# THE INFLUENCE OF SLAT MATERIAL, SLAT COVERAGE AND BREEDER AGE ON BROILER BREEDER REPRODUCTION AND PROGENY GROWTH

by

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ABSTRACT

This study was conducted to examine the potential of plastic slats as flooring material for maintenance of broiler breeders. Although plastic slats are more expensive than wood slats, plastic slats are more durable and easier to clean.

Wood and plastic slats were tested as full and partial flooring to determine the ideal proportion of slats for broiler breeder floors. Space allotment was 2040 $cm^2$/bird on all floor treatments. Arbor Acres broiler breeders, one of the more common strains in British Columbia, were raised to 58 weeks of age to monitor the influence of slat material and slat coverage on egg production and progeny growth over one production cycle.

Since the pens were not set up to determine the number of eggs lost through slats, "egg production" values were actually egg recovery values. Over-all egg recovery was significantly higher on partial wood (PWS) and partial plastic slats (PPS) than on either of the full slat treatments. Breeders on full wood slats (FWS) had higher over-all egg production than those on full plastic slats (FPS).

Differences were significant for three biweekly periods, but slats did not influence the over-all incidence of floor eggs and cracked floor eggs. The incidence of cracked nest eggs was significantly higher in FWS and FPS than in PWS and PPS pens during four lay periods and over-all.

The proportion of non-cracked nest eggs, which was taken as an approximation of the proportion of settable eggs, was higher for partial slat pens than full slat pens, and FWS pens had a higher proportion of non-cracked nest eggs than FPS pens.

To monitor fertility and hatchability, eggs were incubated at 37, 42, 46, 50 and 56 weeks of breeder age. Fertility, hatchability of total eggs set and hatchability of fertile eggs was not affected by type of slats.

Progeny from the hatch at 37, 46 and 56 week of breeder age were grown in Petersime battery cages to three weeks of age. The progeny of breeders on FPS had lower first week weight gain than the other progeny groups due to moisture loss when 7 FPS progeny were lost during the second growth trial. Weekly and over-all feed conversion of progeny was not affected by types of slats used by parents.

The 56th week progeny were grown in Petersime battery cages to market age (six weeks). PWS and FPS progeny had higher third week weight gain than PPS progeny. During the sixth week, FWS and PWS progeny had higher weight gain than FPS and PPS progeny. The sixth week feed conversion of FPS progeny was higher than that of the other three progeny groups. No other differences were seen.

As long as slats were used as partial flooring, there were no differences in egg production on wood or plastic slats. The proportion of "settable" eggs, fertility, and hatchability of eggs of plastic slat breeders were comparable with that of wood slat breeders regardless of slat coverage. There were significant differences in the 3-week growth of 37th, 46th and 56th week progeny and the 6-week growth of 56th week progeny on the different slat types, but the differences were not due to slat treatments. There was no interaction between breeder age and slat material, therefore the influence of slat material on egg production and progeny growth did not vary with breeder age. Although egg recovery and the number of settable eggs were lower for FPS breeders, breeders on plastic slats performed as well as those on wood slats in the present study.

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# 1. INTRODUCTION

Housing has become an important aspect of present-day poultry production systems. In non-tropical latitudes, the total confinement of poultry has made possible the year-round production of eggs and meat despite seasonal variation in daylength and environmental temperatures. Poultry can now be grown and eggs produced at all seasons by controlling light, temperature and ventilation in "windowless" houses (Wilson, 1974).

Prior to the development of environment-controlled housing, poultry house construction in the United States and Canada varied from one region to another in order to make the best of local climatic conditions. Extremes in weather conditions resulted in poor production (Wilson, 1974).

The advent of large commercial flocks in totally-enclosed houses necessitated changes in floor management. In North America, partial slat flooring and wire cages became popular solutions to the problem of wet litter (Wilson, 1974). Wet litter has been known to result in dirty and contaminated eggs, increased ammonia ($NH_3$) production, respiratory distress and other disease conditions, all leading to poor egg production and poor weight gain among birds (Wilson and Vohra, 1980; Wilson, 1974).

# 2. LITERATURE REVIEW

## 2.1. *STUDIES ON SLATS*

### 2.1.1. Slats and Egg Production

Broiler breeders have generally been maintained on litter floors at 3600 $cm^2$/bird. Layers, however, have been kept not only on litter but also on slat floors in combination with litter or wire floors (Wilson, 1974; Cooper and Barnett, 1972). Consequently, earlier studies on slats were conducted using commercial layers (Magruder and Nelson, 1965; Osborn et al., 1959; Yao, 1959). Fertility and hatchability were not reported. Nevertheless, egg production data from these studies were useful, leading the way for studies on alternative floor types for broiler breeders (Andrews et al., 1988; Parkhurst, 1974; Cooper and Barnett, 1972; Nordskog and Schierman, 1965).

Osborn et al. (1959) and Yao (1959) reported that the disincentives to using full slat floors were as follows: lower egg production per bird, more non-layers, higher mortality, and more birds laying fewer than 50 eggs during their respective 6- and 5-month experiments. The advantages to using full slat floors were as follows: 2.5 times as many eggs produced per square foot on slat floor as on litter (3 $ft^2$/bird, or 2787 $cm^2$/bird on litter vs. 1 $ft^2$/bird, or 929

$cm^2$/bird on slats) and a lower mature body weight. Yao (1959) found statistically significant differences between the two floor systems in terms of egg production per bird, egg production per square foot and mature body weight. Because of the difference in mature body weight, Yao (1959) inferred that less feed was consumed for each dozen of eggs produced on slats than on litter.

A longer, 3-year study by Magruder and Nelson (1965) found that mortality was higher, and egg production was lower on full slat floors. This was in agreement with Osborn et al. (1959) and Yao (1959). Although nothing was said about mature body weight, Magruder and Nelson (1965) reported that less feed, although not significantly, was required to produce a dozen eggs on full litter than on full slats. This last finding did not support the inference put forward by Yao (1959). Space allotment per bird was 675 $cm^2$ on slats, vs. 1800 $cm^2$ on litter.

Studies conducted to investigate the influence of cage density on layer performance would later explain why egg production and body weight gain was not as good on slats compared to litter. It has been found that egg production (Madrid et al., 1981; Carew et al., 1980; Sefton, 1976; Mather and Greaves, 1970) and body weight gain (Madrid et al., 1981; Carew et al., 1980) decreased as the area per bird decreased and the number of birds per cage increased within a certain range. Madrid et al. (1981) suggested that a high proportion of the energy consumed by crowded layers was spent for maintenance rather than for production (i.e., egg production, body weight gain); thus, the lower egg production on slats when more birds were placed on full slats than on full litter.

The compromise that resulted was the combination of slat and litter floors, or what is known today as partial slat floor. Producers found that optimal bird density was lower on partial slats than on full slats and yet higher than on litter. There was so much interest in slats that only combination floors and full slat floors were compared at first (Parkhurst, 1974; Cooper and Barnett, 1972).

Cooper and Barnett (1972), in comparing the partial slat floor (60% slat, 40% litter) with full slat floor found that hen-day egg production was significantly higher on the partial slat floors (59.7% vs. 53.2%). Each bird had 1672 $cm^2$ of floor space on both floor types. Parkhurst (1974) found that hen-day egg production was higher, but not significantly, on 50% slat-50% litter than on full slat floor. Average egg production was 56.3%, 57.0%, 55.5% and 53.2% vs. 51.9%, 55.2%, 55.0% and 54.4%, on full vs. partial slat respectively, for 4 different strains. Space allotment was 2000 $cm^2$/bird on all floor types.

Later, Andrews et al. (1988) compared egg production on full litter, 2/3 slat-1/3 litter combination (wood or plastic-covered wire) and full slat floors of plastic-covered wire, at 2730 $cm^2$/, 1740 $cm^2$/ and 1660 $cm^2$/bird, respectively. They found significantly higher hen-day egg production (59.8%) and significantly less feed consumed per dozen eggs produced among broiler breeders on full litter floor than on other floor types; the latter finding is in agreement with that of Magruder and Nelson (1965). There were no significant differences in egg production or feed consumption per dozen eggs between the other three floor types despite differences in bird density between full and partial slat treatments. Hen-day egg production on the other floor types were as follows: 51.7% on partial wood slats, 50.5% on floors of partial plastic-covered slats and 50.3% on floors of full plastic-covered wire.

An earlier study, conducted by Johnston and Zindel (1963) found that percent hen-day egg production was 61.0% in cages, 60.5% on litter floor and 56.0% on slatted floor. Floor space per bird was 405 $cm^2$ in cages and 2088 $cm^2$ on litter and slatted floor. No significant differences in egg production were found between the latter two floor types. As a proportion of the total number of eggs laid, floor eggs accounted for 7.3% and 6.3%, respectively, from the birds on litter and slatted floor. Without any clarification in the said study about the floor types, "slatted floor" was taken to mean fully slatted floor in the context of the present study.

### 2.1.2. Slats and the Incidence of Cracked Eggs

The study by Cooper and Barnett (1972) found that cracked eggs comprised 2.3% and 2.9% of total eggs produced on full slat and partial slat floors, respectively. Without stating the values, Magruder and Nelson (1965) found that the percentage of broken shells was the same for full wood and full litter floors. No distinction was made between cracked nest eggs and cracked floor eggs.

### 2.1.3. Slats and Fertility

Cooper and Barnett (1972) found that cumulative fertility was higher on the combination floors than on the full slat floors. During nine 28-day periods, Parkhurst (1974) found that fertility in Pilch-DeKalb breeders tended to be higher on the partial slat floors than on full slat floors during the first 28-day and the last four 28-day period. Neither Cooper and Barnett (1972) nor Parkhurst (1974) found these differences to be significant.

Nordskog and Schierman (1965) examined cumulative fertility of White Leghorns on full litter, 50% slat-50% litter, and full slat floors. Floor space per bird was 2945

$cm^2$ for all floor types. They found that in one of the two trials, fertility was best on litter and poorest on slats during the first ten days of mating. After 18 days the difference in percent fertility between the highest and the lowest test group was only 2%. They suggested that slats caused a lag in normal mating activity in some males which may extend for a week to 10 days.

Through seven 28-day periods, Andrews et al. (1988) found significant differences in fertility only during the second 28-day period, and only between partial wood (97.2%) and partial plastic-covered wire (92.2%) slats. Full litter (94.7%) and full plastic-covered wire slats (95.6%) were intermediate. Cumulative fertility was highest for full plastic-covered wire slats (95.2%) and lowest for partial plastic slats (93.5%). There was no drop in fertility among birds on slats (full or partial, both wood and plastic-covered wire) during the second half of production as seen by Parkhurst (1974). In the study by Andrews et al. (1988), birds on slats did not specifically exhibit a lag in fertility at the start of production. Instead, partial wood slats gave improved over-all fertility.

### 2.1.4. Slats and Hatchability

In this section, all hatchability data will be hatchability of all eggs set except where stated otherwise.

Parkhurst (1974) and Cooper and Barnett (1972) did not find any significant differences in cumulative hatchability between full and partial slat floors.

Andrews et al. (1988) found significant differences in the hatchability of total eggs set at the end of the second and third 28-day periods after 24 weeks of age, but not in the over-all hatchability. At the end of the second period, hatchability in full litter (92.2%), partial wood (93.1%) and full plastic-covered wire slat (92.8%) pens was significantly higher than that in partial plastic-covered wire pens (86.8%). At the end of third period, hatchability was significantly higher in partial plastic-covered wire (92.8%) and partial wood (92.8%) slat pens than in full plastic-covered wire slat (88.7%) pens.

Andrews et al. (1988) also reported significant differences in the hatchability of fertile eggs at the end of the second, third and seventh 28-day periods, although none was found in over-all hatchability of fertile eggs. At the end of the second and seventh 28-day periods, hatchability was significantly higher in full litter (97.4% and 97.2%, respectively) than in partial plastic-covered wire slat (94.1% and 94.2%, respectively) pens, and intermediate in partial wood (97.0% and 96.3%, respectively) and full plastic-covered wire slat (97.1% and 95.3%, respectively) pens. At the end of the third 28-day period, hatchability was significantly higher in partial wood (96.2%) than in full plastic-covered wire slat (92.4%) pens, and intermediate in full litter (92.6%) and partial plastic-covered wire slat (95.2%) pens.

Andrews et al. (1988) suggested that the significant differences in hatchability at the end of certain periods while none was found in over-all hatchability was due to the immaturity of some of the males or the variation in the handling of eggs prior to incubation.

Bacterial contamination of hatching eggs is an inherent risk in keeping breeders on litter. In a study by Quarles et al. (1968), average counts of bacteria on egg surface were higher in litter than in wire floor houses. Air in litter floor houses averaged 5 to 10 times as many bacteria per cubic meter as in air of wire floor houses. Hatchability was significantly higher for eggs from wire floor houses.

A later study by Quarles et al. (1970) using a similar comparison, confirmed the previous results. Furthermore, the number of bacteria in the air was significantly correlated with the number of bacteria on the egg surface, but neither air nor egg surface bacterial count was correlated with hatchability. Examination of unhatched eggs showed that 94% of pipped eggs and late dead embryos and 100% of cull chicks from litter floor tested positive for coliform bacteria compared with 33% and 20%, respectively, of those from wire floor (Quarles et al, 1970).

When Carter et al. (1973) compared partial slat and wire floors, they found that bacteria counts on the egg shell surface was significantly higher in partial slat houses. Counts of bacteria in the air were not taken, and hatchability was not compared between the two floor types. Instead, Carter et al. (1973) chill-stressed chicks and isolated more types of enteric bacteria from chicks of breeders on partial slat than from counterparts on total wire floor. No further study was done to test the effect of the presence of enteric bacteria on the growth of broiler chicks.

### 2.1.5. Slats and Labor Requirements

Because more birds were housed on slat floors than on litter floors, producers were able to handle more birds with less work, and thus utilize chore time more efficiently (Wallace's Farmer, 1962; Marley, 1959; Wallace's Farmer, 1958).

Barn clean-out was required less frequently with slat floors; producers cleaned out once a year or after shipping a flock (Wallace's Farmer, 1962; Marley, 1959; Wallace's Farmer, 1958). This "all-in-all-out" practice of housing flocks has been recognized as an effective method of controlling the spread of disease between the previous and the subsequent flock.

Magruder and Nelson (1965) found a reduction in labor requirement from 35.3 to 19.7 minutes/bird/year by using full slat floors instead of full litter floors. As forecast by France (1959), full slat floors reduced labor requirements by about half.

### 2.1.6. Conclusions

These studies show that by placing more birds per unit floor space, slats minimize labor but lower egg production per hen. Egg quality, fertility and hatchability are not significantly affected by the use of slats. Full litter gave the best egg production, however the labor and floor space requirements of today's large flocks favor the use of slats. Partial slats may be the ideal middle ground.

## 2.2. STUDIES ON BREEDER AGE

### 2.2.1. Breeder Age and Egg Production

At the start of egg production, layers and breeders quickly increase egg numbers, reaching a peak at about 30-32 weeks of age (Nordskog, 1980).

Mather and Laughlin (1979) have found evidence that in caged broiler breeders, the average length of the clutch decreases from 4.15 eggs at peak production to 1.10 eggs 48 weeks later. Therefore, the decline in egg production among older breeders is partly due to the increase in the number of non-productive days between clutches. Mather and Laughlin (1979) also suggested that the eggs may spend a longer time in the oviduct of older birds, but have not found any evidence to support their claim.

As production progresses, larger eggs represent a progressively larger proportion of the total eggs laid. When McNaughton et al. (1978) grouped chicken eggs into 2-gram weight classes, the resulting frequency distribution showed that the first 50.3% of the eggs from the 29-week old breeders was spread from the <47-gram to the 55-56 gram class. At 58 weeks of age, the first 52.2% of the eggs from the same breeders was spread from the 51-52-gram to the 65-66-gram class.

Four-week production data from 3 different Ross I broiler breeder flocks indicated that the average egg weight consistently increased from 55 grams at 28 weeks of age to 75-76 grams at 60-62 weeks of age (Kirk et al., 1980).

In a study involving 3 commercial breeder flocks of the same strain, Mather and Laughlin (1979) found that the mean egg weight consistently increased in all of the flocks. In the first flock, mean egg weight increased from 54.5 grams at 28 weeks of age to 66.3 grams at 53 weeks of age. In the second flock, the mean egg weight increased from 57.4 grams at 30 weeks to 67.2 grams at 55 weeks; and, in the third flock, from 60.4 grams at 32 weeks to 69.3 grams at 57 weeks.

### 2.2.2. Breeder Age and Fertility

Studies involving chicken indicate that fertility, like egg production, increases at the beginning of the production cycle, peaks and then slowly declines.

Kirk et al. (1980) noted that Ross I broiler breeding stock had a peak fertility of nearly 100% at about 34 weeks of age; at 60 weeks of age, fertility declined to about 89%.

The fertility of 12 different flocks of New Hampshire breeders, with an average age of 160 days (22.8 weeks) at the start of production, was monitored by Tomhave (1958) for 365 days (52.1 weeks) of production. The study period was divided into 50-day production periods. A peak fertility of 90.0% was attained during days 51-100 of production (30.1-37.1 weeks of age). This production period includes the 34th week of age, the age at which peak fertility was detected by Kirk et al. (1980) in Ross I broiler breeders. The proportion of fertile eggs declined considerably from 87.1% during days 201-250 to 81.4% during days 251-300.

