EFFECTS OF STOCKING DENSITY ON CAGED WHITE LEG HORN LAYERS

By

Ghulam Ahmad Bhat

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IN

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HISAR

1988

DEDICATED

TO MY

FATHER

CERTIFICATE I

This is to certify that this thesis entitled, "Effects of stocking density on caged white leghorn layers" submitted for the degree of Master of Veterinary Science, in the subject of Livestock Production and Management (Poultry Science), of the Haryana Agricultural University, is a bonafide research work carried out by Dr. Ghulam Ahmad Bhat under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

11\5\88

(C.K. Aggarwal)
Major Advisor

CERTIFICATE II

This is to certify that this thesis entitled, "Effects of stocking density on caged white leghorn layers" submitted by Dr. Ghulam Ahmad Bhat to the Haryana Agricultural University in partial fulfilment of the requirements for the degree of Master of Veterinary Science, in the subject of Livestock Production and Management (Poultry Science) has been approved by the Students' Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

EXTERNAL EXAMINER

MAJOR ADVISOR

HEAD OF THE DEPARTMENT

DEAN OF POST-GRADUATE STUDIES

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CONTENTS

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The present study was undertaken to study the effects of two stocking densities and the influence of cage level on the following parameters:

1. Age at 50% production
2. Body weight
3. Feed consumption
4. Egg production
5. Egg quality
6. Mortality
7. Alkaline phosphate level in blood plasma

INTRODUCTION

The system of rearing birds in cages is gaining popularity, because of the advantages like economy in space, disease prevention and control, savings in feed, laying efficiency, and production of clean eggs. It makes pedigree breeding easy and avoids the laborious trapnesting. The dustiness in poultry houses is considerably reduced which may cause significant decrease in respiratory ailments. This system of housing is regarded as super intensive system of poultry rearing compared to deep litter intensive system.

The poultry farming is more concentrated around metropolitan cities because of ready availability of market for poultry and poultry products. However, the cost of land near such cities is quiet high which compels the farmers to reduce the floor space per bird. A method is needed by which this can be done without having significant effect on the performance of birds. On this account the poultrymen express the idea of the use of multi-deck cage system for layers. Scientific records about these ideas are available on the basis of work carried out in foreign countries where the climatic conditions are much different than those in India. Even after long use of cages by certain farmers, there are still uncertainties about the proper shape, density and deck system. The research reports to give scientific data for the use of cage system (multi-deck cage system) under Indian conditions are insufficient and, therefore, there is need to undertake scientific studies of this nature.

The present study was undertaken to study the effects of two stocking densities and the influence of cage level on the following parameters:

1. Age at 50% production
2. Body weight
3. Feed consumption
4. Egg production
5. Egg quality
6. Mortality
7. Alkaline phosphate level in blood plasma

REVIEW OF LITERATURE

Effect of Cage space on Body weight

Lowe and Heywang (1964) in 3 different experiments conducted during three successive years provided 8"x18" and 10"x18" space to individual birds. These workers also provided 12"x18" and 24"x18" space for 2 and 5 birds, respectively. They observed that gains in body weight were greater in multiple caged birds although the floor space was less in individually caged birds.

Wilson *et al*. (1967) in two experiments provided 8"x18" and 10"x18" space to one, two and three birds per cage and reported that an increase in bird density resulted in smaller body weight gain during 19-65 weeks of age.

Ruggles (1967) conducted two experiments concurrently to study the effect of bird density, light intensity and dietary energy level on the reproductive characteristics of sex-linked hens in a windowless cage house. A significant decrease in weight gains resulted from increase in bird density.

Dorminey and Arscott (1971) conducted three trials by housing 4,6,8 and 10 hens per 61x61 cm cage, 1, 2 and 3 hens per 30.5x45.7 cm cage and 3 and 4 hens per 30.5x45.7 cm cage. Body weight gain was significantly less with 10 hens per cage than with other densities.

Grover *et al*. (1972) provided 30.5x45.7 cm floor space for 2 and 3 birds and observed that greater bird density depressed body weight gain.

Hill (1977) reported the productivity and profitability of two commercial strains of WLH measured simultaneously at space allowance of 0.0310, 0.0387 and 0.0464m^2 per bird and in groups of 3,6 and 12 birds per cage. In both tests there were significant increase in body weight with increasing space allowance. Pullets in groups of three were also heavier than those in groups of 6 and 12. In both tests single birds given 0.0619m^2 were the heaviest.

Johri and Sharma (1978) in an experiment with 1,2,3 and 4 bird per cage provided 1222, 611, 564 and 616 cm^2 of floor area per bird, respectively. They observed that density in cages do not affect the body weight in the layers.

Mathew <u>et al</u>. (1979) provided 900, 600 and 450 cm^2 floor area per bird with density level 2,3 and 4 birds per cage. It was reported that the birds provided 900 cm^2 space each had significantly higher body weight than their cage mates at other densities.

Robinson (1979) reported that body weight gain was 19 per cent higher at higher floor area allowance (0.046 m^2/bird) than at lower floor area allowance (0.035 m^2/bird).

Cunningham and Ostrander (1981) observed that increasing the bird number per cage (reducing floor space) resulted in significant reductions in final body weights of birds kept in deep or shallow cages.

Ramos *et al.* (1986) reported that hens housed at 464 cm^2 of floor area/hen had significantly lower weight gain than those housed at 348 cm^2.

Rao (1986) in an experiment provided 0.50, 0.62 and 0.75 sq. ft. of floor area per bird and the density was kept 3, 2 and 2 birds/cage. He observed that body weights were not influenced by floor area per bird.

Davami *et al.* (1987) studied the effect of two treatments viz. 5 hens/cage with 420 cm^2 floor space per hen and 7 hens/cage with 300 cm^2 floor space per hen. As the cage space allowance increased, weight gains were higher.

Effect of Cage level (deck) on Body weight

Grover *et al.* (1972) conducted two experiments to study the effect of cage level on body weight of heavy type chicken. Body weight gains were higher in upper cage row groups.

Cunningham (1983) reported the results of experiments conducted during 1979 to 1981 to compare the layer performance at different levels in tri-deck cage system. No significant differences for cage level were observed for any of the performance traits e.g. body weight. He suggested that with good management cage level should not be a factor in performance of birds.

Effect of Cage space on Feed consumption

Lowe and Heywang (1964) in three different experiments conducted during three successive years provided 8"x18" and 10"x18" space to individuals birds and also provided 12"x18" and 24"x18" space to 2 and 5 birds, respectively. No significant difference was observed among these groups in total feed consumption.

Ruggles (1967) conducted 2 concurrent experiments with bird densities of one, two, three and four per 12"x18" cage. He did not found significant differences in feed consumption of birds of different groups.

Dorminey and Arscott (1971) on the basis of three studies reported that the bird density did not have any consistent effect on feed consumption.

Grover <u>et al</u>. (1972) housed 1, 2, 3 and 4 birds per cage (1393, 697, 465 and 368 cm^2 per bird). It was found that the bird density effects on feed consumption were not detected.

Asriyan (1975) reported that the pullets reared at higher densities tended to have lower feed consumption than those reared at lower densities. Connor and Burton (1975) reported that increasing bird numbers per cage or stocking density had little effect on feed consumption.

Hill (1977) simultaneously measured the productivity and profitability on 2 commercial strains of W.L. at a space allowance of 0.0310, 0.0387 and 0.0464 m^2 per bird and in groups of 3, 6 and 12 birds/cage. A space allowance of 0.0310 m^2 per bird resulted in increased feed consumption.

Robinson (1979) provided a cage area of 0.035 m^2 and 0.046 m^2/bird and the colony size was 2, 3, 4 and 6 birds/cage. He observed that feed intake per hen were similar at both the floor areas.

Reddy (1981) in an experiment provided a floor space of 0.75, 0.62 and 0.50 sq. ft./bird. Birds given 0.50 sq.ft./bird resulted in significantly less feed consumption than those of other two groups. Rao et al. (1983) provided 0.4 and 0.5 sq.ft. of floor space/bird and observed that floor space allowance had no effect on feed consumption.

Adams and Craig (1985) published a review of research conducted during 1971 to 1983 on the effects of crowding and cage shape on performance of layers. The overall results suggested that reducing the floor space per hen from an average of 387 cm^2 (medium) to 310 cm^2 (high) decreased feed consumption by 1.9 gm/hen/day.

Rao (1986) provided 0.50, 0.62 and 0.75 sq.ft. of floor space per bird keeping the density at 3, 2 and 2 birds per cage. He observed that floor space allowance did not appear to influence feed consumption though lower space allowance tended to restrict feed consumption.

Effect of Cage level (deck) on Feed consumption

Grover et al. (1972) reported a higher feed consumption in upper cage row groups than in lower, in double deck batteries. Cunningham (1983) did not report any effect of cage level on feed consumption in tri-deck cage system.

Effect of Floor space on Egg production

Lowe and Heywang (1964) in three different experiments conducted during successive years provided 8"x18" and 10"x18" space to individual, 12"x18" and 24"x18" space for 2 and 5 birds, respectively. It was found that increasing bird density resulted in reduced hen housed and hen day egg production.

Wilson (1967) conducted two experiments with 8"x18" and 10"x18" cages. One, two and three pullets per cage were compared. Egg production was significantly less with 3 birds/cage than with one or two birds/cage.

Ruggles (1967) conducted two experiments concurrently to study the effect of bird density. Bird densities of one, two, three and four per 12"x18" cage were studied. Significant decrease in egg production resulted from increase in bird density.

Dorminey and Arscott (1971) conducted 3 studies to determine the effect of bird density on performance of layers in cages. In first experiment, the birds were housed at the rate of 4, 6, 8 and 10 hens per 61x61 cm cage. 1, 2 and 3 hens per 30.5x45.7 cm cage were housed in second and 3 and 4 hens per 30.5x45.7 cm cage in experiment third. In each study there was non-significant decrease in hen-day and hen-housed egg production of birds.

