than their counterparts maintained on the litter floor. Incidences of leg problems occur more frequently in broiler breeders maintained in cages than on the litter floor as well as more incidences occur in males than females. Chicks hatched from large size eggs have an initial higher body weight up to 12 weeks of age than those from smaller size eggs. Fertility and hatchability are positively correlated with egg size. Natural mating of broiler breeders on the litter floor is common in the poultry industry. There is evidence that maintaining broiler breeders in cages using artificial insemination would yield good fertility and offspring performance. However, there is limited research reported on the performance of broiler breeders maintained in the colony cages using natural mating and the performance of their offspring.

2.9 Objectives

The first objective of this experiment was to compare production efficiency between broiler breeders maintained in commercial broiler breeder colony cages using natural mating with those maintained on the conventional floors. A second objective was to compare production efficiency between broiler breeders maintained in the top tier using natural mating with those maintained in the bottom tier commercial broiler breeder colony cages. A third objective was to evaluate the productive performance of progeny from broiler breeders maintained in the commercial broiler breeder colony cages using natural mating versus offspring from broiler breeders maintained on the conventional floor system when reared on the litter floor.

CHAPTER 3. MATERIALS AND METHODS

3.1 Experimental Procedure

Day old (189 males and 1,500 females), Hubbard Hi-Y parent broiler breeders were raised separately on floor pens in accordance with the breeder management guide (Hubbard farms, 1994). Broiler breeder starter ration containing 17-18% crude protein and 2,810-2,800 M.E. calories kg^{-1} was fed *ad libitum* from day 1 to 7 days of age. Feed restriction according to the chicks age using the same feed was started in the second week. From 2 weeks of age, 50 chicks were chosen randomly and weighed every week to determine the average feed requirement for that week. From 12 to 19 weeks of age, a skip-a-day restricted feeding program using a broiler breeder grower ration containing 15-16% crude protein and 2,920 M.E. calories kg^{-1} was used. At 20 weeks of age, 40 pullets were randomly selected and weighed individually to determine the average amount of broiler breeder layer ration containing, 15-16% of crude protein and 2,920 M.E. calories kg^{-1} (Appendix 1, Table J), to be fed in that week. Restricted feeding recommendations as outlined in the broiler breeder management guide (Hubbard farms, 1994) were followed to maintain broiler breeder body weight targets, skeletal size, and body weight uniformity.

A centralized hot air heating system was used to provide brooding heat. Chicks were started at a temperature range of 30-31 ^{0}C then lowered to approximately 3 ^{0}C per week until 18-21 ^{0}C was reached. Correct brooding temperature was determined by observing the even spread of the chicks over their entire brooding area. Twenty four hours of artificial light was provided per day in a light controlled house from one to three days of age. Twelve hours per day of the same light was provided from 4 to 21 days of age followed by eight hours light up to 20 weeks of age. Water was provided *ad libitum* in all age groups using nipple waterers.

At 20 weeks of age 25 healthy pullets were randomly chosen and placed in each commercial broiler breeder colony cage unit (Figure 3.2.1). Each colony cage unit measuring 2 meters long, 1.05 meters wide, and 0.7 meters high housed 28 broilers. Birds were spaced at 13 broilers/m^2. A skip-a-day feed control program initiated at 12 weeks of age continued until the first egg was laid at 24 weeks of age when restricted daily feeding was adopted. Feed volume was increased by 454 grams per 100 birds immediately after 5% egg production was reached at 27 weeks of age. The amount of feed was increased at the same rate after each increase of 5% egg production until over 35% egg production was achieved at 28 weeks of age. House temperature was maintained at 16-27 ^{0}C using fans and window curtains. Lighting in the curtain sided laying house was artificially controlled, starting with 14 light hours per day at 21 weeks of age and increasing by an hour every two weeks until a maximum of 17 hours was reached at 27 weeks of age.

During the 20th week of age, 3 roosters were randomly selected and placed with the 25 pullets in each colony cage. This made a 1:8.3 male to female ratio. Nine hens (three per colony cage) and three roosters (one per colony cage) from the top tier were weighed weekly to determine the average amount of broiler breeder layer ration to be fed to both layers and roosters in that week. The same number was weighed from the bottom tier colony cages. Hens were allowed to feed from any 72 feeding spaces through cage grills measuring 5 cm. long by 24 cm. high, but the roosters had 4 special feeding spaces measuring 8 cm. long by 24 cm. high within the feeder grills to restrict their feed intake. The feeding system was automated. Each cage had a 200 cm. long, 5 cm. wide and 5 cm. high perch along the center. In addition, each colony cage had a darkened grey colored laying areas at one end measuring 40 cm. long, 105 cm. wide and 70 cm. high. Each replicate of the commercial colony cage unit housed 150 pullets and 18 roosters (Figure 3.2.1). There were four replicates making a total of 600 hens and 72 roosters maintained in the colony cages.

To compare the influence of managing broiler breeders in colony cages using natural breeding with those on the conventional floor pens, 180 pullets and 18 cockerels were randomly chosen from the same broiler breeder pullet and cockerel flock as those placed in colony cages. These broiler breeders were placed in 4 conventional floor pens, denoting four replicates. Each pen unit measured 8.9 meters long, 4.4 meters wide, and 2.5 meters high making a spacing of 5 birds/m^2. There was a total of 720 pullets with 72 roosters to maintain a 1:10 male to female ratio on the litter floors. Individual laying nests with grey colored pads measuring 30 cm. long, 30 cm wide, and 35 cm. high were raised 45 cm. from the floor in two tiers. There were 25 laying nests per row in each replication. Ten hens and three roosters from each pen were randomly caught and weighed weekly to determine the average amount of broiler breeder laying ration to be fed that week (Appendix 1, Table J). To keep hens from feeding from the roosters feeders, rooster feeder pan rims were raised to the average height level of the rooster's backs. Hens were fed from 16 automated round feeders each with 14 feeding slots measuring 5 cm. by 8 cm. to restrict roosters from getting the feed. Roosters were hand fed using two tube feeders. Feeding, watering, and lighting regime for floor maintained broiler breeders were similar to those maintained in the colony cages. The study comprised 1,464 broiler breeders (672 maintained in cages and 792 on the litter floors).

In both housing systems eggs were collected and recorded daily from 24 to 61 weeks of age. These eggs were compared for differences in egg weight, fertility, and hatchability. Every week, 10 egg samples, randomly collected at the same time from the two housing systems and their replicates, were incubated at 36.7 ^{0}C for 7 to 10 days (North and Bell, 1990). These eggs were then candled to determine fertility. Other comparisons in this study included hen-day laying percentage, body weight per broiler, feed conversion per dozen eggs, and mortality rate. Performance of offspring from broiler breeders maintained on the litter floors versus those maintained in the colony cages fed broiler complete ration (Appendix 1, Table I) in *ad libitum* were evaluated through comparisons of their growth rate, feed conversion ratio, and mortality rate when they were reared on the litter floor to 42 days (market time).

3.2 Experimental Design

Trial one data was divided into the main treatment and sub-treatment groups for statistical analysis. Data for broiler breeders maintained on the conventional floor pen unit compared to broiler breeders maintained in the colony cages Top tier-2A and Bottom tier-2A (Figure 3.2.1) formed the main treatment groups. Each treatment had four replicate groups. Data for broiler breeders maintained in the Top tier-2A compared to breeders maintained in the Bottom tier-2A formed the sub-treatment groups. There were four replicates in the sub-treatment groups. In the second trial, offspring from breeders maintained on the litter floor pen units 1 and 3 were compared to the performance data of progeny from breeders maintained in the Top tier-2A and Top tier-2B with the Bottom tier-2A and Bottom tier-2B respectively, to form three treatment groups. Each treatment group had one replicate. Growth rate data was recorded weekly. The broiler production parameters measured against time (age) as a sub-unit resulted in a split-plot experimental design in both trials.

The number of cracked eggs and fertility data comparisons were analyzed through a contingency table in the Chi-square test of homogeneity model. The other production parameter data were analyzed using the General Linear Model (GLM.) procedure (SAS Institute, 1991) for analysis of variance and regression analysis. The statistical significance was based on a probability of $P<$ 0.05 and 0.01 (Steel and Torrie, 1980). Mean responses were separated by Duncan's multiple range test for variables.

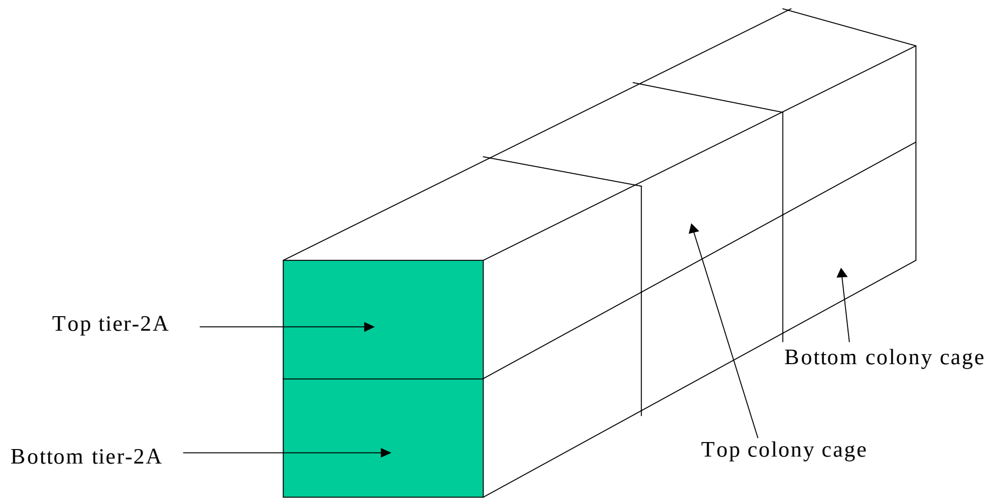

Figure 3.2.1 This sketch represents one of the four replicates used for maintaining broiler breeders in the colony cages. Each colony cage housed 25 hens and 3 roosters.

CHAPTER 4. RESULTS

4. 1. Body Weight

4.1.1. Layer Body Weight

In figure 4.1.1.1 and 4.1.1.2 body weights of broiler breeder hens maintained on the conventional floors versus those reared in the commercial broiler breeder colony cages as compared to their management targets (Hubbard farm, 1984) are presented. The weekly broiler breeder body weights in cages was below the company's targets, and were also significantly ($P<0.05$) lower than that of the hens maintained on the conventional floors. Body weights of layers maintained on the conventional floors were above the company's target. There were differences ($P<0.05$) in body weights between hens maintained on the conventional floors with those maintained in the colony cages from 43 to 61 weeks of age. There was no significant ($P>0.05$) difference in body weights between broiler breeder hens maintained on the top with those maintained in the bottom tier colony cages (Figure 4.1.1.2).

