EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE OF COMMERCIAL HYBRID LAYERS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE OF COMMERCIAL HYBRID LAYERS** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy,
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CERTIFICATE

Certified that this thesis, entitled **EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE OF COMMERCIAL HYBRID LAYERS** is a record of research work done independently by Kumari A.G. GEO under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

Poultry production constitutes an integral part of agricultural operation in Asia and Pacific areas. Chicken meat and eggs form important quality protein sources in these regions, but, their production is not in pace with the demand of ever increasing human population. India ranks second in the world, in respect of human population. Presently, only 12.5 per cent of our population do have a real discretionary income. Further, the purchasing power of majority is limited and this situation comes in the way of people in consuming balanced diets, and leads to malnutrition.

According to a study made in 15 states in India in 1983, by the United States Agency for International Development (USAID) over 60 to 70 per cent of the population consume less than the minimum requirement of protein and calories. Protein, being the most limiting nutrient, usually result in protein - calorie inbalance and leads to consequent health problems (Anon., 1990). Egg is a protein rich ingredient that is easily digestable and if included in the regular diet, it can bring down the malnutrition problem in the country. Moreover, egg protein is cheaper when compared to other animal protein sources. Hence, supplementation of diet with egg as an affordable protein source assumes significance. The Nutritional Advisory Committee (NAC) has recommended that we would require atleast half an egg per head per day and 7.72 kg of meat per person per year. To meet these requirements, the annual egg production should be trebled to 60,000 million and broiler production by six fold to 1,200 million towards the end of this century (Anon., 1990).

During the last two decades, most of the Asian countries have achieved remarkable progress in poultry production. In India, the layer population has increased from 35 million (1961) to 113 million (1989) and the annual egg production which was 2000 million in 1961 increased to 22,400 million in 1989. Although India holds fifth position in total egg prodution, it would rank only among the countries having low per capita availability: 26 eggs (Anon., 1990).

Inspite of being a very potential sector, to contribute respectably to the national economy, the prospects for Poultry Industry for the coming years appear to be critical, because of the escalating prices of inputs and higher cost of housing. The capital investment for housing is one of the important items of non-recurring expenses in new poultry enterprises. The increase in cost of construction of poultry houses tempt to make alterations in the stocking density in view of maximum utilization of available space without adversely affecting the production performance. The Bureau of Indian Standards has recommended a floor space of 2300 to 2800 sq.cm. per layer of light breeds (BIS, 1972). But, since the declaration of this standard the body size of the commercial layers have shown considerable reduction warranting re-evaluation of the above standard. Therefore, studies on floor density under the hot humid climate existing in Kerala would go a long way in the efficient and economic utilization of available floor space.

The hybrid layer ILM-90, developed at the Mannuthy Centre of All India Co-ordinated Research Project has been released for commercial exploitation based on its superior performance. In order to prescribe a package of practices for this commerical hybrid, among other things, its performance under different floor densities needs study under the hot humid climatic profile of Kerala.

Therefore, the present study was undertaken to evaluate the performance of ILM-90 in three different floor densities under deep litter system of rearing in the agro-climatic conditions of Kerala, to identify a suitable floor space for them.

Review of Literature

REVIEW OF LITERATURE

The literature pertaining to the effects of floor space allowances on performance of layers under various environmental conditions are reviewed in this chapter.

Meteorological Profile of Mannuthy

A summary of five year monthly average of meteorological data at Mannuthy (Latitude 10°32"N; Longitude 76°16"E; Altitude 22.25m above MSL) was given by Somanathan (1980). He has reported that, when the meteorological factors from May to September were compared, the highest mean maximum temperature was recorded during May (32.35°C) and lowest during July (28.15°C). Then again the mean temperature rose to 30.25°C during September. The lowest mean minimum temperature recorded was 23.28°C during July and highest mean minimum temperature was 25.27°C during May. The daily average of per cent relative humidity varied between 75.68 during May to 86.52 during July. Climatograph of this locality fell within the hot and moist climate.

1.0. Impact of Meteorological Factors on Production Parameters

Froning and Funk (1958) studied the seasonal variation in quality of eggs laid by hens on deep litter and in cages. They observed that egg size was significantly lowered ($P<0.01$) in July when the temperature was highest and it increased during November and January, when the temperature was lower. They also observed better shell thickness associated with cooler temperature. Period variations in Haugh Unit were found to be significant ($P <0.01$). But no definite relationship of Haugh Unit to the average maximum temperature was established. They also reported variations in Albumen Index in different months of the year.

Muller (1961) evaluated the effect of constant and fluctuating environmental temperature on the biological performance of laying pullets from 150 to 435 days of age and found that a constant temperature of 90°F increased mortality and depressed egg production, feed intake, egg weight and shell quality as compared to a constant temperature of 55°F. Pullets kept in an environment where temperature cycled from 55°F to 90°F and back to 55°F every 24 h, produced more eggs than pullets kept at a constant temperature of 55°F. Egg weight and shell quality in the cycling environment were significantly lower than in the constant 55°F environment, but, significantly better than in the constant 90°F environment.

Esmay (1969) stated that the feed requirements for poultry are directly related to bird weight, ambient temperature and rate of egg production. He also reported that the upper and lower optimum housing temperature of 29.4° and 12.8°C provide the desirable temperature range for summer to winter housing. The upper optimum temperature of 29.4°C is however too high if constant and associated with high humidities. Day time temperature may be 29.4°C on a diurnal basis if night time temperature drop to 21.1°C or lower.

McDowell (1972) reported that in warm, humid areas where air temperature is 21°C or above, livestock production is affected when the relative humidity is 60 per cent and above.

Summarised results of the effect of temperature on egg production indicated that rate of lay is probably maximal at around 18-21°C with production depression at temperature above or below this range. The details of strain difference in response is far from complete, but, white strains are probably more tolerant to very high temperatures than brown strains, largely due to differences in feather cover and comb size. The feed intake of birds fed ad lib. was lowered as temperature rose and is about 1.50 per cent per degree centigrade at moderate temperature (18-24°C). The rate of fall was less than this at lower temperature and a great deal faster at high temperatures (H.M.S.O., 1976).

Kothandaraman (1985) citing the observations of Appa Rao stated that the mean daily average temperature and egg production had a highly negative correlation. Every 1°F rise in air temperature resulted in 2.18 per cent decline in egg production.

Chand and Razdan (1976) reported that the egg production on hen-day per cent, differed significantly in different months of the year. Maximum production was recorded in March (59.13 per cent) when poultry shed temperature ranged from 10.0 to 32.2°C. There was a tendency towards drop in egg production during December-January, when temperature ranged from 3.3° to 23.3°C. They also reported that the feed consumption was low during the months when environmental temperature was high.

North (1984) stated that as the ambient temperature increased, economic parameters like feed intake, bird weight, egg production, egg weight, egg shell thickness, and interior egg quality decreased.

2.0. Effect of floor density on production parameters

2.1. Body weight

Mathew *et al*. (1979) reported that in deep litter system, body weight (1.47 kg) was better at high density (1575 sq.cm. per bird) than in 1800 (1.43 kg) or 2100 sq.cm. (1.44 kg) per bird ($P < 0.01$).

Reddy *et al*. (1981) observed that, there was no significant difference in 40 week body weight due to difference in floor densities in deep litter. They provided a floor space of 2.00 and 2.66 sq. ft. per bird. The mean 40 week body weight obtained were 1478 and 1465 g respectively.

Ali and Cheng (1984) after comparing the performance of birds in two flock sizes (5 and 20 birds) and two densities (1000 and 2000 sq. cm. per bird) under deep litter system of rearing reported that the low density group had a slightly higher body weight gain (267.10 g Vs 263.40 g) than the high density group. But, this was not statistically significant. They observed a significant density x flock size interaction and opined that the small flock - low density combination had highest gain in weight.

Koelkebeck and Cain (1984) reported that in deep litter system, there was no significant increase in body weight as the floor space allowance decreased from 0.373 to 0.187 sq. m. per bird. But, birds with 0.094 sq. m. floor space had a significantly heavier ($P<0.05$) body weight than the above two groups. The body weight obtained were 1.46, 1.47 and 1.52 kg respectively for the above mentioned floor spaces.

After comparing the performance in two floor densities in deep litter (2.00 and 1.60 sq.ft. per bird) Prasad <u>et al</u>. (1984) concluded that there was no significant difference in bodyweight gains due to stocking densities.

Koelkebeck <u>et al</u>. (1987) reported that in deep litter system, a reduction in floor space from 0.373 to 0.094 sq. m. per bird did not significantly influence body weight gain. They observed a body weight gain of 0.05 and 0.02 kg for the two treatment groups respectively.

Lee (1989) reported that body weight at 52 weeks of age was not significantly influenced by a decrease in floor space allowance from 0.40 to 0.29 or from 0.26 to 0.19 sq. m. per bird in litter floor. The mean body weight obtained were 1641, 1645; 1651 and 1613 g respectively for the different floor spaces given above.

2.2. Age at 50 per cent production

Strain *et al.* (1959) reported that reduction in floor space from 3.00 to 1.70 sq.ft. per bird in litter floor, did not have any significant effect on age at 50 per cent production.