Wells (1971) conducted 3 experiments and concluded that it does not necessarily follow that the productivity of layers will decline if stocking density and/or colony size is increased.

Grover *et al.* (1972) conducted two experiments and stocked 1, 2, 3 and 4 birds per cage giving a space of 1393, 697, 465 and 368 cm^2 per bird in the first and 2 and 3 birds per cage in the second experiment giving a space of 697 and 465 cm^2 per bird. In experiment I highly significant depression in egg production due to greater bird density was noted. The depressing effect on egg production was associated with increase in the number of birds/cage and was found to be more severe when four bird density treatment was compared with either the two or three bird densities than when the latter treatments were compared with single bird treatment.

Samalo and Sathe (1974) provided a floor space of 160 and 80 sq. inches/bird. There was slight but non-significant adverse effects of density on egg production. Connor and Burton (1975) reported that increasing bird numbers per cage or stocking density decreased egg production. Furuta (1975) reported that housing density had no effect on egg production.

Sefton (1976) observed that when number of birds per cage was held constant and the space per bird increased from 460 to 575 cm^2, there was no significant difference im egg production. When area per bird decreased and number of birds per cage increased, there was significant reduction in egg production.

Hill (1977) measured productivity of 2 commercial strains of W.L. at space allowances 0.0310, 0.0387 and

0.0464 m^2/bird and in groups of 3, 6 and 12 birds/cage. A space allowance of 0.0310 m^2 per bird adversely affected the production.

Jhori and Sharma (1978) housed 1, 2, 3 and 4 birds/cage with space allowance 1222, 611, 564 and 616 cm^2 and studied the effect of stocking density on egg production. The percentage of hen-day - egg production was significantly higher in birds kept singly in cages (1222 cm^2/bird) as compared to 2, 3 and 4 birds/cage.

Mathew <u>et al</u>. (1979) housed 2, 3 and 4 birds per cage (45 cm x 40 cm) providing 900, 600 and 450 cm^2 floor area per bird. Birds housed at different densities did not differ significantly in their production performance.

Reddy (1981) provided 0.75, 0.62 and 0.50 sq.ft. of floor space per bird. Birds with floor space allowance of 0.62 sq.ft./bird did better than either 0.75 or 0.50 sq.ft.

Quart and Adams (1982) housed 3 and 4 birds per cage (516 cm^2 and 387 cm^2/bird) and observed that decreased population and concomitant increased floor area per bird increased hen-day (3.4%) and hen housed (3.5%) egg production.

Roush <u>et al</u>. (1983) in a study in which 3, 4 or 5 birds were placed in a 12"x20" cage (30.5x50.8 cm) with 80, 60 and 48 sq. inches of floor area reported that egg production declined as the area per hen was reduced.

Rao <u>et al</u>. (1983) reported that birds provided with 0.4 sq.ft./bird of space in cage gave significantly better production than birds with 0.5 sq.ft. space per bird. Jongenburger (1983) made a comparison between birds given 350, 400 and 500 cm^2 floor area per bird and reported that hen-housed egg production was significantly higher in birds given 450 cm^2 than in those given 350 or 400 cm^2.

Roush et al. (1984) placed 3, 4 and 5 birds/cage (30.5x50.8 cm) with 516, 387 and 310 cm^2 of floor area per hen. Egg production declined as the area per hen was reduced.

Adams and Craig (1985) reviewed the research published between 1971 and 1983 on the effects of crowding and reported that reducing floor space per hen from an average 387 cm^2 to 310 cm^2 reduced the number of eggs per hen housed to 16.6. Reduction in floor space from 516 to 387 cm^2, reduced the egg production by 7.8 eggs per hen housed.

Ramos (1986) reported that hens housed at 464 cm^2 of floor area/hen in cages had significantly higher hen-housed egg production than those housed at 348 cm^2. Rao (1986) reported that birds housed with the density of 3, 2 and 2 birds/cage with floor area 0.50, 0.62 and 0.75 sq.ft./bird resulted in marginal increase in egg production at lower space allowance than at higher allowance.

Davami et al. (1987) housed birds with the density of 5 and 7 hens/cage with 420 and 300 cm^2 as floor area per hen, respectively. It was observed that increase in population size reduces floor area per hen and resulted in significant decline in per cent egg production.

From the above review of literature it can be seen that conclusive results of effect of density of birds in cages on egg production are not available. The studies carried out in our country, where climatic conditions are different on this aspect are also few.

Effect of Cage level (deck) on Egg production

Jaeger (1967) made trials with 4 rows of 10"x16" triple decked cages and semi-stair step cages. Differences between certain rows and decks were noted in the first trial. There were no significant differences between any of the house segments in the second trial.

Hurnick et al. (1974) reported higher egg production from birds housed in the upper tier than in the lower tier. Sefton (1976) reported that hens housed in the top tier of cages layed at a lower rate than those housed in the bottom tier. Cunningham (1983) did not observe any significant difference in egg production of birds housed in a tri-deck-cage system.

Saraswat (1979) housed birds in 3 tier cages and recorded their first 100 days egg production from sexual maturity. The egg production and analysis of variance indicated that egg production of birds in cage I of each tier (where light and ventilation was equal/same in all the tiers) was same. Reduction in egg production of birds of lower tier in cages II, III, IV, which were away from window was noted down and it was considered to be due to variation in the availability of light to bottom tiers.

Jackson and Waldroup (1987) conducted an experiment with 3 tier conventional cages (30.5x45.7 cm) or 4 tier reverse cages (40.6x 35 cm). The top tier of each cage was at the same height. It was observed that tier played a very significant role in affecting egg production. The laying was adversely affected progressing from bottom to top tier.

<u>Effect of Cage space on Mortality</u>

Lowe and Heywang (1964) in three different experiments conducted during three successive years provided 8"x18" and 10"x18" space to individual birds, 12"x18" for 2 and 24"x18" and 24"x16" space for 5 birds, respectively. Mortality, due mainly to vent picking averaged about 34 per cent in the groups with 5 birds/cage. Average mortality was about 16 per cent in the groups with 2 birds per cage and less than 8 per cent in the groups with 1 bird/cage.

Ruggles (1967) conducted two experiments concurrently to study the effect of bird density on mortality. Bird densities of one, two, three and four birds per 12"x18" cage were studied. Significant increase in mortality resulted from increase in bird density.

Wilson <u>et al</u>. (1967) in two experiments provided 8"x18" and 10"x18" space to one, two and three birds per cage and reported that mortality was increased by placing more than 1 bird per cage. The increase was partly due to cannibalism.

Dorminey and Arscott (1971) conducted three trials by housing 4, 6, 8 and 10 hens per 61x61 cm cage; 1, 2 and 3 hens per 30.5x45.7 cm cage and 3 and 4 birds per 30.5x45.7 cm cage. Mortality was not significantly affected by bird density in any experiment.

Grover et al. (1972) conducted two experiments concurrently, in one of these they housed pullets at the densities of 1, 2, 3 and 4 birds/cage (1393, 697, 465 and 368 cm^2/bird). Mortality was found to increase with increased density. Within the four density treatments the effect was highly significant.

Samalo and Sathe (1974) conducted experiments to study the effects of increasing bird density and protein level on the performance of layers kept on floor and cages. In cages the space given was 160 and 80 sq. inches per bird. There was no appreciable effect of treatments on mortality.

Connor and Burton (1975) reported that increasing bird numbers per cage increased mortality. Cannibalism was a significant cause of death. Johri and Sharma (1978) housed one, two, three and four birds/cage. The floor space area provided was 1222, 611, 564 and 616 cm^2. There was no mortality in treatment 1 and 2 (1 and 2 birds/cage) whereas 3 and 4 birds in treatment 3 and 4, showing an increase in mortality percentage in higher densities of birds per cage.

Mathew et al. (1979) housed birds with 2, 3 and 4 birds/ cage cell. Each cage cell measured 45 x 45 cm, so floor space per bird was 900, 600, 450 cm^2, respectively. A higher rate of mortality was encountered for the highest cage density groups.

Reddy *et al.* (1981) provided 0.75, 0.60 and 0.50 sq.ft. of floor space per bird in cages. The differences in the overall liability at the end of the experiments under different floor space allowances were statistically non-significant.

Roush *et al.* (1983) in a study in which 3, 4 or 5 birds were placed in a 12"x20" cage with 80, 60, and 48 sq.inches of floor space per bird found that the mortality was significantly related to the increased hen number per cage area.

Bell (1983) summarized 27 cage space experiments comparing hens with more than 70 sq. inches of floor space to hens with less than 70 sq.inches of floor space. The results showed a difference of 5.6 per cent mortality in favour of the greater floor space. The recently completed North-caro-lina Random Sample Test compared 72 with 54 sq. inches of floor space in three types of cage housing and with 12 strains of chickens. A difference of 5.1 per cent mortality was observed between the two floor spaces.

Jongenburger (1983) reported that in 2 trials conducted, the mortality did not differ significantly between birds housed at a density of 3, 4 or 5 birds/cage. Roush *et al.* (1984) placed 3, 4 or 5 hens per cage (30.5x50.8 cm) with 516, 387 and 310 cm^2 of floor area per hen, respectively. Mortality was significantly related to a reduction in cage area per hen.

Adams and Craig (1985) reviewed research published between 1971 and 1983 on the effects of crowding and cage shape on performance of layers. Reducing floor space per hen from an average of 387 cm^2 (medium) to 310 cm^2 (high increased mortality by 4.8% ($P \angle 0.01$). Data from comparisons of 516 cm^2 (low) Vs 387 cm^2 (medium) showed that increase in crowding increased mortality by 2.8 per cent.

Ramos et al. (1986) reported that hen housed rate of lay, mortality, weight gain, feed conversion and feather scores were significantly affected by bird density. Rao (1986) in an experiment (Experiment II) provided 0.5 and 0.4 sq.ft. of floor area per bird in cages. He observed that layer house mortality was not influenced by floor area. Davami et al. (1987) compared 420 cm^2 with 300 cm^2 of floor area/hen housed in cages. As the cage space allowance increased the mortality was lowered.