4.1.2 Roosters body Weight

Roosters maintained on the litter floors had body weights above (Figure 4.1.2.1) the company's targets (Hubbard farms, 1984). Roosters maintained in the colony cages did not show significant ($P>0.05$) differences in body weight increment with those managed on the conventional floors as their age advanced.

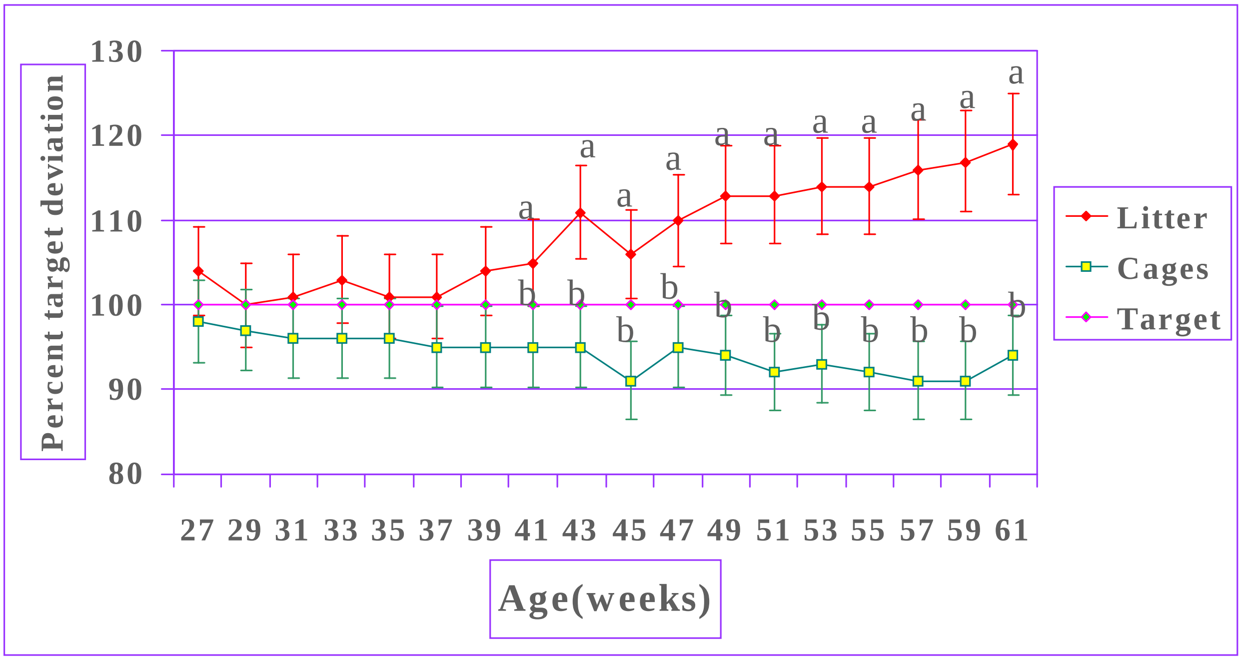

Figure 4.1.1.1. Percentage deviation of weight of hens maintained on the litter floors versus those in the colony cages as compared to their expected target weights during the laying phase. Values within time points with no common letters differ significantly (P<0.05).

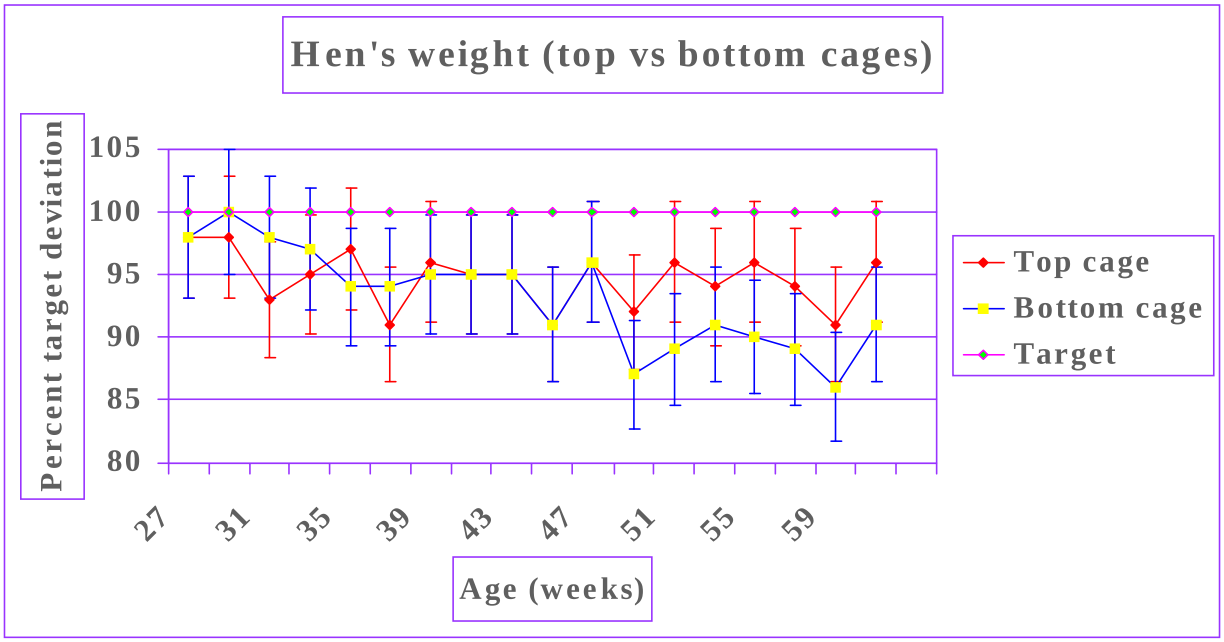

Figure 4.1.1.2. Percentage deviation of weight of hens managed in the top versus those managed in the bottom tier colony cages as compared to their expected target weights.

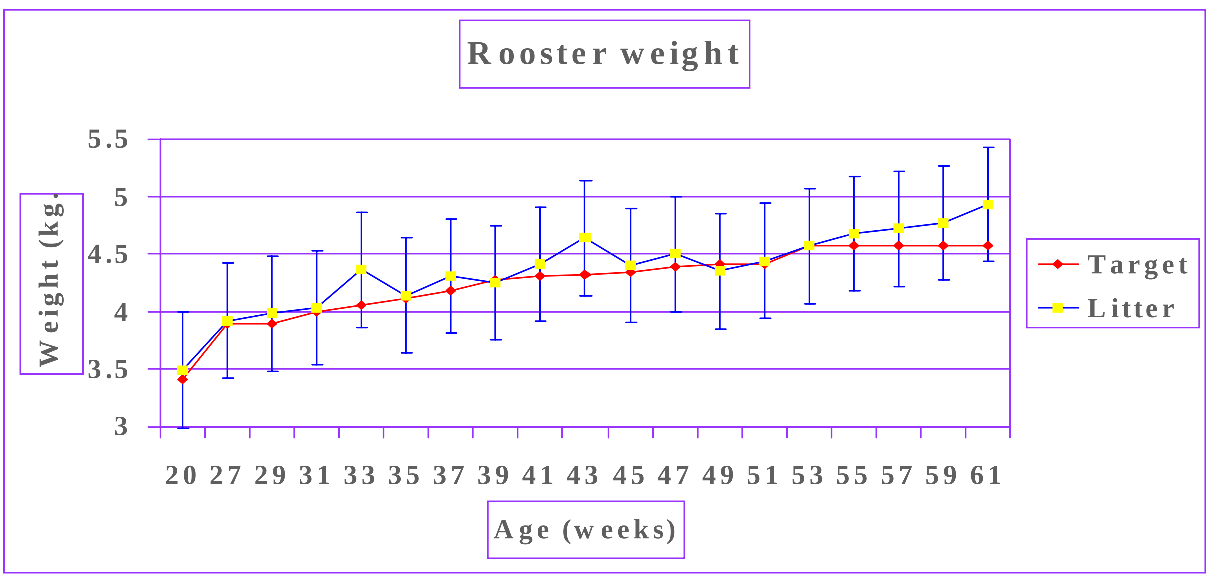

Figure 4.1.2.1. Mean ± SEM weight of roosters managed in the conventional floor as compared to their expected target weights during their natural mating period.

4.2 Egg Production

Egg weight was not different ($P>0.05$) between broiler breeders maintained in the colony cages with those maintained on the conventional floors (Appendix 1, Table A). Hens maintained in colony cages significantly ($P<0.05$) reached their peak egg production six weeks earlier (Figure 4.2.1) than those maintained on the conventional floors. Although, the hen-day production for broiler breeders maintained in commercial broiler breeder colony cages was significantly ($P<0.05$) higher than for breeders maintained on the conventional floors from 29 to 35 weeks of age, the entire period data did not show any difference ($P> 0.05$). Egg production for both treatments formed a binomial curve with peaks at 31 to 47 and 35 to 49 weeks of age respectively for broiler breeders maintained in the colony cages and those maintained on the litter floors. Improved ($P< 0.05$) hen-day production occurred in broiler breeders maintained in the bottom tier than in breeders maintained in the top tier breeder colony cages from 33 to 35 weeks of age (Figure 4.2.2). However, this difference was not significantly different ($P> 0.05$) when data was analyzed across the board.

4.3 Cracked Eggs

More ($P< 0.05$) cracked eggs occurred in commercial broiler breeder colony cages than on the litter floors (Figure 4.3.1). The number of cracked eggs collected from the top and the bottom tier colony cages were not different ($P>0.05$) throughout the experiment (Figure 4.3.2).

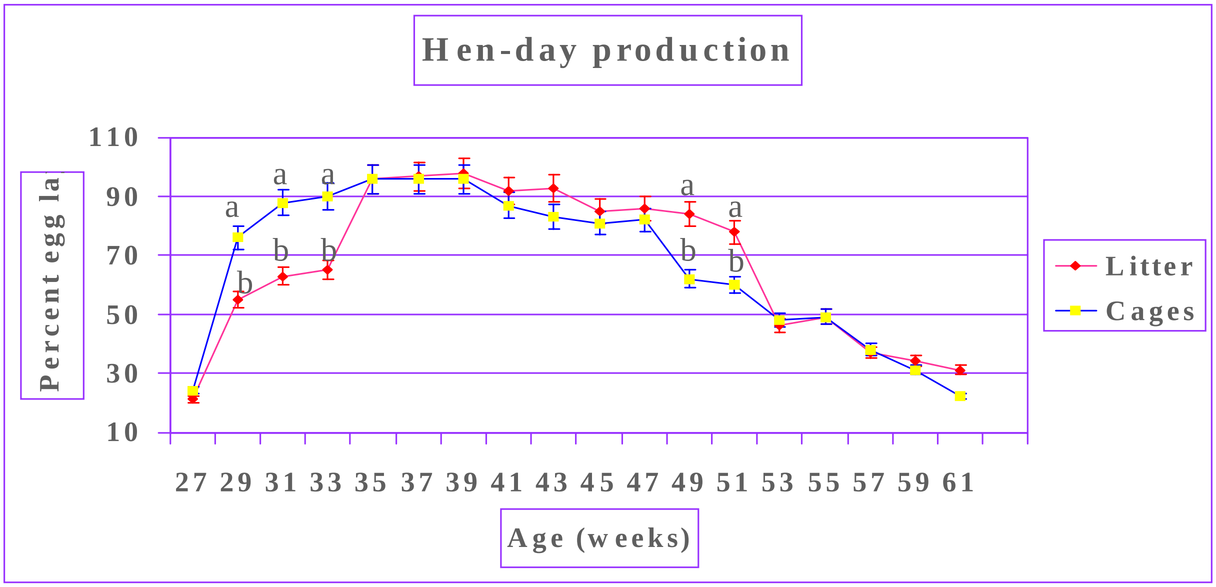

Figure 4.2.1. Percentages of hen-day production between broiler breeders maintained on the conventional floors and in the colony cages.