Parkhurst (1974) observed an increase in fertility among broiler breeders on all full and partial wood slats during the first three 28-day periods after 23 weeks of age, with fertility peaking during the third test period. Thereafter, fertility decreased. The third 28-day period includes week 34 of breeder age, the time during which Kirk et al. (1980) observed a peak of nearly 100% fertility in Ross I breeders. Additionally, the third 28-day period is included within days 51-100, the period of peak fertility in the study by Tomhave (1958).

Andrews et al. (1988) found significant differences in fertility between partial wood slat and full and partial flooring of plastic-covered wire, found significant differences in fertility between partial wood (97.2%) and partial plastic-covered wire slats (92.2%) during the third 28-day period after 24 weeks of age. Fertility on full litter (94.7%) and full plastic-covered wire (95.6%) slats was intermediate; no significant differences were found in over-all fertility.

Regardless of floor type, Nordskog and Schierman (1965) detected an increase in fertility during the first 10 days of putting male and female White Leghorns on partial slat and full litter floors, with birds on the partial slat floors showing a slower increase. The report did not elaborate on fertility trends after the first 10 days of production.

Reinhart and Hurnik (1984) found that fertility of eggs laid at 33-35 weeks of breeder age was significantly higher ($p<0.001$) compared with those laid by the same breeders at 50-52 weeks of age (96.3% vs. 91.9%).

Without reporting egg production, Quarles et al. (1970) stated that in Single Comb White Leghorns, production (i.e., age of breeder) was correlated with fertility; fertility increased with production during sixteen 14-day test periods after 20 weeks of breeder age. There was no distinct peak, but fertility declined during the last quarter of the experimental period.

Tindell and Morris (1964) noted that the fertility of chicken eggs collected from different hatcheries progressively increased as average egg weight increased from 42.5 to 61.5 grams. Assuming that the larger eggs were laid by older breeders, Tindell and Morris (1964) stated that the females laying the small eggs were just coming into production and were not being covered by the males as efficiently as their counterparts laying larger eggs, hence the lower fertility in small eggs.

A very early study, conducted by Halbersleben and Mussehl (1922), showed that "extremely small and extremely large" chicken eggs (46-49 and 59-65 grams, respectively) had the lowest fertility (80-81%), while eggs weighing 50-58 grams had the best fertility (87%). The authors did not mention the breed studied, or whether the different sizes of eggs came from hens of different ages.

Proudfoot and Hulan (1981) did not see differences in fertility between chicken eggs weighing 46-50 grams and 53-57 grams. These investigators concluded that fertility is not influenced by egg size. In light of the study by Halbersleben and Mussehl (1922), Proudfoot and Hulan (1981) should have observed higher fertility in eggs weighing 46-50 grams than in those weighing 53-57 grams. Neither report mentions the breed of chicken used for the study. Proudfoot and Hulan (1981) obtained all egg sizes from breeders of the same age, but Halbersleben and Mussehl (1922) made no statement in this respect. Therefore the discrepancy could not be attributed to differences in the breed used or to the fact that egg sizes represented different breeder ages in one study and not in the other.

### 2.2.3. Breeder Age and Hatchability

The influence of breeder age on hatchability seems to be a function of egg weight. Egg sizes in the extreme have been shown to have lower hatchability than those in the intermediate. Since chicken eggs have been found to consistently increase in size as the flock ages (Kirk et al., 1980; Mather and Laughlin, 1979), extremely small eggs near the beginning of lay and extremely large eggs near the end of lay would have lower hatchability than eggs laid during the middle of the laying cycle.

Except when stated otherwise, all hatchability data presented will be hatchability of total eggs set.

In the study by Kirk et al. (1980) the maximum hatchability of Ross I broiler breeder eggs was 91%, and occurred at 44 weeks of age; average egg weight at this time was 65 grams. At 60 weeks of age, hatchability had declined to 82%, and average egg weight was 75 grams. The lower hatchability before and after the peak was thought to be due, in part, to an effect of egg weight. It appeared that an optimal egg weight was involved, and that the smaller eggs from a young flock and the larger eggs from an older flock were not as hatchable as those weighing close to the optimal weight.

No mention was made of egg weight in a study by Tomhave (1958), but it was found that the age of breeders had little influence on the hatchability during the first five 50-day test periods (250 days). Hatchability slowly increased from the start of production until it peaked at 79.7% during days 151-200 of production, and then decreased from 77.4% during days 201-250 to 69.3% during days 251-300. The peak period covers weeks 44-51 of age, and confirms the results from the study by Kirk et al. (1980) where peak hatchability of all eggs set was seen at 44 weeks of age. The hatchability of fertile eggs remained consistently between 88.1 and 90.3% from days 1-250, and stayed within 85% from day 251 to the end of the study period (day 365).

McNaughton et al. (1978) found significant differences in hatchability between eggs from parents of different ages only when egg sizes were different. Eggs from 29-week old breeders were assigned to either the 47-52 or 57-62-gram groups, and those from 58-week old breeders to either the 57-62 or 67-74-gram groups. The hatchability of the three weight groups were significantly different from each other. The lightest group had the highest hatchability (86%), the 57-62-gram group was intermediate (80.3 at 29 weeks of age and 81.4% at 58 weeks of age) and the 67-74-gram group the lowest (75.4%).

Without stating that eggs of different size groups came from parents of different ages, Halbersleben and Mussehl (1922) reported that "extremely large (59-65 grams) and extremely small (46-49 grams) eggs" did not hatch as well as those weighing 50-58 grams. Average hatchabilities were 29%, 33% and 41.6%, respectively.

Proudfoot and Hulan (1981) concluded that within the intermediate size ranges, hatchability was unaffected by size differentials. Their study indicated that hatchability of eggs weighing 46-50 grams (56.5%) was not significantly different from that of eggs weighing 53-57 grams (58.6%). No explanation was given for the low over-all hatchability.

### 2.2.4. Breeder Age and Embryo Mortality

Although the pattern of embryo mortality during incubation in chicken and turkey eggs has been well documented (Byerly et al., 1933; Byerly, 1930; Payne, 1919), very little work has been done to investigate the changes that occur in the pattern with the change in breeder age.

The two critical periods found by Payne (1919) during the incubation of chicken eggs occurred on days 4-6 and on days 18-20 of incubation, and were consistent for both natural and artificial incubation.

Insko and Martin (1935) found two peaks of chicken embryo mortality; one on day 2 and the other on day 19 of incubation, with the early peak being two days earlier than, and the late peak coinciding with Payne's (1919).

The two critical periods detected by Insko and Martin (1935) in the development of turkey embryos were days 4 and 25 of incubation. They stated that the second mortality peak occurred at the same relative time as in chicken eggs. However, the first peak did not, and Insko and Martin (1935) attributed this difference to the greater length of time required to heat turkey eggs to incubation temperature.

## LITERATURE REVIEW

Reinhart and Hurnik (1984) divided the incubation period of chicken eggs into days 1-8, days 9-18 and days 19-21 to correspond with the mortality periods in the earlier studies (Insko and Martin, 1935; Payne, 1919). Mortality during days 1-8 and days 9-18 was higher, but not significantly, in eggs from 50-52-week old breeders than in eggs from 33-35-week old breeders. Mortality during days 19-21 was significantly higher in eggs from the older breeders. For both breeder ages, the eggs were assigned to four weight groups: small, medium, large and extra large with average weight of 59.3, 63.0, 65.6 and 69.6 grams respectively. The report did not state the proportion of eggs from each of the two breeder age groups in each egg weight group. Therefore, it is unknown whether larger eggs predominated when breeders were 50-52 weeks old, as is usually seen for chickens. Embryo mortality during days 1-8 was higher, but not significantly, in the small and extra large eggs than in the medium and large eggs. Mortality during days 9-18 was similar for all weight group. During days 19-21, the mortality in extra large eggs was significantly higher than in the other three groups. There was no significant interaction between breeder age and egg weight.

### 2.2.5. Breeder Age and Progeny Growth

A consistent relationship has been found between the weight of the unincubated egg and the weight of the chick at hatch. In a summary of studies in six domestic bird species, Shanawany (1987) concluded that hatching weight depended upon a linear function of egg weight at setting. It was estimated that hatching weight increases by 0.59 gram for every gram increase in egg weight. Shanawany (1987) reported that on average, hatching weight of chicken, turkey, duck, goose, pheasant and quail represent 68.0%, 63.0%, 57.8%, 58.9%, 62.0% and 66.9%, respectively, of the unincubated egg weight. The percentage was significantly different between the species except between the duck and the goose.

Since Kirk et al. (1980) and McNaughton et al. (1978) reported that larger eggs predominate in older chicken breeders, chicks from these breeders would be heavier than those from younger breeders.

Numerous studies have been conducted to investigate the influence of egg weight on chick growth (Proudfoot and Hulan, 1981; Deaton et al., 1979; Gardiner, 1973; Tindell and Morris, 1964; Goodwin, 1961; Kosin et al., 1952; Skoglund et al., 1952; Wiley, 1950; Upp, 1928; Halbersleben and Mussehl, 1922) but few have addressed the influence of egg weight on chick growth as related to breeder age (Pone et al., 1985; McNaughton et al., 1978).

In two experiments, McNaughton et al. (1978) investigated the influence of breeder age on the body weight of chicks using eggs of comparable weight. From 29-week old breeders, eggs weighing 47-54 and 57-62 grams were obtained, and from 58-week old breeders, 57-62 and 67-74 grams. Broilers from the heavier eggs were consistently heavier at 1 day and 2, 4 and 6 weeks of age. Statistical comparisons were made between the body weights at market age only, with the two sexes separate. In the first experiment, birds were marketed at 8 weeks of age, and at seven weeks and four days of age in the second trial. Both experiments showed that there were no significant differences in the body weight of female chicks from 29- and 58-week old breeders when the egg weights were uniform. On the other hand, the female progeny of 29-week old breeders obtained from eggs weighing 47-54 grams were significantly lighter than those from 57-62 grams and the progeny of 58-week old breeders. During the first experiment, male broilers hatched from eggs weighing 67-74 grams were significantly heavier than those from eggs weighing 47-54 grams. No differences in male body weight were detected during the second experiment. McNaughton et al. (1978) concluded that the age of parents influenced the market body weights of their progeny through differences in egg weights.

Without choosing a particular egg weight group at 27, 42 and 52 of breeder age, Pone et al. (1985) compared the growth of male chicks from 27-, 42- and 52-week old Cobb breeders. The broilers were raised separately according to parental age and intermingled, both on litter and plastic-covered perforated metal floors.

At one day of age, body weights for the respective parental age groups were 36.1, 41.2 and 42.7 grams. The 31-day body weights were 948, 998 and 1030 grams, respectively. At both times, the body weight of the three progeny groups were significantly different from each other. At 44, 47 and 52 days of age, the body weights of progeny from 42- and 52-week old breeders were statistically equal and were significantly higher than that of progeny of 27-week old breeders.

Grouping the male broilers according to the type of flooring, Pone et al. (1978) found that those raised on slats were consistently heavier than those raised on litter. When male broilers from all parental age groups were grown intermingled on each of the two floor types, differences were significant only at 52 days of age. On the other hand, when the parental age groups were raised separately, differences were significant at 44 and 47 days of age. It was concluded that the type of rearing (separate vs. competitive) did not alter the influence of parental age on chick weight.

Without showing feed consumption values, Pone et al. (1985) stated that broilers from the youngest parents consumed less feed at each of the weighing days mentioned. In agreement with McNaughton et al. (1978), Pone et al. (1985) concluded that the effect of breeder age on the growth of progeny is not manifested when egg weights are equalized.

### 2.2.6. Conclusions

Hatchability and fertility increase shortly after the beginning of egg production, peak and then decline. Progeny growth however, increases constantly with egg weight. Information on the influence of breeder age on embryo mortality is insufficient for any conclusion to be made.

# 3. OBJECTIVES

Present-day intensive poultry production systems require the use of slats as a manure management practice. Wood slats have been widely used, however there has been some interest in plastic slats. Some of the apparent benefits of plastic slats are cleaner flooring and greater durability.

This study was conducted to investigate the influence of wood and plastic slats, either in combination with litter or as full flooring, on the important economic performance parameters of Arbor Acres broiler breeders and growth of the progeny over one production cycle.

The following hypotheses were tested:

1) Plastic slats result in higher egg production, fertility and hatchability.
2) The progeny of plastic slat breeders grow more efficiently than wood slat progeny.

# 4. MATERIALS AND METHODS

## 4.1. BROODING PROCEDURES

Arbor Acres broiler breeders housed at the Animal Science Poultry Unit breeder barn were used for this study. The Arbor Acres Male and Female Management Guide (1985) was adhered to in raising the broiler breeders to 24 weeks of age.

Brooder heat lamps were used to supply additional heat during brooding. A temperature of 32°C at floor level was maintained for the first 3 days. Temperature was dropped every 3 days until 21-22°C was attained. The last heat lamps were removed at 26 days of age. Room temperature was maintained near 15°C thereafter.

From one day to 4 weeks of age, males and females were brooded together on wood shavings at 159 birds for each of eight 3 m x 3.6 m pens. At 4 weeks of age, 60 cm-high slats were installed on 60% of the floor area of all the pens. At 11 weeks of breeder age, full slat arrangements were installed in half of the 24 pens, and birds in each of the 8 brooding pens were divided into three groups and assigned to respective pens.

At 13 weeks of age, the chicks were diagnosed to have staphylococcus infection, and were given tetracycline for a week, followed by penicillin at 17, 19 and 30 weeks of age.

The chicks were vaccinated against Marek's disease at one day of age, and against Newcastle/Bronchitis at 2, 10 and 16 weeks of age.

## 4.2. LIGHTING

Lighting in each pen was provided by a 100-watt incandescent bulb from the time the heat lamps were removed through to the end of the 17th week. In each hallway, one 22-watt circle fluorescent lamp was provided for each of two adjacent pens. The broiler breeders were provided with 10 hours of light from one day of age to the end of the 17th week. At the start of the 18th week, photoperiod was increased by one hour every week, until 14 hours was attained. Photoperiod was maintained at 14 hours until the end of the study.

## 4.3. HOUSING DURING LAY

Shortly prior to the onset of lay (week 22) the number of birds per pen was equalized into 47 females and 6 males. Dead and culled females were replaced until 28 weeks of age.

Each pen was 3 m x 3.6 m, and floor space allotment was 2040 $cm^2$/bird. The pens were situated in two rooms which were separated by the feedroom. The first room contained pens 1 to 8, and the second contained pens 9 to 24. The pens formed two lines down the middle of each room.

## MATERIALS AND METHODS

The influence of slat material (wood vs. plastic) and slat coverage (full vs. partial) were examined on parameters which will be mentioned subsequently. Breeders were fed two types of diet, formulas for which are listed in Appendix Tables 5, 6 and 7. Since there was no significant diet effect, replicates have been combined for the analysis of this thesis. Another variable name, slat type, was created to distinguish each of the four kinds of flooring systems resulting from the slat material and slat coverage treatments. Six pens were assigned randomly to each of the 4 slat type treatments.

The slat type names were as follows:

1) Full wood slats (FWS)
2) Partial wood slats (PWS)
3) Full plastic slats (FPS)
4) Partial plastic slats (PPS)

Each of the 8 variable combinations was represented by one pen in the room containing pens 1 to 8, and by two pens in the other room. The rooms were assigned to treatments at regular interval.

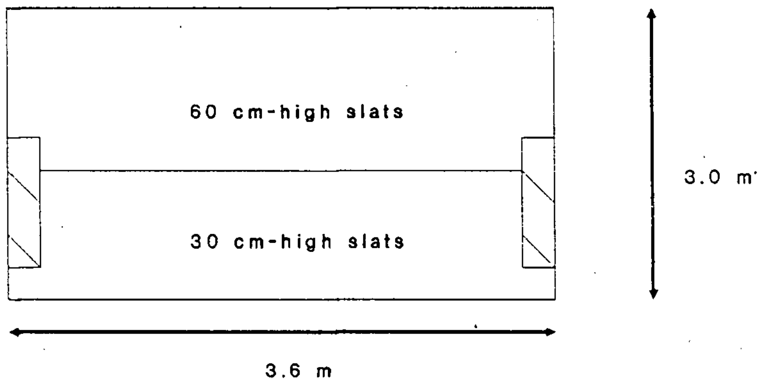
Figure 1 illustrates the pen set-up. In pens with partial slats (PWS and PPS), 60% of the floor area was covered with slats raised 60 cm above the concrete floor, and the rest of the floor area was covered with 5 cm-deep wood shavings. A slatted step-up, 30 cm wide and 30 cm above the concrete floor, was placed along the slatted area on recommendation of the broiler breeder company. In full slat pens (FWS and FPS), 60% of the floor area was covered with slats raised 60 cm above the floor, and the rest with slats raised 30 cm above the floor.

Each pen had four 20-kg tube feeders with pans at 41.9 cm diameter and one hanging round automatic waterer at 34.3 cm diameter. A 12-hole metal nest, with wooden perches, was situated on each of two sides of every pen at the uniform height of 60 cm above the floor. In partial slat pens, one end of the nests was set on the slats and the other over extended over the litter area. In full slat pens, one end of the nests was set over the 60-cm high slats and the other extended over the 30-cm high slats.