Effect of Cage level (deck) on Mortality

Grover et al. (1967) conducted two experiments concurrently. In first experiment pullets were housed at 1, 2, 3 and 4 birds per cage (1393, 697, 465, 368 cm^2 per bird) in double deck batteries. In second experiment birds were housed at 2 and 3 birds per cage. In this experiment also double deck batteries were used. In first experiment the single and two-bird densities suffered higher mortality in the upper row of cages where-as the three and four bird density treatments experienced higher mortality in the lower cage row. The cage level effects on mortality in experiment second were found to be in agreement with the results obtained in first experiment. Sefton (1976) reported that livability in pullets was not significantly influenced by cage tier.

Cunningham (1983) in an experiment conducted in 3 deck batteries with deep cages of dimensions (152x20") at two shallow design cages (24"x14" and 24"x12.5") with population densities of 4, 5 and 6 birds per cage did not find any significant differences for level for any of the performance traits.

Jackson and Waldroup (1987) reported that tier played a very significant role in affecting mortality. It was adversely affected progressing from bottom to top tier in either 3 tier high conventional cages or 4 tier high reverse cages.

Effect of Floor space on Age at 50% production

McClung et al. (1971) studied the performance of a mini strain (M), an intermediate strain in size (I) and a strain (N) near average in size of commercial W.L.H. types upto 52 weeks. Cage densities of 2 and 3 birds per 8"x16" and 3, 4, 5 and 6 birds per 16"x16" cages were studied. Fifty per cent production was reached at 156, 158, 197 days in cages, respectively for (N), (I) and (M), respectivel

Reddy et al. (1981) in an experiment provided 0.75, 0.62 and 0.50 sq.ft. floor area per bird. He reported that there was no difference in age at 50 per cent production in the three different floor space allowance and it was 148 days.

Effect of Cage space on Egg quality

Wilson et al. (1967) conducted two experiments with two commercial strains (HyLine (A) and H N(B)) of leghorn pullets which were weighed and randomly housed into 8"x18" and 10"x18" deep layer cages with one, two and three pullets per cage. The experiments started when the pullets were of the age of 19 weeks. Twelve replications of six birds each were used for each bird density in each size cage. The replicates were divided equally between the 2 strains. In first experiment egg quality measurements were made at 225 and 400 days of age and in the second experiment at 200 and 350 days of age. Egg quality characteristics (Haugh Unit) were affected little by treatment and major differences were due to strain effects. Differences in shell quality (sp. gravity) were small and showed no definite trends.

Mareks et al. (1970) in an experiment housed 50 birds in one-bird cages (25 x 45 cm) with 1125 cm^2 of floor space per bird, 50 birds in 25 two-bird cages (25 x 45 cm) with 562 cm^2 of floor space per bird and 50 birds in five-bird cages (50 x 45 cm) with 450 cm^2 of floor space per bird. No significant difference was observed for Haugh Units due to different cage densities.

Wolferd and Tanaka (1970) reported that housing density on a litter floor or in cages had no significant effect on egg shell thickness or sp. gravity. Christmas et al. (1973) in an experiment maintained birds in cages at the rate of two or three birds per 25.4 x 45.7 cm cage. Cages housing 2 birds produced eggs with significantly better shell quality than the cages in which 3 birds were housed.

Relationship between Alkaline phosphatase levels in Blood-plasma of layers and Egg laying

Auchinachie and Emslie (1934) reported that plasma phosphatase activity of strictly normal hens may be little affected by egg laying. Common (1936) studied the serum phosphatase activity in normal birds from hatching to maturity, laying birds receiving Vit. D supplement in the ration and laying birds receiving high and low calcium rations. The serum phosphatase of 32 normal laying hens varied from 3.6 to 40.2 Bodansky units. There was no significant difference between laying and non-laying hens. Administration of Vit. D concentrate did not reduce the range of serum phosphatase in laying birds.

Gutowska *et al.* (1943) in an experiment with groups of single comb RIR laying hens reported highest phosphatase activity 13.60 - 15.25 K.A. unit per 100 ml of blood plasma with an average of 14.17 units in good producers of eggs with strong shells. The lowest phosphatase activity 10.60 to 11.90 K.A. units with an average 11.48 units was found in poor producers and having poor shelled eggs.

Stutts *et al.* (1957) reported the relationship between plasma phosphatase activity and egg production and found that there was no significant difference in phosphatase activity of laying and non-laying hens. They did not observe a simple relationship between phosphatase activities in June and number of eggs produced during subsequent 53 days. Age had no significant influence on phosphatase activity in mature females.

Bell (1960) reported about 50 per cent increase in the average levels of plasma enzymic activity of hen when about 50 per cent of the birds come into lay. In some hens a fairly steady level of activity with small fluctuations was obtained after first two months of intensive egg production. Other birds, however, continued to show very large fluctuations in PAP activity with no apparent tendency to the establishment of homeo-statis with respect to this enzyme. The massive temporary increase in plasma phosphatase activity shown by laying hen was believed to reflect a stimulation of the osteoblastic recalcification process called into action by the drain on skeletal calcium required for egg shells.

Bell and Siller (1962) in a pathological study of 40 cases of cage layer fatigue among heavy-laying W.L.H. pullets reported that the plasma showed abnormally high alkaline and acid phosphatase activities.

Snapir and Perek (1970) in an experiment with ten white leghorn (WLH) and ten white plymouth Rock (WPR) seven months old hens of similar production status. They did not observe any correlation between egg production rate and alkaline phosphatase activity. Shell quality values of the eggs laid by the (WPR) were significantly higher than those of WLH but no significant differences between breeds were noted while comparing PAP and carbonic anhydrose activities.

Engh and Wilcox (1971) reported that starch gell electro-phoretic studies utilizing 14 egg production strains that plasma alkaline phosphatase decreased markedly with age but increased significantly ($P \leq 0.01$) in summer in all the 3 age groups. The values were 3.49 ± 0.082; 4.025 ± 0.096 and 5.493 ± 0.196 (K.Au/100 ml) in 3 age groups. The higher values indicate the ability to retain more calcium in medullary bone possibly by increasing osteblastic activity.

MATERIALS AND METHODS

Three hundred fifty (350) straight run white leghorn day old chicks were reared together on deep litter upto 8 weeks of age. All the chicks were vaccinated against New Castle and Marek's diseases. Debeaking was performed at the age of 10 days. The chicks were again vaccinated for the prevention of New Castle and Foul Pox diseases at the age of 8 weeks. The cockerals were separated at 15 weeks of age and the females were reared upto 20 weeks on the floor. During this period the birds were provided starter (0-8 weeks) and grower (8-20 weeks) rations. The composition of rations is given in Table 1.

At 20 weeks of age 108 pullets were randomly selected, leg-banded, weighed and distributed in four, 3 tier batteries each having 18 individual compartments of 30 x 30 cm. each. The detailed manner of distribution of birds in these four batteries has been presented in Table 2.

The layer mash (Table 1) was fed ad-libitum to all the birds during the experimental period. Daily mortality was recorded. However, the dead birds were replaced from similar extra birds to maintain a constant stocking density during the first two 28-day periods i.e. 20-24 and 24-28 weeks of age. A 16 hour daily common light schedule was followed for all the birds after 20 weeks of age. The experiment was conducted upto 52 weeks of age of birds. The following observations were recorded:

Table 1: Composition of rations fed to birds at different ages

Ingradients	0-8 weeks	8-20 weeks	After 20 weeks
Maize	40.000	54.500	55.000
Rice Polish	06.000	-	15.000
G.N.C.	40.000	34.000	19.500
Fish meal	12.000	10.000	07.000
Mineral mixture with salt	02.000	01.500	01.500
Shell Grit	-	-	04.500
Rovimix	00.025	00.025	00.025
	Calculated values		
ME (K.cal./kg)	2703	2978	2820
CP (%)	23.13	22.89	15.960
CF (%)	5.148	4.709	4.672

Table 2: Random distribution of birds to various treatments (2 different floor spaces and 3 heights (decks) of cages)

Battery Number	Floor space per bird	Deck	Number of birds per compartment	Total number of birds/deck
A	900 cm^2	Upper	1	6
		Middle	1	6
		Lower	1	6
B	900 cm^2	Upper	1	6
		Middle	1	6
		Lower	1	6
C	450 cm^2	Upper	2	12
		Middle	2	12
		Lower	2	12
D	450 cm^2	Upper	2	12
		Middle	2	12
		Lower	2	12

1. Daily egg production of each cage cell.
2. Feed consumption during 20-24, 24-28, 28-32, 32-36, 36-40, 40-44, 44-48 and 48-52 weeks.
3. Body weight of birds at 20, 24, 28, 32, 36, 40, 44, 48 and 52 weeks of age.
4. Plasma alkaline phosphatase level of blood of birds at 20, 24, 28, 32, 36, 40, 44, 48 and 52 weeks of age.
5. Egg quality traits like Haugh unit, shell thickness, yolk height and yolk width of eggs laid during the last 3 consecutive days of the different period (20-24, 24-28, 28-32, 32-36, 36-40, 40-44, 44-48 and 48-52 weeks).

From these observations the following parameters were calculated:

1. Age at 50% production

The age upto the first day when 50 per cent birds in each replicate of the treatments laid at a time was considered as age at 50 per cent production.

2. Egg quality

(a) Haugh Unit: This was recorded directly by a Haugh meter. Two observations were taken on both sides between the edge of the yolk and the outer edge of thick albumen. The mean of the 2 readings was considered as the Haugh Unit of the egg.

(b) Yolk index: The width of the yolk was measured with the help of vernier calliper and the height of the yolk by a spherometer. The yolk index was calculated by the following formula:

$$\frac{\text{Yolk height}}{\text{Yolk width}} \times 100$$

(c) Shell thickness: This was measured with the help of shell thickness gauge. The shell membranes were removed before the measurement of shell thickness.

Alkaline phosphatase

This was measured by AMES BLOOD ANALYZER using Reagent Kit for quantitative determination of plasma alkaline phosphatase. The detailed procedure has been presented in Appendix I.