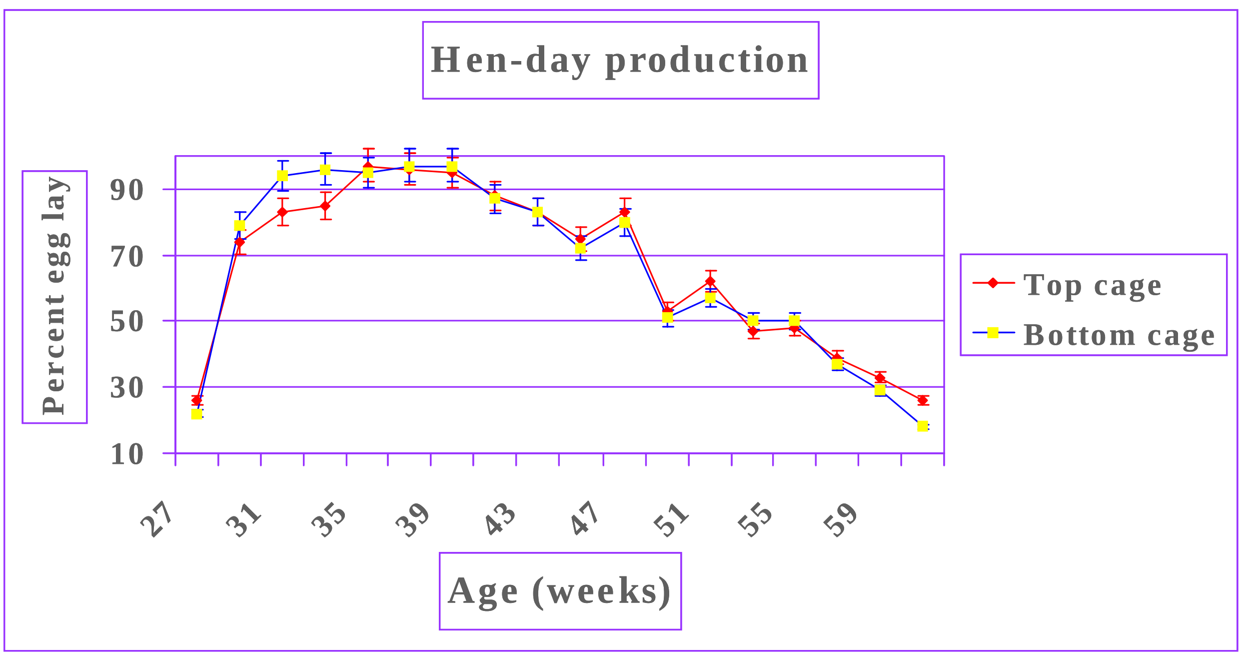

Figure 4.2.2. Percentages of hen day production between broiler breeders maintained in the top tier with those maintained in the bottom tier colony cages.

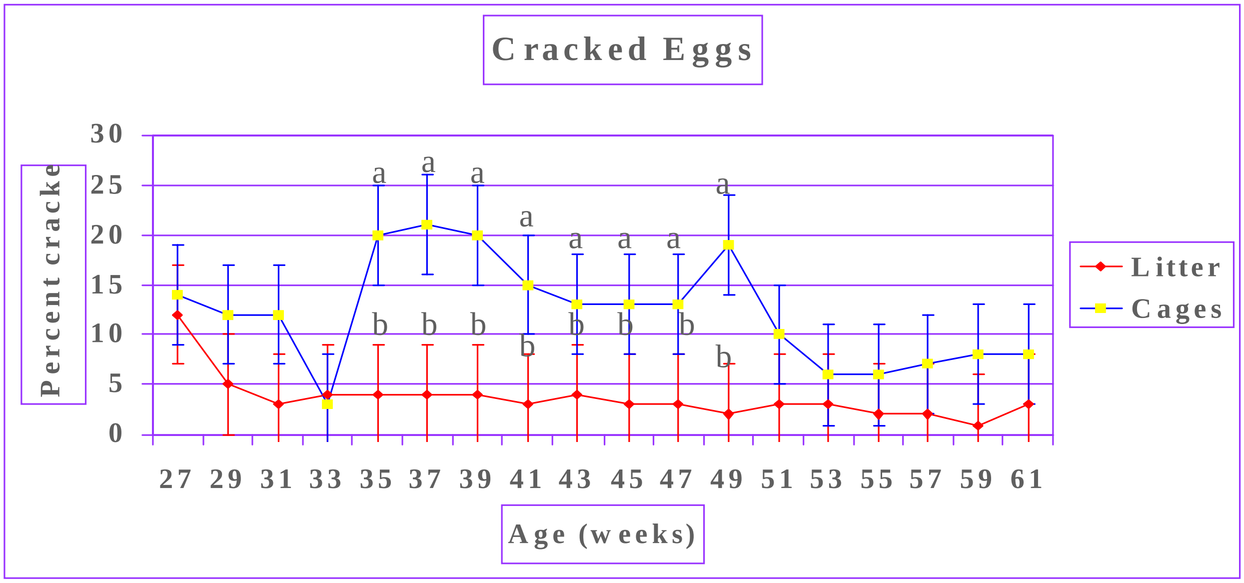

Figure 4.3.1. Percentages of eggs collected with cracks for broiler breeders maintained on the litter floors versus those in colony cages. Values within time points with no common letters differ significantly (P <0.05).

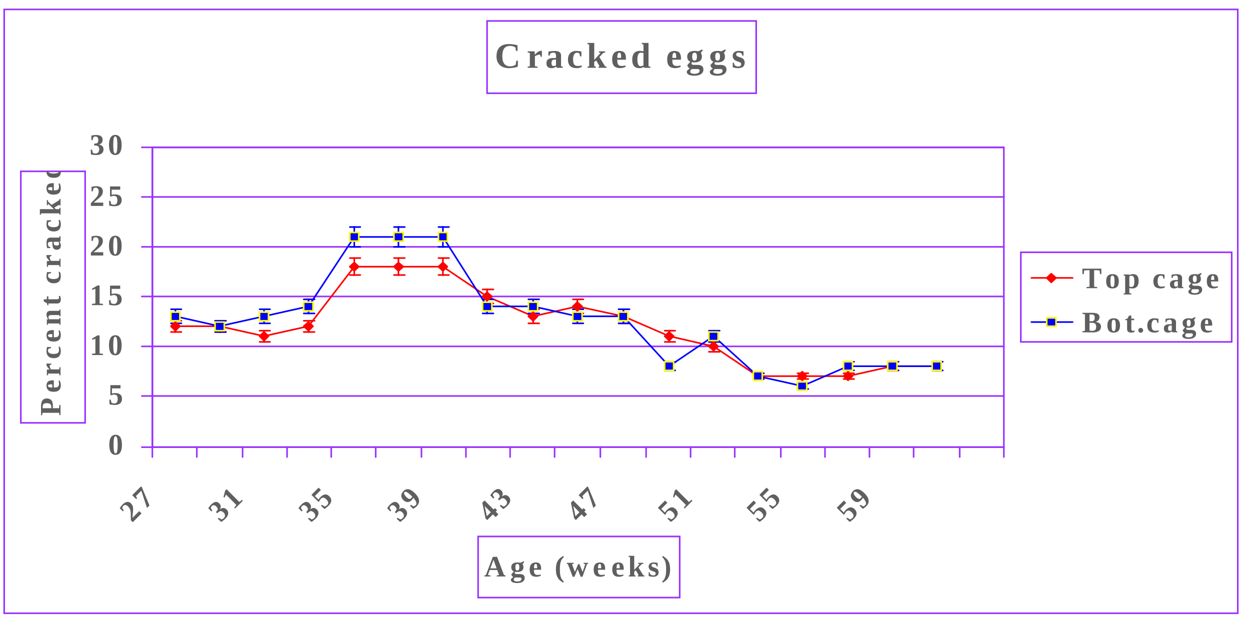

Figure 4.3.2. Percentages of eggs collected with cracks between broiler breeders maintained in the top tier and bottom tier colony cages.

4.4. Feed Conversion Ratio per Dozen Eggs

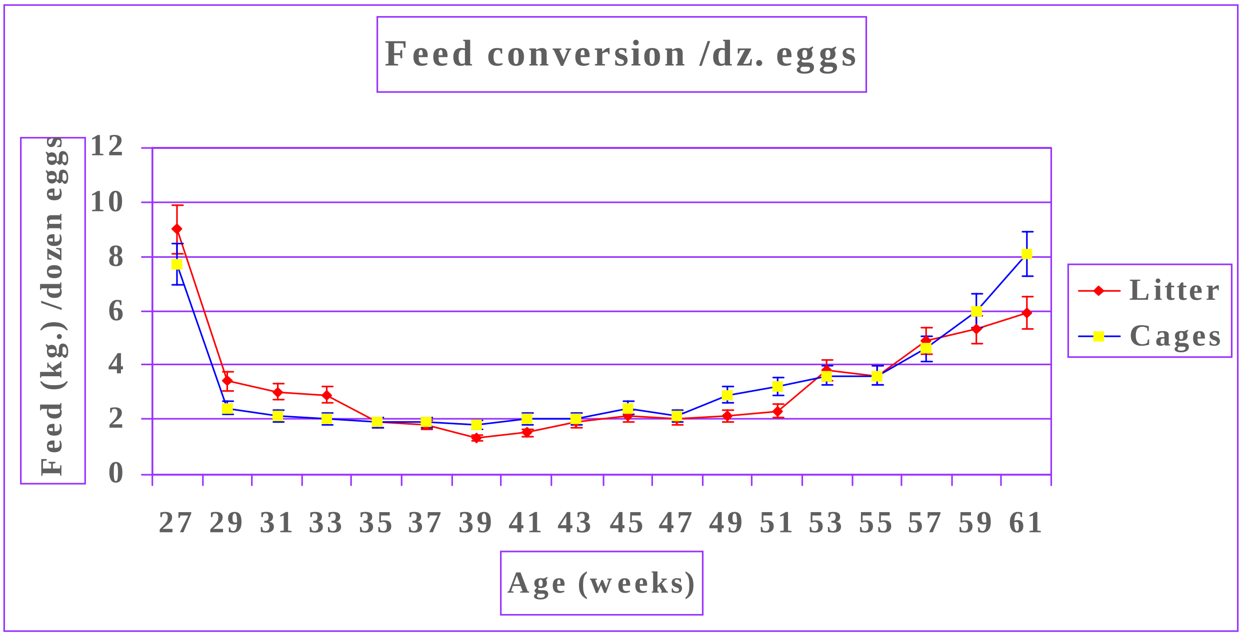

Figure 4.4.1. Feed conversion ratio per dozen eggs produced by broiler breeders maintained on the conventional floors versus those maintained in the colony cages during the laying phase.