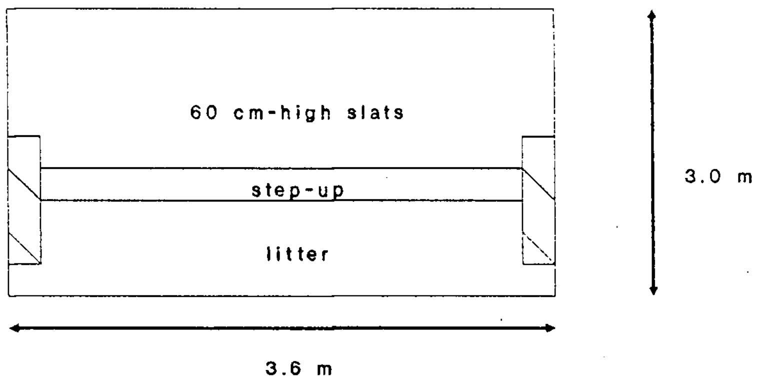
Figure 2 is an illustration of the dimensions of wood and plastic slats. The plastic slats were 1.2 cm wide, and had 1.8 cm x 9.3 cm openings which were separated by 0.8 cm-strip along the short axis. The wood slats were 3.5 cm wide and 2 cm apart.

Waste was allowed to accumulate under the slat area throughout the study, but the wood shavings in partial slat pens was periodically changed.

Figure 1. Dimensions of Pens*




FULL SLAT PENS

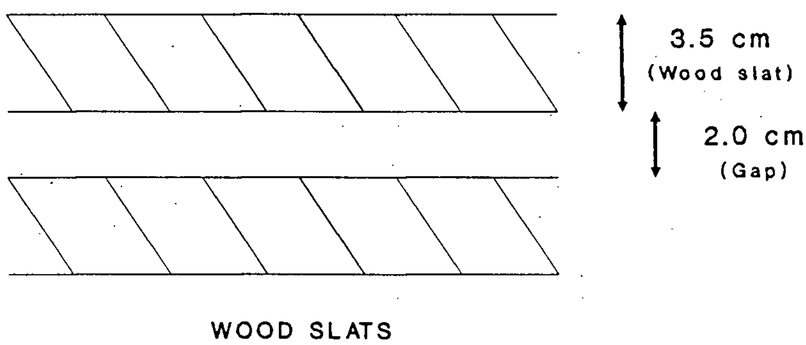


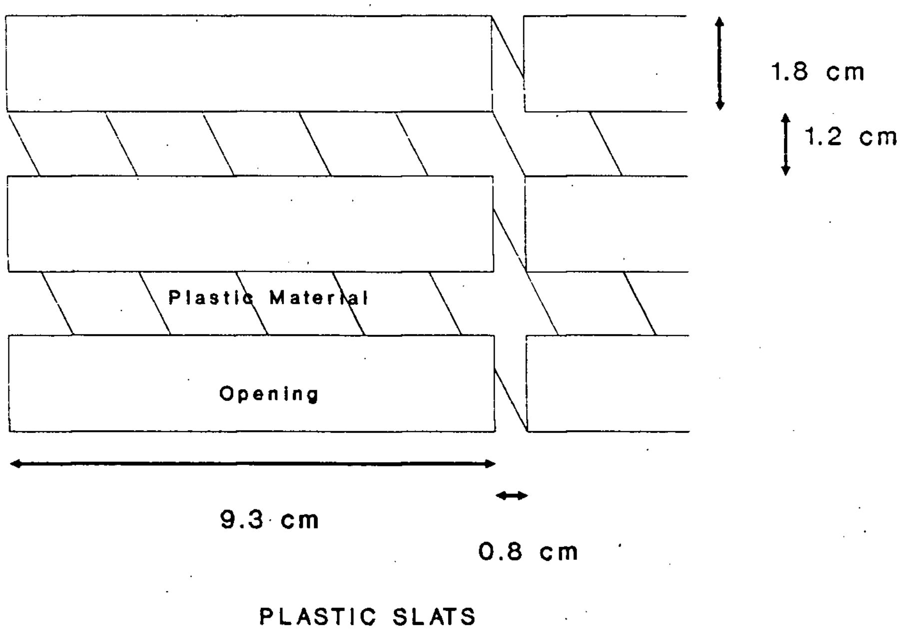

PARTIAL SLAT PENS

*Not drawn to scale.

Nests.

Figure 2. Dimensions of Slats*




*Not drawn to scale.

## 4.4. FEEDING PROGRAM

Breeders were fed starter diets *ad lib* from day one to the end of 3 weeks. From 4 to 20 weeks, breeders were fed developer diets on a limited feed program skipping the Wednesday and Sunday of each week. From 21 weeks of age to the end of the study, breeder diets were fed everyday as recommended by the Arbor Acres Broiler Breeder Male and Female Feeding and Management Guide (1985). Diet formulas are listed in Appendix Tables 5, 6 and 7.

## 4.5. EGG COLLECTION

Starting at 24 weeks of age, eggs were collected from the nests and the slat and slat-litter floor in each pen 3 times a day. Eggs that fell through the slats were not counted. Eggs on the floor were counted separately from eggs in the nest. The numbers of cracked eggs on the floor and in the nest were also recorded. Eggs were shipped to a commercial hatchery once a week for hatching. The breeders were shipped after 58 weeks of age.

## 4.6. FERTILITY AND HATCHABILITY TESTS

Settable eggs were incubated to hatch at the UBC Animal Science Poultry Unit approximately every five (5) weeks starting at 37 weeks of age for fertility and hatchability. As in commercial hatcheries, dirty, cracked and thin-shelled eggs were discarded. Sample size was 75-100 eggs per pen. Eggs were left overnight at room temperature prior to incubation. A relative humidity of 60-70% during the first 18 days and 80% during the last 3 days of incubation was aimed at, but the Robbins incubators fluctuated greatly in relative humidity for short periods of time. Incubator temperature was more consistent and thermometer readings of $99.2^{o}F \pm 0.90$ ($37.3^{o}C \pm 0.50$) were attained.

The eggs that were set were candled between the 7th and 10th days of incubation to remove infertile eggs and early dead embryos. Viable embryos as determined during the candling were transferred to a Robbins hatcher at day 18 for hatching. Those unhatched after 21 days of incubation were opened to determine the final stage of development and to record abnormalities.

The time of death of the embryo was classified into 4 stages: early (days 0-7), middle (days 8-14), late (days 15-21) and pipped for embryos that break the egg shell but do not hatch.

## 4.7. GROWTH TRIALS

Chicks were selected from the hatch of the 37th- and 46th-week collections and grown out to three weeks. Chick from the 56th week collection were grown out to market age (six weeks). Except for discarding the deformed and crippled chicks, no culling was practiced. Two replicate groups of ten chicks were randomly assigned to battery brooders to represent each of the parental pens. Body weight and feed intake were measured at the end of each week.

Battery cages (Petersime Chick Batteries) used to house chicks from the first to the third week were 98 cm(L) x 69 cm(W) x 24 cm(H). The 48 battery cages were on 4 trolleys of 12 cages each; in each trolley the 12 cages were stacked 6 high, side by side. Each battery cage was equipped with 63 cm-long feed troughs and 67 cm-long water troughs. Heating coils in each cage provided additional heat during the first two weeks, when battery cage temperature was maintained near 27°C. Thereafter, the temperature was maintained near 20°C.

The 56th week progeny were taken only from eggs which weighed 66-78 grams before incubation. This procedure, done only for this growth trial, was aimed at minimizing variation due to differences in egg weight and initial chick weight. The chicks were sexed after hatching, so that each parental pen was represented by one group of 10 male chicks and one group of 10 female chicks. After body weight and feed intake were measured on the third week, each replicate of 10 birds was reduced to 7 birds for optimum space allotment in grower cages; cripple and weak birds were discarded, and in pens without cripple or weak birds, excess chicks were randomly picked out. Body weight and feed intake were measured on the 5th and 6th weeks.

During the third to the sixth week of the last grow-out trial, chicks were housed in 66 cm(L) x 66 cm(W) x 36 cm (H) cages. Each of the 4 trolleys of 12 cages had 3 groups of 4 cages high. The feed and water troughs were 60 cm long.

The broiler chicks were given non-medicated commercial feed. During the first three weeks, broiler starter with 23% protein was used. During the fourth and fifth weeks of the last trial, broiler grower with 20% protein was given to the chicks, and broiler finisher with 18% protein on the sixth week.

Feed and water were provided ad lib to the broilers throughout the experiment. A 100-watt incandescent bulb, hung about 1 meter above each trolley, provided light 24 hours a day throughout the study.

## 4.8. STATISTICAL ANALYSIS

Analysis of variance (ANOVA), specifically the General Linear Models procedure of SAS (1985), was applied to all of the egg production and progeny growth parameters. Analysis showed that except in interactions with the other main effects, breeder diet did not significantly influence any of the parameters measured. Therefore, means of breeder diet groups were combined and the degrees of freedom were added to the error term in subsequent analyses.

Parameters measured included percent biweekly and overall egg production, percent floor eggs, cracked nest eggs, cracked floor eggs and "settable" eggs. Percentage values were transformed using arcsine transformation for statistical analysis (Li, 1964). The statistical model used was:

$$Y_{ijkl} = \mu + R_i + M_j + C_k + (MC)_{jk} + E_{ijkl},$$

and $i=1,2,\ldots,6$; $j=1,2$; $k=1,2$; $l=1,2,\ldots,24$; where $Y_{ijkl}$ = one of the dependent variables (% biweekly egg production, % floor eggs, % cracked nest eggs, % cracked floor eggs or % "settable" eggs). $Y_{ijkl}$ is the egg production status of the $l^{th}$ pen of the $i^{th}$ replicate with the $j^{th}$ slat material and the $k^{th}$ slat coverage; $\mu$ = the theoretical population mean, $R_i$ = effect of the $i^{th}$ replication, $M_j$ = effect of whether slat material was wood or plastic, $C_k$ = effect of whether slat coverage was full or partial; $(MC)_{jk}$ = effect of two-way interaction involving main effects; $E_{ijkl}$ = random error.

The influence of breeder age, slat material and slat coverage on percent fertility, percent hatchability, and percent incidence of embryo mortality were also analyzed using ANOVA with repeated measures. Arcsine transformation

(Li, 1964) was applied to percentage values before statistical analysis. The statistical model used was:

$$Y_{ijkln} = \mu + R_i + M_j + C_k + (MC)_{jk} + E1_{ijk} + A_l + (AM)_{jl} + (AC)_{kl} + (AMC)_{jkl} + E2_{ijkln},$$

and i=1,2,..,6; j=1,2; k=1,2; l=1,2,..,5; n=1,2,..,120; where $Y_{ijkln}$ = is one of the dependent variables (% fertility, % hatchability, % incidence of embryo mortality). $Y_{ijkln}$ is the reproductive status of the females in the $n^{th}$ pen of $i^{th}$ replication with the $j^{th}$ slat material and the $k^{th}$ slat coverage, during the $l^{th}$ breeder age; $\mu$ = theoretical population mean, $R_i$ = effect of the $i^{th}$ replication, $M_j$ = effect of whether slat material was wood or plastic, $C_k$ = effect of whether slat coverage was full or partial, $(MC)_{jk}$ = effect of two-way interaction between the main effects, $E1_{ikl}$ = error term for testing the main effects, $A_l$ = the effect of a specific breeder age, $(AM)_{jl}$, $(AC)_{kl}$ = effects of two-way interactions involving breeder age, $(AMC)_{jkl}$ = effect of three-way interaction between the main effects and breeder age, $E2_{ijkln}$ = error term for testing the sub-plot effects.

The influence of breeder age, slat material and slat coverage on the three-week growth of 37th, 46th and 56th week progeny were analyzed using the following statistical model:

$$Y_{ijklmn} = \mu + R_i + RP_{ij} + M_k + C_l + (MC)_{kl} + E1_{ijkl}$$

$$+ A_m + (AM)_{km} + (AC)_{lm} + (AMC)_{klm} + E2_{ijklmn},$$

and $i=1,2,..,6$; $j=1,2$; $k=1,2$; $l=1,2$; $m=1,2,3$; $n=1,..,144$; where $Y_{ijklmn}$ = is one of the growth parameters of progeny (body weight, weight gain, feed intake, feed conversion). $Y_{ijklmn}$ is the growth status of the progeny in the $j^{th}$ cage from the $i^{th}$ parental pen with the $k^{th}$ slat material and the $l^{th}$ slat coverage during the $m^{th}$ breeder age; $\mu$ = theoretical population mean, $R_i$ = effect of the $i^{th}$ parental pen, $RP_{ij}$ = effect of the $j^{th}$ progeny cage from the $i^{th}$ parental pen, $M_k$ = effect of whether slat material of the parental pen was wood or plastic, $C_l$ = effect of whether slat coverage of the parental pen was full or partial, $(MC)_{kl}$ = effect of two-way interaction between the main effects, $E1_{ijkl}$ = error term for testing the main effects, $A_m$ = effect of a specific breeder age, $(AM)_{km}$ and $(AC)_{lm}$ = effect of two-way interactions involving breeder age; $(AMC)_{klm}$ = effect of three-way interaction between the main effects and breeder age $E2_{ijklmn}$ = error term for testing the sub-plot effects.

Hatching weight of progeny was adjusted in a covariance analysis to eliminate the effect of breeder age on the growth of progeny (Hicks, 1982). The following statistical model was used:

$$Y_{ijklmn} = \mu + R_i + RP_{ij} + M_k + C_l + (MC)_{kl} + E1_{ijkl}$$
$$+ A_m + (AM)_{km} + (AC)_{lm} + (AMC)_{klm} + E2_{ijklmn}$$

$+ HBWT_{ijklmn}$,

and $i=1,2,..,6$; $j=1,2$; $k=1,2$; $l=1,2$; $m=1,2,3$; $n=1,..,144$; where $Y_{ijklmn}$ = is one of the growth parameters of progeny (body weight, weight gain, feed intake, feed conversion). $Y_{ijklmn}$ is the growth status of the progeny in the $j^{th}$ cage from the $p^{th}$ parental pen with the $k^{th}$ slat material and the $l^{th}$ slat coverage during the $m^{th}$ breeder age; $\mu$ = theoretical population mean, $R_i$ = effect of the $i^{th}$ parental pen, $RP_{ij}$ = effect of the $j^{th}$ progeny cage from the $i^{th}$ parental pen, $M_k$ = effect of whether slat material of the parental pen was wood or plastic, $C_l$ = effect of whether slat coverage of the parental pen was full or partial, $(MC)_{kl}$ = effect of two-way interaction between the main effects; $E1_{ijkl}$ = error term for testing the main effects, $A_m$ = effect of a specific breeder age, $(AM)_{km}$ and $(AC)_{lm}$, = effect of two-way interactions involving breeder age; $(AMC)_{klm}$ = effect of three-way interaction between the main effects and breeder age, $E2_{ijklmn}$ = error term for testing the sub-plot effects, $HBWT_{ijklmn}$ = the covariate, hatching weight of progeny.

In the analysis of the six-week growth of 56th week progeny, the independent variables involved were slat material, slat coverage and sex of progeny. The following statistical model was used:

$$Y_{ijkln} = \mu + R_i + M_j + C_k + S_l + (MC)_{jk} + (MS)_{jl}$$

$$+ (CS)_{kl} + (MCS)_{jkl} + E_{ijkln},$$

and i=1,2..,6; j=1,2; k=1,2; l=1,2; n=1,2,...,48; where $Y_{ijkln}$ = is one of the growth parameters of progeny (body weight, weight gain, feed intake, feed conversion). $Y_{ijkln}$ is the growth status of progeny of the $l^{th}$ sex in the $i^{th}$ replication, produced by breeders on the $j^{th}$ slat material and the $k^{th}$ slat coverage; $\mu$ = theoretical population mean, $M_j$ = effect of whether slat material of the parental pen was wood or plastic, $C_k$ = effect of whether slat coverage of the parental pen was full or partial slat, $S_l$ = effect of whether sex of progeny was male or female; $(MC)_{jk}$, $(MS)_{jl}$, $(CS)_{kl}$ = effects of two-way interactions between the main effects; $(MCS)_{jkl}$ = the effect of three-way interaction between the main effects; $E_{ijkln}$ = random error.

The pdiff procedure of the SAS General Linear Models (1985) was used to evaluate treatment differences among the means in all of the above analyses.

# 5. RESULTS

The influence of slat material and slat coverage on egg production, fertility, hatchability, distribution of embryo mortality and growth of 37th, 46th and 56th week progeny will be presented. The influence of breeder age on fertility, hatchability, distribution of embryo mortality and growth of 37th, 46th and 56th week progeny, as well as the influence of sex of progeny on the growth of 56th week progeny will likewise be presented.

Due to wide variations in weekly data, egg production, the incidence of floor eggs, cracked nest and cracked floor eggs were analyzed on a biweekly basis (lay periods).

## 5.1. *THE INFLUENCE OF SLAT MATERIAL AND SLAT COVERAGE*

### 5.1.1. Egg Recovery

The slat material x slat coverage interaction was significant for over-all egg recovery (Table 1). Partial wood (PWS) and partial plastic (PPS) slat pens had higher over-all egg recovery rate than either full wood (FWS) or full plastic (FPS) slat pens, and FWS pens had higher egg recovery rate than FPS pens. During lay periods 5, 6, 7, 10, 12, 13 and 14, PWS and PPS pens had higher egg recovery than either FWS or FPS. Except during lay periods 12, 15 and 16, egg recovery was higher in FWS pens than in FPS pens. The replication effect was significant during lay periods 2, 5 and 6.