Reddy *et al.* (1981) reported that the age at 50 per cent production of birds in pens with floor space allowance of 2.00 and 2.66 sq. ft. per bird were 151.5 and 152.5 days respectively. But, this difference was not statistically significant.

2.3 Egg production

In an experiment carried out to study the stocking rates in hen houses, Pokrovskii (1957) housed hens at the rate of 2, 3, 4 and 5.4 per sq. m. floor space. He observed that the egg production decreased progressively from an average of 165.70 eggs when there were 2 hens per sq. m. to 88.20 eggs when there were 5.4 hens per sq. m.

Significant reduction in total egg production in White Leghorn pullets confined to 1.33 sq. ft. per bird for 196 days, than in those confined at 4.00 sq. ft. per bird for the same period, was reported by Siegel (1959). He also noted that eggs per bird laying and mean cycle (clutch) length were significantly reduced in more densely populated groups, but, the number of birds laying per group was not. There was significant interaction of floor space x period which indicated that area per bird influenced egg production during different periods. In addition to this, they observed that environmental condition during winter season also influenced higher density groups. Pituitary and thyroid weights were not affected by the increase in population density, but adrenals were significantly heavier than those of less densely populated groups. Adrenal hypertrophy, an indicator of mild physiological stress was observed in 1.33 sq.ft. group, but could not be correlated with egg production factors.

Strain et al. (1959) reported a decrease in egg production by two eggs per bird when the floor space was reduced from 3.00 to 1.70 sq.ft. per bird.

Kinder (1960) conducted a floor space study using laying hens after 10 months of production, in three different floor densities of 3.00, 2.25 and 1.50 sq.ft. per bird and the production obtained were 58.70, 59.90 and 56.90 per cent.

Kinder and Stephenson (1962) reported that when yearling hens were housed with 1.50, 2.25 and 3.00 sq. ft. floor space per bird in deep litter system, there were no significant differences in egg production among the groups due to different floor spaces.

Noles _et al_. (1962) conducted a study to determine the floor space requirements of light breed hens kept under management conditions similar to those used commercially in the South eastern portion of the United States, by providing 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00 sq.ft. per bird. They found no significant difference in egg production due to difference in floor space. They opined that a decrease upto 1.50 sq. ft. is harmless.

In an experiment using Rhode Island Red pullets provided with 4.00, 3.00 and 2.00 sq.ft floor space per bird, Panda and Mohapatra (1964) observed that the percentage egg production obtained were 54.60, 48.40 and 43.60 respectively for the different floor density groups.

Quisenberry and Bradley (1964) studied the effects of different floor densities on performance of birds in floor pens. The densities used were 1.00 and 2.00 sq.ft. per bird and found that the higher bird density depressed egg production by 5.70 per cent.

Logan (1965) evaluated the performance of birds in floor pen with an area of 58" x 35" at two densities - 6 birds and 12 birds per pen and found that the hen-day production was significantly higher ($P < 0.01$) for low density group (254) than high density group (209).

Bressler and Maw (1967) reported that they obtained 242 eggs per bird per year when Leghorn pullets were housed at 1.00 sq.ft. per bird in deep litter system.

Hyre et al.(1968) evaluated White Leghorn strain crosses providing a floor space of 1.50, 2.00 and 2.50 sq. ft. per bird in deep litter system and found that it would be more profitable to house layers at high density.

Chand and Razdan (1976) in an experiment to compare the performance of White Leghorn pullets under floor pen housing at different floor densities (0.28 and 0.14 sq. m. per bird) found that the hen-day egg production was not influenced by the difference in floor densities.

When the performance of laying hens kept on floor, provided with 3.00 and 1.50 sq.ft.per bird were compared, Samalo and Sathe (1976) found that, although the birds housed at a high density tended to have lower egg production, the difference was not statistically significant.

In an experiment using 88 five months old White Leghorn pullets, Chand et al. (1977) found no significant difference in hen-day egg production of birds reared in deep litter system with a floor space of 0.28 and 0.14 sq. m. per bird.

By evaluating the nine experiments carried out in 1967-'75 with White Leghorn hens kept on floor with 6, 8 or 12 birds per sq. m. Eskeland et al. (1977) concluded that increasing the population density upto 12 birds per sq.m. on floor will not affect laying performance, but, it was adversely affected with 16 hens per sq. m.

Petersen (1978) found that for hens in deep litter, an increase in housing density significantly decreased the egg production.

Mathew et al. (1979) evaluated the performance of birds in different floor densities in two rearing systems viz. deep litter and cages. In deep litter system, the size of the pens was 210 x 180 cm and the number of birds housed were 18, 21 and 24 per pen for treatment 1, 2 and 3 respectively. The corresponding floor area provided were 2100, 1800 and 1575 sq. cm. per bird for the different treatment groups. The mean hen-day egg production were 66.09, 61.58 and 60.05 per cent respectively for treatment 1, 2 and 3. The analysis of variance of the data for egg production revealed apparently better production with 2100 sq. cm. but was not significantly superior to that of the lowest area (1575 sq. cm. per bird).

Reddy et al. (1981) studied the effect of different floor densities and different housing systems on production performance of 476 commercial layers and found that in litter floor, the hen-day production was better in groups provided with 2.00 sq. ft. per bird (76.53 per cent) than those with 2.66 sq.ft. per bird (76.01 per cent), but this difference was not statistically significant.

Rao et al. (1983) evaluated the influence of housing system and stocking density on production performance of commercial egg type chicken and found that in litter floor system, the birds with 1.60 sq. ft. per bird performed significantly better (P < 0.05) than the birds with 2.00 sq.ft. per bird. Hen-day egg production reported were 80.71 and 78.15 per cent for the two floor spaces respectively.

Ali and Cheng (1984) investigated the effect of flock size and bird density on the performance of 22 week old Minnesota Marker line birds for a period of eight weeks in deep litter system using two flock sizes of 5 and 20 birds at two densities of 1000 and 2000 sq. cm.per bird. They reported a higher hen-day egg production (49.80 per cent) for the low density group than for the high density group (42.20 per cent) but, statistical analysis showed that this difference was not significant.

Koelkebeck and Cain (1984) studied the performance and economic returns of laying White Leghorn hens in deep litter, cage and range system of rearing provided with 15 L : 9 D photoperiod and claimed that in deep litter system there were virtually no effect on hen-day egg production when the floor space per hen increased from 0.094 to 0.373 sq.m. per bird. The floor space provided were 0.094, 0.187 and 0.373 sq. m. per bird and per cent hen-day egg production were 51.40, 50.20 and 50.20 respectively for the above floor spaces.

Prasad et al. (1984) evaluated the performance of White Leghorn layers under deep litter, cage and slat system of rearing with varying levels of floor space, fed with two levels (18 and 15 per cent) of dietary protein for eight 28 day periods. They found that in each of the housing system, a lower floor space allowance gave better performance than the higher allowance. In litter floor, the floor spaces tried were 2.00 and 1.60 sq.ft. per bird and found that the per cent hen day production was higher in the high density group with 1.60 sq.ft. per bird (68.58 per cent) than in the low density group with 2.00 sq. ft. per bird (62.72 per cent).

In an attempt to evaluate the effect of feeding bacitracin on floor space requirement of White Leghorn laying hens, Sharma et al. (1985) provided birds with 2.50, 2.00 and 1.50 sq.ft. floor space per bird. The results indicated that egg production declined significantly ($P < 0.01$) with less floor space of 2.00 and 1.50 sq.ft. compared to 2.50 sq.ft. per bird in the control group. The per cent egg production were 80.51, 80.25 and 89.78 for the above floor spaces respectively.

Mench et al. (1986) while evaluating the production performance and behaviour of floor and cage reared hens observed that on litter floor, birds provided with 1394 sq. cm. each had a premoult egg production of 47.10 per cent for 48 weeks of production.

Koelkebeck et al. (1987) evaluated the performance of commercial laying hens in deep litter system of housing at floor densities of 0.094 and 0.037 sq.m. per bird and observed that hen-day egg production were 73.40 per cent and 74.40 per cent for the above given floor spaces respectively. Statistical analysis showed that this difference between different floor densities were not significant.

Lee (1989) after carrying out three experiments with White Leghorn pullets reared on litter floor reported that decreasing floor space allowance per bird and thereby increasing group size or a combination of the two had no significant effect on hen-day egg production. In the first experiment, the floor spaces given were 0.40 and 0.29 sq.m. per bird, in the second experiment 0.31 sq. m. per bird with two flock sizes and in the third experiment the spaces given were 0.19 and 0.26 sq. m. per bird.

In a survey conducted in and around Namakkal, the production performance of laying birds in three different floor space allowances viz. 1.50 to 1.75, 1.75 to 2.00 and 2.00 to 2.50 sq. ft. per bird were compared by Mohan et al. (1991) and they observed that birds given the highest floor space had significantly higher ($P < 0.01$) egg production. The corresponding per cent egg production were 77.39, 78.68 and 82.34 respectively for the different floor space groups.