Statistical methods

The means and standard errors were calculated by using the following formula:

$$\text{Mean} = \frac{\Sigma X}{n}$$

$$\text{S.E.} = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n-1}}$$

The analysis of variance was run using the following mathematical model:

$$Yijk = \mu + ai + bj + (ab)ij + eijk$$

Where,

Yijk = Kth observation in the jth floor space and ith deck of the 3 tier battery

μ = Overall mean

ai = Effect of two stocking densities (i = 1,2)

bj = Effects of 3 decks (j = 1,2 & 3)

(ab)ij = Effect of interactions of decks and stocking densities

eijk = Random error

On preliminary analysis using method 1 of Henderson (Harvey, 1960) the interaction effects were found non-significant. The analysis was, therefore, redone ignoring the effects of interaction.

As the number of observations between two treatments (two floor spaces) were small 't' test was used to test the significance of these treatments. The effect of floor space in most of the cases was also non-significant ($P \geq 0.05$). In cases where the deck effect was non-significant no further analysis was needed. However, in cases where the deck effect was significant ($P \leq 0.05$) multiple mean comparison test was run using Duncan's multiple range test (Snedecor and Cochran, 1968).

For testing the significance of mortality Chi-square test of goodness of fit was applied (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Effect of cage space on body weight

The means and standard errors for body weight of birds given 900 and 450 cm^2 of cage space during 20 to 52 weeks of age have been presented in Table 3. Table 5 presents the effect of cage space on body weights. From this table it was found that the differences in body weights of birds were non-significant.

The 20 weeks body weight and 32 weeks body weight of birds provided 450 cm^2 of space was lower than those provided 900 cm^2 of space. At all other ages the birds provided lesser floor space were heavier than their counter-parts. The birds getting lesser floor space in cages get less exercise and are expected to be heavier than those given more cage space. Thus, the observations of this experiment are within expectations. Although the differences are statistically non-significant, yet a definite trend as mentioned above is visible from the above results. Lowe and Heywang (1964) and Ramos et al. (1986) also observed an increase in body weight with increase in density. However, Johri and Sharma (1978) and Rao (1986) found that density has no effect on body weight of layers. In the present study the non-significant differences in body weights of layers are in agreement with the findings of Lowe and Heywang (1964) and Ramos et al. (1986). Many workers like Wilson et al. (1967), Ruggles (1967), Grover et al. (1972),

Table 3: Means and standard errors for body weights (g) of birds given different floor space at different ages

Space in cage (cm^2)	20 weeks Mean S.E.	24 weeks Mean S.E.	28 weeks Mean S.E.	32 weeks Mean S.E.	36 weeks Mean S.E.	40 weeks Mean S.E.	44 weeks Mean S.E.	48 weeks Mean S.E.	52 weeks Mean S.E.
900	1401±239 (36)	1504±196 (36)	1476±210 (36)	1430±248 (23)	1478±260 (13)	1361±315 (7)	1436±331 (7)	1364±317 (7)	1450±295 (7)
450	1350±254 (72)	1485±177 (72)	1503±201 (72)	1423±219 (55)	1560±236 (42)	1530±322 (35)	1568±301 (24)	1639±309 (24)	1669±327 (24)

Figures in parentheses are number of observations.
Differences between the two treatments were non-significant at $P \geqslant 0.05$.

Table 4: Means and standard errors for body weights (g) of birds kept in different decks of batteries at different ages

Deck	20 weeks Mean S.E.	24 weeks Mean S.E.	28 weeks Mean S.E.	32 weeks Mean S.E.	36 weeks Mean S.E.	40 weeks Mean S.E.	44 weeks Mean S.E.	48 weeks Mean S.E.	52 weeks Mean S.E.
Upper	1359±276 (36)	1469±199 (36)	1486±196 (36)	1372±243 (32)	1479±250 (19)	1379±302 (14)	1443±279 (10)	1428±306 (10)	1607±299 (10)
Middle	1362±256 (36)	1520±114 (36)	1503±195 (36)	1443±266 (21)	1597±278 (16)	1515±316 (13)	1584±221 (13)	1627±289 (13)	1625±304 (13)
Lower	1380±243 (36)	1485±221 (36)	1494±226 (36)	1478±247 (25)	1554±205 (20)	1605±299 (15)	1581±268 (8)	1684±259 (8)	1626±312 (8)

Figures in parentheses are number of observations.
Difference between the 3 treatments were (decks) non-significant at $P \geqslant 0.05$.

Table 5: Analysis of variance showing the effect of floor space and deck on body weight of birds at different ages

Source of variation	20 weeks		24 weeks		28 weeks		32 weeks		36 weeks		40 weeks		44 weeks		48 weeks		52 weeks	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Between treatments	1	64061	1	8437.50	1	17604.22	1	963	1	65616	1	165200	1	94716	1	410726	1	259324
Between decks	2	4480	2	25225	2	2500	2	83616	2	63240	2	185496	2	66731	1	172784	2	1133
Treatment x deck interaction	2	9072	2	39837.49	2	38854.40	2	74827	2	25085	2	33191	2	112092	2	136799	2	96321
Error	102	110529	102	27948.40	102	45748.56	72	35081	49	90420	36	135150	25	139485	25	21444	25	174542

Hill (1977), Mathew *et al.* (1979), Robinson (1979), Cunningham and Ostrander (1981) and Davami *et al.* (1987) obtained results contrary to above findings. The difference in results with the present study may be mainly due to difference in the amount of space provided and the season during which the studies were carried out. The present experiment was conducted during summer when the environmental temperature was very high. As growth inhibition of birds at high environmental temperatures has been observed by Huston and Edwards (1961) so it is expected that if the same experiment is conducted during winter better results can be obtained. The body weight of layers also varies with the level of production which can be another reason for difference between results of this study with the above workers.

Effect ofdeck on body weight

Means and standard errors for body weight of birds kept in different decks of 3 deck batteries have been presented in Table 4. These neither revealed any significant difference between each other (Table 5) nor presented any trend that can lead to any definite conclusion in this regard. Cunningham (1983) on the basis of experiments conducted during 1979-1981 suggested that with good management the cage level should not be a factor in performance of birds. Grover *et al.* (1972) on the other hand found, higher weight gains in chicken of upper cage row groups. However, the results are not directly comparable with the present studies as his experimental birds were heavy type chickens because of different genetic material compared to white leghorn layers in the present case. The effect of cage level on body weight has not been thoroughly investigated and significant number of earlier reports were not available for making comparisons and drawing valid conclusions.

From the above results it can be inferred that the body weight of W.L.H. layers during 20 to 52 weeks of age is not affected by cage level (in tri deck cages) or floor space upto 450 cm^2 per bird.

Effect of cage space on feed consumption

The means and standard errors for feed consumption of birds given 900 and 450 cm^2 of cage space during 20-52 weeks of age have been presented in Table 6. Table 8 presents the effect of cage space on feed consumption. From this table, it was found that the differences in feed consumption of birds were significant only during the periods 28-32, 32-36, 44-48 and 48-52 weeks but on an overall review of the performance of the birds during the whole experimental period (eight 28 day periods) it is observed that reduction in cage space per bird decreased the feed consumption. This decrease in feed consumption was, however, not same throughout the experimental period.

By increasing the density the movement of the birds and availability of the feeder space gets reduced. This perhaps leads to reduced feed consumption of birds given

Table 6: Means and standard errors for feed consumption (g) per bird given different floor space during different period of age

Space in cage (cm^2)	20-24 wks Mean S.E.	24-28 wks Mean S.E.	28-32 wks Mean S.E.	32-36 wks Mean S.E.	36-40 wks Mean S.E.	40-44 wks Mean S.E.	44-48 wks Mean S.E.	48-52 wks Mean S.E.
900	2442±294	2592±312	3172±378 [a]	3082±442 [a]	2668±484	3214±313	3580±433 [a]	3888±496 [a]
	(36)	(36)	(23)	(13)	(7)	(7)	(7)	(7)
450	2358±258	2421±295	2460±327 [b]	2431±408 [b]	2242±419	3036±193	2713±326 [b]	2751±436 [b]
	(36)	(36)	(28)	(21)	(18)	(12)	(12)	(12)

Figures in parentheses are number of observations.
Figures with different superscripts in a column differ significantly at $P \leq 0.05$.

Table 7: Means and standard errors for feed consumption (g) per bird kept in different deck of batteries during different periods of age

Deck	20-24 wks Mean S.E.	24-28 wks Mean S.E.	28-32 wks Mean S.E.	32-36 wks Mean S.E.	36-40 wks Mean S.E.	40-44 wks Mean S.E.	44-48 wks Mean S.E.	48-52 wks Mean S.E.
Upper	2360±271	2374±317	2699±350	2381±415 [a]	2197±438	3127±436	2703±477	3222±541
	(24)	(24)	(21)	(12)	(8)	(6)	(6)	(6)
Middle	2368±348	2551±337	2665±380	2868±483 [b]	2465±481	3054±268	3120±450	3053±498
	(24)	(24)	(13)	(10)	(8)	(8)	(8)	(8)
Lower	2481±273	2594±352	2970±405	2822±440 [b]	2419±505	3147±318	3288±471	3296±513
	(24)	(24)	(17)	(12)	(9)	(5)	(5)	(5)

Figures in parentheses are number of observations.
Figures with different superscripts in a column differ significantly at $P \leq 0.05$.

Table 8: Analysis of variance showing the effect of floor space and deck on feed consumption (g) during different periods of age

Source of variation	20-24 wks df	20-24 wks MS	24-28 wks df	24-28 wks MS	28-32 wks df	28-32 wks MS	32-36 wks df	32-36 wks MS	36-40 wks df	36-40 wks MS	40-44 wks df	40-44 wks MS	44-48 wks df	44-48 wks MS	48-32 wks df	48-32 wks MS
Between treatments	1	128102	1	522753	1	6412892*	1	399121*	1	913991	1	140133	1	3320701*	1	5718632*
Between decks	2	121002	2	326798	2	461002	2	833284*	2	165168	2	16105	2	762852	2	102336.5
Treatment x deck interaction	2	138155	2	38960	2	533251.80	2	476962	2	194850	2	380.5	2	236366	2	484782.5
Error	66	110007	66	340113	45	245063	28	246795	19	313376	13	31815	13	263133	13	184531

*Significant at $P \leq 0.05$.