Data collected for the feed conversion ratio per dozen eggs formed a negative binomial curve in both treatments (Figure 4.4.1 & 4.4.2). Appendix 1, Table C and D shows a summary of the feed conversion ratio for broiler breeder hens maintained on the conventional floors and in the colony cages. Broiler breeder hens maintained in the commercial broiler breeder colony cages had a significant ($P<0.01$) lower feed conversion ratio per dozen eggs (Figure 4.4.1) than their counterparts maintained on the conventional floors from 29 to 33 weeks of age. However, the overall data showed no difference ($P>0.01$) between these treatments. Although, there was a better feed conversion ratio per dozen eggs produced in the top than the bottom tier commercial broiler breeder colony cages, this difference was not significant ($P>0.01$) (Figure 4.4.2).

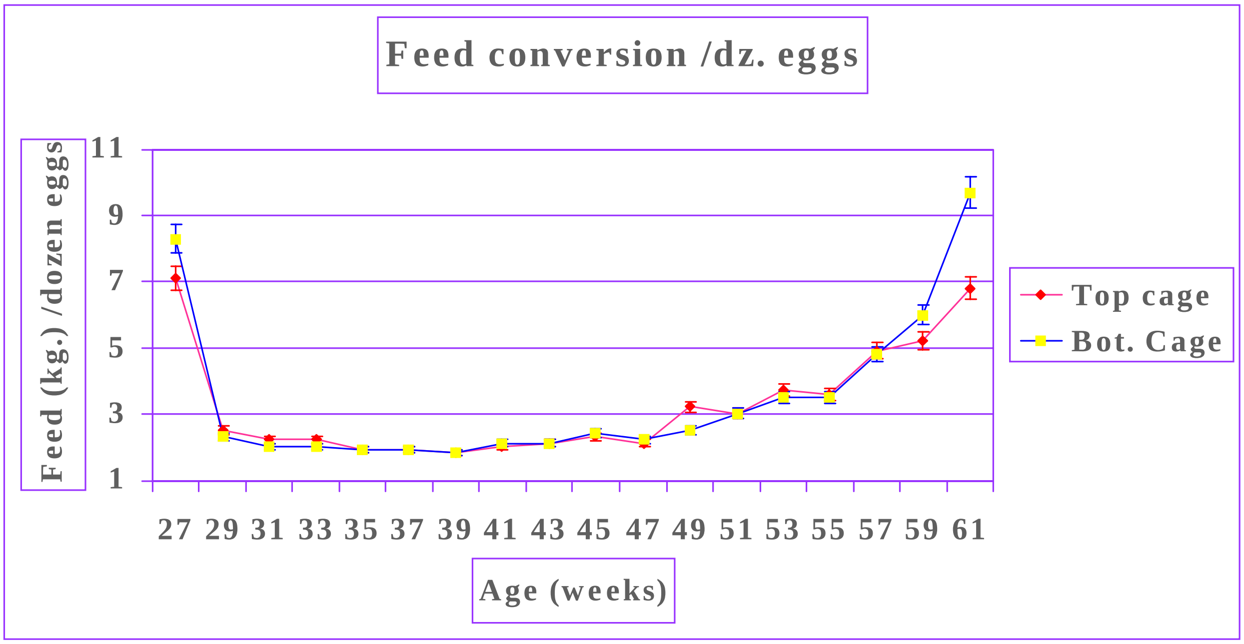

Figure 4.4.2. Feed conversion ratio per dozen eggs produced by broiler breeder hens maintained in the top versus those in the bottom tier colony cages.

4.5 Egg Fertility

Natural mating of broiler breeders maintained on the conventional floors had a higher (P<0.05) fertility rate than naturally breeding of breeders maintained in the commercial broiler breeder colony cages. This difference was significant (P<0.05) from 53 to 61 weeks of age for broiler breeders maintained and fertilized naturally on the conventional floors versus those maintained in the commercial broiler breeder colony cages (Figure 4.5.1). Fertility rate of eggs produced by broiler breeders maintained in the top and bottom colony cages was below 80% after 51 weeks of age and had declined to less than 50% from 57 weeks of age to the end of the trial. There was no differences (P>0.05) in fertility rate between eggs produced by broiler breeders maintained in the top versus those produced by breeders in the bottom tier colony cages (Figure 4.5.2).

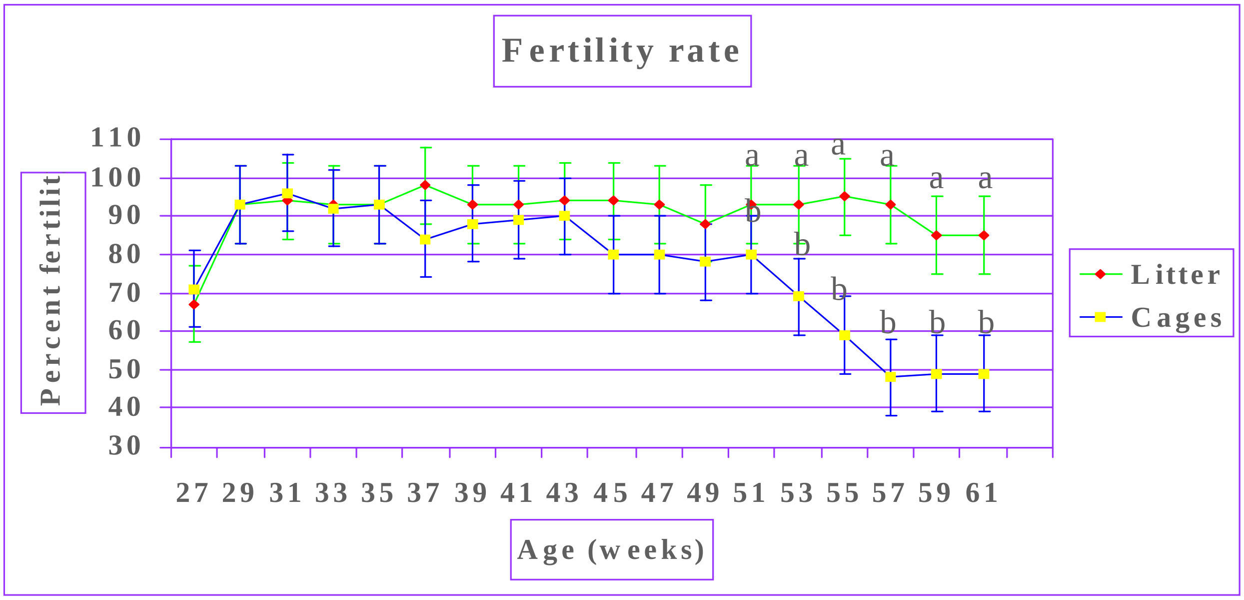

Figure 4.5.1. Fertility rate of broiler breeders maintained on the conventional floors using natural mating versus those maintained in colony cages with the same treatment. Values within time points with no common letters differ significantly (P <.0.05).

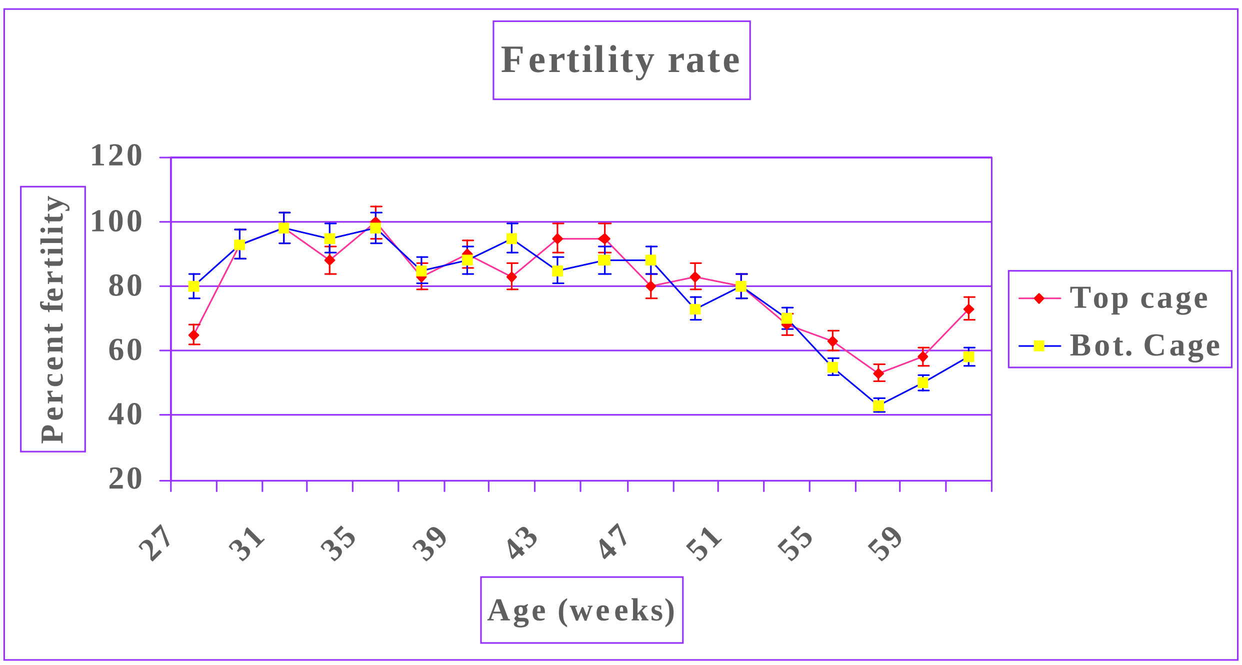

Figure 4.5.2. Fertility rate of broiler breeders maintained in the top tier using natural mating versus those maintained in the bottom tier colony cages.