2.4. Feed consumption

Chand and Razdan (1976) reported that when White Leghorn pullets kept under floor pen housing at different floor densities (0.28 and 0.14 sq.m./bird) and 3-tier individual laying cages, the feed consumption was found to be highly influenced ($P < 0.01$) by differences in housing conditions. The average daily feed consumption per bird were found to be 110.69, 113.17 and 97.58 g respectively for the different housing conditions.

Reddy et al. (1981) tested layers in litter floor provided with 2.66 and 2.00 sq.ft. per bird and found that the difference in floor space allowances did not influence the feed consumption.

Rao et al. (1983) evaluated the influence of housing systems and floor densities on the performance of layers by providing 0.50 and 0.40 sq. ft. per bird in cages, 1.00 and 0.80 sq. ft. per bird in slat and 2.00 and 1.60 sq. ft. per bird in litter floor and claimed that the system of housing and floor space allowance had no significant effect on feed consumption.

Ali and Cheng (1984) reported that in deep litter system, the feed requirement increased from 154.40 to 160.40 g per bird per day, as the floor space allowance increased from 1000 to 2000 sq. cm. per bird, but, this difference was not statistically significant. They observed a significant density x flock size interaction for feed consumption and reported that small flock-low density combination had the highest feed requirement.

Koelkebeck and Cain (1984) after evaluating the performance of commercial hens in different floor densities claimed that there were no significant differences in feed consumption in hens reared on litter floor even after increasing floor space from 0.094 to 0.373 sq. m. per bird.

Prasad *et al*. (1984) evaluated the effect of different floor densities in different housing systems such as litter floor, cage and slat floor and different protein levels (18 and 15 per cent) and found that stocking density within a housing system and protein level had no significant effect on feed consumption. The feed consumption per bird per day for litter floor reared birds were 97 and 98 g respectively.

Lee (1989) evaluated the effects of floor space and group size using White Leghorn pullets reared on litter floor pens and observed that feed consumption of birds given less floor space (0.29 sq. m. per bird) was significantly higher ($P < 0.05$) than birds given more floor space (0.40 sq.m. per bird). The feed consumption were 117.90 and 111.50 g respectively for the above floor spaces given. But, in another experiment, provided with 0.19 and 0.26 sq.m. per bird, there were no significant differences in feed consumption.

2.5. Feed efficiency

From the results of different trials on production using yearling hens housed on litter floor with 1.50, 2.25 and 3.00 sq.ft. floor space per bird, Kinder and Stephenson (1962) stated that floor density did not influence feed efficiency significantly.

Noles *et al.* (1962) found a significant relation for floor space with feed conversion. They provided 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00 sq.ft. per bird and reported that as more birds were kept per unit floor space, more feed is required to produce a dozen eggs.

Panda and Mohapatra (1964) reported that when Rhode Island Red birds were provided with 4.00, 3.00 and 2.00 sq. ft. floor space per bird, the feed consumption in kg/10 eggs laid were found to be 2.20, 2.60 and 2.70 respectively and were directly correlated with floor spaces.

Bressler and Maw (1966) reported that when White Leghorn pullets were reared at 1.00 sq.ft. per bird under deep litter system, they consumed 4.32 lb of feed to produce one dozen of eggs.

Eskeland et al. (1977) evaluated the performance of White Leghorn hens, in nine experiments, kept on floor with 6, 8 or 12 birds per sq. m., and reported that the feed conversion efficiency tended to decrease with an increasing number of birds per sq. m.

Mathew et al. (1979) tried to evaluate the effect of floor and cage housing in relation to stocking densities on the performance of the layers and claimed that the feed efficiency was better ($P < 0.05$) at low density (2100 sq. cm.

per bird) in deep litter system. The corresponding values for feed efficiency were 2.15, 2.31 and 2.28 for 2100, 1800 and 1575 sq. cm. per bird.

Reddy et al. (1981) found that in litter floor, feed efficiency was better in birds provided with 2.00 sq.ft. per bird than with 2.66 sq.ft. per bird (1.54 Vs 1.61) but these were statistically comparable among each other.

Rao et al. (1983) reported that in litter floor rearing system, birds with 1.60 sq. ft. floor space gave significantly better ($P < 0.05$) feed efficiency (1.41) than those with 2.00 sq.ft. per bird (1.48).

Koelkebeck and Cain (1984) found that there was no significant difference in feed efficiency in birds reared in floor pens when floor space per hen was increased from 0.094 to 0.373 sq.m.

Prasad et al. (1984) claimed that in litter floor housing, the birds with less floor space allowance utilized feed more efficiently than the birds provided with higher floor space allowanace. The feed efficiency (kg feed/dozen eggs) for birds with 1.60 and 2.00 sq.ft. per bird were 1.75 and 1.91 respectively.

Sharma et al. (1985) provided birds with 2.50, 2.00 and 1.50 sq.ft. per bird in deep litter system of rearing and the feed efficiency obtained were 2.02, 2.00 and 2.02 respectively for the different floor spaces given. The results indicated that the floor space allowance did not influence feed efficiency significantly.

Koelkebeck et al. (1987) reported that feed efficiency was not significantly influenced when floor space was increased from 0.094 to 0.373 sq.m. per hen in deep litter system of rearing. The feed efficiency obtained were 2.07 and 1.99 respectively for the two floor spaces.

Lee (1989) found that a reduction in floor space from 0.40 to 0.29 sq. m. per bird or from 0.26 to 0.19 sq. m. per bird or an increase in group size from 26 to 36 birds or a combination of the two had no significant effect on feed efficiency. The feed efficiency values were 2.118 and 2.109; 2.065 and 2.125 for the different floor spaces respectively.

2.6. Egg weight

Fox and Clayton (1960) reported that floor densities (1.00, 2.00 and 3.00 sq.ft. per bird) or flock size in slat floor system had no significant effect on egg size.

Noles *et al.* (1962) reported that there was no significant difference in egg size which could be attributed to difference in floor densities. The different floor spaces given were 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00 sq. ft. per bird.

Panda and Mohapatra (1964) could not find any significant influence of floor density on egg size, when pullets were provided with 4.00, 3.00 and 2.00 sq. ft. per bird.

Quisenberry and Bradley (1964) observed no significant difference in egg size when birds were reared in floor pens with 1.00 and 2.00 sq. ft. per bird.

In an experiment using 88, five months old White Leghorn pullets, Chand *et al.* (1977) observed that as the floor space allowance was reduced from 0.28 sq. m. to 0.14 sq. m. per bird in deep litter system, the egg weight increased from 52.08 to 53.69 g and this increase was significant statistically ($P < 0.01$). They also observed a consistant increase in egg weight with advancing age upto 13 months of age, after this the egg weights reduced consistently.

Mathew *et al*. (1979) reported that egg size was found to be better for birds receiving least floor space (1575 sq.cm. per bird) than those with 1800 and 2100 sq. cm. per bird. The egg weight recorded were 55.70, 54.40 and 54.90 g respectively.

Ali and Cheng (1984) in an experiment under deep litter system, using two flock sizes (5 and 20 birds per flock) and two densities (1000 and 2000 sq. cm. floor space per bird) found that small flock - low density combination had the heaviest egg weight. Density as a main factor did not affect egg weight significantly.

Moran (1986) reported that egg weights of caged hens typically increased with hen age and were not significantly influenced by different floor density levels until after eight weeks of experimentation.

Koelkebeck *et al*. (1987) reported that egg weight was not significantly influenced by a reduction in floor space from 0.373 to 0.094 sq.m. per bird in deep litter system. The corresponding egg weights obtained were 55.30 and 56.00 g.

Lee (1989) reported that a decrease in floor space allowance from 0.40 to 0.29 or from 0.26 to 0.19 sq.m. per bird or change in group size from 26 to 16 or 36 to 26 did not significantly affect egg weight in White Leghorn birds. The egg weight obtained were 61.20 and 60.80 g; 61.80 and 60.60 g respectively for the different floor spaces given.

2.7 Other egg quality parameters

Romanoff and Romanoff (1949) reported an increase in Shape Index with advancement of age. They also reported that flocks of the same breed of chicken differ greatly in average Shape Index and within a single flock there may be enormous variation and also the individual hen lay eggs that are more or less uniform in contour and Shape Index. Wide variation in shell thickness due to individual variation had also been reported by them.

Fox and Clayton (1960) reported that flock density did not have perceptible effect on albumen height in eggs collected from slat reared birds.

Chand et al. (1977) while evaluating the effect of floor density on egg quality indices observed that in deep litter system, as the floor space allowance per bird decreased from 0.28 to 0.14 sq.m., Yolk Index increased significantly from 41.90 to 43.32 and Albumen Index increased significantly from 8.99 to 9.50. But, the increase in shell thickness from 0.315 to 0.323 mm was not statistically significant and the Shape Index also remained unaffected.

Eskeland et al. (1977) could not find any significant influence of population density on egg quality, when birds were evaluated on floor, on different densities of 6, 8 and 12 birds per sq.m..