### 5.1.2. Incidence of Floor Eggs

Although the incidence of floor eggs during lay periods 4, 9 and 15 was influenced by slats, the over-all incidence of floor eggs was not (Table 2). During lay periods 4 and 9, the incidence of floor eggs was higher in PWS and FPS pens than in FWS pens. During lay period 15, PWS, FPS and PPS pens had a higher proportion of floor eggs than FWS pens.

### 5.1.3. Incidence of Cracked Floor Eggs

During lay periods 10 and 11, the incidence of cracked floor eggs was higher in FPS pens than in PWS and PPS pens. During lay period 14, FPS pens had a higher incidence of cracked floor eggs than PWS, FPS and PPS pens (Table 3).

### 5.1.4. Incidence of Cracked Nest Eggs

The incidence of cracked nest eggs was higher in FWS and FPS pens than in PWS and PPS pens during lay periods 4, 8, 9 and 11 (Table 4). Differences were seen only during two other lay periods; during lay period 12, the incidence of cracked nest eggs was higher in FWS and FPS pens than in PWS pens; and, during lay period 16, FPS pens had a higher incidence of cracked nest eggs than FWS, PWS and PPS pens.

The over-all incidence of cracked nest eggs was higher in FWS and FPS pens than in PWS and PPS pens, and this was reflected in the higher over-all incidence of cracked nest eggs in full than partial slat pens.

### 5.1.5. Percent "Settable" Eggs

When the number of non-cracked nest eggs was used as an estimate of percent "settable" eggs, it was found that the slat material x slat coverage interaction was significant (Table 5). PWS and PPS pens had a higher proportion of "settable" eggs than either FWS or FPS pens. Additionally, the proportion was higher in FWS pens than in FPS pens .

Table 1. The Influence of Slats on Egg Recovery[1]

| Lay Period | Breeder Age (Weeks) | Slat Type[2] FWS | PWS | FPS | PPS | Standard Error of the Mean |
|---|---|---|---|---|---|---|
| 1 | 24-25 | $9.2^{a}$ | $10.0^{a}$ | $6.1^{b}$ | $9.9^{a}$ | 1.00 |
| 2* | 26-27 | $42.2^{a}$ | $45.7^{a}$ | $33.5^{b}$ | $44.9^{a}$ | 1.15 |
| 3 | 28-29 | $66.6^{a}$ | $70.4^{a}$ | $55.3^{b}$ | $67.3^{a}$ | 2.05 |
| 4 | 30-31 | $69.3^{b}$ | $75.4^{a}$ | $60.8^{c}$ | $71.6^{a,b}$ | 1.67 |
| 5* | 32-33 | $72.0^{b}$ | $78.8^{a}$ | $62.3^{c}$ | $77.5^{a}$ | 1.33 |
| 6* | 34-35 | $70.9^{b}$ | $76.9^{a}$ | $61.4^{c}$ | $76.8^{a}$ | 1.21 |
| 7 | 36-37 | $66.6^{b}$ | $72.5^{a}$ | $59.5^{c}$ | $73.6^{a}$ | 1.50 |
| 8 | 38-39 | $65.4^{b}$ | $69.9^{a,b}$ | $59.0^{c}$ | $70.9^{a}$ | 1.64 |
| 9 | 40-41 | $63.1^{b}$ | $68.0^{a}$ | $56.1^{c}$ | $66.8^{a,b}$ | 1.38 |
| 10 | 42-43 | $59.8^{b}$ | $67.3^{a}$ | $53.5^{c}$ | $65.4^{a}$ | 1.58 |
| 11 | 44-45 | $58.7^{a}$ | $63.7^{a}$ | $52.2^{a}$ | $64.4^{a}$ | 2.17 |
| 12 | 46-47 | $55.3^{b}$ | $60.8^{a}$ | $50.2^{b}$ | $62.5^{a}$ | 1.76 |
| 13 | 48-49 | $52.3^{b}$ | $57.4^{a}$ | $47.7^{b}$ | $60.6^{a}$ | 1.59 |
| 14 | 50-51 | $50.4^{b}$ | $54.6^{a}$ | $46.0^{c}$ | $57.5^{a}$ | 1.38 |
| 15 | 52-53 | $47.1^{a}$ | $53.9^{a}$ | $44.7^{a}$ | $53.2^{a}$ | 1.84 |
| 16 | 54-55 | $47.1^{b}$ | $51.6^{a,b}$ | $43.7^{b}$ | $54.0^{a}$ | 1.65 |
| | **Mean** | $56.0^{b}$ | $61.1^{a}$ | $49.5^{c}$ | $61.1^{a}$ | 1.20 |
| | Mean[x] | $58.4^{a}$ (Wood) | | $55.2^{b}$ (Plastic) | | 0.84 |
| | Mean[x] | $52.7^{b}$ (Full) | | $60.9^{a}$ (Partial) | | 0.84 |

1 Percent hen-day egg recovery.

2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

a,b,c Values followed by different letters within a line are significantly different ($P<0.05$).

x Slat material x slat coverage interaction is significant ($P<0.05$).

* Significant replication effect ($P<0.05$).

## RESULTS

Table 2. The Influence of Slats on the Incidence[1] of Floor Eggs

| Lay Period | Breeder Age (Weeks) | Slat Type[2] FWS | PWS | FPS | PPS | Standard Error of the Mean |
|---|---|---|---|---|---|---|
| 1 | 24-25 | 10.8[a] | 13.2[a] | 8.0[a] | 6.6[a] | 3.11 |
| 2 | 26-27 | 6.0[a] | 9.6[a] | 6.9[a] | 6.8[a] | 1.43 |
| 3 | 28-29 | 4.3[a] | 7.3[a] | 5.5[a] | 5.8[a] | 1.02 |
| 4 | 30-31 | 2.4[b] | 5.9[a] | 4.9[a] | 4.7[a,b] | 0.92 |
| 5 | 32-33 | 3.4[a] | 6.8[a] | 7.5[a] | 4.6[a] | 1.05 |
| 6 | 34-35 | 3.2[a] | 6.5[a] | 7.3[a] | 4.8[a] | 1.05 |
| 7 | 36-37 | 2.2[a] | 5.4[a] | 6.4[a] | 5.0[a] | 0.95 |
| 8 | 38-39 | 2.6[a] | 5.0[a] | 5.8[a] | 4.7[a] | 0.90 |
| 9 | 40-41 | 2.8[b] | 5.3[a] | 6.4[a] | 4.7[a,b] | 0.86 |
| 10 | 42-43 | 2.0[a] | 4.9[a] | 5.1[a] | 4.7[a] | 0.93 |
| 11 | 44-45 | 2.0[a] | 4.6[a] | 4.0[a] | 4.5[a] | 1.07 |
| 12 | 46-47 | 2.1[a] | 2.9[a] | 3.6[a] | 3.8[a] | 0.75 |
| 13 | 48-49 | 2.2[a] | 4.1[a] | 4.3[a] | 4.1[a] | 0.99 |
| 14 | 50-51 | 1.9[a] | 3.2[a] | 2.4[a] | 3.2[a] | 0.62 |
| 15 | 52-53 | 1.3[b] | 3.0[a] | 4.2[a] | 4.1[a] | 0.67 |
| 16 | 54-55 | 2.4[a] | 4.1[a] | 3.7[a] | 4.8[a] | 1.00 |
| | **Mean** | 3.2[a] | 5.7[a] | 5.4[a] | 4.8[a] | 0.77 |
| | Mean | 4.4[a] (Wood) | | 5.1[a] (Plastic) | | 0.54 |
| | Mean | 4.3[a] (Full) | | 5.2[a] (Partial) | | 0.54 |

[1] Floor eggs as a percentage of total egg production for a given lay period.

[2] FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

[a,b] Values followed by different letters within a line are significantly different ($P<0.05$).

Table 3. The Influence of Slats on the Incidence[1] of Cracked Floor Eggs

| Lay Period | Breeder Age (Weeks) | Slat Type[2] | | | | Standard Error of the Mean[3] |
|---|---|---|---|---|---|---|
| | | FWS | PWS | FPS | PPS | |
| 1 | 24-25 | 16.7[a] | 16.7[a] | 13.9[a] | 1.6[a] | 6.90 |
| 2 | 26-27 | 17.8[a] | 18.1[a] | 20.5[a] | 24.3[a] | 4.52 |
| 3 | 28-29 | 13.3[a] | 15.1[a] | 22.1[a] | 17.1[a] | 3.99 |
| 4 | 30-31 | 22.6[a] | 9.6[a] | 18.9[a] | 14.2[a] | 5.31 |
| 5 | 32-33 | 20.1[a] | 14.0[a] | 27.5[a] | 14.4[a] | 5.35 |
| 6 | 34-35 | 15.5[a] | 9.8[a] | 20.3[a] | 13.2[a] | 3.61 |
| 7 | 36-37 | 30.5[a] | 16.4[a] | 18.0[a] | 13.0[a] | 5.13 |
| 8 | 38-39 | 24.4[a] | 18.8[a] | 23.2[a] | 5.3[a] | 6.73 |
| 9 | 40-41 | 15.8[a] | 12.1[a] | 27.1[a] | 11.3[a] | 4.55 |
| 10 | 42-43 | 16.8[a,b] | 7.8[b] | 27.1[a] | 10.2[b] | 3.26 |
| 11 | 44-45 | 16.2[a,b] | 1.3[b] | 20.2[a] | 3.8[b] | 4.84 |
| 12 | 46-47 | 19.3[a] | 21.3[a] | 24.4[a] | 5.6[a] | 6.90 |
| 13 | 48-49 | 13.2[a] | 15.1[a] | 17.9[a] | 16.1[a] | 5.87 |
| 14 | 50-51 | 14.8[b] | 12.6[b] | 40.5[a] | 12.4[b] | 6.85 |
| 15 | 52-53 | 35.2[a] | 13.8[a] | 37.1[a] | 13.9[a] | 9.90 |
| 16 | 54-55 | 26.1[a] | 8.5[a] | 21.0[a] | 10.7[a] | 7.85 |
| | **Mean** | 19.9[a] | 13.2[a] | 23.7[a] | 11.7[a] | 2.76 |
| | Mean | 16.6[a] (Wood) | | 17.7[a] (Plastic) | | 2.01 |
| | Mean | 21.8[a] (Full) | | 12.4[a] (Partial) | | 2.18 |

1 Cracked eggs on the floor as a percentage of the number of floor eggs for a given lay period.

2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

a,b Values followed by different letters within a line are significantly different ($P<0.05$).

Table 4. The Influence of Slats on the Incidence[1] of Cracked Nest Eggs

| Lay Period | Breeder Age (Weeks) | Slat Type[2] FWS | PWS | FPS | PPS | Standard Error of the Mean |
|---|---|---|---|---|---|---|
| 1 | 24-25 | 0.8[a] | 0.2[a] | 0.9[a] | 0.3[a] | 0.50 |
| 2 | 26-27 | 1.4[a] | 0.9[a] | 1.4[a] | 1.0[a] | 0.20 |
| 3 | 28-29 | 1.1[a] | 0.6[a] | 1.1[a] | 0.2[a] | 0.23 |
| 4 | 30-31 | 1.5[a] | 0.7[b] | 1.5[a] | 0.7[b] | 0.22 |
| 5 | 32-33 | 1.8[a] | 0.6[a] | 2.0[a] | 0.9[a] | 0.26 |
| 6 | 34-35 | 1.1[a] | 0.9[a] | 1.6[a] | 0.8[a] | 0.30 |
| 7 | 36-37 | 1.5[a] | 0.5[a] | 1.8[a] | 0.7[a] | 0.36 |
| 8 | 38-39 | 1.6[a] | 0.5[b] | 2.2[a] | 0.8[b] | 0.23 |
| 9 | 40-41 | 2.1[a] | 0.7[b] | 1.9[a] | 0.8[b] | 0.19 |
| 10 | 42-43 | 2.2[a] | 0.6[a] | 1.5[a] | 1.0[a] | 0.26 |
| 11 | 44-45 | 1.8[a] | 0.8[b] | 2.3[a] | 1.0[b] | 0.22 |
| 12* | 46-47 | 1.5[a] | 0.8[b] | 2.2[a] | 1.0[a,b] | 0.29 |
| 13 | 48-49 | 2.1[a] | 1.1[a] | 1.9[a] | 1.0[a] | 0.32 |
| 14 | 50-51 | 1.9[a] | 1.6[a] | 2.5[a] | 1.5[a] | 0.45 |
| 15 | 52-53 | 3.3[a] | 2.0[a] | 2.8[a] | 2.3[a] | 0.56 |
| 16 | 54-55 | 1.9[b] | 1.5[b] | 3.2[a] | 2.0[b] | 0.34 |
| | **Mean** | 1.7[a] | 0.9[b] | 1.9[a] | 1.0[b] | 0.13 |
| | Mean | 1.3[a] (Wood) | | 1.5[a] (Plastic) | | 0.09 |
| | Mean | 1.8[a] (Full) | | 1.0[b] (Partial) | | 0.09 |

1 Cracked eggs in the nest as a proportion of total number of eggs in the nest.

2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

a,b Values followed by different letters within a line are significantly different ($P<0.05$).

* Significant replication effect ($P<0.05$).

Table 5. The Influence of Slats on the Settability of Eggs

| Variable | Percent Settable Eggs[1] |
|---|---|
| Slat Type[3] | |
| FWS | 53.4[b] (5300)[2] |
| PWS | 57.2[a] (5786) |
| FPS | 45.9[c] (4622) |
| PPS | 57.5[a] (5779) |
| SEM[4] | 1.16 (150.7) |
| Slat Material[x] | |
| Wood | 55.3[a] (5543) |
| Plastic | 51.7[b] (5200) |
| SEM[4] | 0.82 (106.5) |
| Slat Coverage[x] | |
| Full | 49.7[b] (4961) |
| Partial | 57.3[a] (5782) |
| SEM[4] | 0.82 (106.5) |

1 The number of non-cracked nest eggs as a proportion of the total number of eggs in the nest and on the floor.

2 Values in parentheses are the cumulative number of non-cracked nest eggs from 24 to 56 weeks of breeder age.

3 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

4 Standard error of the mean.

a,b,c Values followed by different letters within a column and within a variable are significantly different ($P<0.05$).

x Slat material x slat coverage interaction is significant ($P<0.05$).

### 5.1.6. Fertility, Hatchability of Total Eggs Set (TES) and Hatchability of Fertile Eggs (FES)

Table 6 shows that slats did not influence fertility, hatchability of total eggs set (TES) and hatchability of fertile eggs (FES).

### 5.1.7. Temporal Distribution of Embryo Mortality

Except for the incidence of early dead embryos, slat material and slat coverage did not influence the temporal distribution of embryo mortality (Table 7). Eggs from wood slat breeders, as opposed to eggs from plastic slat breeders, had a higher incidence of early dead (ED) embryos.

Table 6. The Influence of Slats on Percent Fertility and Hatchability

| Variable | Fertility | Hatchability of Total Eggs Set (TES) | Hatchability of Fertile Eggs (FES) |
|---|---|---|---|
| Slat Type | | | |
| FWS | 90.8[a] | 67.6[a] | 73.9[a] |
| PWS | 94.4[a] | 71.8[a] | 75.8[a] |
| FPS | 93.9[a] | 67.8[a] | 72.1[a] |
| PPS | 91.0[a] | 69.9[a] | 76.3[a] |
| SEM[1] | 0.91 | 1.35 | 1.25 |
| Slat Material | | | |
| Wood | 92.6[a] | 69.7[a] | 74.8[a] |
| Plastic | 92.5[a] | 68.9[a] | 74.2[a] |
| SEM[1] | 0.74 | 1.04 | 0.92 |
| Slat Coverage | | | |
| Full | 92.3[a] | 67.7[a] | 73.0[a] |
| Partial | 92.7[a] | 70.9[a] | 76.0[a] |
| SEM[1] | 0.74 | 1.04 | 0.92 |

1 Standard error of the mean.
2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.
a,b Means followed by different letters within a column and within a variable are significantly different ($P<0.05$).

Table 7. The Influence of Slats on the Temporal Distribution of Embryo Mortality

| Variable | Embryo Mortality[1,2] ED | MD | LD | PA | PD |
|---|---|---|---|---|---|
| Slat Type[3] | | | | | |
| FWS | 6.9[a] | 0.6[a] | 6.7[a] | 7.8[a] | 1.2[a] |
| PWS | 6.1[a] | 0.8[a] | 6.9[a] | 7.5[a] | 1.3[a] |
| FPS | 5.2[a] | 0.8[a] | 8.4[a] | 10.3[a] | 1.4[a] |
| PPS | 5.2[a] | 0.3[a] | 6.7[a] | 7.6[a] | 1.2[a] |
| SEM[4] | 0.50 | 0.18 | 0.62 | 0.79 | 0.21 |
| Slat Material | | | | | |
| Wood | 6.5[a] | 0.7[a] | 6.8[a] | 7.6[a] | 1.3[a] |
| Plastic | 5.2[b] | 0.6[a] | 7.6[a] | 9.0[a] | 1.3[a] |
| SEM[4] | 0.35 | 0.13 | 0.44 | 0.56 | 0.15 |
| Slat Coverage | | | | | |
| Full | 6.0[a] | 0.7[a] | 7.6[a] | 9.0[a] | 1.3[a] |
| Partial | 5.7[a] | 0.6[a] | 6.8[a] | 7.6[a] | 1.3[a] |
| SEM[4] | 0.35 | 0.13 | 0.44 | 0.56 | 0.15 |

1 Values represent percent mortality of total eggs set.
2 ED = early dead; MD = mid-dead; LD = late dead; PA = pipped alive; PD = pipped dead.
3 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.
4 Standard error of the mean.
a,b Means followed by different letters within a column and within a variable are significantly different ($P<0.05$).