450 cm^2 floor area. Moreover, the birds getting lesser floor space get less exercise and their maintenance requirement is reduced which leads to reduced feed consumption. The intensity of reduction in feed consumption during different periods may be attributed to the fluctuations in the environmental temperature.

Asriyan (1975) and Reddy (1981) also observed that decrease in floor space leads to lesser feed consumption. However, Lowe and Heywang (1964), Ruggles (1967), Dorminey and Arscott (1971), Grover et al. (1972), Robinson (1979), Rao et al. (1983), Adams and Craig (1985) and Rao (1986) found that density has no effect on feed consumption of layers.

Hill (1977) obtained results contrary to the present findings. He reported that decreased floor space per bird leads to increased feed consumption for which the author attributed the reason as interaction between the birds.

The differences in results of Hill (1977) may be due to hot season during which the present studies were conducted.

Effect of deck on feed consumption

Means and standard errors for feed consumption of birds kept in different decks of 3 deck batteries did not reveal any significant difference except during 32-36 weeks of age (Table 7 and 8). During this period (32-36 weeks) birds in upper cage row (upper deck) consumed lesser feed than birds in other two decks. Cunningham (1983) suggested that there is no effect of cage level on feed consumption, however, Grover (1972) reported higher feed consumption in upper cage row groups.

<u>Effect of cage space and deck on age at 50% production</u>

The means and standard errors for age at 50% production of birds provided 900 and 450 cm^2 floor area per birds and kept in different decks of batteries have been presented in Table 9. The birds provided more floor space (900 cm^2/bird) reached age at 50% production 3 days earlier than those which were provided lesser floor space (450 cm^2/bird) but this difference was not statistically significant (Table 10). This difference may be related with the feed consumption. The birds provided 900 cm^2 floor space consumed more feed than their counter-parts.

Body weights of birds provided 900 and 450 cm^2 floor area did not differ significantly, as has already been discussed. Since the relationship between age at sexual maturity and body weight has been reported in the literature and has become an established fact, such results can be expected. The results of our studies indicate that birds can be given half the space than the usual being used at present without any adverse effects on body weights or age at sexual maturity.

So far different decks are concerned, birds housed in top decks reached age at 50 per cent production 2 days earlier than the birds housed in other two decks. The analysis of variance of the data (Table 10) revealed that this difference is statistically non-significant. However, this minor difference may be due to more ventilation or more light available in top tiers.

Effect of cage space on egg production

The means and standard errors for egg production of birds given 900 and 450 cm^2 of cage space during 20-52 weeks of age have been presented in Table 11. The birds provided 900 cm^2 space in general laid at a higher rate than those provided 450 cm^2 at all ages except 36-40 weeks of age. The analysis of variance of the data for egg production (Table 13) for the 2 housing conditions viz. 900 and 450 cm^2, however, did not reveal any significant difference except during 28-32 and 48-52 weeks of age. The overall egg production during 20-52 weeks (Per cent hen day basis) also reveal significant difference between the two treatments. During these periods the birds provided more floor space laid at a higher rate than those provided 450 cm^2 space per bird.

Dorminey and Arscott (1971), Wells (1971), Samalo and Sathe (1974), Furuta (1975) and Mathew et al. (1979) reported that birds housed at different densities did not differ significantly in their production performance. However, Lowe and Heywang (1964), Wilson (1967), Ruggles (1967), Grover et al. (1972), Connor and Burton (1975), Sefton (1976), Hill (1977), Johri and Sharma (1978), Reddy (1981), Quart and Adams (1982), Jongenburger (1982), Roush et al. (1984), Adams and Craig (1985), Ramos (1986) and Davami et al. (1987) reported that by decreasing the floor area per hen, decrease in egg production was observed.

Table 9: Means and standard errors for age at 50% production of birds given different floor space and kept in different decks of batteries

Space in cage cm^2	Age at 50% production (days)	S.E.	Deck	Age at 50% production (days)	S.E.
900	149.33	4.27	Upper	149.75	6.02
450	152.83	4.11	Middle	151.75	0.95
			Lower	151.75	5.50

Differences between 2 floor spaces and among 3 decks of batteries were non-significant at $P \geq 0.05$.

Table 10: Analysis of variance showing the effect of floor space and deck on age at 50% production

Source of variation	df	MS
Between treatments	1	37
Between decks	2	5.50
Treatment x deck interaction	2	30.50
Error	6	17.33

is statistically non-significant. However, this minor difference may be due to more ventilation or more light available in top tiers.

Effect of cage space on egg production

The means and standard errors for egg production of birds given 900 and 450 cm^2 of cage space during 20-52 weeks of age have been presented in Table 11. The birds provided 900 cm^2 space in general laid at a higher rate than those provided 450 cm^2 at all ages except 36-40 weeks of age. The analysis of variance of the data for egg production (Table 13) for the 2 housing conditions viz. 900 and 450 cm^2, however, did not reveal any significant difference except during 28-32 and 48-52 weeks of age. The overall egg production during 20-52 weeks (Per cent hen day basis) also reveal significant difference between the two treatments. During these periods the birds provided more floor space laid at a higher rate than those provided 450 cm^2 space per bird.

Dorminey and Arscott (1971), Wells (1971), Samalo and Sathe (1974), Furuta (1975) and Mathew et al. (1979) reported that birds housed at different densities did not differ significantly in their production performance. However, Lowe and Heywang (1964), Wilson (1967), Ruggles (1967), Grover et al. (1972), Connor and Burton (1975), Sefton (1976), Hill (1977), Johri and Sharma (1978), Reddy (1981), Quart and Adams (1982), Jongenburger (1982), Roush et al. (1984), Adams and Craig (1985), Ramos (1986) and Davami et al. (1987) reported that by decreasing the floor area per hen, decrease in egg production was observed.

Table 11: Means and standard errors for number of eggs laid per bird given different floor space during different periods of lay

Space in cage cm^2	20-24 wks Mean S.E.	24-28 wks Mean S.E.	28-32 wks Mean S.E.	32-36 wks Mean S.E.	36-40 wks Mean S.E.	40-44 wks Mean S.E.	44-48 wks Mean S.E.	48-52 wks Mean S.E.	20-52 wks (Per cent hen-day basis)
900	12 ± 4.87 (36)	17 ± 3.91 (36)	16^{a} ± 3.16 (23)	7 ± 1.87 (13)	6 ± 4.42 (7)	8 ± 4.70 (7)	11 ± 4.95 (7)	15^{a} ± 3.86 (7)	46.62^{a} ± 8.98
450	10 ± 3.89 (36)	16 ± 5.21 (36)	12^{b} ± 3.45 (28)	7 ± 2.38 (21)	8 ± 4.13 (18)	8 ± 5.13 (12)	9 ± 5.09 (12)	9^{b} ± 3.86 (12)	40.13^{b} ± 10.58

Figures in parentheses are number of observations.
Figures with different superscript in a column differ significantly at $P \leq 0.05$.

Table 12: Means and standard errors for number of eggs laid per bird kept in different decks of batteries during different periods of lay

Deck	20-24 weeks Mean S.E.	24-28 wks Mean S.E.	28-32 wks Mean S.E.	32-36 wks Mean S.E.	36-40 wks Mean S.E.	40-44 wks Mean S.E.	44-48 wks Mean S.E.	48-52 wks Mean S.E.	20-52 wks (Per cent hen-day basis)
Upper	11 ± 4.74 (24)	15 ± 3.41 (24)	14 ± 3.55 (21)	7 ± 1.18 (12)	10 ± 3.96 (8)	10 ± 3.07 (6)	11 ± 5.49 (6)	11 ± 4.16 (6)	43.45 ± 6.87
Middle	10 ± 4.39 (24)	17 ± 4.50 (24)	13 ± 4.03 (13)	7 ± 2.68 (10)	7 ± 4.20 (8)	6 ± 3.81 (8)	9 ± 4.34 (8)	11 ± 3.02 (8)	40.98 ± 11.06
Lower	12 ± 4.09 (24)	17 ± 5.68 (24)	13 ± 4.34 (17)	7 ± 2.67 (12)	8 ± 3.82 (9)	10 ± 4.52 (5)	10 ± 4.53 (5)	12 ± 4.25 (5)	44.72 ± 12.82

Figures in parentheses are number of observations.
Differences between the 3 treatments (decks) were non-significant at $P \geq 0.05$.

Table 13: Analysis of variance showing the effect of floor space and deck on number of eggs laid during different periods of lay

Source of variation	20-24 wks		24-28 wks		28-32 wks		32-36 wks		36-40 wks		40-44 wks		44-48 wks		48-52 wks	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Between treatments	1	26	1	35	1	212*	1	0.853	1	16	1	0.226	1	16	1	125*
Between decks	2	13.50	2	23	2	2.50	2	1.451	2	42	2	43.33	2	3.5	2	8.50
Treatment x deck interaction Int	2	9	2	16	2	20.50	2	2.422	2	32.50	2	21.740	2	7	2	31
Error	66	19.78	66	21.42	45	11	28	5.298	19	13.63	13	14.433	13	46.15	13	13.46

*Significant at $P \leq 0.05$.

Rao et al. (1983) and Rao (1986) found that the birds provided lesser floor space allowance gave better production than their counter-parts. The difference between the present findings and the findings of the above mentioned authors may be due to difference in season because during winter if the density is increased, heat loss from the body of the bird is decreased because of the warm environment of the house and performance of the bird remains better.

On the basis of the present findings the desirability of providing 450 cm^2 of floor space without having any significant effect on egg production of W.L.H. layers cannot be ruled out. The present experiment was conducted during April to November when the temperature is generally high and we know ovulation is most easily affected by both external and internal influences. The extreme heat of late summer decreases the rate of ovulation and the egg production declines.