Roland (1979) reported that the total amount of shell deposited on the egg at 3 months of lay did not decrease, but, remained fairly constant or increased slightly throughout the remainder of the laying period. However, the increase in egg weight, with no proportionate increase in shell deposition resulted in a decline in shell quality (shell thickness and specific gravity). Eggs which had the greater increase in size throughout lay had the greater decline in shell quality. Neither the number of eggs laid by the hen, nor absolute egg size had any influence on shell quality. However, the shell quality at the end of lay was directly related to that at the beginning of lay.

Reddy et al. (1981) reported no significant effect of stocking densities on egg weight, Haugh Unit, and shell thickness. The experiment was conducted with White Leghorn 'M' strain layers provided with 450, 600, 900 and 1800 sq. cm. floor space per bird in cage system of rearing.

Pandey et al. (1988) evaluated the egg quality traits for 15 different strain and breed crosses of chicken at 168, 224 and 280 days of age and found that, in general, shell thickness increased between 168 and 224 days and then decreased slightly at 280 days of age. Albumen Index and Haugh Unit score declined continuously with increasing age of hens. Initial Yolk Index improved slightly in some crosses or was maintained in others upto 224 days but declined thereafter with increasing age of hens. Though overall decrease in Haugh Unit score was recorded in all crosses, except one, no consistent trend was observed among periods. The rate of decline was more in Albumen Index than in Haugh Unit. However, ability to maintain albumen quality differed among birds and with age.

Lee (1989) reported that a reduction in floor space from 0.40 to 0.29 or from 0.26 to 0.19 sq.m. per bird or a change in group size from 22 to 16 or from 26 to 36 was not found to affect albumen height significantly. The albumen height obtained for the different floor space allowances were 5.98 and 6.40; 6.26 and 6.26 mm respectively. But he found that a reduction in floor space from 0.40 to 0.29 sq.m. significantly reduce shell thickness from 0.327 to 0.304 mm. However, no such difference could be observed when floor space was reduced from 0.26 to 0.19 sq.m. per bird (0.34 mm).

Anitha (1991) reported that the Albumen Index, Yolk Index, Haugh Unit and shell thickness were 0.09, 0.44, 81.54 and 0.34 respectively for White Leghorn strain cross birds reared on deep litter system provided with a floor space of 2700 sq. cm. per bird.

Bhat and Aggarwal (1991) reported no significant effect of stocking density on Haugh Unit and Yolk Index of eggs from caged layers provided with 450 or 900 sq. cm. per bird.

2.8 Mortality

Strain *et al.* (1959) reported that a reduction in floor space from 3.00 to 1.70 sq.ft. per bird had no significant influence on mortality.

From the data of four trials on production using yearling hens in deep litter floor with 1.50, 2.25 and 3.00 sq.ft. floor space per bird, Kinder and Stephenson (1962) concluded that the difference in floor density did not have influence on mortality.

Noles _et al_. (1962) observed no significant difference in livability among birds provided with floor space of 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00 sq.ft. per bird.

Panda and Mohapatra (1964) reported that when Rhode Island Red pullets were housed with 4.00, 3.00 and 2.00 sq.ft. per bird, the mortality per cent obtained were 10.00, 3.80 and 6.70 respectively. Mortality rates did not seem to be affected by the degree of crowding within the range studied.

Bressler and Maw (1966) found that the mortality averaged 10 per cent when Leghorn pullets were housed with 1.00 sq.ft. floor space per bird under deep litter system.

Eskeland _et al_. (1977) reported that mortality was not found to be affected by population density, when White Leghorn birds were kept on floor with 6, 8 or 12 birds per sq.m.

Mathew _et_ _al_. (1979) observed an increase in mortality per cent as the floor space increased in deep litter system of rearing. They provided 1575, 1800 and 2100 sq. cm. per bird and the mortality per cent recorded were 10.40, 11.90 and 16.60 respectively.

Reddy _et_ _al_. (1981) reported that an increase in floor space from 2.00 to 2.66 sq. ft. per bird in deep litter system of rearing did not have any significant effect on livability.

Koelkebeck and Cain (1984) reported that in deep litter system a reduction in floor space from 0.373 to 0.094 sq. m per bird did not affect viability significantly.

Prasad _et_ _al_. (1984) evaluated the effect of different housing systems - deep litter, cage and slat; at different floor densities - deep litter (2.00 and 1.60 sq. ft. per bird); cage (0.50 and 0.40 sq. ft. per bird) and slat (1.00 and 0.80 sq. ft. per bird) and two levels of protein, 18 and 15 per cent and reported that there were no significant differences in per cent livability due to housing systems, stocking densities or protein levels.

Sharma *et al.* (1985) claimed that mortality significantly increased ($P<0.01$) from 1.66 to 6.00 per cent, as the floor space allowance per bird was reduced from 2.50 to 1.50 sq. ft. He found that the mortality per cent for 2.00 sq. ft. floor space group was 2.66 which significantly differed from that of 1.50 sq. ft. group but similar to that of 2.50 sq. ft. treatment.

Koelkebeck *et al.* (1987) reported that viability was not significantly affected by a reduction in floor space from 0.373 to 0.094 sq. m. per bird in deep litter system. The per cent viability observed were 99.30 and 98.50 for the two treatment groups respectively.

Lee (1989) reported that lower floor space allowances (0.29 when compared to 0.40 sq. m. per bird in one experiment and 0.19 when compared to 0.26 sq.m. per bird in another experiment) in deep litter with the number of birds per pen held constant (17 birds and 26 birds in experiments I and II respectively) produced significantly higher ($P < 0.05$) mortality per cent. The per cent mortality were 11.80 and 2.10 in the I experiment and 21.80 and 9.00 in the II experiment for the different floor spaces studied.

Materials and Methods

MATERIALS AND METHODS

An experiment was carried out at the Centre for Advanced Studies in Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the production performance of the commercial hybrid layer ILM-90, developed at the All India Co-ordinated Research Project on Poultry for Eggs, Mannuthy, in three different floor densities under deep litter system of rearing.

Three hundred and twelve (312) White Leghorn strain cross (ILM-90) pullets, at the age of 20 weeks were used for the study. All the pullets were vaccinated against Mareks disease, Ranikhet disease and Fowl pox and were debeaked before housing. The experiment was started during the month of April 1991.

Body weight was recorded individually at 20 weeks of age and the birds were distributed to three different floor density levels in deep litter pens as detailed below.

Treatment groups	Floor space per bird (sq. cm.)	Number of replicates
I	1350	6
II	1575	6
III	1800	6

Each treatment group was assigned to six replicates. The allotment of birds to each treatment group and replicate was made at random. The mean body weight of birds within each treatment and replicate was kept fairly uniform at the commencement of the experiment.

Feed and water were provided ad. lib. Commercial layer mash was fed throughout the experiment. The nutrient composition of the diet is presented in Table 1. The proximate composition of the ration was estimated according to the procedure described in A.O.A.C. (1970). The available carbohydrate content in the feed was estimated as per Clegg (1956). The metabolizable energy value of the ration was calculated using the prediction equation suggested by Carpenter and Clegg (1956). Standard managemental practices were followed throughout the experimental period.

The production performance of the birds were recorded for six, 28-day periods. Due to mild attack of Ranikhet disease, though, mortality was less, low production occurred during 21-24 weeks of age. So, the data pertaining to first period (21-24 weeks of age) and one replicate from each treatment were not included for statistical analysis.

Table 1. Per cent proximate composition of nutrients in layer mash on dry matter basis

Nutrient	Per cent
Dry matter	89.65
Crude protein	22.76
Ether extract	2.31
Nitrogen free extract	47.66
Crude fibre	3.72
Total ash	13.2
Acid insoluble ash	5.67
Calcium	2.98
Phosphorus	0.76
Metabolizable Energy (k cal/kg feed)	2705

The following observations were recorded during the experimental period

1. Meteorological parameters such as temperature and relative humidity inside the poultry house.

2. Body weight at 20 and 44 weeks of age.

3. Age at sexual maturity

4. Egg production - period-wise

5. Feed consumption - period-wise

6. Feed efficiency

7. Egg weight - last three days of each period throughout the experimental period.

8. Other egg quality parameters

   i. Shape Index

   ii. Shell thickness

   iii. Albumen Index

   iv. Haugh Unit

   v. Yolk Index

9. Mortality.

Age at first egg and average age at 50 per cent production for each treatment was noted. Egg production in each replicate was recorded daily and the mean hen-housed per cent for group was calculated. The feed issued to each pen was recorded and balance feed in hoppers on the last day of each period was recorded. From this data, the mean daily feed intake per bird in each period was calculated. Feed efficiency was calculated period-wise in each group as kilogramme feed consumed to produce dozen eggs. Mortality in each group was recorded replicate-wise. However, the dead birds were replaced with birds of the same hatch which were kept as reserve for this experiment to maintain constant floor density throughout the experimental period.