### 5.1.8. Growth, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny

The weekly body weight of 37th, 46th and 56th week progeny was not affected by the slat material and slat coverage in the parental pens (Table 8).

The first week weight gain (BWTGN-1) of FWS, PWS and PPS progeny was higher than that of FPS progeny. The weight gain of progeny during the rest of the three-week study was not affected by slats.

PWS progeny had higher feed intake during the first week (FI-1), as well as higher total feed intake (C-FI) than the other three progeny groups. During the second week, FWS and PWS progeny had higher feed intake than FPS and PPS progeny. There was a significant parental pen replication effect in the second week and over-all feed intake and feed conversion.

Despite differences in weight gain and feed intake, no significant differences were found in the weekly and over-all feed conversion of the different progeny groups.

Table 8. The Influence of Breeder Slats on Body Weight, Body Weight Gain, Feed Intake and Feed Conversion, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny

| | Slat Type[1,2] | | | | Standard Error of the Mean |
|---|---|---|---|---|---|
| | FWS | PWS | FPS | PPS | |
| Body weight(g)[3]: | | | | | |
| H-BWT | $47.4^{a}$ | $47.2^{a}$ | $47.2^{a}$ | $47.2^{a}$ | 0.20 |
| BWT-1 | $154.0^{a}$ | $156.5^{a}$ | $148.6^{a}$ | $153.9^{a}$ | 1.40 |
| BWT-2 | $370.7^{a}$ | $376.5^{a}$ | $363.7^{a}$ | $365.8^{a}$ | 3.31 |
| BWT-3 | $674.4^{a}$ | $688.8^{a}$ | $662.0^{a}$ | $668.5^{a}$ | 7.67 |
| Body weight gain(g)[4]: | | | | | |
| BWTGN-1 | $106.6^{a}$ | $109.3^{a}$ | $101.4^{b}$ | $106.7^{a}$ | 1.34 |
| BWTGN-2 | $216.7^{a}$ | $220.0^{a}$ | $215.1^{a}$ | $211.9^{a}$ | 2.54 |
| BWTGN-3 | $303.7^{a}$ | $312.3^{a}$ | $298.3^{a}$ | $302.7^{a}$ | 6.54 |
| C-BWTGN | $627.0^{a}$ | $641.6^{a}$ | $614.8^{a}$ | $621.3^{a}$ | 7.63 |
| Feed intake(g)[5]: | | | | | |
| FI-1 | $125.2^{b}$ | $129.8^{a}$ | $123.0^{b}$ | $126.8^{b}$ | 1.44 |
| FI-2* | $299.9^{a}$ | $307.6^{a}$ | $296.6^{b}$ | $297.2^{b}$ | 2.86 |
| FI-3 | $483.5^{a}$ | $497.8^{a}$ | $484.0^{a}$ | $481.2^{a}$ | 5.17 |
| C-FI* | $908.6^{b}$ | $935.2^{a}$ | $903.6^{b}$ | $905.2^{b}$ | 7.63 |
| Feed conversion[6]: | | | | | |
| FC-1 | $1.17^{a}$ | $1.19^{a}$ | $1.21^{a}$ | $1.19^{a}$ | 0.013 |
| FC-2* | $1.38^{a}$ | $1.40^{a}$ | $1.38^{a}$ | $1.40^{a}$ | 0.012 |
| FC-3 | $1.59^{a}$ | $1.59^{a}$ | $1.62^{a}$ | $1.59^{a}$ | 0.033 |
| C-FC* | $1.45^{a}$ | $1.46^{a}$ | $1.47^{a}$ | $1.46^{a}$ | 0.014 |

1 Each replicate was a cage of ten birds.
2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.
3 H-BWT, BWT-1, BWT-2 and BWT-3 are body weight at hatch and at the end of Weeks 1, 2 and 3, respectively.
4 (BWTGN-1) = (BWT-1)-(H-BWT); BWTGN-2 = (BWT-2)-(BWT-1); (BWTGN-3) = (BWT-3)-(BWT-2); C-BWTGN = (BWT-3)-(H-BWT).
5 FI-1, FI-2, FI-3 are feed intake during Weeks 1, 2 and 3, respectively; (C-FI) = (FI-1)+(FI-2)+(FI-3).
6 (FC-1) = (FI-1)/(BWTGN-1); (FC-2) = (FI-2)/(BWTGN-2);

(FC-3) = (FI-3)/(BWTGN-3); (C-FC) = (C-FI)/(C-BWTGN).
a,b Values followed by different letters within a line are significantly different ($P<0.05$).
* Significant replication effect ($P<0.05$).

### 5.1.9. Growth, from Hatch to Six Weeks of Age, of 56th Week Progeny

Parental slat material and slat coverage did not influence the body weight and feed intake of 56th week progeny at any time during the 6-week growth trial (Table 9).

The third week body weight gain (BWTGN-3) of PWS and FPS progeny was higher than that of PPS progeny. During the sixth week, FWS and PWS progeny had higher weight gain than FPS and PPS progeny.

FPS progeny had higher sixth week feed conversion (FC-6) than the other three progeny groups. No other differences in feed conversion were seen.

Table 9. The Influence of Slats on Body Weight, Body Weight Gain, Feed Intake and Feed Conversion, from Hatch to Six Weeks of Age, of 56th Week Progeny

| | Slat Type[1,2,3] | | | | Standard Error of the Mean |
|---|---|---|---|---|---|
| | FWS | PWS | FPS | PPS | |
| Body weight(g)[4]: | | | | | |
| H-BWT | 50.2[a] | 50.6[a] | 50.0[a] | 49.8[a] | 0.44 |
| BWT-1 | 152.0[a] | 157.9[a] | 153.4[a] | 154.0[a] | 2.56 |
| BWT-2 | 371.0[a] | 373.4[a] | 364.5[a] | 373.2[a] | 4.24 |
| BWT-3 | 699.5[a] | 709.9[a] | 699.3[a] | 689.8[a] | 7.14 |
| BWT-5 | 1488.8[a] | 1524.4[a] | 1496.4[a] | 1498.2[a] | 17.76 |
| BWT-6 | 1881.8[a] | 1908.7[a] | 1838.4[a] | 1874.4[a] | 27.54 |
| Body weight gain(g)[5]: | | | | | |
| BWTGN-1 | 101.8[a] | 107.3[a] | 103.4[a] | 104.2[a] | 2.57 |
| BWTGN-2 | 219.0[a] | 215.5[a] | 211.1[a] | 219.3[a] | 3.47 |
| BWTGN-3 | 328.5[a,b] | 336.5[a] | 334.9[a] | 316.6[b] | 5.40 |
| BWTGN-5 | 789.3[a] | 814.5[a] | 797.1[a] | 808.4[a] | 14.90 |
| BWTGN-6 | 393.0[a] | 384.4[a] | 342.0[b] | 376.2[b] | 14.53 |
| C-BWTGN | 1831.6[a] | 1858.2[a] | 1788.5[a] | 1824.7[a] | 27.54 |
| Feed intake(g)[6]: | | | | | |
| FI-1 | 114.7[a] | 126.4[a] | 115.2[a] | 115.5[a] | 3.26 |
| FI-2 | 292.2[a] | 298.7[a] | 292.3[a] | 291.4[a] | 3.30 |
| FI-3 | 490.5[a] | 510.3[a] | 493.0[a] | 481.8[a] | 7.74 |
| FI-5 | 1697.3[a] | 1720.4[a] | 1651.2[a] | 1714.7[a] | 28.92 |
| FI-6 | 1101.8[a] | 1045.8[a] | 1058.6[a] | 1031.8[a] | 29.49 |
| C-FI | 3696.5[a] | 3701.6[a] | 3610.3[a] | 3635.2[a] | 59.13 |
| Feed conversion[7]: | | | | | |
| FC-1 | 1.13[a] | 1.18[a] | 1.11[a] | 1.11[a] | 0.043 |
| FC-2 | 1.33[a] | 1.39[a] | 1.38[a] | 1.33[a] | 0.019 |
| FC-3 | 1.49[a] | 1.52[a] | 1.47[a] | 1.52[a] | 0.019 |
| FC-5 | 2.15[a] | 2.11[a] | 2.07[a] | 2.12[a] | 0.030 |
| FC-6 | 2.80[b] | 2.72[b] | 3.10[a] | 2.74[b] | 0.136 |
| C-FC | 2.02[a] | 1.99[a] | 2.02[a] | 1.99[a] | 0.020 |

1 The range of weight of hatching eggs was 66-78 grams.

2 Each parental slat type was represented by 6 cages of 10 male and six cages of 10 female chicks from hatch to three weeks of age. From the fourth to the sixth week, the number of birds per cage was reduced to 7.

3 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

4 H-BWT, BWT-1, BWT-2, BWT-3, BWT-5 and BWT-6 are body weight at hatch and at the end of Weeks 1, 2, 3, 5 and 6, respectively.

5 (BWTGN-1) = (BWT-1)-(H-BWT); (BWTGN-2) = (BWT-2)-

(BWT-1); (BWTGN-3) = (BWT-3)-(BWT-2); (BWTGN-5) = (BWT-5)-(BWT-3); (BWTGN-6) = (BWT-6)- (BWT-5); (C-BWTGN) = (BWT-6)-(H-BWT).

6 FI-1, FI-2, FI-3, FI-5 and FI-6 are feed intake during Weeks 1, 2, 3, 4 and 5, and 6, respectively; (C-FI) = (FI-1)+(FI-2)+(FI-3)+(FI-5)+(FI-6).

7 (FC-1) = (FI-1)/(BWTGN-1); (FC-2) = (FI-2)/(BWTGN-2); (FC-3) = (FI-3)/(BWTGN-3); (FC-5) = (FI-5)/(BWTGN-5); (CFC-6) = (FI-6)/(BWTGN-6); (C-FC) = (C-FI)/(C-BWTGN).

a,b Values followed by different letters within a line are significantly different (P<0.05).

## 5.2. THE INFLUENCE OF BREEDER AGE

### 5.2.1. Fertility, Hatchability of Total Eggs Set (TES) and Hatchability of Fertile Eggs (FES)

Table 10 shows that fertility was high (94.8-96.7%) when breeders were 37, 42 and 46 weeks of age. A significant decrease in fertility was seen at 50 weeks of breeder age. A further decrease in fertility occurred when breeders were 56 weeks old.

The hatchability of total eggs set (TES) was influenced by the breeder age x slat material and the breeder age x slat material x slat coverage interactions (Table 10). The hatchability of fertile eggs (FES) was highest at 37 weeks of breeder age. FES decreased at 42 weeks, and did not decrease again until 56 weeks of breeder age.

Table 10. Percent Fertility and Hatchability of Eggs at Different Breeder Ages[1]

| Breeder Age (Weeks) | Fertility | Hatchability of Total Eggs Set (TES)[x,y] | Hatchability of Fertile Eggs (FES) |
|---|---|---|---|
| 37 | 96.7[a] | 86.6[a] | 89.7[a] |
| 42 | 94.8[a] | 70.5[b] | 74.1[b] |
| 46 | 95.4[a] | 70.8[b] | 74.3[b] |
| 50 | 89.4[b] | 65.2[c] | 73.0[b] |
| 56 | 86.3[c] | 53.3[d] | 61.5[c] |
| SEM[2] | 1.17 | 1.50 | 1.39 |

1 Mean egg weight was 68.1, 68.6, 70.6 and 71.8 g at 42, 46, 50 and 56 weeks of breeder age, respectively; egg weight at 37 weeks of age was unknown.

2 Standard error of the mean.

a,b,c,d Values followed by different letters within a column are significantly different ($P<0.05$).

x Breeder age x slat material interaction is significant ($P<0.05$).

y Breeder age x slat material x slat coverage interaction is significant ($P<0.05$).

### 5.2.2. Temporal Distribution of Embryo Mortality

The incidence of early dead (ED) and late dead (LD) embryos both increased significantly at 42 weeks from the time when breeders were 37 weeks old (Table 11). At 56 weeks of breeder age, ED and LD embryos increased further over the 50th week incidence.

The incidence of pipped alive (PA) and pipped dead (PD) embryos increased at 42 weeks of breeder age, and did not increase further.

The incidence of MD embryos was not influenced by breeder age.

Table 11. The Influence of Breeder Age on the Distribution of Embryo Mortality

| Breeder Age (Weeks) | Embryo Mortality[1,2,3] | | | | |
|---|---|---|---|---|---|
| | ED | MD | LD | PA | PD |
| 37 | 2.9[c] | 0.4[a] | 2.4[c] | 3.9[b] | 0.4[b] |
| 42 | 4.9[b] | 1.1[a] | 6.2[b] | 10.3[a] | 1.7[a] |
| 46 | 6.4[b] | 0.5[a] | 7.9[b] | 8.5[a] | 1.2[a] |
| 50 | 6.2[b] | 0.5[a] | 7.8[b] | 8.1[a] | 1.6[a] |
| 56 | 8.9[a] | 0.5[a] | 11.5[a] | 10.6[a] | 1.6[a] |
| SEM[4] | 0.56 | 0.21 | 0.69 | 0.88 | 0.23 |

1 Mean egg weight was 68.1, 68.6, 70.6 and 71.8 g at 42, 46, 50 and 56 weeks of breeder age, respectively; egg weight was not taken at 37 weeks of age.

2 Values represent percent mortality of total eggs set.

3 ED = Early dead; MD = Mid-dead; LD = Late dead; PA = Pipped alive; PD = Pipped dead.

4 Standard error of the mean.

a,b,c Values followed by different letters within a column are significantly different ($P<0.05$).

### 5.2.3. Growth, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny

The 56th week progeny had the highest hatching body weight (H-BWT), followed by the 46th week progeny; the 37th week progeny had the lowest hatching weight (Table 12). No other significant differences in the body weight and weight gain of progeny were found except where the BWTGN-1 was higher for the 37th week progeny.

The 37th week progeny had higher first week (FI-1), second (FI-2) week and over-all feed intake (C-FI) than the other two progeny groups. Additionally, the first week feed intake (FI-1) of the 46th week progeny was higher than that of 56th week progeny. The over-all (C-FI) feed intake of the 56th week progeny was higher than that of 46th week progeny.

The 37th week progeny had higher weekly and over-all feed conversion than the other two progeny groups. The 46th week progeny had higher first week feed conversion (FC-1) than the 56th week progeny. The second week feed conversion (FC-2) of the 56th week progeny was higher than that of 46th week progeny. There were no differences in the third week (FC-3) and over-all (C-FC) feed conversion of the 46th and 56th progeny.

Table 13 shows that the adjustment of hatching weight (H-BWT) to 47.2 grams resulted in the elimination of differences in second (FC-2) and third week feed conversion (FC-3) seen in Table 12, as well as the differences in the over-all feed intake (C-FI).

Table 12. The Influence of Breeder Age on Body Weight, Body Weight Gain, Feed Intake And Feed Conversion, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny[1]

| | Breeder Age (Weeks)[2] | | | Standard Error of the Mean |
|---|---|---|---|---|
| | 37 | 46 | 56 | |
| Body weight(g)[3]: | | | | |
| H-BWT | 43.7[c] | 47.8[b] | 50.3[a] | 0.20 |
| BWT-1 | 154.0[a] | 151.2[a] | 154.6[a] | 1.20 |
| BWT-2 | 367.5[a] | 371.0[a] | 369.4[a] | 2.77 |
| BWT-3 | 663.2[a] | 666.5[a] | 691.3[a] | 6.44 |
| Body weight gain(g)[4]: | | | | |
| BWTGN-1 | 110.3[a] | 103.4[b] | 104.3[b] | 1.21 |
| BWTGN-2 | 213.5[a] | 219.8[a] | 214.8[a] | 2.19 |
| BWTGN-3 | 295.7[a] | 295.5[a] | 321.9[a] | 5.48 |
| C-BWTGN | 619.5[a] | 618.7[a] | 641.0[a] | 6.42 |
| Feed intake(g)[5]: | | | | |
| FI-1 | 141.3[a] | 121.5[b] | 115.8[c] | 1.28 |
| FI-2* | 316.4[a] | 291.0[b] | 293.7[b] | 2.47 |
| FI-3 | 508.1[a] | 457.8[a] | 493.9[a] | 4.42 |
| C-FI* | 963.6[a] | 869.9[c] | 903.4[b] | 6.19 |
| Feed conversion[6]: | | | | |
| FC-1 | 1.27[a] | 1.18[b] | 1.11[c] | 0.012 |
| FC-2* | 1.49[a] | 1.32[c] | 1.37[b] | 0.011 |
| FC-3 | 1.75[a] | 1.55[b] | 1.54[b] | 0.028 |
| C-FC* | 1.56[a] | 1.41[b] | 1.41[b] | 0.012 |

1 Mean egg weight was 68.6 g and 71.8 g 46 and 56 weeks of breeder age, respectively; egg weight was not taken at 37 weeks of age.