4.6 Offspring

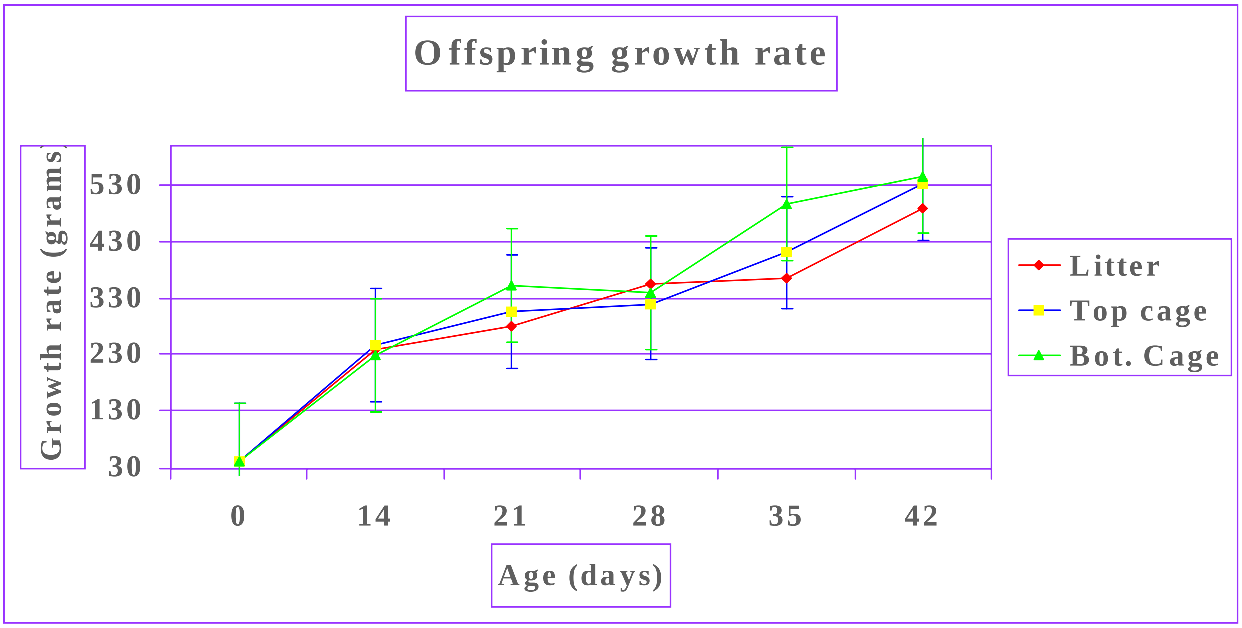

Figure 4.6.1. Mean ± SEM growth rate values of offspring from broiler breeders maintained on the conventional floors versus offspring from breeders maintained in the top and bottom tier colony cages for 42 days.

A summary of growth rate for offspring from broiler breeders maintained in the colony cages and on conventional floors is presented in Figure 4.6.1. No difference (P>0.05) in growth rate per week between progeny from broiler breeders maintained on the conventional floors and those from breeders maintained in the colony cages for the total feeding period was found (Appendix 1, Table H). However, progeny from broiler breeders maintained in the commercial broiler breeder colony cages showed an insignificant (P>0.05) faster growth rate than those from breeders maintained on the conventional floors from 14 to 42 days of age (Figure 4.6.1). No difference (P>0.05) was found in feed conversion kg^{-1} of weekly body weight gain for offspring from broiler breeders maintained on conventional floors versus those from breeders maintained in commercial broiler breeder colony cages (Figure 4.6.2).

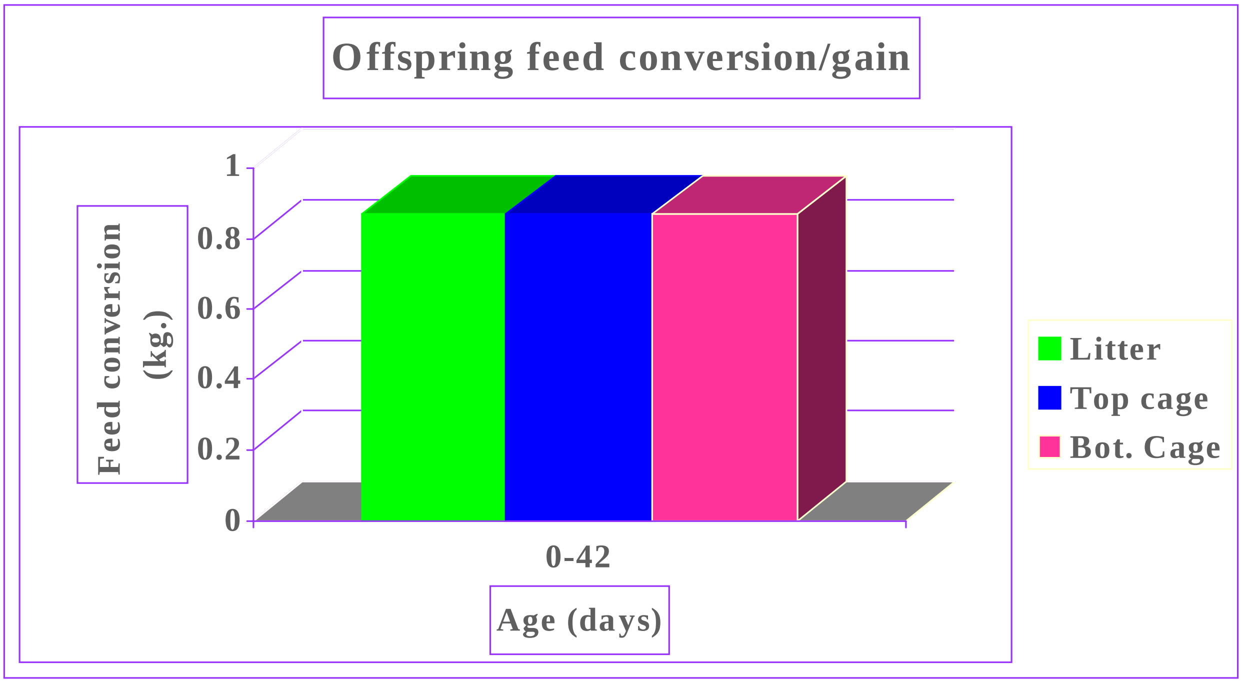

Figure 4.6.2 Feed conversion ratio for progeny from broiler breeders maintained on the conventional floors with natural mating versus their counterparts from the top and bottom tier colony cages.

4.7 Mortality Rate

The mortality rate of broiler breeder hens maintained on conventional floors was not different (P>0.05) from those maintained in colony cages (Figure 4.7.1). No mortality difference (P>0.05) occurred between broiler breeder hens maintained in the top tier versus those in the bottom tier colony cages (Figure 4.7.2). No difference (P>0.05) was found in mortality rate of offspring from broiler breeders maintained on conventional floors with progeny from breeders in colony cages (Figure 4.7.3).

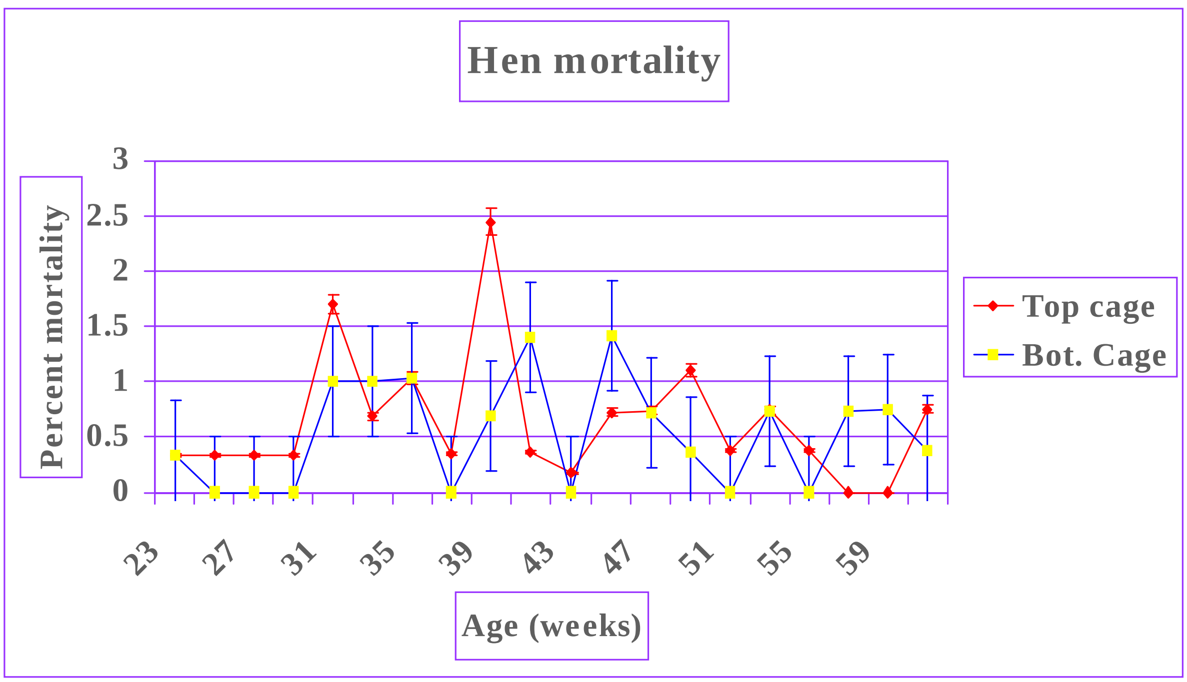

Figure 4.7.1. Mortality rate of broiler breeder hens maintained on the conventional floors versus those in colony cages with a similar treatment.

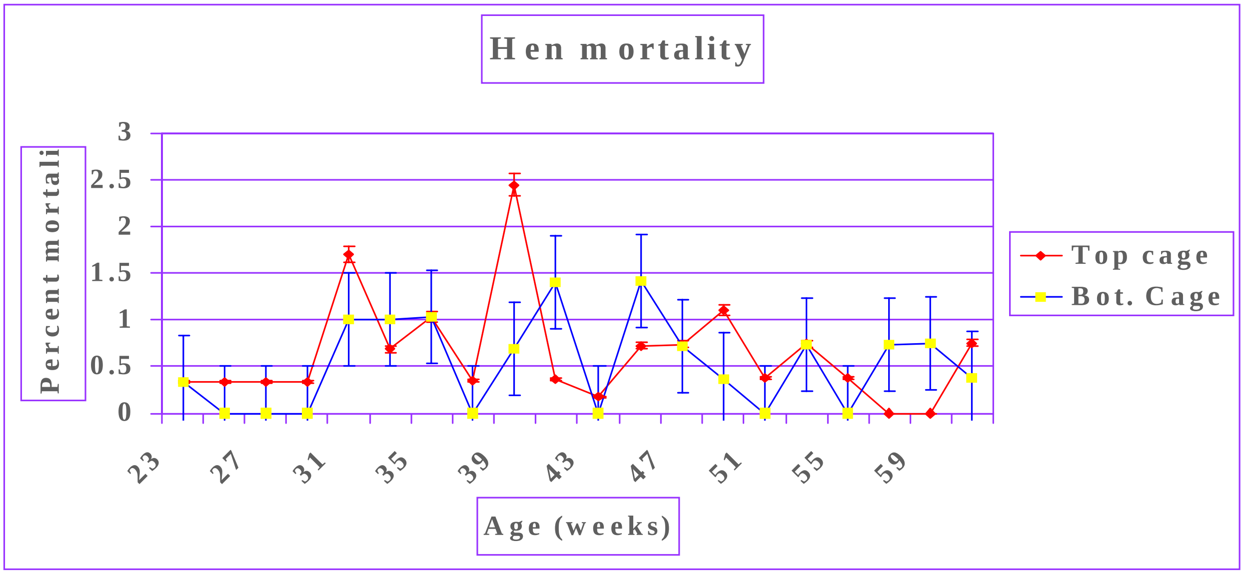

Figure 4.7.2. Mortality rate of broiler breeder hens maintained in the top tier versus those maintained in the bottom tier colony cages.