The eggs from each replicate during the last three consecutive days of each period were weighed and recorded individually and mean egg weight was calculated. Three eggs from each replicate were taken at random during last three days of each period. They were marked, weighed individually and stored in refrigerator overnight for internal quality studies on the next day. The breadth and length of eggs were recorded using Vernier calipers and Shape Index was calculated. Length and width of albumen and diameter of yolk were measured using Vernier calipers. The height of albumen and yolk were measured using Ame's tripod stand micrometer. From these data, Albumen Index and Yolk Index were calculated. Shell thickness was measured using Ame's micrometer for measuring shell thickness, after removing the shell membranes. Haugh Unit values were obtained directly from the Ame's tripod stand micrometer. Individual body weight of birds were recorded at the end of the experiment.

The data were analysed as per method of Snedecor and Cochran (1967).

Results

RESULTS

The data recorded in the study, to evaluate the effects of floor density on production traits in hybrid White Leghorn laying hens (ILM-90) is presented in this chapter.

Meteorological observations

The data pertaining to microclimate inside the experimental house in respect of ambient temperature (°C) and relative humidity (per cent) recorded during the experimental period are presented in Table 2. The highest mean maximum temperature recorded was during the first period of the study (33.96°C). Subsequently during second to fifth periods, the mean maximum temperature varied between 28.11 and 29.93°C. The mean minimum temperature ranged from 23.74 to 26.92°C during the experimental period. The per cent relative humidity ranged from 79.96 to 89.71 in the morning and 58.04 to 81.67 in the evening.

1.0. Effect of Floor Density on Production Parameters

1.1. Body weight

The mean body weights recorded at 20 and 44 weeks of age in groups I, II and III are presented in Table 3 and the statistical analysis in Appendix I and II. The weight of birds at 20 weeks of age, provided with a floor space of 1350, 1575 and 1800 sq.cm. per bird averaged 886.90, 882.94 and 886.27 g respectively. The mean body weight of birds in the corresponding groups at 44 weeks of age were 1411.80, 1426.12 and 1400.80 g respectively. Statistical analysis showed that the body weights at commencement of the experiment as well as at the termination were not significantly different among treatment groups.

1.2. Age at sexual maturity.

The average age at first egg and at 50 per cent production of the experimental birds for the different treatment groups are presented in Table 4 and the analysis of variance of age at first egg in Appendix III and age at 50 per cent production in Appendix IV. Though there were numerical differences in both the cases between treatment groups, the magnitude of variations among the mean values were not statistically significant. The average age at first egg were 153.2, 152.0 and 157.0 and age at 50 per cent production were 185.0, 187.4 and 183.4 days for groups I, II and III respectively.

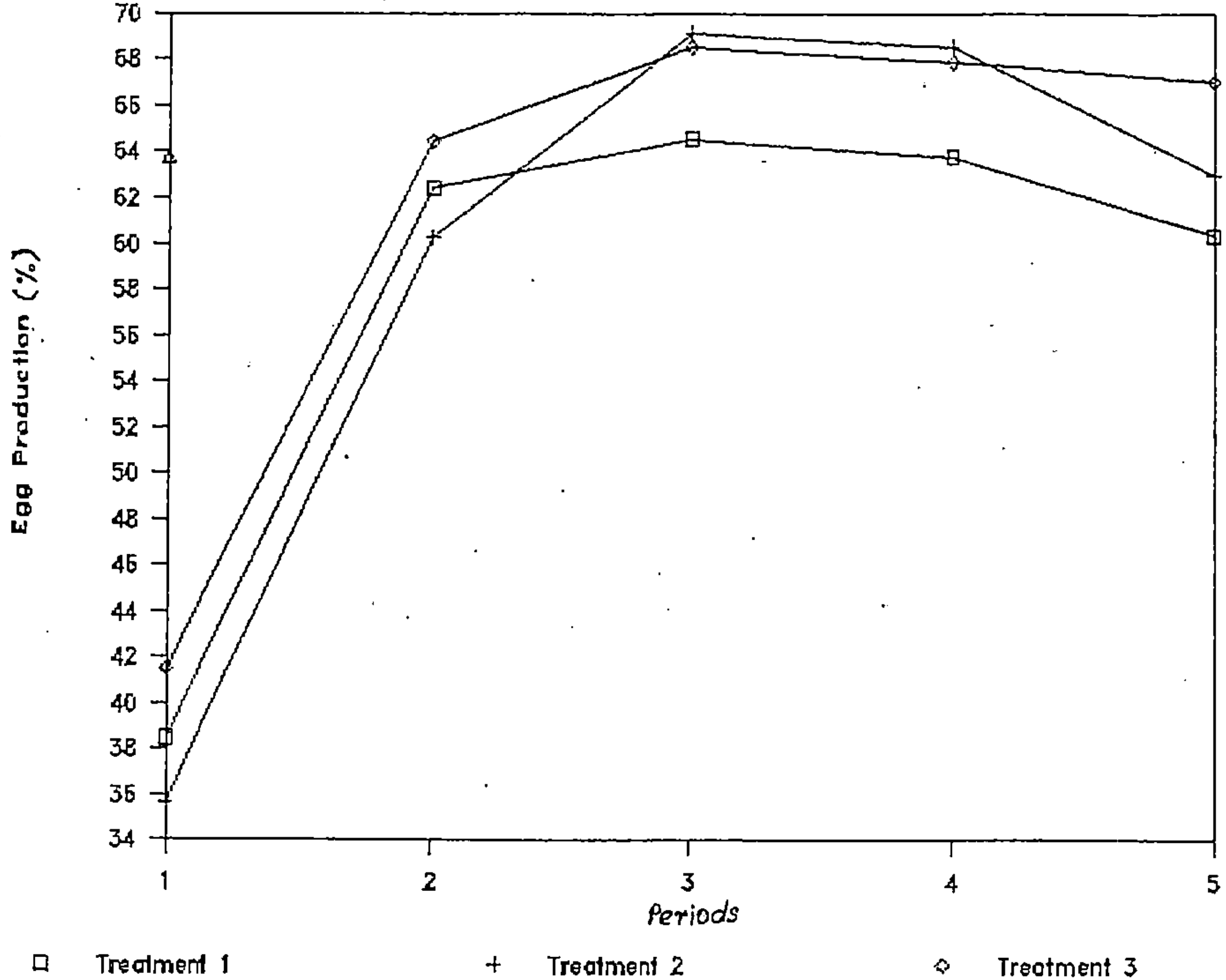
1.3. Egg production.

The mean hen-housed per cent egg production calculated period-wise for the different treatment groups are set out in Table 5 and represented graphically in Fig.1. Since the birds were replaced whenever there was mortality, hen-day and hen-housed production were same. The overall mean per cent hen-housed egg production were 57.94, 59.34 and 61.90 for the groups provided with 1350, 1575 and 1800 sq.cm. floor area per bird respectively. The egg production per cent (61.90) recorded in the group III provided with a floor space of 1800 sq.cm. per bird was significantly higher ($P < 0.05$) than that of group I provided with a floor space of 1350 sq.cm. However, the group II reared in a floor space of 1575 sq.cm. was intermediary with a production performance of 59.34 per cent and was comparable statistically with the other two groups.

The period-wise per cent hen-housed egg production showed that there was significant difference in egg production among periods. The hen-housed percentages during the first period (38.56) was significantly lower ($P < 0.01$) than those of other periods. The overall mean values for the periods, two to five were 62.41, 67.44, 66.77 and 63.46 per cent respectively. Egg production during the second

Fig 1. EGG PRODUCTION (HH%)

AS INFLUENCED BY DIFFERENT FLOOR DENSITIES



period was significantly lower (P <0.01) than those recorded during third and fourth periods, but was comparable with that of fifth period. Egg production for the periods three to five did not differ statistically. The statistical analysis of egg production data is given in Appendix V, and it revealed no interaction effect between treatments and periods on egg production.