2 Each parental slat type was represented by 12 cages of 10 chicks. For the 56th week growth trial, each parental slat type was represented by 6 cages of 10 male and 6 cages of 10 female chicks.

3 H-BWT, BWT-1, BWT-2 and BWT-3 are body weight at hatch, and at the end of Weeks 1, 2 and 3, respectively.

4 (BWTGN-1) = (BWT-1)-(H-BWT); (BWTGN-2) = (BWT-2)-(BWT-1); (BWTGN-3) = (BWT-3)-(BWT-2); (C-BWTGN) = (BWT-3)-(H-BWT).

5 FI-1, FI-2, FI-3 are feed intake during Weeks 1, 2 and 3, respectively; (C-FI) = (FI-1)+(FI-2)+(FI-3).

6 (FC-1) = (FI-1)/(BWTGN-1); (FC-2) = (FI-2)/(BWTGN-2); (FC-3) = (FI-3)/(BWTGN-3); (C-FC) = (C-FI)/(C-BWTGN).

a,b,c Values followed by different letters within a line are significantly different ($P<0.05$).

* Significant replication effect ($P<0.05$).

Table 13. The Influence of Breeder Age on Body Weight, Body Weight Gain, Feed Intake And Feed Conversion, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny, with Adjusted Hatching Weight[1]

| | Breeder Age (Weeks)[2] | | | Standard Error of the Mean |
|---|---|---|---|---|
| | 37 | 46 | 56 | |
| Body weight(g)[3]: | | | | |
| H-BWT | 47.2 | 47.2 | 47.2 | |
| BWT-1 | 158.1$^{a}$ | 150.6$^{a}$ | 151.1$^{a}$ | 2.46 |
| BWT-2 | 376.0$^{a}$ | 369.7$^{a}$ | 361.9$^{a}$ | 5.86 |
| BWT-3 | 686.9$^{a}$ | 663.0$^{a}$ | 670.8$^{a}$ | 13.51 |
| Body weight gain(g)[4]: | | | | |
| BWTGN-1 | 110.8$^{a}$ | 103.4$^{b}$ | 103.8$^{b}$ | 2.46 |
| BWTGN-2 | 217.9$^{a}$ | 219.1$^{a}$ | 210.8$^{a}$ | 4.53 |
| BWTGN-3 | 310.9$^{a}$ | 293.3$^{a}$ | 308.8$^{a}$ | 11.63 |
| C-BWTGN | 639.6$^{a}$ | 615.8$^{a}$ | 623.5$^{a}$ | 13.51 |
| Feed intake(g)[5]: | | | | |
| FI-1 | 146.0$^{a}$ | 120.9$^{b}$ | 112.1$^{c}$ | 2.52 |
| FI-2* | 327.0$^{a}$ | 289.5$^{b}$ | 284.7$^{b}$ | 5.03 |
| FI-3 | 515.0$^{a}$ | 456.9$^{b}$ | 488.2$^{a}$ | 9.10 |
| C-FI* | 987.0$^{a}$ | 867.0$^{b}$ | 884.6$^{b}$ | 12.75 |
| Feed conversion[6]: | | | | |
| FC-1 | 1.30$^{a}$ | 1.18$^{b}$ | 1.09$^{c}$ | 0.024 |
| FC-2* | 1.50$^{a}$ | 1.32$^{b}$ | 1.36$^{b}$ | 0.010 |
| FC-3 | 1.69$^{a}$ | 1.59$^{a}$ | 1.59$^{a}$ | 0.058 |
| C-FC* | 1.55$^{a}$ | 1.41$^{b}$ | 1.42$^{b}$ | 0.012 |

1 Mean egg weight was 68.6 g and 71.8 g 46 and 56 weeks of breeder age, respectively; egg weight was not taken at 37 weeks of age.

2 Each parental slat type was represented by 12 cages of 10 chicks. For the 56th week growth trial, each parental slat type was represented by 6 cages of 10 male and 6 cages of 10 female chicks.

3 H-BWT, BWT-1, BWT-2 and BWT-3 are body weight at hatch, and at the end of Weeks 1, 2 and 3, respectively.

4 (BWTGN-1) = (BWT-1)-(H-BWT); (BWTGN-2) = (BWT-2)-(BWT-1); (BWTGN-3) = (BWT-3)-(BWT-2); (C-BWTGN) = (BWT-3)-(H-BWT).

5 FI-1, FI-2, FI-3 are feed intake during Weeks 1, 2 and 3, respectively; (C-FI) = (FI-1)+(FI-2)+(FI-3).

6 (FC-1) = (FI-1)/(BWTGN-1); (FC-2) = (FI-2)/(BWTGN-2); (FC-3) = (FI-3)/(BWTGN-3); (C-FC) = (C-FI)/(C-BWTGN).

a,b,c Values followed by different letters within a line are significantly different ($P<0.05$).

## 5.3. THE INFLUENCE OF SEX OF PROGENY ON GROWTH

### 5.3.1. Growth, from Hatch to Six Weeks of Age, of 56th Week Progeny

From three to six weeks of age, male progeny had higher weekly body weight, body weight gain and feed intake Table 14). Additionally, male progeny had higher over-all weight gain and feed intake than female progeny. The second week body weight (BWT-2) and weight gain (BWTGN-2) were influenced by an interaction between sex of progeny, slat material and slat coverage.

Female progeny had higher third week feed conversion than male progeny. No other differences in the feed conversion of male and female progeny were detected during the six-week growth trial.

Table 14. Body Weight, Body Weight Gain, Feed Intake and Feed Conversion, from Hatch to Six Weeks of Age, of Male and Female Progeny of 56-Week Old Breeders[1]

| | Sex of Progeny[2] | | Standard Error of the Mean |
|---|---|---|---|
| | Male | Female | |
| Body weight(g)[3]: | | | |
| H-BWT | 50.3[a] | 50.0[a] | 0.31 |
| BWT-1 | 155.3[a] | 153.6[a] | 1.81 |
| BWT-2[y] | 378.5[a] | 362.6[b] | 3.00 |
| BWT-3 | 731.6[a] | 667.6[b] | 5.05 |
| BWT-5 | 1569.4[a] | 1434.5[b] | 12.56 |
| BWT-6 | 1970.2[a] | 1781.4[b] | 19.47 |
| Body weight gain(g)[4]: | | | |
| BWTGN-1 | 105.0[a] | 103.3[a] | 1.82 |
| BWTGN-2[y] | 223.2[a] | 209.0[b] | 2.45 |
| BWTGN-3 | 353.1[a] | 305.0[b] | 3.82 |
| BWTGN-5 | 837.8[a] | 766.9[b] | 10.53 |
| BWTGN-6 | 400.8[a] | 347.0[b] | 10.27 |
| C-BWTGN | 1919.9[a] | 1731.4[b] | 19.47 |
| Feed intake(g)[5]: | | | |
| FI-1 | 116.8[a] | 119.0[a] | 2.30 |
| FI-2 | 298.4[a] | 288.9[a] | 2.33 |
| FI-3 | 507.4[a] | 480.3[b] | 5.48 |
| FI-5 | 1763.8[a] | 1627.9[b] | 20.45 |
| FI-6 | 1111.1[a] | 1008.0[b] | 20.85 |
| CF-I | 3797.5[a] | 3524.1[b] | 41.81 |
| Feed conversion[6]: | | | |
| FC-1 | 1.11[a] | 1.15[a] | 0.031 |
| FC-2 | 1.34[a] | 1.38[a] | 0.013 |
| FC-3 | 1.44[b] | 1.57[a] | 0.013 |
| FC-5 | 2.11[a] | 2.12[a] | 0.020 |
| FC-6 | 2.77[a] | 2.90[a] | 0.096 |
| C-FC | 1.98[a] | 2.04[a] | 0.014 |

1 The range of weight of hatching eggs was 66-78 grams.

2 Each parental slat type was represented by 6 cages of 10 male and six cages of 10 female chicks from hatch to three weeks of age. From the fourth to the sixth week, the number of birds per cage was reduced to 7.

3 H-BWT, BWT-1, BWT-2, BWT-3, BWT-5 and BWT-6 are body weight at hatch and at the end of Weeks 1, 2, 3, 5 and 6, respectively.

4 (BWTGN-1) = (BWT-1)-(H-BWT); (BWTGN-2) = (BWT-2)-(BWT-1); (BWTGN-3) = (BWT-3)-(BWT-2); (BWTGN-5) =

(BWT-5)-(BWT-3); (BWTGN-6) = (BWT-6)- (BWT-5); (C-BWTGN) = (BWT-6)-(H-BWT).

5 FI-1, FI-2, FI-3, FI-5 and FI-6 are feed intake during Weeks 1, 2, 3, 4 and 5, and 6, respectively; (C-FI) = (FI-1)+(FI-2)+(FI-3)+(FI-5)+(FI-6).

6 (FC-1) = (FI-1)/(BWTGN-1); (FC-2) = (FI-2)/(BWTGN-2); (FC-3) = (FI-3)/(BWTGN-3); (FC-5) = (FI-5)/(BWTGN-5); (FC-6) = (FI-6)/(BWTGN-6); (C-FC) = (C-FI)/(C-BWTGN)

a,b Values followed by different letters within a line are significantly different ($P<0.05$).

y Sex of progeny x slat material x slat coverage interaction is significant ($P<0.05$).

# 6. DISCUSSION

## 6.1. THE INFLUENCE OF SLAT MATERIAL AND SLAT COVERAGE

### 6.1.1. Egg Recovery

In the present study, egg recovery was taken as an approximation of egg production. The hypothesis that plastic slats result in higher egg production is supported by the higher egg recovery in PPS vs. FWS (Table 1). However, as long as the proportion of slat coverage was consistent for wood and plastic slats, wood slats had as equal (PWS vs. PPS), or better (FWS vs. FPS), egg recovery as plastic slats.

The replication effect during three lay periods indicates that environmental conditions in the barn was not homogeneous. The replication effect during lay period 2 was due to the higher value in two replicates. During lay period 5, the value in one replicate was higher, and in another replicate lower, than others; during lay period 6, the value for one replicate was lower. There is no apparent explanation for the influence of pen location on egg recovery.

Parkhurst (1974), who found that egg production was higher, although not significantly, on partial than full slats, believed that low egg production in full slat pens was due to lower recovery of eggs in the latter pens. For this hypothesis to explain the difference in over-all egg production in full and partial slat pens, two assumptions have to be made: firstly, the number of eggs laid (before breakage and other losses) was equal in full and partial slat pens, and secondly, an equal proportion of floor eggs were laid on slats as on litter in partial slat pens. The difference in egg production would then be attributed to the higher number of eggs remaining on the floor in partial slat pens. The pens were not set up to count the eggs that broke and went through the slats, therefore it is not possible to determine the extent to which the egg production values obtained in the present study underestimated the actual number of eggs laid. In this respect, the "egg production" values reported in Table 1 are actually egg recovery values.

Although differences were significant only during three lay periods, data in Table 3 suggest that floor eggs on full slats were more likely to crack than floor eggs on partial slats. If the proportion of cracked floor eggs is indicative of the proportion of eggs that broke and went through the slats, then Parkhurst's (1974) hypothesis could explain the lowered egg recovery in full slat pens compared to partial slat pens (Table 1).

Andrews et al. (1988), on the other hand, did not find any significant differences in "egg production" between full-slat (plastic-covered wire) and either of two partial slat floors (plastic-covered wire and wood). Floor space per bird was slightly higher on partial slat floors than on full slat floors in the study by Andrews et al. (1988). Floor space per bird was uniform for partial and full slat pens in the present study, and was slightly higher than that for either partial or full slat pens by Andrews et al. (1988). However, the difference in floor space allotment would not fully account for the disagreement in the results. Cooper and Barnett (1972), with equal floor space per bird on full and partial slats, found that "egg production" on the partial slats was significantly higher than on full slats. Floor space per bird was also equal for full and partial slat pens in the study by Parkhurst (1974), but space allotment was slightly higher than in the study by Cooper and Barnett (1972) and nearly equal to that in the present study. Parkhurst (1974) found that "egg production" was equal for full and partial slat pens.

Only Andrews et al. (1988) compared wood slats with another flooring material. These workers, however, did not find significant differences in the over-all "egg production" of broiler breeders in partially floored pens of plastic-covered wire and wood slats. In the present study, slat material influenced over-all egg recovery from breeders in full slat pens but not breeders in partial slat pens.

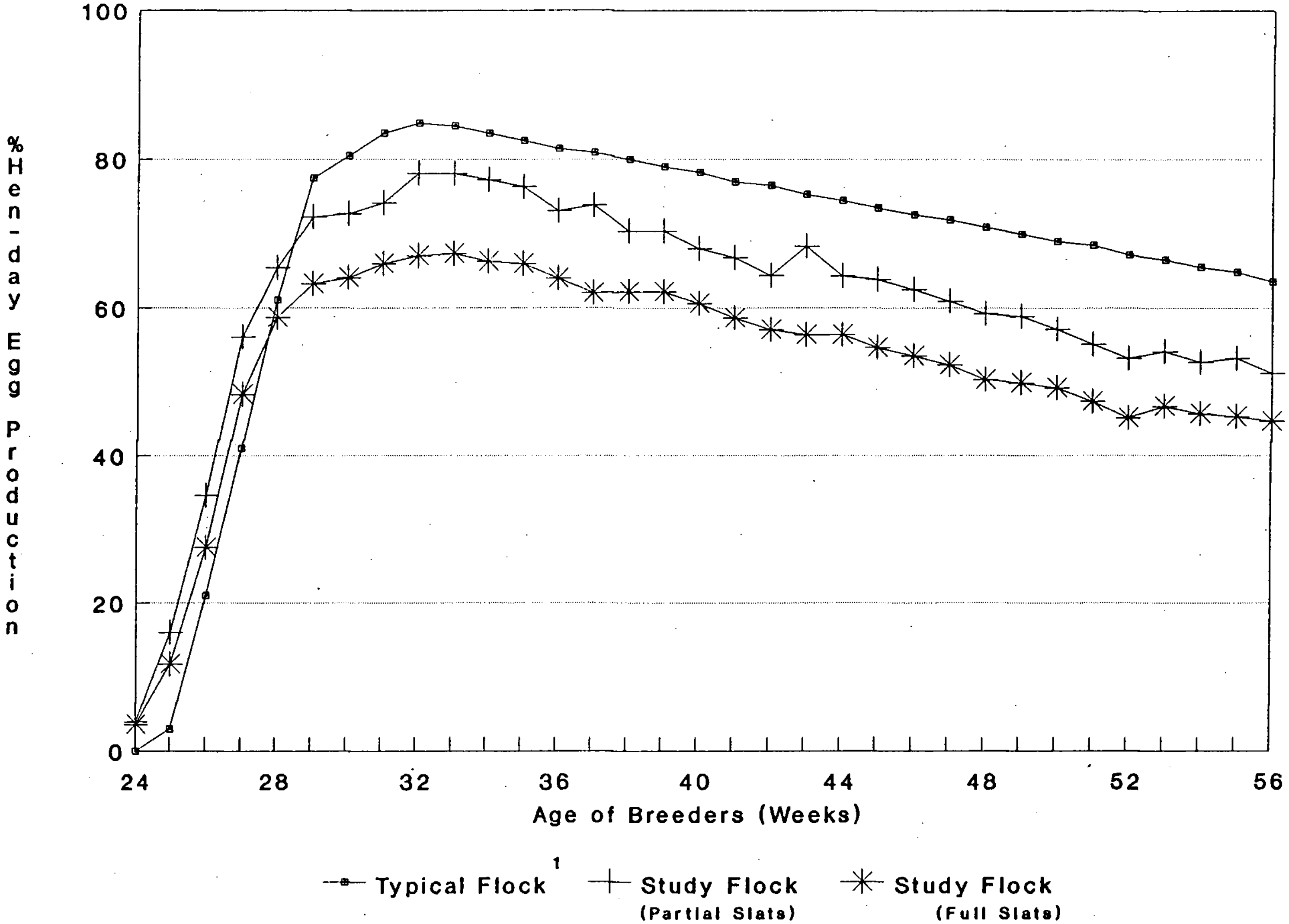
# DISCUSSION

The differences in over-all egg recovery between wood and plastic slat breeders appear to be a function of slat coverage.

The higher over-all egg recovery from partial slat (PWS and PPS) breeders could be attributed, in part, to the higher egg numbers compared to full slat (FWS and FPS) breeders during lay periods 5, 6, 7, 10, 12, 13 and 14. Similarly, the higher over-all egg "recovery" from FWS breeders compared to FPS breeders reflects the higher biweekly egg numbers among the former breeders throughout the study except for lay periods 11, 12, 13, 15 and 16.

Compared to typical Arbor Acres broiler breeder flocks, the experimental flock had lower over-all "egg production". Figure 3 shows that peak production occurred at 32-33 weeks of age for both the study flock and typical Arbor Acres flock, after which time the difference in "egg production" between the two flocks slightly increased in favor of the latter. Despite depressed egg recovery, the general shape of the production curve of the study flock closely resembled that of the typical Arbor Acres flock with a difference in over-all production levels of 15% and 7% for full and partial slats, respectively.