Reddy (1986) reported that the ideal temperature for optimum egg production lies between 10-15°C (50-60°F) but the bird remains comfortable even from 20-25°C. Panting is normally initiated at about 29°C but it is affected by relative humidity. When the ambient temperature is higher, more water is consumed by the birds which leads to wet droppings and this in turn leads to increased humidity with the result there is decreased evaporation from the surface of lungs and the bird remains under heat stress. Layers have greater difficulty in adjusting the temperature changes than non-layers. Exposure to heat sends the hen into a state resembling a partial moult. Laying is reduced to about once a week.

Deaton et al. (1982) reported that heat stress (39°C) resulted in a significantly greater reduction in egg production.

Since some interaction between high environmental temperature and cage space is always expected, therefore, it can be suggested that the effect of this temperature is expected to be more when cage space is less. Also when the hen is disturbed as she is about to lay, the egg is retained and ovulation is delayed. This condition may be more common in cages in which 2 hens have been kept in each cage cell that is why birds provided 450 cm^2 floor area laid at a lower rate. Hughes (1975) reported that crowding hens reduces egg numbers. Kiley (1977) interpreted this phenomenon as an effect of increased social stress.

Effect of deck on egg production

The averages for egg production of birds kept in different decks of 3 deck batteries have been presented in Table 12. The analysis of variance of the data (Table 13) did not reveal any significant difference in egg production of birds kept in different deck of batteries. In this regard, Jaeger (1967), Cunningham (1983), Saraswat (1979) did not observe any significant difference in egg production of birds housed in different decks of batteries. However, Hurnik et al. (1974) reported higher egg production in upper tiers than in lower tier. Sefton (1976) reported that hens in top tier of cages layed at lower rate than in those in the bottom tier. Jackson and Waldroup (1987) observed that laying was adversely affected progressing from bottom to top tier.

These differences in results of different authors may be due to difference in housing conditions like availability of equal light, in different decks, ventilation, environmental temperature, humidity and their interaction.

Effect of cage space on Haugh Unit

The means and standard errors for Haugh Unit of eggs laid by birds given 900 cm^2 and 450 cm^2 of cage space during 20-52 weeks of age has been presented in Table 14. The analysis of variance of the data for Haugh Unit (Table 16), for the 2 housing conditions did not reveal any significant difference which indicates that the birds getting lesser cage space (450 cm^2) and consuming lesser feed than their counter-parts, lay eggs which are in no way inferior in albumen quality to those laid by birds getting 900 cm^2 cage space and consuming more feed.

Wilson et al. (1967) observed that characteristics like Haugh Unit were little affected by cage space per bird. Marek's et al. (1970) also reported that no significant difference is observed for Haugh Units due to different cage densities.

Averages for Haugh Unit of eggs laid by birds kept in different decks of 3 deck batteries also do not reveal any significant difference between each other (Table 15 and 16) which indicates that even if we use multi deck (3 deck

Table 14: Means and standard errors for Haugh Unit of eggs laid by birds given different floor space at different ages

Space in cage cm^2	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
900	83.00 ± 4.63 (54)	84.06 ± 7.63 (29)	83.02 ± 5.53 (28)	81.00 ± 8.12 (17)	80.45 ± 4.00 (11)	79.75 ± 4.36 (8)	79.53 ± 2.10 (13)	77.81 ± 1.32 (11)
450	83.63 ± 5.99 (59)	83.22 ± 6.93 (61)	81.51 ± 4.67 (39)	80.73 ± 5.81 (23)	79.11 ± 3.96 (17)	78.16 ± 4.23 (12)	79.35 ± 5.17 (34)	76.41 ± 1.81 (24)

Figures in parentheses are number of observations.
Difference between the two treatment were non-significant at $P \geqslant 0.05$.

Table 15: Means and standard errors for Haugh Unit of eggs laid by birds kept in different decks *of batteries at different ages*

Deck	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
Upper	82.97 ± 5.65 (38)	83.29 ± 7.57 (27)	83.34 ± 6.46 (23)	81.36 ± 7.27 (11)	78.80 ± 4.15 (10)	80.66 ± 4.92 (6)	79.83 ± 4.55 (18)	77.14 ± 2.47 (7)
Middle	82.92 ± 5.22 (42)	82.37 ± 8.43 (29)	81.14 ± 4.22 (21)	79.21 ± 5.59 (14)	81.11 ± 3.85 (9)	78.62 ± 4.17 (8)	79.17 ± 3.24 (17)	76.50 ± 1.91 (14)
Lower	83.21 ± 5.49 (33)	84.61 ± 5.74 (34)	82.34 ± 4.19 (23)	82.00 ± 7.58 (15)	79.11 ± 3.88 (9)	77.16 ± 3.54 (6)	79.08 ± 6.11 (12)	77.07 ± 1.26 (14)

Figures in parentheses are number of observations.
Difference between the three treatments (decks) were non-significant at $P \geqslant 0.05$.

Table 16: Analysis of variance showing the effect of floor space and deck on Haugh Unit of eggs laid by the birds at different ages

Source of variation	24 weeks		28 weeks		32 weeks		36 weeks		40 weeks		44 weeks		48 weeks		52 weeks	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Between treatments	1	47	1	14	1	59.81	1	0.665	1	12	1	12	1	0.324	1	12
Between decks	2	1	2	40	2	26.70	2	30.09	2	15	2	18.50	2	2.716	2	0.50
Treatment x deck interaction	2	15	2	43	2	0.194	2	12.22	2	4.50	2	38	2	8.86	2	2.50
Error	107	29.83	84	53.82	61	26.28	34	50.46	22	17	14	15.57	41	22.28	29	3.03

batteries) batteries for rearing poultry, the egg quality (Haugh Unit) will not be adversely affected.

Effect of cage space on shell thickness

The means and standard errors for shell thickness of birds given 900 and 450 cm^2 of floor area have been presented in Table 17. The birds provided 900 cm^2 floor area laid eggs with higher shell thickness than those provided 450 cm^2 floor area at all ages. The analysis of variance of the data for shell thickness (Table 19), however, revealed that the difference in shell thickness for the 2 housing conditions were significant only at 32 and 40 weeks of age.

Christmas et al. (1973) observed that a decrease in bird density resulted in better shell quality. Wilson et al. (1967) reported that the difference in shell quality due to different densities were small and showed no definite trends. These observations are in agreement with the present findings.

The shell thickness of eggs laid by birds in both the housing conditions was found lesser than reported in the literature which may be due to high environmental temperature as exposure of birds to high environmental temperature leads to decreased shell thickness. Warren and Schnepel (1940) suggested that egg shell thickness deteriorated when the hens were subjected to 35°C for an extended period. Hadi and Sykes (1982) reported that thermal panting results in respiratory alkalosis in laying hens exposed to 35, 38 and 41°C and this alkalosis may decrease the amount of carbonate available for egg shell formation and thus

Table 19: Analysis of variance showing the effect of floor space and deck on shell thickness of eggs laid by birds at different ages

Source of variation	24 weeks		28 weeks		32 weeks		36 weeks		40 weeks		44 weeks		48 weeks		52 weeks	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Between treatments	1	0.0021	1	0.0003	1	0.0016*	1	0.0008	1	0.0012*	1	0.0001	1	≃ 0	1	0.0007
Between decks	2	0.0015	2	0.0008	2	0.0001	2	0.0001	2	0.0001	2	0.0010	2	0.0003	2	0.0001
Treatment x deck interaction	2	0.0007	2	0.0002	2	≃ 0	2	0.0001	2	0.0008*	2	0.0004	2	0.0001	2	0.0001
Error	107	0.0014	84	0.0010	61	0.0003	34	0.0005	22	0.0002	14	0.0132	41	≃ 0	29	0.0003

*Significant at $P \leq 0.05$.

contribute towards thin shells which are frequently seen in hot climates. Izat et al. (1985) reported that shell thickness was thinnest in spring and summer when the temperature was 32.2^{o}C inside the house and it was thickest during fall when the temperature reached 15.6^{o}C inside the house.

Averages for shell thickness of eggs laid by the birds kept in different decks of batteries (Table 18) did not reveal significant differences between each other (Table 19).

Effect of cage space on yolk index

The means and standard errors for yolk index of eggs laid by birds given 900 and 450 cm^2 floor area have been presented in Table 20. From these results it can be seen that in the beginning (24 weeks) and at the last phase of the experiment (48 and 52 weeks of the age of birds) the trend is towards larger yolk index of birds kept on 450 cm^2 floor area per bird. At 32, 36, 40 and 44 weeks of age, the birds provided 900 cm^2 floor area showed greater yolk index than the birds with 450 cm^2 floor area per bird. This difference in the trend of yolk index values in the beginning and at the end of the experiment seemed to be related with the high environmental temperature rather than cage floor area. During 32 to 44 weeks of age the birds getting lesser floor area might have felt the heat stress greater than their counter-parts resulting in reduced synthesis of yolk material in liver.

Averages of yolk index of eggs laid by birds kept in different decks of batteries also did not reveal any significant difference between each other except at 40 weeks of age

Table 20: Means and standard errors for yolk index of eggs laid by birds given different floor space at different ages

Space in cage cm^2	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
900	44.00^a ±3.45 (54)	47.40 ±2.36 (29)	45.82 ±2.90 (28)	43.14 ±2.95 (17)	44.71^a ±2.21 (11)	45.02 ±3.35 (8)	43.65 ±3.68 (13)	42.80 ±2.87 (11)
450	45.57^b ±2.99 (59)	47.50 ±2.12 (61)	45.23 ±4.70 (39)	42.68 ±3.42 (23)	41.44^b ±2.89 (17)	43.33 ±2.89 (12)	44.66 ±3.27 (34)	43.06 ±2.14 (24)

Figures in parentheses are number of observations.
Figures having different superscripts in a column differ significantly at $P \leq 0.05$.