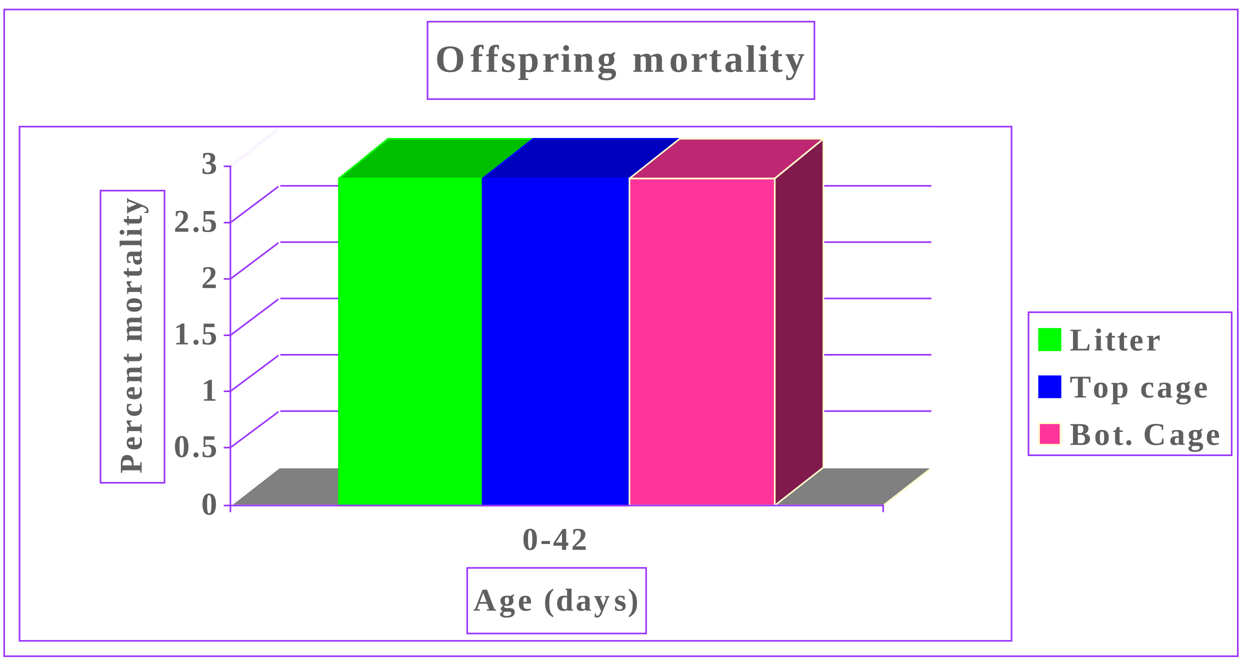

Figure 4.7.3. Mortality rate of progeny from broiler breeders maintained on the conventional floors as compared to breeders maintained in the top and bottom tier colony cages with the same treatment.

CHAPTER 5. DISCUSSION

5.1 Broiler Breeder Body Weights

Boiler breeder hens body weights were maintained as close as possible to the Hubbard company targets through a restricted feeding program (Appendix 1, Table B). In spite of feed restriction during the laying phase, broiler breeder hens maintained on conventional floors had body weights above their weekly targets (Appendix 1, Table F). Their counterparts maintained in commercial broiler breeder colony cages had body weights below the company's targets (Appendix 1, Table F and G). The increasing body weights results found on the conventional floors were similar to those found by Bilgilli and Renden (1985). They reported that as broiler breeder hens grew older their feed intake and body weights increased. In the current study body weights of broiler breeders maintained in the commercial colony cages were lower than their expected targets. These results differs with those observed by Bilgilli and Renden (1985) who reported an increasing body weight trend when using *ad libitum* feeding regime. The lower than expected body weights for hens maintained in the colony cages in the current study could be due to stress in cages. Another reason for the aforementioned difference could be due to the restricted amount of feed given to the breeders as outlined in the broiler breeder management guide (Hubbard farms, 1994) which did not consider feed adjustment if the broilers lost, or gained too much weight (Appendix 1, Table B). The decreasing in weight could be associated with the broilers not getting adequate gross energy in feed to acount for maintenance and weight gain. Hens maintained on the litter floors increased in body weight with age (Figure 4.1.1.1). This weight increase could be due to less stress and feed given according to Hubbard weekly feeding regime (Appendix 1, Table B) which supplied the hens with adequate energy for maintenance and egg production. In addition, increase in weight could be due to more fat deposition in the hens maintained on the conventional floors versus those maintained in the colony cages (Poultry Science Association meeting poster # 318, personal communication, August 4, 1998). In both treatments, roosters body weights were slightly above the company's targets but no significance difference occurred.

5.2 Egg production

Egg weight was not significantly different between hens maintained on the litter floors with those maintained in the colony cages (Appendix 1, Table A). These results concur with those reported by Carter et al. (1970) when he compared the egg weights of wire caged broiler breeders to those reared on the conventional floors. However, other studies (Reece et al. 1971; Fuquay and Renden 1980; Pettite et al. 1993) reported that broilers reared in the cages produced heavier eggs than those raised on the conventional floor in an *ad libitum* feeding program. The lack of egg weight difference in the current study could be due to the feed restriction, and lower than expected body weights in breeder hens maintained in the colony cages. North and Bell (1990) concluded that a delay in egg production in broiler breeders through feed restriction to between 23 and 24 weeks of age would produce bigger hens which laid bigger eggs. The first of the phases of egg production period data analysis in the current study showed a higher hen-day production than the rest of the production period in caged broiler breeders and those maintained on the conventional floors (Figure 4.2.1). This could be attributed to broiler breeders maintained on the conventional floors being more active which could have deverted energy from egg production as opposed to confined broiler breeders managed in the colony cages. As the birds aged hen-day production in cages decreased. This decrease could be due to loss in body weight which could be associated with the restricted feeding regime (Appendix 1, Table B). The amount of feed given to broiler hens in cages may have been adequate for body maintenance and more was required for egg production and weight gain. McDaniel and Brake (1981) associated the drop in egg production for broiler breeders reared in cages with increased broiler breeder body weight. Fuquay and Renden (1980) found that broiler breeders reared on the conventional floor produced more eggs than those raised in cages.

Eggs produced by broiler breeder hens maintained in the colony cages had more cracks than breeders maintained on the conventional floors (Figure 4.3.1). These results differ with an expectation that more eggs were cracked when produced by layers reared on the conventional floors than those maintained in the cages. It is expected that hens reared on the litter floors could lay some eggs on the floor, in the corners, and crowding in laying nests would cause more cracks. Also, eggs produced by hens maintained on the litter floors were at a higher risk of being pecked especially if they were laid on the litter floors and not in laying nests. In the present study individual laying nests with grey colored pads for breeders managed on the conventional floors may have been responsible for the low number of cracks.. There is evidence that broiler breeder hens preferred laying eggs in nests with grey colored pads than black, brown, or green colored pads (Brake, 1993). Brake also observed that hens producing eggs on laying nests with grey colored pads had better hen-day production than those using nests with black, brown, or green colored pads. North and Bell (1990) associated egg cracking in cages with egg rolling slopes which increased the rolling speed of an egg. In addition, they reported that eggs from caged broilers may crack due to accumulation of eggs in the troughs due to delay in collection during the day. In the current experiment, eggs were collected twice (10 a.m and 4 p.m) per day even during the peak production periods which may have led to the increased number of cracks. Frequent egg collection at intervals of two hours from 9 a.m during peak egg production per day and three hour intervals during low egg production in the colony cages could reduce egg cracks. North and Bell (1990) recommended placing a rubber, or bumper at the front of the collection site could reduce egg breakages. In addition, egg gathering labor and breakages in the colony cages could be reduced by use of automation devices which have mobile belts to transfer eggs from the cages to collection areas at the end of the house, or to a conveyor which transports the eggs to packing units.

5.3 Feed Conversion Ratio

At 29 to 33 weeks of age there was an insignificant improved feed conversion ratio per dozen eggs produced by hens maintained in the cages than by those maintained on the conventional floors (Appendix 1, Table C). This difference in feed conversion could be attributed to the fact that broiler breeders maintained in the cages had adequate feed energy for maintenance and egg production. Broiler breeders maintained in cages had less opportunity for exercise, and did not require as much energy for maintenance as their counterparts maintained on the litter floors. Hypes (1994) found that broilers reared in cages were more efficient feed converters than those reared on the litter floor. Renden and Pierson (1982) found insignificant differences in feed conversion per dozen eggs produced by dwarf broiler breeder hens reared on litter floors, or those maintained in cages which concurs with the results of the current study. Broiler breeders maintained in the bottom tier had a higher (2.94 kg.) feed conversion ratio per dozen eggs than (2.92 kg) for those maintained in the top tier broiler breeder colony cages (Appendix 1, Table D). These results were expected due to the fact that hens maintained in the top tier could receive greater light intensity than those in the bottom deck cages. This light is passed through the eyes to the peneal gland which shuts down melatonin production in the hen’s body. Low levels of melatonin causes a surge of follicle stimulating hormone from the hypothalamus. This in-turn triggers the ovary to secret high levels of progesterone hormone which induces the hypothalamus to produce high levels of the leutenizing hormone. Increased levels of the leutenizing hormone has been associated with ovulation (Singer, 1997).