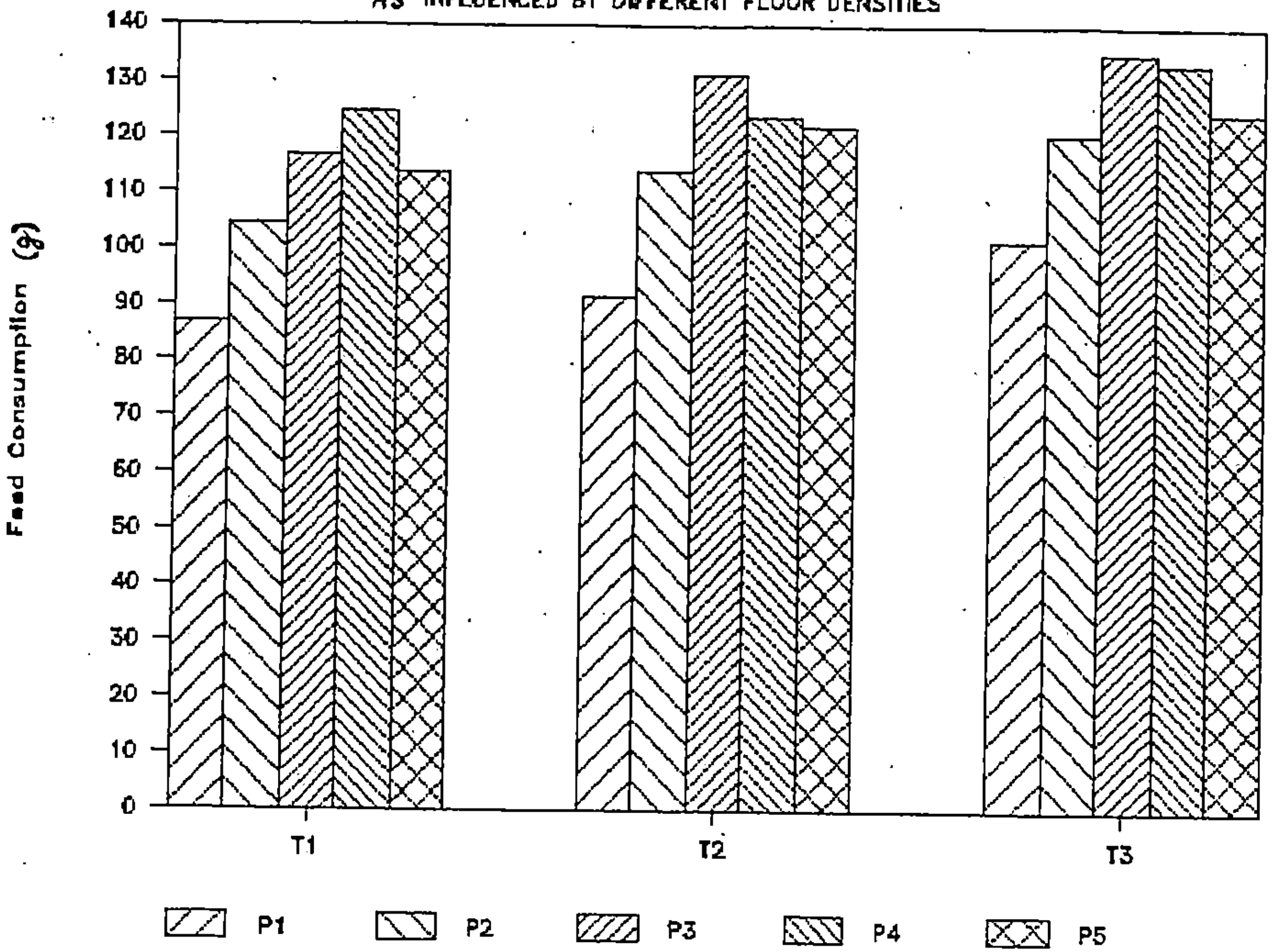
1.4. <u>Feed consumption</u>.

The period-wise mean daily feed intake of birds reared on different floor densities are presented in Table 6, its statistical analysis in Appendix VI, and graphical representation in Fig. 2. The results indicated that the overall mean daily feed consumption of birds provided with a floor space of 1350, 1575 and 1800 sq.cm. were 109.32, 116.51 and 123.08 g respectively and were significantly different (P <0.01) among each other. An increasing trend of feed intake with increasing levels of floor space was observed generally.

Statistical analysis of period-wise mean daily feed consumption revealed that the differences among periods were statistically (P <0.01) significant. During the initial

Fig 2. FEED CONSUMPTION (g /day/bird)

AS INFLUENCED BY DIFFERENT FLOOR DENSITIES



T - TREATMENT

P - PERIOD

three periods, the feed intake showed a progressive increase. But, during the fourth period the overall feed intake (127.27 g) was statistically similar to that of third period (127.71 g). In all the groups, the feed intake was lower during 41-44 weeks of age with an overall mean of 120.13 g and registered a significant reduction in overall feed intake at this stage.

1.5. Feed efficiency.

The period-wise feed efficiency calculated as kilogramme feed per dozen eggs in the three different groups is presented in Table 7 and the analysis of variance in Appendix VII. The overall mean feed efficiency in group I, II and III were 2.31, 2.44 and 2.45 respectively and the differences among groups were not statistically significant. The feed conversion efficiency was almost same in groups II (2.44) and III (2.45) but the numerical value was low (2.31) in the group I, reared with a floor space of 1350 sq.cm. per bird.

However, the mean period-wise feed consumption (kg) to produce one dozen of eggs was significantly high at first period (2.96) in comparison to those of other periods

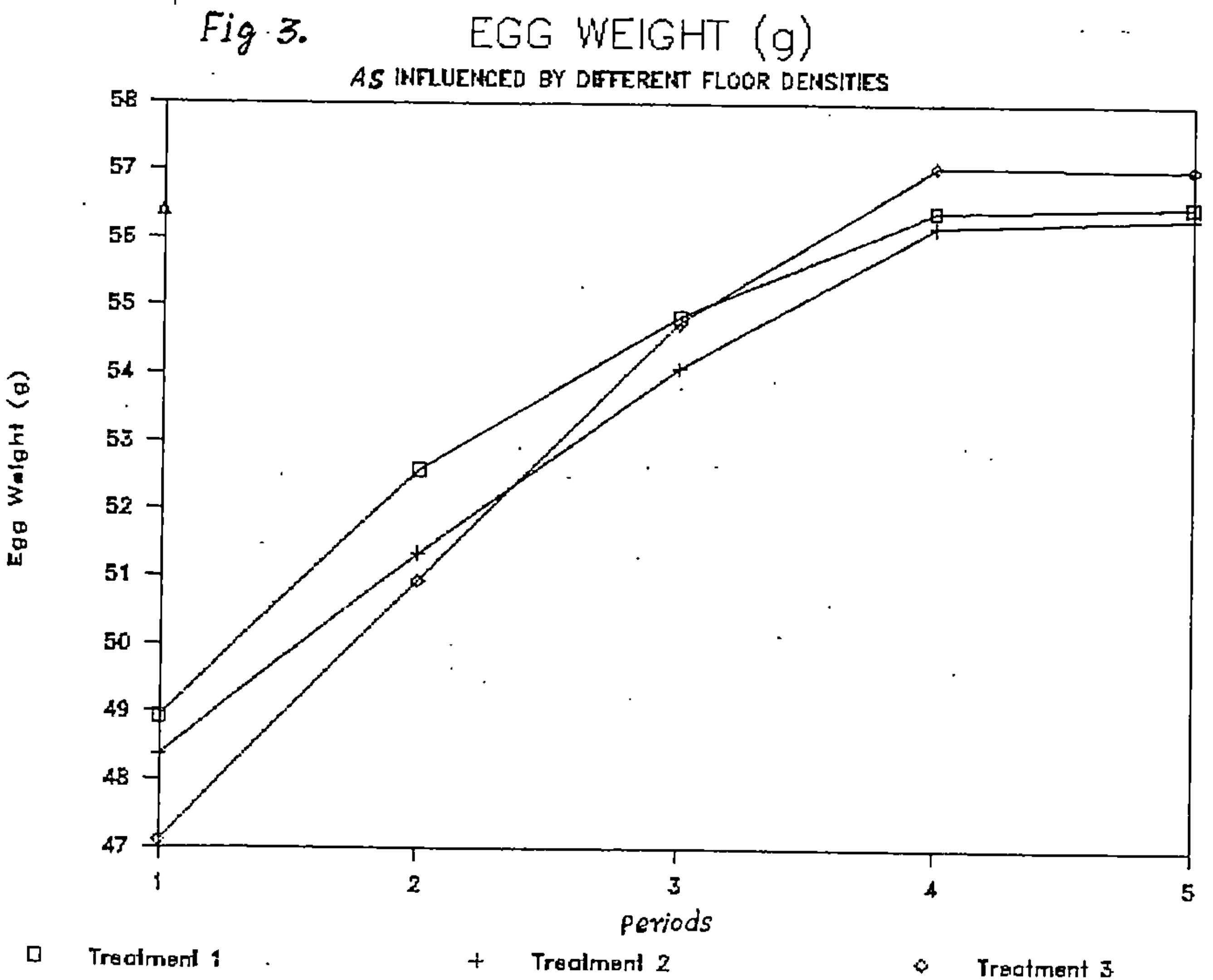
(P <0.01). During the second and subsequent periods the mean feed efficiency was statistically similar.

1.6. Egg weight.

The mean egg weight in each period for the birds reared in different floor densities are presented in Table 8 and depicted in Fig. 3. The average egg weight in groups I, II and III were 53.86, 53.27 and 53.31 g respectively. Statistical analysis revealed that the overall mean egg weight in all groups were homogenous. Analysis of variance is given in Appendix VIII.

The period-wise overall mean egg weight revealed that, it was significantly low at first period (48.14 g) and increased progressively until 40 weeks of age. The mean egg weights at second, third and fourth periods were 51.49, 54.57 and 56.56 g respectively and the differences between the means were significant. However, the overall mean egg weight registered during fifth period (56.63 g) was comparable to that of the fourth period. In all groups, the mean values registered during 37 to 44 weeks remained close to each other.

Fig. 3.


EGG WEIGHT (g)
AS INFLUENCED BY DIFFERENT FLOOR DENSITIES
58
57
56
55
54
53
52
51
50
49
48
47
Egg Weight (g)
1
2
3
4
5
periods
Treatment 1
Treatment 2
Treatment 3

1.7. Other Egg Quality Parameters.

1.7.1. Shape Index

The Shape Indices of eggs were computed and the data are presented in Table 9 and the analysis of variance in Appendix IX. The overall mean values obtained were 73.48, 73.88 and 73.64 for the groups I, II and III respectively. The analysis showed no significant differences in Shape Indices among treatment groups.