Table 21: Means and standard errors for yolk index of eggs laid by birds kept in different decks of batteries at different ages

Deck	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
Upper	44.68 ±3.16 (38)	47.70 ±2.85 (27)	45.39 ±4.99 (23)	43.63 ±3.28 (17)	42.72^a ±3.41 (10)	44.13 ±1.52 (6)	44.63 ±3.07 (18)	43.50 ±2.86 (7)
Middle	45.23 ±2.94 (42)	47.00 ±2.32 (29)	45.09 ±3.87 (21)	42.78 ±4.35 (14)	43.00^b ±2.44 (9)	45.17 ±2.07 (8)	44.77 ±3.67 (17)	42.16 ±1.77 (14)
Lower	44.60 ±3.86 (33)	47.80 ±1.25 (34)	45.91 ±3.15 (23)	42.42 ±1.60 (15)	42.46^a ±2.68 (9)	42.33 ±4.80 (6)	43.44 ±3.82 (12)	43.53 ±2.52 (14)

Figures in parentheses are number of observations.
Figures having different superscript in a column differ significantly at $P \leq 0.05$.

Table 22: Analysis of variance showing the effect of floor space and deck on yolk index of eggs laid by birds at different ages

Source of variation	24 weeks df	24 weeks MS	28 weeks df	28 weeks MS	32 weeks df	32 weeks MS	36 weeks df	36 weeks MS	40 weeks df	40 weeks MS	44 weeks df	44 weeks MS	48 weeks df	48 weeks MS	52 weeks df	52 weeks MS
Between treatments	1	62	1	1	1	6	1	2	1	72.182*	1	13.736	1	8.742	1	0.577
Between decks	2	4.5	2	5.5	2	4	2	5	2	22.119*	2	13.908	2	6.981	2	7.755
Treatment x deck interaction	2	10	2	6	2	4.5	2	5	2	3.285	2	1.402	2	11.846	2	10.841
Error	107	10.48	84	4.79	61	17.26	34	11.11	22	6	14	10.03	41	11.804	29	5.208

*Significant at $P \leq 0.05$.

(Table 21 and 22). At 40 weeks of age birds kept in middle decks showed greater yolk index than the birds kept in other two decks of batteries. This difference is hard to explain.

<u>Effect of cage space on plasma alkaline phosphatase (PAP) level and its relationship with egg production</u>

The means and standard errors for plasma alkaline phosphatase levels of birds provided 900 and 450 cm^2 floor area per bird have been presented in Table 23. The analysis of the data (Table 25) revealed that the difference for floor space of this trait was significant only at the age of 40 weeks. However, on critical review of Table 23 it could be seen that the birds provided 900 cm^2 floor area showed higher levels of plasma alkaline phosphatase than their counter-parts with 450 cm^2 floor area at the age of 20 and 24 weeks. After 24 weeks of age the trend reversed. This difference in PAP levels between the two housing conditions continued upto the end of the experiment.

Plasma alkaline phosphatase is an enzyme and is understood to originate in bones, particularly in the osteoblasts. This enzyme is directly related with recalcification of the bones. During this process the osteoblasts produce higher concentrations of this enzyme which is an effective pyrophosphatase. Pyrophosphate form a significant amount of the phosphate of the osteoid. The alkaline phosphatase liberates the phosphate ion from pyrophosphate and makes it available for combination with calcium and other ions to form the bone crystals.

Table 23: Means and standard errors for plasma alkaline phosphatase levels (I.U./100 ml) of birds given different floor space at different ages

Space in cage cm^2	20 weeks Mean ± S.E.	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
900	35.66±4.85 (6)	37.16±3.97 (6)	38.00±6.44 (6)	44.66±6.12 (6)	61.16±5.98 (6)	75.50[a]±5.99 (6)	86.50±6.15 (6)	96.50±6.18 (6)	91.50±5.89 (6)
450	34.00±3.76 (12)	36.00±4.39 (12)	40.91±4.44 (12)	49.66±6.89 (12)	68.16±8.67 (12)	81.75[b]±5.27 (12)	90.25±9.75 (12)	104.50±9.90 (12)	97.33±10.56 (12)

Figures in parentheses are number of observations.
Figures having different superscripts in a column differ significantly at $P \leq 0.05$.

Table 24: Means and standard errors for plasma alkaline phosphatase level (I.U./100 ml) of birds kept in different decks of batteries at different ages

Deck	20 weeks Mean ± S.E.	24 weeks Mean ± S.E.	28 weeks Mean ± S.E.	32 weeks Mean ± S.E.	36 weeks Mean ± S.E.	40 weeks Mean ± S.E.	44 weeks Mean ± S.E.	48 weeks Mean ± S.E.	52 weeks Mean ± S.E.
Upper	35.50±5.24 (6)	36.50±4.88 (6)	40.16±4.44 (6)	50.00±6.89 (6)	68.33±7.96 (6)	82.00[a]±5.36 (6)	88.83±11.91 (6)	105.16±10.55 (6)	99.66±12.2 (6)
Middle	33.66±4.80 (6)	35.83±4.79 (6)	39.33±3.07 (6)	45.00±7.66 (6)	59.66±7.68 (6)	75.00[b]±3.57 (6)	86.83±8.35 (6)	99.83±11.32 (6)	93.50±8.84 (6)
Lower	34.50±2.07 (6)	36.83±3.43 (6)	40.53±8.86 (6)	49.00±8.29 (6)	69.50±6.97 (6)	82.00[a]±6.89 (6)	91.83±5.56 (6)	100.50±6.74 (6)	93.00±6.87 (6)

Figures in parentheses are number of observations.
Figures having different superscript in a column differ significantly at $P \leq 0.05$.

Table 25: Analysis of variance showing the effect of floor space and deck on plasma alkaline phosphatase levels at different ages

Source of variation	20 weeks		24 weeks		28 weeks		32 weeks		36 weeks		40 weeks		44 weeks		48 weeks		52 weeks	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Between treatments	1	11.110	1	5.444	1	34.027	1	100	1	196	1	156.26*	1	56.25	1	256	1	136.11
Between decks	2	5.055	2	1.555	2	1.722	2	42	2	173.165	2	98.00*	2	39.50	2	50.66	2	82.72
Treatment x deck interaction	2	45.862	2	53.861	2	142.111	2	100.75	2	18.083	2	25.75	2	42.25	2	58.58	2	71.36
Error	12	191.375	12	15	12	11.437	12	35.375	12	52	12	19.85	12	89.35	12	87.66	12	91.16

*Significant at $P \leq 0.05$.

Different workers have shown the significance of PAP in different ways but no reference could be traced in which this enzyme would have been studied in relation to different cage densities. There are so many factors which effect the PAP levels in birds and the number of eggs laid is one among them. The present findings indicated that the PAP levels were not only related with egg production but also with the calcium intake. The perusal of Table 11 and Table 23 revealed that birds provided 900 cm^2 floor area laid at a higher rate during 20-24, 24-28 and 28-32 weeks of age than their counter-parts getting 450 cm^2 floor area but the PAP levels were higher in these birds on 900 cm^2 floor area at 20 and 24 weeks only.

During 20-24, and 24-28 weeks there was little difference in feed consumption between the birds kept in the 2 housing conditions and the birds laying at a higher rate showed higher levels of PAP but during 28-32 weeks of age although the egg production continued to be higher in birds with 900 cm^2 floor area, the feed consumption by the birds provided 450 cm^2 floor area comparatively decreased leading to decreased calcium intake and finally to elevated PAP levels. During 28-32 weeks of age the birds with 450 cm^2 laid eggs at a lower rate but the calcium intake was so low that the birds had to utilize their own calcium resources more extensively than their counter-parts, with 900 cm^2 floor area which perhaps resulted in the higher PAP levels in these birds.

During 32-44 weeks of age there was little difference in egg production in birds placed in two housing conditions but still PAP levels were elevated in 450 cm^2 floor area group of birds. Lesser feed consumption leading to reduced calcium intake may be one of the probable reasons, for these higher values of PAP in this group of birds. From 44-52 weeks of age the birds with 900 cm^2 floor area laid at a higher rate but showed lower PAP levels than the birds provided 450 cm^2 space during this period. The reason being that the birds getting 450 cm^2 floor area consumed lesser feed resulting in the reduced calcium intake and higher PAP levels.

From these findings it appeared that PAP are probably more related with egg production and calcium intake by birds than with the floor area per bird. Environmental temperature also appeared to be a factor which affects PAP levels indirectly by altering the feed consumption by the birds.

Auchinachie and Emslie (1934) reported that PAP activity of strictly normal hens may be little affected by egg laying. These workers suggested that conditions not optimum for Ca and P metabolism of the bird show abnormally high PAP activity. Common (1936) reported that the serum phosphatase activity of 32 normal laying hens varied from 3.6 to 40.2 Bodansky units. There was no significant difference between laying and non-laying hens. Snapir and Perek (1970) did not observe any correlation between egg production rate and PAP activity. Engh and Wilcox (1971) reported that egg production is not directly related to the isozyme frequency

Kansal and Gangwar (1984) reported that the higher values of PAP levels during summer indicate the ability to retain more calcium in medullary bone possibly by increasing osteoblastic activity. The low calcium level in blood in summer and less intake of feed might increase the level of alkaline phosphatase in summer. Similar findings have been reported by Hurwitz and Gringer (1961) by feeding low calcium diet. Thus, the higher levels of alkaline phosphatase indicate more stress due to low calcium level. The findings of all these workers support the findings/results of the present experiment. However, Gutowska et al. (1943) reported that good producer hens with strong shells showed higher levels of PAP than poor producer hens having poor shelled eggs.

Singh et al. (1983) observed that PAP activities were higher in pullets selected for higher production. They suggested that increased alkaline phosphatase activity is thought to indicate stimulation of the osteoblastic activity to meet the calcium demand for production. They further reported that the activities of this enzyme was significantly higher in caged birds at 35 and 50 weeks of age than birds on floor which may be due to cage stress.

In the present experiment since the cage stress was more in birds which were provided lesser floor area and this could be another reason for higher PAP levels in these birds especially after 24 weeks of age when the environmental temperature was very high.