5.4 Egg Fertility

The current experiment revealed that fertility of broiler breeders was reduced as their age advanced. This observation was more pronounced in cage managed broiler breeders than those maintained on the conventional floors (Figure 4.5.1). These results are consistent with those found in previous studies (Bilgil and Renden, 1985) in regard to the effects of age on fertility. Bilgilli and Renden (1985) suggested that the increased hen's body weight with age, reduced fertility. In the current experiment the boiler breeder company cautioned that weekly body weight targets (Appendix 1, Table F) of the broiler hens should be maintained by following its restricted feeding regime. Although, this feeding program was followed in the current experiment, broiler breeder hens maintained on the conventional floors weighed more than the company's targets (Figure 4.1.1.1) while those maintained in the colony cages weighed less. In addition, the fertility rate of breeder hens managed in colony cages was lower than those maintained on the conventional floors (Figure 4.5.1). Broiler breeders maintained in the colony cages appeared to have more curled toes and swollen feet-pads than breeders maintained on the litter floors. This condition appeared to occur more in broiler breeder males than in females maintained in the colony cages. Rooster weights in both treatments increased with age, but the difference among them was not significant. These roosters weight increment could have contributed to low fertility rates in broiler breeders maintained in the colony cages due to the theory that heavier roosters have a lower libido. Naturally roosters chase hens during matings as observed in broiler breeders maintained on the litter floors, but roosters maintained in the colony cages may have been denied the chance to boost their male ego. In addition, low fertility rates in breeders maintained in the colony cages could be due to broiler breeder roosters appearing to have more culled toes and swollen feet-pads which could be painful during mating. Since the difference in body weights of roosters maintained in the colony cages and on the conventional floors was not significant, the drop in fertility for breeders maintained in the colony cages could be associated with other contributing factors and not increase in male body weight *per se* as their age advanced. This trend could possibly be reversed by introducing 20 week old cockerels when broiler breeder hens managed in the colony cages are 40 weeks of age. These young cockerels would be expected to have low body weights, less leg problems and a high libido to compete in mating the hens. Another possibility could be to increase the ratio of broiler breeder males to females maintained in the colony cages from the current 12% to 16% to increase male competition for mating hens. This should be accompanied by frequent culling of roosters and hens which appear to have leg problems (Poultry Science Association poster # 318, personal communication August 4, 1998).

5.5 Offspring

A summary of the offspring growth values are presented in Appendix 1, Table H. No difference in weekly growth rates of progeny from broiler breeders maintained on the conventional floors and those maintained in the top and bottom tier colony cages was observed. However, the growth trend showed that offspring from broiler breeders maintained in the colony cages grew faster, but not significant ($P>0.05$) than those from breeders maintained on the conventional floors from 14 to 42 days of age (Figure 4.6.1). Petitte (1983) found that rearing offspring from broiler breeder hens managed in cages were significantly heavier than progeny from hens managed on the conventional floor when reared for 42 days of age. However, no significant evidence was observed in progeny weight when some of the offspring were slaughtered at 49 days of age. There was no evidence ($P>0.05$) in the current trial between feed conversion ratio of progeny from broiler breeders maintained on the conventional floors with offspring from breeders maintained in the colony cages.

5.6 Hen Mortality

The overall mortality did not differ ($P>0.05$) between broiler breeder hens maintained in cages and those maintained on the conventional floors (Figure 4.7.1). The mortality rate was less than three percent which was within an acceptable range in the poultry industry (North and Bell, 1990). The cause of mortality in most hens was due to cannibalism and other unidentified causes.

5.7 Offspring Mortality

Mortality rate was not different ($P>0.05$) between offspring from broiler breeders maintained on conventional floors and those maintained in colony cages (Figure 4.7.2). This mortality occurred in the first and second week of age in both treatments. The mortality rate was less than 3%, a range acceptable in the broiler industry. Runts were culled because they could not reach feeders and waterers rim and lip heights. These feeder rims and water-nipple heights were adjusted weekly to the levels of the offspring's back and tail respectively in the present experiment. Other causes of death/culling were due to leg deformities and unidentified causes.

6.0 Future Study Recommendations on Broiler Breeders Maintained in Colony Cages

6.1. To investigate the effects of introducing a new group of 20 weeks old cockerels to the 40 weeks old breeding hens. It is expected that these young males having stronger legs, lower body weights, and high libido would be more competent in mating the hens than the 40 weeks old roosters (Poultry Science Association poster # 318, personal communication, August 4, 1998).

6.2. To increase the male to female ratio from the current 12% to 16% in order to increase the male competition for mating the females. Therefore there will be four roosters instead of the current three in the colony cages. This should be accompanied by regular culling of males, and females which appear to have leg problems (Poultry Science Association poster # 318, personal communication, August 4, 1998).

6.3. Feed adjustments should be made according to the changes in the broiler breeders body weight. A ration with low energy would reduce weight gain and vice versa. Consequently, reduced feed intake would reduce weight gain as opposed to increased feed intake.

CHAPTER 6. CONCLUSION

The present study focused on the performance of broiler breeders maintained in commercial broiler breeder colony cages with natural mating versus traditional conventional floor system. Rooster body weight increments were not significantly different in both treatments. Roosters maintained in the colony cages appeared to have more leg problems than their counterparts maintained on the conventional floors. Fertility rate declined as broiler breeders age advanced. This decline was more marked in breeders maintained in the colony cages than those on the conventional floors. The data analysis indicated that natural breeding in the colony cages was feasible up to 43 weeks of age when the fertility rate was equal to, or more than eighty percent. The fertility rate then declined to less than fifty percent from 55 weeks of age to the end of the trial. Since hen body weight increments were significantly different between the treatments, but egg size was not, other factors apart from hen's body weight and age advancement may have been involved in the increased fertility decline in hens maintained in the colony cages. In addition, stress on roosters and leg problems may have contributed to the declining fertility in cages.

In the first of the three phases of the production period, there was an improved feed conversion ratio per dozen eggs produced by hens maintained in colony cages as compared to those maintained on conventional floors. Hens maintained in colony cages reached peak hen-day production earlier than those maintained on conventional floors. There was no significant difference in egg production between broiler breeder hens maintained in colony cages and those maintained on conventional floors. Although not significant, growth rate and feed conversion ratio of progeny from breeders maintained in the colony cages was better than offspring from breeders maintained on conventional floors.

Since the common practice to increase broiler breeder egg production using natural mating is by construction of new poultry buildings, the use of colony breeding cages would allow upward expansion within exhisting buildings. Although the initial cost of the colony cages would be high, it would be economically cheaper in the long run than building new poultry buildings. Producers could use commercial colony cages to produce naturally fertilized eggs economically (Appendix 1, Table E) up to 40 weeks of broiler breeder's age. Since broiler breeders fertility then declines at a rapid rate after 40 weeks of age , further studies are recommended to overcome this problem. Breeding in the colony cages will save construction costs of new broiler breeders buildings and will go along way in conforming with zoning laws where expansion on the litter floors would be illegal.

CHAPTER 7. SUMMARY

Broiler breeder hens maintained in broiler breeder colony cages weighed less than those maintained on the conventional floor due to restricted feeding program. Egg size between treatments was not significantly different. Although, hen-day production by broiler breeder hens maintained in the colony cages was significantly higher in the 29 to 35 weeks of age than breeders maintained on the conventional floors this difference was not significant across the entire data. Significantly, more cracked eggs occurred in eggs laid in colony cages than those laid on the conventional floors.

There was a significant lower feed conversion ratio per dozen eggs produced by broiler breeder hens reared in the colony cages in the 29 to 33 weeks of age than those on the conventional floors, but the overall data was not significantly different. Although not significant, broiler breeder hens reared in the bottom tier had a lower feed conversion ratio per dozen eggs than those maintained in the top tier colony cages.

Fertility rate of broiler breeders maintained on the conventional floor was higher than those in the colony cages. The fertility rate of broiler breeders declined at a higher rate in cages as the breeders advanced in age. There was no significant difference in weekly weight gain and feed conversion ratio of offspring from broiler breeders maintained in the colony cages versus those maintained on the conventional floors. Mortality rate was insignificant between broiler breeder hens maintained in the colony cages with those maintained on the conventional floors. No mortality difference occurred in broiler breeder offspring from parents maintained in the colony cages using natural mating versus those maintained on the conventional floors.

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APPENDIX

APPENDIX 1. TABLES

Appendix 1.

Table A. Egg weights for hens maintained on the conventional floors and in the commercial colony cages.

	Egg weight (grams)	
	Litter	**Cages**
Mean	61.25	60.25
Sd	1.71	2.25

	Top cage	**Bottom cage**
Mean	58.5	62
Sd	1.73	0.82

Appendix 1.

Table B. Hubbard company broiler breeder feeding guide.

Classic Female				Hubbard Male			
Age (wk)	Body weight (kg)	Type of Ration	Daily feed gm/bird	Age (wk)	Body weight (kg)	Type of Ration	Daily feed gm/bird
20	2-2.13	Pre-breeder	85-105	20	2.8	Separate	95-115
21	2.15-2.29		90-110	21	2.94	male	100-120
22	2.3-2.45		95-115	22	3.08	ration	105-125
23	2.45-2.61		100-125	23	3.22		110-130
24	2.725-2.905	Breeder	115-135	24	3.5		115-135
25	2.86-3.04		135-150	25	3.6		120-140
26	2.95-3.13		155-165	26	3.7		125-145
27	3.04-3.22		155-165	27	3.76		125-145
28	3.13-3.31		155-165	28	3.82		125-145
29	3.18-3.36		155-165	29	3.88		125-145
30	3.23-3.41		155-165	30	3.94		125-145
31	3.25-3.43		155-165	31	4		125-145
32	3.27-3.45		155-165	32	4.05		125-145
34	3.31-3.49		155-165	34	4.11		125-145
36	3.35-3.53		Gradually	36	4.17		125-145
40	3.43-3.61		reduce	40	4.27		125-145
44	3.45-3.63		-do-	44	4.34		125-145
48	3.47-3.65		-do-	48	4.41		125-145
52	3.49-3.67		-do-	52	4.46		125-145
56	3.51-3.69		-do-	56	4.51		125-145
60	3.53-3.71		-do-	60	4.56		125-145
64	3.55-3.37		-do-	64	4.61		125-145
68	3.57-3.75		135-138	68	4.66		125-145

Source: Hubbard classic breeder management guide (1994).

Appendix 1.

Table C. Feed conversion ratio per dozen eggs for broiler breeders maintained on the conventional floors and commercial colony cages.