Analysis of the data period-wise showed that there was a progressive increase in Shape Index during the first three periods, and the differences were statistically significant ($P < 0.01$). The overall mean Index during the fourth and fifth periods were statistically similar and were comparable to that of the second period.

1.7.2. Shell thickness

The shell thickness of the eggs laid by the birds reared at different floor densities is presented in Table 10 and the analysis of variance in Appendix X. The mean shell thickness of eggs in all density levels was 0.38 mm. Statistical analysis revealed that the shell thickness observed during the first, second, third and fifth periods were similar, whereas during fourth period it was significantly higher (P <0.01) than those in other periods (0.39 mm).

1.7.3. Albumen Index

The data pertaining to Albumen Index of eggs from birds confined at different floor density levels are set out in Table 11 and the statistical analysis in Appendix XI. For all the three treatment groups the Albumen Index score was above 0.090 and was comparable to one another. But, there was statistical differences between period-wise overall mean Albumen Index. It was significantly low (P <0.01) at 37-40 weeks of age (0.077) and significantly higher (P < 0.01) during 29-32 weeks of age (0.106). During all other periods Albumen Index was comparable statistically.

1.7.4. Haugh Unit

The data obtained in respect of Haugh Unit score of eggs from layers reared at different floor densities are set out in Table 12 and the related statistical analysis in Appendix XII. The overall Haugh Unit scores in the study for 1350, 1575 and 1800 sq.cm. floor space allowances per bird were 83.24, 83.00 and 83.68 respectively and were comparable among themselves. Statistical analysis of the data revealed significant differences due to periods and the score was significantly low (78.80) during fourth period at 37-40 weeks of age. Haugh Unit score for first period was 85 and second period was 87.80 and were statistically similar. Haugh Unit score recorded during third period was 81.60 and fifth period was 83.33 and were statistically comparable.

1.7.5. Yolk Index

The Yolk Indices of eggs collected from layers kept in different floor density levels are presented in Table 13 and the statistical analysis in Appendix XIII. The overall mean Yolk Index for group I, II and III were 0.431, 0.432 and 0.432 respectively. The statistical analysis revealed that Yolk Indices were not significantly influenced by the different floor density levels.

However, statistical analysis of the first four periods did not reveal any significant difference. But, it was significantly lower at 41-44 weeks of age in comparison with those of 25-28 and 33-36 weeks of age.

1.8. Mortality.

The mortality rate of the experimental birds which occured during the entire period of experimentation is presented in Table 14. The layer house mortality recorded during 25 to 44 weeks of age in the groups reared with 1350, 1575 and 1800 sq.cm. floor space were 4, 3 and 3 respectively.

1.9. Economics.

The economics of production in the three floor densities were calculated in terms of return over feed cost and is presented in Table 15. The data revealed that the return over feed cost per bird for the period of experimentation was positive with a value of Rs 0.54 for the group provided with 1350 sq.cm. per bird. Whereas, the corresponding values were Rs -2.64 and Rs -3.82 respectively for the groups provided with 1575 and 1800 sq. cm. per bird. The return over feed cost per sq.m. floor area used also showed similar trend. The values were Rs +4.00, Rs -16.64 and Rs -21.26 for 1350, 1575 and 1800 sq.cm. per bird respectively.

Table 2. Mean values of meteorological parameters recorded in the experimental house

	Age of birds in weeks (period)				
	25-28 (6th May to 2nd June)	29-32 (3rd June to 30th June)	33-36 (1st July to 28th July)	37-40 (29th July to 25th August)	41-44 (26th August to 22nd September)
	Ambient temperature (°C)				
Maximum	33.96	28.35	28.70	28.11	29.93
Minimum	26.92	24.96	24.10	23.74	24.34
	Per cent Relative Humidity				
Morning	79.96	89.12	89.5	89.71	86.41
Evening	58.04	81.67	78.42	78.89	64.38

Table 3. Body weight (g) of experimental birds as influenced by different floor densities .

Treatment Groups	Floor Densities sq.cm./ bird	20th week	44th week
I	1350	886.90 ± 7.27	1411.80 ± 20.14
II	1575	882.94 ± 15.35	1426.12 ± 13.56
III	1800	886.27 ± 10.43	1400.80 ± 18.73

Table 4. Age at first egg and Age at 50 per cent production (days) of experimental birds as influenced by different floor densities

Treatment groups	Floor Densities Sq.cm./bird	Age at first egg mean ± SE	Age at 50 per cent production mean ± SE
I	1350	153.20±2.35	185.00 ± 2.61
II	1575	152.00±2.19	187.40 ± 3.12
III	1800	157.00±1.48	183.40 ± 2.29

Table 5. Mean per cent Hen-housed egg production as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./ bird)	Periods					
		I	II	III	IV	V	Overall mean±SE
I	1350	38.50	62.46	64.57	63.82	60.36	57.94[a]±2.28
II	1575	35.67	60.29	69.16	68.57	62.98	59.34[ab]±2.68
III	1800	41.52	64.47	68.57	67.91	67.05	61.90[b]±2.37
Overall mean		38.56[a]	62.41[b]	67.44[c]	66.77[c]	63.46[bc]	

Means bearing the same superscript within row (P<0.01) and within column (P < 0.05) do not differ significantly.

Table 6. Mean daily feed consumption (g/bird) as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./ bird)	Periods I	II	III	IV	V	Overall mean±SE
I	1350	86.89	104.61	116.68	124.75	113.68	109.32[a]±2.96
II	1575	91.60	113.86	131.18	123.78	122.14	116.51[b]±3.15
III	1800	101.62	120.62	135.29	133.28	124.57	123.08[c]±3.21
Overall mean		93.37[a]	113.03[b]	127.71[d]	127.27[d]	120.13[c]	

Means bearing the same superscript within row and within column do not differ significantly (P<0.01).

Table 7. Mean feed efficiancy (kg feed/dozen egg) as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./bird)	Periods I	II	III	IV	V	Overall mean±SE
I	1350	2.73	2.03	2.16	2.35	2.27	2.31±0.06
II	1575	3.15	2.28	2.28	2.17	2.33	2.44±0.09
III	1800	3.00	2.26	2.38	2.36	2.23	2.45±0.08
Overall mean		2.96^{b}	2.19^{a}	2.27^{a}	2.29^{a}	2.28^{a}	

Means bearing the same superscript within row do not differ significantly (P<0.01).

Table 8. Mean egg weight (g) as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./bird)	Periods I	II	III	IV	V	Overall mean±SE
I	1350	48.94	52.58	54.85	56.42	56.51	53.86±0.64
II	1575	48.38	51.35	54.09	56.19	56.33	53.27±0.68
III	1800	47.09	50.95	54.76	57.08	57.06	53.31±0.86
Overall mean		48.14[a]	51.49[b]	54.57[c]	56.56[d]	56.63[d]	

Means bearing the same superscript within row do not differ significantly ($P<0.01$).

Table 9. Mean Shape Index of eggs as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./bird)	Periods					
		I	II	III	IV	V	Overall mean±SE
I	1350	72	74	74	74	74	73.48±0.28
II	1575	72	74	75	74	74	73.88±0.31
III	1800	72	74	75	74	73	73.64±0.30
Overall mean		71.87^{a}	74.00^{b}	74.87^{c}	74.00^{b}	73.60^{b}	

Means bearing the same superscript within row do not differ significantly ($P<0.01$).

Table 10. Mean shell thickness (mm) of eggs as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./ bird)	Periods I	II	III	IV	V	Overall mean±SE
I	1350	0.38	0.37	0.37	0.39	0.38	0.38±0.002
II	1575	0.38	0.37	0.38	0.40	0.38	0.38±0.003
III	1800	0.38	0.37	0.38	0.39	0.38	0.38±0.003
Overall mean		0.38[a]	0.37[a]	0.38[a]	0.39[b]	0.38[a]	

Means bearing the same superscript within row do not differ significantly (P <0.01).

Table 11. Mean Albumen Index of eggs as influenced by different floor densities

Treat- ment groups	Floor densities (Sq. cm./ bird)	Periods					
		I	II	III	IV	V	Overall mean±SE
I	1350	0.092	0.109	0.083	0.079	0.094	0.091±0.003
II	1575	0.092	0.101	0.089	0.076	0.091	0.090±0.003
III	1800	0.090	0.108	0.085	0.077	0.093	0.091±0.003
Overall mean		0.091^{b}	0.106^{c}	0.085^{b}	0.077^{a}	0.093^{b}	

Means bearing same superscript within row do not differ significantly (P<0.01).

Table 12. Mean Haugh Unit value of eggs as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./ bird)	Periods I	II	III	IV	V	Overall mean$\pm$SE
I	1350	84	88	80	80	84	83.24$\pm$0.93
II	1575	85	86	83	79	82	83.00$\pm$0.95
III	1800	86	89	82	78	84	83.68$\pm$0.97
Overall mean		85.00^{cd}	87.80^{d}	81.60^{b}	78.80^{a}	83.33^{bc}	

Means bearing the same superscript within row do not differ significantly ($P < 0.01$).