Effect of deck on alkaline phosphatase activity

The means and standard errors for PAP activity of birds kept in different decks of batteries (3 deck batteries) have been presented in Table 24. Analysis of variance of the data (Table 25) revealed that there is no significant difference in PAP levels in birds kept in different decks except at 40 weeks of age. At this age birds in the middle decks showed lower value of PAP than the birds housed in the other two decks. Perhaps the reason seems to be lesser egg production by birds in the middle decks during this period.

Effect of cage space on mortality

The average per cent mortality of birds provided 900 and 450 cm^2 floor area have been presented in Table 26. The Chi-square (X^2) values for making statistical comparison between mortality in different treatments, which is an all or none trait have been provided under the same table.

The difference in mortality percentage between two housing conditions (1 bird per cage and 2 birds/cage) were non significant except during 36-40 weeks of age when the birds provided 900 cm^2 floor area showed a higher percentage of mortality than the groups kept on 450 cm^2 floor area per bird.

The mortality in general was higher in loosely housed birds (900 cm^2 floor area/bird) than those given lesser floor area (450 cm^2) except during 40-44 weeks. During this period some of the birds in 450 cm^2 floor area developed leg

Table 26: Average per cent mortality of birds given different floor space during different periods of age

Space in cage cm^2	20-24 weeks	24-28 weeks	28-32 weeks	32-36 weeks	36-40 weeks	40-44 wks	44-48 wks	48-52 wks
900	0	16.66	36.11	43.47	46.15	No mortality was observed.		
450	5.55	08.33	23.61	23.63	16.66	31.42	No mortality observed	
Cal. X^2 Value	2.076	01.68	01.861	03.070	04.78*	02.980		

*Significant at $P \leq 0.05$.

Table 27: Average per cent mortality of birds kept in different decks of batteries during different periods of age

Deck	20-24 wks	24-28 wks	28-32 wks	32-36 wks	36-40 wks	40-44 wks	44-48 wks	48-52 wks
Upper	0.00	13.88	11.11	40.62	26.31	28.57	No mortality was observed during this period in any treatment.	
Middle	5.55	11.11	41.66	23.80	18.75	00.00		
Lower	5.55	08.33	30.55	20.00	25.00	46.66		
Calculated x values								
Upper x Middle	2.057	0.126	8.651*	1.598	0.281	4.360*		
Middle x Lower	0	0.109	0.96	0.097	0.200	8.08*		
Upper x Lower	2.057	0.56	4.12*	2.763	0	1.007		

*Significant at $P \leq 0.05$.

abnormalities (layer fatigue), they were not able to remain in standing position and take feed and water. Their death occurred due to starvation. After 44 weeks there was no mortality in either of the treatments.

Lowe and Heywang (1964), Ruggles (1967), Wilson et al. (1967), Connor and Burton (1975), Johri and Sharma (1978), Mathew et al. (1979), Bell (1983), Roush et al. (1983), Adams and Craig (1985), Ramos et al. (1985), Davami et al. (1987) reported that increase in bird density resulted in increased mortality. On the other hand Dorminey and Arscott (1971), Samalo and Sathe (1974), Reddy et al. (1981), Jongenburger (1983), Rao (1986) found that layer house mortality was not influenced by floor area.

The findings of the former authors are contrary to the present findings but these results agree with the results of the later workers. Such a wide difference in results of different workers may be due to the reasons that the mortality percentage appear to be dependent more on factors other than housing. The climatic conditions and quantity of feed consumed are some of such factors. The higher per cent mortality in birds provided 900 cm^2 floor area during 24-36 weeks of age can probably be the result of higher feed consumption by birds of this group during this period.

Effect of cage level on mortality

The average per cent mortality of birds kept in different decks of batteries has been presented in Table 27.

The statistical analysis of the data revealed that the differences in per cent mortality among different decks were not significant except during 28-32 and 40-44 weeks of age. During 28-32 weeks the birds in the middle and lower decks suffered higher mortality than the birds kept in upper deck. During 40-44 weeks birds in upper and lower decks suffered higher mortality than those of the middle deck.

Grover et al. (1967) in two experiments reported that the single and two bird densities of the birds suffered higher mortality in upper row of cages where as the 3 and 4 bird density treatments experienced higher mortality in lower cage row. Jackson and Waldroup (1987) reported that position of tier played a significant role in affecting mortality. It was adversely affected progressing from bottom to top tier in either 3 or 4 tier batteries. Sefton (1976) and Cunningham (1983), however, reported that the mortality was not affected significantly by cage level.

SUMMARY AND CONCLUSION

The poultry farming is concentrated around metropolitan cities because of ready availability of market. The land cost in these places is quite high so there is need to develop a system with less space for keeping birds. The three tier cage system is one of the methods by which the space requirements can be reduced. It has been reported that cage system may cause managemental problems partiбularly during summer season. Therefore, the present experiment was undertaken to explore the possibilities of using three tier battery cages in white leghorn layers by providing them less space.

At 20 weeks of age 108 pullets were randomly distributed in four (three tier) batteries each having 18 individual compartments of 30x30 cm each. The birds were provided 450 and 900 cm^2 floor spaces and were kept in 3 different tiers (Upper, Middle and Lower) of batteries. The following salient results were obtained:

The body weight of white leghorn layers during 20-52 weeks of age was not affected by cage level or floor area (450 or 900 cm^2/bird).

The reduction in cage space per bird from 900 to 450 cm^2 floor area resulted in reduced feed consumption. The effect of deck on feed consumption of birds was non-significant.

The reduction in floor space to half than the usual (900 cm^2) being used at present does not adversely affect the age at sexual maturity of birds. The effect of the 3 decks on age at sexual maturity was non-significant.

The birds provided 900 cm^2 floor area in general laid at a higher rate than those provided 450 cm^2 floor area. No effect of deck level was observed on this important trait.

Barring a few exceptions the effect of two spaces in cages and the cage levelon egg quality traits like Haugh Unit, shell thickness and yolk index were non-significant.

The plasma alkaline phosphatase levels of birds remained unaffected by cage space and cage level except at 40 weeks of age.

The birds provided 900 cm^2 floor area per bird showed a higher percentage of mortality than the groups kept on 450 cm^2 floor area per bird. The cage level also did not affect the mortality percentage with some exceptions.

The above results are suggestive of using 450 cm^2 floor area per bird.

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APPENDIX - I

Method of Estimation of Alkaline Phosphatase

Blood samples of 3-4 ml each were drawn from the brachial vein in the heprin rinsed syringe 9 times at 4 weeks intervals during the experimental period. All the samples were drawn between 10-11 A.M.

The tubes containing the blood samples used to be carried in ice (Ice box) from farm to laboratory and was centrifuged in the refrigerator centrifuge at 8°C at 2000 r.p.m. for 20 minutes. The plasma was then poured in the sterlized plasma vials and stored in the deep freeze till it was used for quantitative analysis. The estimation was carried out by AMES BLOOD ANALYZER which gives values as I.U./Litre and then accordingly values as PAP IU/100 ml of plasma were calculated.

Methode

Principle: Alkaline phosphatase hydrolyses p-nitrophenyl phosphate (PNPP) into p-nitrophenol and phosphate at the alkaline pH of the buffered medium. The reaction is stopped by adding sodium hydroxide and the yellow colour developed is measured at 405 nm (400-420 nm). The intensity of the colour developed is proportional to the alkaline phosphatase activity.

Sample: Plasma

Reagents

1 Buffer

1A Substrate (Tablets)

2 Sodium hydroxide

Preparation of daily working solution

Solution I: Dissolve one tablet (Reagent 1A) in 20 ml of Reagent 1. Crush the tablet with a glass rod and mix well until completely dissolved. The solution will be light yellow in colour.

<u>Reagent 2</u>: It is ready for use.

<u>Active ingradients of the Reagents</u>

Sodium p-nitrophenyl phosphate
Diethanolamine
Magnesium chloride
Sodium hydroxide

Solution (1) is stable for about 3 days at 2-8°C and one day at 20-25°C when protected from direct light.

<u>General Instructions</u>: 1. Use clean and dry glass ware
2. Reagents should be at room temperature before use.

<u>Procedure for Ames Blood Analyzer</u>

1. Connect the instrument to the mains and switch on the electrical power. Put the instrument switch in the stand-by position. Allow 10-15 minutes warm up time to enable the incubator to attain the temperature of 37.5°C ± 0.5°C.

2. Put the instrument switch to the 'ON' position from 'stand-by'. Insert the Hemoglobin-Sera-pak dial scale, place the sealed Hemoglobin colour standard in the test well as far as it will go and calibrate to the centre triangle using calibration control. Remove the colour standard and place a clean glass cuvette-one half filled with distilled water. If reading is net '0' then adjust it with the back panel SLOPE control. Put the instrument in the stand-by mode.

3. Remove the Hemoglobin/Sera-Pak. Scale and properly insert the Alkaline phosphatase/Sera-Pak dial scale.

4. Mark cuvetts properly as Blank and Test for each sample. For each sample prepare a separate blank.

5. Pipette 1.0 ml of solution (1) in each cuvette.

6. Insert the cuvetts in the incubator and incubate for about 5 minutes.

7. Add 50 UL (0.05 ml) of the sample in the cuvette marked Test only. Cover the cuvette with stopper and completely invert twice to mix.

8. Insert the cuvettes in the incubator and set the time at 15 minutes.

9. Remove the cuvettes from the incubator when the timer sounds and add 2.0 ml of reagent 2 immediately to both cuvettes and mix.

10. Add 50 UL (0.05 ml) of the sample to the cuvette marked Blank and mix.

11. Put the instrument to the 'ON' position from stand-by wipe the cuvette containing the Blank, insert in the test well as far as it will go and calibrate to read zero IU/L on the Alkaline phosphatase/Sera-pak scale. Remove the cuvette.

12. Wipe the test cuvette and insert in the test well as far as it will go. Read the result in IU/L. The colour of the reaction is stable for 30 minutes.