Figure 3. Weekly Egg Production of Study Flock and Typical Arbor Acres Flock




1 Adapted from Arbor Acres Broiler Breeder Male and Female Feeding and Management Guide (1985).

# DISCUSSION

The broiler breeders had staphylococcus infection at 13 weeks of age. The breeders had swollen hocks, and some were observed to be sitting for longer periods of time than usual. With mobility restricted, breeders were probably not consuming enough nutrients necessary for growth, specifically the development of the reproductive organs, a process which commences at about 12 weeks of age. Improper development of reproductive organs results in lower egg production.

At 43 and 58 weeks of age, mean body weight of female breeders was nearly 6% and 9%, respectively, higher than the upper limit of the target weight suggested by the Arbor Acres Feeding and Management Guide (1985). It is a well-known fact that obesity in chickens results in lower egg production (The Technical Centre for Agricultural and Rural Cooperation, 1987; Nordskog, 1980). No single slat material nor slat coverage group appeared to have higher mean body weight than others during either weighing, therefore the impact of obesity on egg production would have been similar for all slat treatments.

The present study and Cooper and Barnett (1972) have shown that "egg production" was higher on partial than full slat floors. If "egg production" data supplied by Arbor Acres was obtained from flocks housed exclusively or mainly on partial slats, then a reduction in "egg production" could be expected where full slats are used, as was seen in the present study.

### 6.1.2. The Incidence of Floor Eggs

Dorminey (1974) and Hurnik et al. (1973) observed that the incidence of floor eggs was usually highest at the beginning of lay, and then declined as production progressed. The same pattern was evident in the present study (Table 2).

When Dorminey (1974) examined the influence of artificial lighting and nest location on the incidence of floor eggs in partial wood slat pens, one of the treatments was similar to PWS pens in the present study. Dwarf White Leghorn hens were provided with nests on the wall facing 100-W incandescent bulbs off-center. The incidence of floor eggs was 3.3%, 2.8% and 0.9% during 25-29, 37-41 and 49-53 weeks of age. The values stated are lower than that for PWS treatment at corresponding ages in the present study (Table 2). The discrepancy may be due to differences in the loss of floor eggs through slats.

Since the proportion of eggs lost through slats in the present study is unknown, it is difficult to determine the extent to which the reported values of incidence of floor eggs (Table 2) underestimate the actual values, and the impact of such egg loss on egg recovery rates.

### 6.1.3. The Incidence of Cracked Floor Eggs

No differentiation was made as to whether a floor egg was laid on litter or on slats in the partial slat pens. I will assume for this discussion that proportionally as many floor eggs were laid on the slats as on litter in partial slat pens.

Physically, slats are harder material than litter, therefore in the absence of litter in full slat pens, significantly more eggs would be cracked in full than in partial slat pens. The data in Table 3 also suggests that where only slats are present as flooring (as in full slat pens), plastic material results in a higher incidence of cracked floor eggs.

On the other hand, the incidence of cracked floor eggs may be an indication of the probability of egg loss. Pens with a higher incidence of cracked floor eggs may have a higher loss of floor eggs. Therefore, the incidence of cracked floor eggs would not be a true reflection of the influence of slats on the integrity of egg shells.

### 6.1.4. The Incidence of Cracked Nest Eggs

In full slat pens, about 15 cm of one end of the nest perches overhung the 60 cm-high slats and the rest overhung the 30 cm-high slats. In partial slat pens about 15 cm of one end of the nest perches also overhung the 60 cm-high slats however, the rest of the perches was 60 cm above the litter floor. The greater distance between the floor and the perches in partial slat pens may have resulted in lower breeder traffic into and out of the nests. Consequently, nest eggs in partial slat pens would not be subject to as much hen traffic as those in full slat pens. The lower incidence of cracked nest eggs in partial slat pens may be a reflection of lower breeder traffic into and out of the nests..

The absence of litter on the floor may be another reason for the higher breeder traffic in and out of nests in full slat pens. Since litter was present only in the nests in the full slat pens, breeders were using the nests not only for egg-laying but also dusting. On the other hand, breeders in partial slat pens had access to litter on the litter floor, and were not causing any nest traffic other than for egg laying. However, the behaviour was not monitored in the present study.

The lower value in one replicate during lay period 12 resulted in the significant replication effect. This effect may be random.

### 6.1.5. Percent "Settable" Eggs

Since the number of eggs discarded prior to shipping to the commercial hatchery was not monitored, the number of non-cracked nest eggs was taken as an approximation of percent "settable" eggs (Table 5).

As with over-all egg recovery (Table 1), partial slat pens (PWS and PPS) had a higher proportion of "settable" eggs than either of the full slat pens (FWS and FPS), and the said proportion was higher for FWS than FPS pens. Slat material and slat coverage not only influence egg recovery, but also, to a large extent, the suitability of eggs for incubation.

The proportion of settable eggs underlines the importance of flooring systems and management on the profitability of any operation.

### 6.1.6. Fertility

The lack of significant differences in over-all fertility due to slat material and slat coverage (Table 6) does not support the hypothesis that plastic slats result in higher fertility.

Likewise, no differences were found in over-all fertility due to floor type in previous studies (Andrews et al., 1988; Parkhurst, 1974; Cooper and Barnett, 1972; Nordskog and Schierman, 1965). In the present study, fertility levels among breeders on slat material and slat coverage groups were within 1% of each other.

### 6.1.7. Hatchability of Total Eggs Set (TES) and Fertile Eggs (FES)

The lack of significant differences in the hatchability of total eggs set and fertile eggs due to slat material and slat coverage (Table 6) does not support the hypothesis that plastic slats result in higher hatchability.

Only Andrews et al. (1988) has compared wood slats and plastic-covered wire for hatchability. They compared hatchability of eggs from pens with entire floors of plastic-covered wire (FPS), floors with 2/3 plastic-covered wire (PPS) and floors with 2/3 wood (PWS) slats. Andrews et al. (1988) found that the over-all hatchability of total eggs set and fertile eggs was statistically equal for all three floor types tested. The same was found for the corresponding slat types in the present study (Table 6). Andrews et al. (1988) found significant differences in hatchability of total eggs set and fertile eggs near the beginning and end of the study. It was suggested that male immaturity and egg handling procedures were possible causes for the variation of hatchability on slat types, implying that slat types did not directly influence hatchability. Since no significant interaction was found between slat type and breeder age in the present study, the lack of significant differences in hatchability on different slat types was consistent throughout the study. Therefore, the results of the current study are consistent with those of Andrews et al. (1988).

Quarles *et al.* (1968, 1970) inferred that litter in poultry houses may be a source of contamination and could possibly lower hatchability. Results of their studies did not support their inference. Likewise, Table 6 implies that the presence of litter in partial slat pens did not lower hatchability. Parkhurst (1974) and Cooper and Barnett (1972) reported no significant differences in the over-all hatchability of eggs taken from full and partial slat pens.

### 6.1.8. Temporal Distribution of Embryo Mortality

No previous studies have investigated the influence of slats for breeders on embryo mortality. In the present study, significant differences were seen in the incidence of early dead embryos on wood vs. plastic slats (Table 7).

The higher incidence of ED embryos in wood slat pens (Table 7) is difficult to explain. Location in the incubator has been found to influence the development of embryos (Reinhart and Hurnik, 1984). Since slat treatments were not blocked for incubator location, the influence of slat material on ED mortality could not be isolated from the influence of variations within the incubator.

### 6.1.9. The Growth, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny

Seven FPS progeny were lost 4 days after hatch during the second growth trial. Water loss between death of the chicks and weighing lowered the first week weight gain (BWTGN-1) of the progeny group (Table 8).

Despite differences in weight gain and feed intake, no one progeny group had improved weekly or over-all feed conversion due to parental slat material or slat coverage. The results of this study do not support the hypothesis that the progeny of plastic slat breeders grow more efficiently than those of wood slat breeders.

The significant parental pen replication effect in the second week feed intake resulted from the high feed intake of progeny of breeders in one replicate and low feed intake of progeny of breeders in two replicates. The replication effect in the over-all feed intake is due to the low feed intake of progeny of breeders in one replicate. The replication effects mentioned resulted in corresponding replication effects in feed conversion. There is no apparent relationship between the location of parental pens and feed intake of progeny, therefore the replication effects may be random.

### 6.1.10. Growth, from Hatch to Six Weeks of Age, of 56th Week Progeny

Although differences were significant for the third (BWTGN-3) and sixth (BWTGN-6) week weight gain, only the sixth week feed conversion (FC-6) was affected by parental slat material and slat coverage (Table 9). Variations in egg weight could not have caused the differences seen in Table 9 since hatching egg weight was restricted to 66-78 grams, and the mean hatching body weight was equal for all slat type groups. This slat type effect may be random.

### 6.1.11. Conclusions

Over-all egg recovery was higher from broiler breeders on partial slats, regardless of slat material, than from breeders on full slats (Table 1). The over-all egg recovery from breeders on full slats was affected by slat material: breeders on full wood slats (FWS) had significantly higher egg numbers than those on full plastic slats (FPS). The biweekly egg recovery generally reflected over-all egg recovery. There is no apparent explanation for the significant replication effect on egg recovery during three lay periods.

PWS and FPS pens had higher incidence of floor eggs during two lay periods; during one lay period, PWS, FPS and PPS pens had higher incidence of floor eggs (Table 2).

However, the over-all incidence of floor eggs was not influenced by slats.

Low egg production on full slats (Table 1) was further lowered by higher over-all incidence of cracked nest eggs (Table 4). The significant replication effect on the incidence of cracked nest eggs during one lay period was thought to be random.

The proportion of "settable" eggs, based on the proportion of non-cracked nest eggs, was higher for PWS and PPS eggs than for FWS or FPS eggs, and was higher for FWS than FPS eggs (Table 5).

Slat material and slat coverage did not significantly influence fertility and TES or FES hatchability (Table 6).

Only the incidence of ED embryos was influenced by slats (Table 7). The incidence of ED embryos was higher on wood than on plastic slats.

When the influence of parental slats on the growth of 37th, 46th and 56th week progeny was examined, it was found that FPS progeny had lower first week weight gain (BWTGN-1) than the other progeny groups (Table 8). This was likely due to moisture loss when 7 FPS progeny were lost during the second growth trial. Differences were seen in feed intake of the progeny, however the weekly and over-all feed conversion was not influenced by parental slat treatment. The significant parental pen replication effect on the second week and over-all feed intake and feed conversion were thought to be random.

Only the third week (BWTGN-3) and sixth week (BWTGN-6) weight gain and sixth week (FC-6) feed conversion of 56th week progeny were influenced by slats (Table 9). PWS and FPS progeny had higher third week weight gain (BWTGN-3) than PPS progeny. During the sixth week, FWS and PWS progeny had higher weight gain than FPS and PPS progeny. The sixth week feed conversion (FC-6) of FWS, PWS and PPS progeny was better than that of FPS progeny.

## 6.2. THE INFLUENCE OF BREEDER AGE

### 6.2.1. Fertility

Previous studies indicate that fertility, like egg production, is highest during the first six months of production. When the first fertility trial was performed at 37 weeks of age, fertility was at a respectable 96.7% (Table 10), which is typical of a well-managed flock.

Peak fertility at about 37 weeks of age is typical of broiler breeder flocks. Andrews et al. (1988), Kirk et al. (1980), Parkhurst (1974) and Tomhave (1958) detected peak fertility at about the same age.

Reinhart and Hurnik (1984) found that the fertility of eggs laid by breeders was significantly higher ($P<0.001$) at

33-35 weeks of age than at 50-52 weeks of age. In the present study, fertility at 50 weeks of age was also significantly lower than at 37 weeks of age.

Previous studies have shown that average egg weight increases as production progresses (Kirk et al., 1980; Mather and Laughlin, 1979; McNaughton et al., 1978). Furthermore, others have shown that eggs which were produced early and late during the production year, as well as, in the extreme weight classes did not hatch as well (Tindell and Morris, 1964; Halbersleben and Mussehl, 1922).

The correlation between egg weight and fertility levels is indicative of behavioral and physiological changes in domestic fowls during the reproduction cycle. Low fertility in the early part of the reproductive cycle may be due to irregular male mating activity (Tindell and Morris, 1964), or poor semen quality (Moreng and Avens, 1985). The decline in fertility late in the reproductive cycle, as was seen in the present study (Table 10), may be attributed to the decrease in the number of males producing semen and decline in individual semen production, as well as the advancing age of the hen (Moreng and Avens, 1985). In the present study, no distinction was made between the influence of advancing male or female age.

Foot and leg problems have been found to occur more frequently among layers on sloping wire floor when compared with deep litter floors (Simonsen et al., 1980). Foot and leg problems could inhibit mating. There appeared to be minimal foot and leg problems during the laying period in this study.

### 6.2.2. Hatchability of Total Eggs Set (TES) and Fertile Eggs (FES)

Hatchability usually reaches a peak at about the same time as seen for egg production and fertility, and then slowly declines.

The level of total hatchability (TES) in this study was within normal range of the typical flock at peak (Table 10). However, the drop at 42 weeks and later was significant and more dramatic than expected.

The breeder age x slat material x slat coverage interaction in total hatchability (TES) is difficult to explain. The breeder age x slat material interaction is due to a dramatic decrease in total hatchability (TES) of eggs of plastic slat breeders at 42 weeks of breeder age.

The drop in TES hatchability at 50 and 56 weeks of breeder age coincided with a decrease in fertility at the same age (Table 10).

The decline in the hatchability of fertile eggs (FES) at 42 weeks of age apparently resulted from an increase in the incidence of early dead, late dead embryos, pipped alive and pipped dead embryos (Table 11). There was a further significant increase in the incidence of early dead and late dead embryos at 56 weeks of breeder age, coinciding with a decrease in FES hatchability.

The next section will discuss the factors that were thought to increase embryo mortality and, therefore lower hatchability.

### 6.2.3. Temporal Distribution of Embryo Mortality

As the breeders aged and egg production dropped, more egg collections were required for subsequent hatches. Thus, eggs were stored for longer periods. During the first three hatch trials, eggs were collected for three consecutive days and incubated one day after the last collection day. For the fourth trial, eggs were collected for three consecutive days and incubated four days after the last day of incubation. During the fifth trial, eggs were collected for five consecutive days and a sixth day four days later, and incubated the day after the sixth collection day. In the first three trials, eggs collected during the first day were in storage for three days; in the fourth trial, five days; and in the last trial, nine days.

Storage of eggs has been shown to reduce hatchability by increasing the number of embryonic deaths at all stages in incubation and by increasing total incubation period

(Mather and Laughlin, 1976). It has also been shown that the length of egg storage is directly proportional to the retardation of growth and number of malformed embryos regardless of breeder age (Mather and Laughlin, 1979). The increasing length of egg storage as the study progressed could be partly responsible for the decline in hatchability as the breeders aged.

Generally, ED and LD embryos have higher frequency than MD embryos. In young breeder flocks, the incidence of ED, MD and LD is about 3.0%, 0.5% and 2.0%, respectively. In older flocks, the corresponding values are 5.0-7.0%, 1.0-1.5% and 3.0-4.0% (Roberson and McDaniel, 1989).

Sudden onset of cold weather may be partially responsible for the sudden increase in embryonic mortality during the second hatch trial (Table 11). It is a well-known fact that extreme chilling of fertile eggs during storage causes embryonic mortality throughout incubation. In this particular case, the influence of ambient temperature on embryo mortality would be difficult to distinguish from that of breeder age.

Kirk et al. (1980) and Reinhart and Hurnik (1984) have concluded that larger eggs hatch better at low humidity settings. Most of the eggs laid by older breeders would therefore hatch better under humidity settings lower than the optimum for eggs laid by younger breeders. The low surface-to-volume ratio in large size eggs necessitates a low humidity setting to allow adequate gas exchange and water loss across the egg shell needed for embryonic development.

In the present study, RH was generally set at about 70% during days 1-18 and about 80% during days 19-21, but humidity readings fluctuated for short periods of time. The humidity setting was difficult to regulate, much less re-set to compensate for the increase in egg size. High humidity is known to increase embryonic mortality throughout incubation (Rosenberg, 1989), as well as lower hatchability.

The higher incidence of ED embryos from eggs of 50-week old breeders compared to eggs of 37-week old breeders (Table 11) could be due to increased storage periods.

Reinhart and Hurnik (1984) reported significantly higher ($P<0.001$) late embryo (LD) mortality during days 19-21 in eggs from 50-52 week old breeders compared with those from 33-35 week old breeders. Malformations and malpositions were found to be the most common form of mortality. In addition, they observed that the incidence of late dead embryos was significantly higher in extra large eggs (69.6 grams) than in smaller sized eggs (59.3-65.6 grams). It was suggested that the predominance of larger eggs was responsible for the significant increase in the incidence of late dead embryos when breeders were 50-52 weeks of age. The significant increase in egg size with breeder age in the present study (Appendix Table 4) may explain the significant increase in the incidence of LD embryos at 50 weeks of breeder age (Table 11). In the determination of LD embryos, no distinction was made between malformations and malpositions.

Malpositions can be caused by several factors, some of which are failure to turn eggs, nutritional deficiencies, excessively old hens, genetic problems or stale sperm (Rosenberg, 1989). The increasing length of egg storage as the breeders aged may yet be another factor. None of the first two factors mentioned could have possibly influenced the present study. The other factors, or a combination thereof, could have resulted in the increased incidence of LD embryos (Table 23).

According to Rosenberg (1989), malformations are usually not related to incubation, but result from genetics, mating, nutrition and setting eggs upside down. The influence of factors mentioned on the incidence of malformations in the present study was not determined.