	Conventional floors				Cages			
Age (wk)	**Feed (kg.)**	**Egg #**	**Eggs/ dz**	**kg./dz**	**Feed (kg)**	**Egg #**	**Eggs/dz**	**kg./dozen**
26	776.16	100	8.33	93.14	649.95	155	12.91	50.31
27	770.35	1036	86.33	8.92	645.75	1007	83.91	7.69
28	761.95	2043	170.25	4.47	643.65	2410	200.83	3.21
29	745.85	2647	220.58	3.38	641.55	3212	267.67	2.39
30	732.55	2898	241.5	3.03	641.55	3246	270.5	2.37
31	732.9	2978	248.16	2.95	634.2	3679	306.58	2.16
32	728	3127	260.58	2.79	628.6	3800	316.67	1.98
33	725.55	3043	253.58	2.86	632.1	3712	309.33	2.04
35	720.3	4476	373	1.931	619.36	3904	325.33	1.91
37	676.2	4489	374.0833	1.81	625.73	3882	323.5	1.93
39	505.54	4528	377.33	1.33	590.8	3859	321.58	1.83
41	499.8	4135	344.58	1.45	586.6	3449	287.41	2.04
43	648.55	4141	345.08	1.87	566.65	3266	272.17	2.08
45	653.45	3755	312.91	2.08	572.6	3218	268.17	2.13
47	634.45	3751	312.58	2.01	556.5	3170	264.17	2.11
49	628.6	3634	302.83	2.07	553.7	2367	197.25	2.81
51	624.75	3337	278.08	2.24	552.3	2271	189.25	2.92
52	624.75	1992	166	3.76	538.3	2025	168.75	3.18
53	624.75	1969	164.08	3.81	552.3	1846	153.83	3.59
54	625.1	1756	146.33	4.27	552.3	1684	140.33	3.93
55	625.1	2062	171.83	3.64	552.3	1858	154.83	3.56
56	625.1	1593	132.75	4.71	552.3	1550	129.17	4.27
57	625.1	1532	127.67	4.89	552.3	1434	119.5	4.62
58	625.1	1544	128.67	4.85	552.3	1268	105.67	5.22
59	625.1	1411	117.58	5.31	552.3	1184	98.67	5.59
60	625.1	1312	109.33	5.71	552.3	1012	84.33	6.54
61	625.1	1271	105.91	5.91	552.3	823	68.58	8.05
Total	**17815.25**	**70560**	**5880**	**185.29**	**15850.59**	**65291**	**5440.92**	**140.79**

Average Feed Conversion ratio
Litter floors 3.03 kg/dozen eggs.
Colony cages 2.91 kg./dozen eggs.

Appendix 1.

Table D. Feed conversion rate per dozen eggs laid by hens maintained in the top and the bottom tier colony cages.

Top versus Bottom Cages

Age (wk.)	Feed (kg.) Top cage	Feed (kg.) Bottom	Top cages Egg #	Bottom cages Egg #	Dozen # Top cage	Dozen # Bottom	Conv. (kg) Top cage	Conv. (kg) Bottom
26	323.4	326.55	86	69	7.17	5.75	45.13	56.79
27	322.35	323.4	542	465	45.17	38.75	7.14	8.34
28	321.3	322.35	1213	1197	101.08	99.75	3.18	3.23
29	320.25	321.3	1556	1656	129.67	138	2.46	2.32
30	320.25	321.3	1602	1644	133.5	137	2.39	2.34
31	316.05	318.15	1740	1939	145	161.58	2.17	1.96
32	311.5	317.1	1919	1881	159.91	156.75	1.94	2.02
33	316.05	316.05	1743	1969	145.25	164.08	2.17	1.92
35	306.25	313.11	1963	1941	163.58	161.75	1.87	1.93
37	311.5	314.58	1934	1948	161.17	162.33	1.93	1.93
39	290.5	300.3	1904	1955	158.67	162.91	1.83	1.84
41	289.8	296.8	1714	1735	142.83	144.58	2.02	2.05
43	279.3	287.35	1621	1645	135.08	137.08	2.07	2.09
45	283.5	289.1	1450	1420	120.83	118.33	2.34	2.44
47	275.8	280.7	1615	1555	134.58	129.58	2.04	2.16
49	273.7	280	1038	1329	86.5	110.75	3.16	2.52
51	272.3	280	1168	1103	97.33	91.917	2.79	3.04
52	258.3	280	997	1028	83.08	85.67	3.12	3.26
53	272.3	280	893	953	74.417	79.41	3.65	3.52
54	272.3	280	849	835	70.75	69.58	3.84	4.02
55	272.3	280	904	954	75.33	79.5	3.61	3.52
56	272.3	280	771	779	64.25	64.91	4.23	4.31
57	272.3	280	728	706	60.67	58.83	4.48	4.75
58	272.3	280	656	612	54.67	51	4.98	5.49
59	272.3	280	624	560	52	46.67	5.23	6
60	272.3	280	530	482	44.17	40.17	6.16	6.97
61	272.3	280	478	345	39.83	28.75	6.83	9.73
Total	**7842.8**	**8008.14**	**32238**	**32705**	**2686.5**	**2725.42**	**132.87**	**150.62**

<u>Average Feed Conversion ratio</u>

Top cages 2.92 kg/dozen eggs.

Bottom cages 2.94 kg./dozen eggs.

Appendix 1.

Table E. Costing: Feed conversion cost per dozen eggs.

Expenditure:

Breeder ration cost: 2,727.27 kg. = $ 1,325.25 (Southern States feed company).
1.0 kg. = $ 0.49

Feed cost per dozen eggs:

Conventional floor - 3.03 kg. Feed per dozen eggs @$ 0.49 = $ 1.48

Colony cages - 2.91 kg. Feed per dozen eggs @$ 0.49 = $ 1.43

Appendix 1.

Table F. Weights of broiler breeder hens maintained on the conventional floors and in colony cages as compared to Hubbard company's targets. Row values with different superscripts differ significantly ($P<0.05$).

Age (wk.)	Target wt. (Kg)	Actual wt. (kg.) Litter	SEM	Actual wt. (kg.) Cages	SEM
27	3.13	3.255	0.078	3.077	0.075
29	3.27	3.286	0.047	3.173	0.042
31	3.34	3.376	0.343	3.196	0.315
33	3.35	3.466	0.058	3.219	0.065
35	3.42	3.461	0.111	3.27	0.031
37	3.44	3.461	0.111	3.27	0.031
39	3.52	3.674	0.082	3.348	0.045
41	3.52	3.693	0.031	3.357	0.065
43	3.54	3.934 [a]	0.061	3.356 [b]	0.057
45	3.54	3.763 [a]	0.102	3.216 [b]	0.119
47	3.56	3.929 [a]	0.082	3.377 [b]	0.125
49	3.56	4.016 [a]	0.029	3.344 [b]	0.048
51	3.58	4.039 [a]	0.052	3.311 [b]	0.154
53	3.58	4.09 [a]	0.05	3.313 [b]	0.131
55	3.6	4.119 [a]	0.035	3.317 [b]	0.103
57	3.6	4.188 [a]	0.009	3.284 [b]	0.113
59	3.62	4.249 [a]	0.029	3.305 [b]	0.125
61	3.62	4.301 [a]	0.038	3.387 [b]	0.119

Appendix 1.

Table G. Weights of broiler breeder hens maintained in the top and bottom tier commercial colony cages as compared to Hubbard company's targets.

Age (wk.)	Target wt. (kg.)	Actual wt. (kg.) Top cage	SEM	Actual wt. (kg.) Bot. cage	SEM
27	3.13	3.086	0.074	3.069	0.075
29	3.27	3.065	0.033	3.281	0.052
31	3.34	3.119	0.025	3.273	0.604
33	3.35	3.173	0.071	3.265	0.058
35	3.42	3.317	0.052	3.225	0.009
37	3.44	3.117	0.052	3.225	0.009
39	3.52	3.364	0.037	3.333	0.052
41	3.52	3.354	0.058	3.361	0.072
43	3.54	3.348	0.044	3.365	0.07
45	3.54	3.217	0.135	3.215	0.102
47	3.56	3.413	0.12	3.415	0.13
49	3.56	3.259	0.062	3.1	0.034
51	3.58	3.421	0.266	3.2	0.041
53	3.58	3.381	0.22	3.244	0.041
55	3.6	3.402	0.17	3.232	0.036
57	3.6	3.383	0.171	3.186	0.054
59	3.62	3.307	0.176	3.204	0.073
61	3.62	3.467	0.154	3.306	0.084

Appendix 1.

Table H. Weight (grams) gain of offspring from broiler breeders maintained on the conventional floors and those maintained in the top and bottom tier colony cages when reared on litter floors.

	Litter floors		**Top cages**		**Bottom cages**	
Age (days)	**Grams**	**SEM**	**Grams**	**SEM**	**Grams**	**SEM**
0	58.0		58.0		58.0	
14	238.35	297.82	245.73	101.696	227.57	613.81
21	271.48	145.28	306.45	145.28	351.85	36.32
28	356.39	617.44	320.07	326.88	379.66	544.8
35	365.47	1343.84	410.87	690.08	497.13	690.08
42	490.32	72.64	533.45	581.12	544.8	399.52

Appendix 1.

Table I. West Virginia university farm complete broiler ration.

Ingredient	Broiler's age 0 to 3	3 to 6 (weeks)
Number 2 Yellow Corn (8.9%)	61.19	66.19
Soybean Meal (48%) (%)	32.97	28.23
Soybean oil (%)	2.20	2.20
Dical Phos (21% Ca, 18.5%P) (%)	1.85	1.75
Calcium carbonate (38% Ca) (%)	0.95	0.85
Salt (%)	0.35	0.25
Vitamin/Mineral mix (%)	0.25	0.25
Methionine (%)	0.15	0.18
Coban 45 (%)	0.01	0.01

Nutritional Analysis		
Crude protein (%)	21.16	19.50
M. E. (kcal/kg)	3,082.00	3,131.00
Crude Fat (%)	4.74	4.90
Crude Fiber (%)	2.71	2.67
Calcium (%)	0.84	0.78
Total Phosphorus (%)	0.71	0.67
Available Phosphorus (%)	0.46	0.44
Lysine (%)	1.17	1.04
Methionine (%)	0.47	0.48
Methionine & Cystine (%)	0.84	0.82

Appendix 1.

Table J. Complete broiler breeders ration from Southern States broiler breeder feed company.

Nutritional Analysis

		Age (20 to 61 weeks)
Crude protein (%)		16.00
M. E. (Kcal/kg.)	Minimum	2,800.00
M. E. (Kcal/kg.)	Maximum	2,920.00
Crude Fiber (%)	Minimum	4.00
Calcium (%)	Minimum	3.10
Calcium (%)	Maximum	4.10
Phosphorus (%)	Minimum	0.62
Lysine (%)	Minimum	0.78
Methionine (%)	Minimum	0.40
Salt (sodium chloride) (%)	Minimum	0.15
Salt (sodium chloride) (%)	Maximum	0.50
Crude fat (%)	Minimum	3.50

VITA

Name:	Kitogho Justin Mwashighadi		
Birth place:	Taita District, Coast Province - Kenya		
Date of birth:	November 17, 1957		
Parents:	Mwashighadi Simon Ngoma Kulola Evence Mwashighadi		
Wife:	Wakesho Doncia Kitogho		
Son:	Kirando Elvis Kitogho		
Institutes attended:	St. Joseph's Pr. School	Taita - Kenya	1964 -1971
	Voi Secondary school	Voi - Kenya	1972 - 1975
	Egerton University	Njoro - Kenya	1977 - 1980
	West Virginia University	Morgantown - West Virginia	1994 - 1996
Degrees awarded:	Diploma in Animal Science. Egerton University		1980
	Bachelor of Sc. in Animal & Vet. science. West Virginia University		1996
Employment:	Min. of Agriculture and Livestock Dev. Kenya		
Title/Duration:	Livestock extension officer		1980 - 1994

APPROVAL OF EXAMINING COMMITTEE

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Edward C. Prigge, Ph. D.

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Ronald A. Peterson, Ph. D.
Chairman

December 9,**1998**
Date