Reinhart and Hurnik (1984) reported that the proportion of late-removal chicks was significantly higher when breeders were 50-52 weeks than at 33-35 weeks of age. They suggested that larger eggs require longer incubation time than smaller eggs. Thus, as breeders age and produce larger eggs, a greater proportion of the eggs would require longer incubation.

The late-removal chicks that Reinhart and Hurnik (1984) referred to correspond to PA embryos in the present study. Most of these embryos would have hatched later if allowed more time in the incubator. In agreement with the above findings, the incidence of PA embryos was significantly higher at 50 weeks than at 37 weeks of breeder age.

The increase in the incidence of pipped dead embryos at 42 weeks of breeder age may be due to the onset of cold weather during egg collection, as well as the fluctuation in relative humidity.

To attain optimum hatchability, adjustments should be made for the increase in the incubation time for eggs of older breeders. Several hatch pulls can be done so early-hatching chicks do not stay too long in the incubator and get dehydrated.

### 6.2.4. Growth, from Hatch to Three Weeks of Age, of 37th, 46th and 56th Week Progeny

The significant increase in the hatching weight of 46th and 56th week progeny from that of the 37th week progeny (Table 12) was most likely due to the increase in hatching egg weights (Appendix Table 4).

# DISCUSSION

Pone et al. (1985) reported that hatches at 27, 42 and 52 weeks of breeder age resulted in significant increases in the hatching weight of progeny at 42 and 52 weeks of breeder age.

The present study indicates that the significant differences in body weight had disappeared by as early as one week of age (Table 12). Numerous studies have shown that the age to which the body weight advantage could extend is variable and could be influenced by: (a) the breed involved (Kosin et al., 1952; Wiley, 1950), (b) the sex of the chicks (Gardiner, 1973; Merritt and Gowe, 1965; Tindell and Morris, 1964; Kosin et al., 1952), (c) whether the chicks were raised separately according to egg weight (Gardiner, 1973; Tindell and Morris, 1964) and (d) the type of flooring (Pone et al., 1985).

A high correlation has been reported between hatching or day-old weight and body weight during the earlier weeks of growth (Gardiner, 1973; Kosin et al., 1952; Wiley, 1950; Upp, 1928). Therefore, one would expect the 37th week progeny to have been the lightest at one week of age. Instead, there were no significant differences in the first week body weight (BWT-1) of the progeny groups because the 37th week progeny had higher first week weight gain (BWTGN-1).

# DISCUSSION

When the hatching weights were standardized to remove the influence of egg size and hatching weight of chicks on growth, differences in first week weight gain were not eliminated, while some differences in the second week feed conversion (FC-2) and all differences in the third week (FC-3) feed conversion were eliminated. This may be an indication that, independent of egg weight, the progeny of younger breeders utilize feed more efficiently than the progeny of older breeders, and this effect disappears as progeny age.

It has been reported that the transfer of lipids from yolk to chick liver during embryogenesis and shortly after hatch is not as efficient in the progeny of younger breeders (Noble and Tullett, 1989). While the progeny of older breeders can adequately utilize fat both from diet and remnant yolk, the progeny of younger breeders have to rely largely on dietary fat for energy. This effect is demonstrated by higher feed conversion of the 37th week progeny with adjusted hatching weight (Table 13). The possible inefficient utilization of yolk may have raised the feed conversion of the 37th week progeny until the second week of growth, resulting in higher over-all feed conversion for this progeny group.

The significance of the replication effect in the second week and over-all feed intake and feed conversion was discussed in Section 6.1.9.

### 6.2.5. Conclusions

Fertility declined significantly at 50 and 56 weeks of breeder age (Table 10). The hatchability of total eggs set decreased at 42, 50 and 56 weeks of breeder age, with a dramatic decrease in the hatchability of eggs of 42-week old plastic slat breeders. The hatchability of fertile eggs decreased significantly at 42 and 56 weeks of breeder age. The influence of advancing female breeder age was not distinguished from that of advancing male breeder age.

The incidence of ED and LD embryos increased significantly at 42 and 56 weeks, and that of PA and PD embryos at 42 weeks of breeder age (Table 11). The increase in ED, LD, PA and PD mortality at 42 weeks of breeder age was thought to be due to the onset of cold weather during egg collection for the said hatch trial. Increases in embryo mortality were also attributed to the increasing length of egg storage and difficulty in regulating humidity.

As breeders aged, the hatching weight (H-BWT) of progeny increased significantly (Table 12). The 37th week progeny gained more than the other progeny groups during the first week of growth, and had the least favorable feed conversion throughout the three-week growth period. The standardization of hatching body weight eliminated some differences in the second week and over-all feed conversion, but not in the first week weight gain (Table 13).

With adjusted hatching weight, differences in feed conversion disappeared by the third week of growth. Differences during the first two weeks of growth resulted in differences in over-all feed conversion (Table 13). The first week feed conversion of 37th progeny was highest, followed by that of 46th week progeny, while that of 56th week progeny was lowest. The second week and over-all feed conversion of 37th week progeny was higher than that of the other two progeny groups.

## 6.3. THE INFLUENCE OF SEX OF PROGENY

In mammals, as well as in birds, males exhibit a greater increase in early growth than females, and this is due, in part, to higher secretion levels of androgens (Mendel, 1980).

Since the hatching weights of male and female progeny of 56-week old breeders were practically equal, the differences in body weight and weight gain from two to 6 weeks of age (Table 14) could be attributed to different hormone levels, and not to any advantage in hatching egg weight. Table 14 shows that although male progeny consumed significantly more feed from week 3 to 6 and over-all, male progeny utilized feed more efficiently only during the third week of growth.

Results from a study by Gardiner (1973) indicate that when male and female broilers were derived from eggs of the same weight, the males had consistently higher weekly body weights from one week to eight weeks of age. The over-all feed conversion for the entire eight-week study period was slightly higher for males than for females, but the opposite was seen in Table 14.

There seems to be no explanation for the significant sex of progeny x slat material x slat coverage interaction in the second week body weight (BWT-1) and weight gain (BWTGN-1).

### 6.3.1. Conclusions

From the third to the sixth week of growth, the male 56th week progeny had higher body weight and weight gain (Table 14). Male progeny also had higher over-all weight gain (C-BWTGN). Male progeny however, had better (lower) feed conversion than female progeny only during the third week of growth.

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APPENDIX

APPENDIX

Appendix Table 1. Weekly Egg Recovery on Different Slat Types[1]

| Breeder Age (Weeks) | Slat Type[2] | | | | Standard Error of the Mean |
|---|---|---|---|---|---|
| | FWS | PWS | FPS | PPS | |
| 24 | 4.4 | 4.2 | 2.9 | 3.8 | 0.87 |
| 25 | 14.0 | 15.9 | 9.3 | 16.0 | 1.36 |
| 26 | 31.5 | 33.8 | 23.5 | 35.3 | 1.50 |
| 27 | 52.9 | 57.6 | 43.4 | 54.4 | 1.56 |
| 28 | 64.4 | 67.0 | 53.0 | 63.8 | 2.42 |
| 29 | 68.8 | 73.9 | 57.6 | 70.8 | 1.98 |
| 30 | 68.6 | 73.7 | 59.6 | 71.7 | 1.78 |
| 31 | 70.0 | 77.0 | 62.1 | 71.4 | 1.83 |
| 32 | 72.8 | 79.9 | 61.2 | 76.3 | 1.46 |
| 33 | 71.2 | 77.7 | 63.3 | 78.6 | 1.32 |
| 34 | 71.1 | 77.7 | 61.6 | 77.0 | 1.34 |
| 35 | 70.8 | 76.2 | 61.2 | 76.6 | 1.43 |
| 36 | 68.5 | 72.1 | 59.6 | 74.3 | 1.64 |
| 37 | 64.7 | 72.9 | 59.4 | 73.0 | 1.72 |
| 38 | 65.1 | 70.5 | 59.3 | 70.4 | 1.43 |
| 39 | 65.7 | 69.4 | 58.8 | 71.4 | 2.09 |
| 40 | 63.0 | 68.2 | 58.2 | 67.8 | 1.77 |
| 41 | 63.2 | 67.8 | 54.0 | 65.8 | 1.38 |
| 42 | 60.0 | 66.1 | 54.0 | 62.7 | 1.70 |
| 43 | 59.6 | 68.5 | 52.9 | 68.0 | 1.83 |
| 44 | 58.4 | 64.4 | 54.2 | 64.2 | 1.99 |
| 45 | 59.1 | 63.0 | 50.1 | 64.6 | 2.80 |
| 46 | 56.0 | 62.1 | 50.8 | 62.9 | 1.71 |
| 47 | 54.6 | 59.5 | 49.7 | 62.2 | 2.05 |
| 48 | 52.7 | 57.9 | 47.6 | 60.5 | 1.72 |
| 49 | 51.8 | 56.9 | 47.8 | 60.7 | 1.80 |
| 50 | 51.0 | 55.5 | 47.2 | 58.7 | 1.61 |
| 51 | 49.7 | 53.7 | 44.8 | 56.3 | 1.37 |
| 52 | 46.0 | 52.9 | 44.2 | 53.3 | 1.82 |
| 53 | 48.1 | 54.8 | 45.1 | 53.1 | 2.01 |
| 54 | 47.1 | 50.9 | 44.0 | 54.3 | 1.80 |
| 55 | 47.0 | 52.4 | 43.4 | 53.8 | 1.77 |

1 Percent hen-day egg recovery.
2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.

Appendix Table 2. Weekly Egg Recovery on Wood vs. Plastic Slats[1]

| Breeder Age (Weeks) | Slat Material | | Standard Error of the Mean |
|---|---|---|---|
| | Wood | Plastic | |
| 24 | 4.2 | 3.3 | 0.61 |
| 25 | 15.0 | 12.7 | 0.96 |
| 26 | 32.7 | 29.4 | 1.06 |
| 27 | 55.3 | 48.9 | 1.11 |
| 28 | 65.7 | 58.4 | 1.71 |
| 29 | 71.3 | 64.2 | 1.40 |
| 30 | 71.2 | 65.6 | 1.26 |
| 31 | 73.5 | 66.8 | 1.29 |
| 32 | 76.4 | 68.7 | 1.03 |
| 33 | 74.5 | 71.0 | 0.94 |
| 34 | 74.4 | 69.3 | 0.95 |
| 35 | 73.5 | 68.9 | 1.01 |
| 36 | 70.3 | 66.9 | 1.16 |
| 37 | 68.8 | 66.2 | 1.22 |
| 38 | 67.8 | 64.8 | 1.01 |
| 39 | 67.6 | 65.1 | 1.48 |
| 40 | 65.6 | 63.0 | 1.25 |
| 41 | 65.5 | 59.9 | 0.98 |
| 42 | 63.1 | 58.3 | 1.20 |
| 43 | 64.1 | 60.5 | 1.30 |
| 44 | 61.4 | 59.2 | 1.41 |
| 45 | 61.0 | 57.4 | 1.98 |
| 46 | 59.0 | 56.8 | 1.21 |
| 47 | 57.0 | 56.0 | 1.45 |
| 48 | 55.3 | 54.0 | 1.21 |
| 49 | 54.4 | 54.3 | 1.27 |
| 50 | 53.3 | 53.0 | 1.14 |
| 51 | 51.7 | 50.5 | 0.97 |
| 52 | 49.5 | 48.8 | 1.29 |
| 53 | 51.5 | 49.1 | 1.42 |
| 54 | 49.0 | 49.2 | 1.27 |
| 55 | 49.7 | 48.6 | 1.25 |

1 Percent hen-day egg recovery.

Appendix Table 3. Weekly Egg Recovery[1] on Full vs. Partial Slats

| Breeder Age (Weeks) | Slat Coverage | | Standard Error of the Mean |
|---|---|---|---|
| | Full | Partial | |
| 24 | 3.6 | 4.0 | 0.61 |
| 25 | 11.7 | 16.0 | 0.96 |
| 26 | 27.5 | 34.6 | 1.06 |
| 27 | 48.2 | 56.0 | 1.11 |
| 28 | 58.7 | 65.4 | 1.71 |
| 29 | 63.2 | 72.3 | 1.40 |
| 30 | 64.1 | 72.7 | 1.26 |
| 31 | 66.0 | 74.2 | 1.29 |
| 32 | 67.0 | 78.1 | 1.03 |
| 33 | 67.3 | 78.2 | 0.93 |
| 34 | 66.3 | 77.3 | 0.95 |
| 35 | 66.0 | 76.4 | 1.01 |
| 36 | 64.0 | 73.2 | 1.16 |
| 37 | 62.0 | 73.0 | 1.22 |
| 38 | 62.2 | 70.4 | 1.01 |
| 39 | 62.2 | 70.4 | 1.48 |
| 40 | 60.6 | 68.0 | 1.25 |
| 41 | 58.6 | 66.8 | 0.98 |
| 42 | 57.0 | 64.4 | 1.20 |
| 43 | 56.3 | 68.3 | 1.30 |
| 44 | 56.3 | 64.3 | 1.41 |
| 45 | 54.6 | 63.8 | 1.98 |
| 46 | 53.4 | 62.5 | 1.21 |
| 47 | 52.2 | 60.9 | 1.45 |
| 48 | 50.2 | 59.2 | 1.21 |
| 49 | 49.8 | 58.8 | 1.27 |
| 50 | 49.1 | 57.1 | 1.14 |
| 51 | 47.3 | 55.0 | 0.97 |
| 52 | 45.1 | 53.1 | 1.29 |
| 53 | 46.6 | 54.0 | 1.42 |
| 54 | 45.6 | 52.6 | 1.27 |
| 55 | 45.2 | 53.1 | 1.25 |

1 Percent hen-day egg recovery.

Appendix Table 4. The Influence of Breeder Age on Hatching Egg Weight

| Variable | Hatching Egg Weight (g) |
|---|---|
| Breeder Age (Weeks) | |
| 42 | 67.9[d] |
| 46 | 68.7[c] |
| 50 | 70.6[b] |
| 56 | 71.8[a] |
| SEM[1] | 0.21 |
| Slat Material (M) | |
| Wood | 69.8[a] |
| Plastic | 69.6[a] |
| SEM[1] | 0.15 |
| Slat Coverage (M) | |
| Full | 69.8[a] |
| Partial | 69.7[a] |
| SEM[1] | 0.15 |
| Slat Type (M x C)[2] | |
| FWS | 70.0[a] |
| PWS | 69.8[a] |
| FPS | 69.6[a] |
| PPS | 69.7[a] |
| SEM[1] | 0.21 |

1 Standard error of the mean.
2 FWS = full wood slats; PWS = partial wood slats; FPS = full plastic slats; PPS = partial plastic slats.
a,b,c,d Means followed by different letters within one variable are significantly different ($P<0.05$).

Appendix Table 5. Composition of Chick Starter Diets

| | Energy Source | |
|---|---|---|
| Ingredient(g/kg) | Fat | Starch |
| Corn | 539.20 | 339.32 |
| Soybean meal | 279.00 | 287.10 |
| Wheat | 132.61 | 235.02 |
| Corn starch | ----- | 100.00 |
| Calcium phosphate | 17.01 | 17.37 |
| Limestone | 8.51 | 8.09 |
| Iodized salt | 5.00 | 5.00 |
| Vitamin/mineral premix | 2.50 | 2.50 |
| DL Methionine | 0.42 | 0.40 |
| Alphacel | 15.75 | 5.20 |
| | 1000.00 | 1000.00 |
| Calculated analysis: | | |
| Protein (%) | 19.00 | 19.00 |
| ME (kcal/kg) | 2800 | 2800 |

Appendix Table 6. Composition of Developer Diets

| Ingredient (g/kg) | Energy Source: Fat | Energy Source: Starch |
|---|---|---|
| Corn | 423.71 | 415.87 |
| Wheat middlings | 156.86 | 201.60 |
| Barley | 200.00 | 79.44 |
| Soybean meal | 148.65 | 166.29 |
| Wheat | 23.84 | ------ |
| Corn starch | ------ | 100.00 |
| Animal tallow | 10.00 | ------ |
| Calcium phosphate | 18.27 | 17.62 |
| Limestone | 7.82 | 8.32 |
| Iodized salt | 5.00 | 5.00 |
| Vitamin/mineral premix | 5.00 | 5.00 |
| DL Methionine | 0.85 | 0.86 |
| | 1000.00 | 1000.00 |
| Calculated analysis: | | |
| Protein (%) | 15.00 | 15.00 |
| ME (kcal/kg) | 2700 | 2700 |

Appendix Table 7. Composition of Breeder Diets

| | Energy Source | |
|---|---|---|
| Ingredient (g/kg) | Fat | Starch |
| Corn | 685.28 | 570.69 |
| Soybean meal | 200.14 | 213.13 |
| Corn starch | ------ | 100.00 |
| Animal tallow | 10.33 | 5.68 |
| Herring meal | 7.50 | 14.08 |
| Limestone | 65.07 | 64.81 |
| Calcium phosphate | 20.27 | 20.09 |
| Iodized salt | 5.00 | 5.00 |
| Vitamin/mineral premix | 5.00 | 5.00 |
| DL Methionine | 0.92 | 1.14 |
| L Lysine | 0.49 | 0.38 |
| | 1000.00 | 1000.00 |
| Calculated analysis: | | |
| Protein (%) | 15.50 | 15.50 |
| ME (kcal/kg) | 2850 | 2850 |