Table 13. Mean Yolk Index of eggs as influenced by different floor densities

Treatment groups	Floor densities (Sq. cm./ bird)	Periods I	II	III	IV	V	Overall mean±SE
I	1350	0.430	0.436	0.436	0.429	0.424	0.431±0.002
II	1575	0.437	0.430	0.435	0.432	0.424	0.432±0.002
III	1800	0.439	0.427	0.440	0.427	0.428	0.432±0.002
Overall mean		0.435^{b}	0.431^{ab}	0.437^{b}	0.430^{ab}	0.425^{a}	

Means bearing the same superscript within row do not differ significantly ($P<0.05$)

Table 14. Mortality (number) as influenced by different floor densities

Treat- ment groups	Floor densities (Sq. cm./ bird)	Periods					
		I	II	III	IV	V	Total
I	1350	-	1	2	1	-	4
II	1575	-	-	-	2	1	3
III	1800	-	-	1	2	-	3

Table 15. Effect of floor density on economics of production in commercial hybrid layers (25-44 weeks of age)

	Groups		
	I	II	III
Floor space per bird (sq. cm.)	1350	1575	1800
Number of birds per treatment	100	85	75
Total number of eggs in 140 days	8112	7061	6500
Cost of eggs @ Rs 0.95/egg (Rs)	7706.40	6707.95	6175.00
Total feed consumed in 140 days (kg)	1530.48	1386.47	1292.34
Feed consumed/bird/day (g)	109.32	116.51	123.08
Return over feed cost per bird in 140 days (Rs)	+0.54	-2.64	-3.82
Return over feed cost per unit floor space (m^2) in 140 days (Rs)	+4.00	-16.64	-21.26

Discussion

DISCUSSION

In an effort to flock intensification, as a means of achieving greater labour efficiency and reducing housing cost, the present study was carried out to evaluate the production performance of hybrid White Leghorn layers (ILM-90) under different floor densities. The results obtained in this experiment are discussed in this chapter.

Meteorological observations

The meteorological data are presented in Table 2. Highest mean maximum temperature of 33.96°C was recorded during the first period and lowest mean minimum temperature of 23.74°C during the fourth period and a mean maximum relative humidity of 89.71 per cent and a mean minimum relative humidity of 58.04 per cent were recorded during the experimental period. The mean maximum and mean minimum temperature as well as the mean relative humidity - morning and evening, recorded during the course of the experiment is similar in trend to that reported by Somanathan (1980). The data obtained in this study therefore, indicated that the maximum temperature as well as the minimum temperature fell within the stress level as adjudged by Esmay (1969), McDowell (1972), H.M.S.O. (1976) and North (1984).

1.0. Effect of Floor Density on Production Parameters

1.1. Body weight.

The differences in mean body weight of experimental birds in different floor density groups at 20th week of age were not statistically significant, indicating homogenisity among the experimental subjects (Table 3). There was no significant difference in mean body weight of birds among different density levels at 44th week of age as well. The results indicated that the difference in floor density did not influence the adult body weight of birds. This finding is in agreement with those of Reddy et al. (1981), Ali and Cheng (1984), Prasad et al. (1984), Koelkebeck et al. (1987) and Lee (1989).

Koelkebeck and Cain (1984) reported that a decrease in floor space upto 0.187 sq.m.per bird did not influence body weight but, they observed an increase in body weight when floor space was reduced to 0.094 sq.m. per bird. Mathew et al. (1979) also reported better body weight in birds provided with less floor space (1575 sq.cm. per bird) than those with 1800 and 2100 sq.cm. per bird in deep litter system of rearing.

1.2. Age at Sexual maturity.

The data obtained on age at first egg and at 50 per cent production (Table 4) indicated that the variation in floor space allowance did not influence the Age at first egg and at 50 per cent production. These findings agree with those of Strain *et al*. (1959) and Reddy *et al*. (1981).

1.3. Egg production.

Overall mean per cent hen housed egg production summarised in Table 5 revealed that there were significant differences (P < P.05) among different floor space groups employed in this study. The birds housed with a floor density of 1800 sq.cm. per bird(Group III) had the highest egg production (61.90 per cent), eventhough the statistical analysis did not reveal any significant difference from group II, which had a floor area of 1575 sq.cm. per bird. Birds housed with a floor space allowance of 1350 sq.cm. per bird (Group I) recorded the lowest hen housed egg production (57.94 per cent) though, it was statistically comparable with group II. However, group I had significantly lower (P < 0.05) hen-housed egg production than group III. This indicated that area per bird influenced egg production. The results of this study corroborate with the findings of Siegel (1959), Strain *et al.* (1959), Quisenberry and Bradley (1964), Logan (1965), Ali and Cheng (1984), Sharma *et al.* (1985) and Mohan *et al.* (1991).

A reduction in social tension due to availability of increased dispersal facility and subsequent higher feed consumption might have contributed to the better performance of the low density group, especially in the hot humid climate.

But, Noles *et al.* (1962), Chand *et al.* (1977), Mathew *et al.* (1979), Koelkebeck and Cain (1984), Koelkebeck *et al.* (1987) and Lee (1989) could not find any significant difference in hen-housed egg production among different floor density groups.

Contrary to the present finding, Reddy *et al.* (1981), Rao *et al.* (1983) and Prasad *et al.* (1984) reported better production in high density group than in low density group.

Statistical analysis of period-wise egg production data revealed significant differences among periods. The results indicated that the egg production during the first period was statistically low and it improved during second period and peaked during the third period. Same trend was noticed in all the treatment groups. There was numerical drop in egg production during the fourth and fifth periods. However, the differences among the periods - third, fourth and fifth were not statistically significant and followed the natural egg production trend in pullet year production. This finding agrees with those reported by Romanoff and Romanoff (1949) and Mathew et al. (1979).

1.4. Feed consumption.

The data on mean daily feed consumption presented in Table 6 revealed significant difference among different groups. Group I with 1350 sq.cm. per bird had a feed consumption of 109.32 g and was significantly lower than that observed for group II (1575 sq.cm. per bird). Group provided with 1575 sq.cm. per bird had a significantly lower (116.51 g) feed consumption than those with 1800 sq.cm. per bird (123.08 g). These results indicated a marked increase in feed intake as the floor space was increased from 1350 to 1800 sq.cm. per bird. Similar trend of increased feed consumption with increasing floor space per bird was reported by Ali and Cheng (1984).

Increased energy expenditure consequent to increased dispersal facility as well as higher egg production lead to an increased nutrient requirement. This might have attributed to the increased feed consumption in the higher floor space groups.

But Reddy _et al_. (1981), Rao _et al_. (1983), Koelkebeck and Cain (1984), Prasad _et al_. (1984) and Lee (1989) reported no significant influence of floor space allowance on feed consumption.

On the other hand Lee (1989) in one experiment, reported significantly higher feed consumption in group provided with less floor space (0.29 sq.m. per bird) than in group provided with 0.40 sq.m. per bird.

The differences in feed consumption due to periods observed in this study were highly significant ($P < 0.01$). During the first period the feed consumption was 93.37 g and was significantly lower than that of the second period (113.03 g). The feed.consumption during the third and fourth periods was almost uniform and was slightly more than 127 g per bird per day. Significantly low feed consumption (120.13 g) was observed during the fifth period in comparison with third and fourth periods. The mean maximum temperature recorded during this period was 29.93°C, which was higher than that recorded during earlier periods (Table 2). The lower feed intake during this period, therefore, might be due to an increase in the environmental temperature. This finding agrees with the report of North (1984). The reduced feed consumption during the first period can be attributed to several factors viz. younger age of the birds, low body weight, low egg production and high environmental temperature which prevailed at this period. Similar results have been reported by Esmay (1969), H.M.S.O. (1976) and Chand and Razdan (1976).

The gradual increase in feed consumption from first period through subsequent periods is a natural phenomenon which occur due to increase in body weight as well as egg production as age advances.

1.5. Feed efficiency.

Data on feed efficiencies (Table 7) revealed numerical differences among groups provided with different floor densities. Group with 1350 sq.cm. per bird showed high efficiency (2.31) followed by group II with 1575 sq.cm. per bird (2.44) and group III with 1800 sq.cm. per bird (2.45). However, the magnitude of variation among the groups did not show any statistically significant difference indicating that birds on different floor density levels were equally efficient in utilizing the feed. Kinder and Stephenson (1962), Koelkebeck and Cain (1984), Sharma et al. (1985), Koelkebeck et al. (1987) and Lee (1989) also reported similar results.

But Noles et al. (1962) and Eskeland et al. (1977) reported a decrease in feed efficiency with increase in bird density. An increase in feed efficiency with increase in floor space was also reported by Mathew et al. (1979).

Contrary to this, Reddy et al. (1981), Rao et al. (1983) and Prasad et al. (1984) reported better feed efficiency in high density group than in low density group.

Statistical analysis of the period-wise data revealed significant difference in feed efficiency between first and second periods. The lower feed efficiency (2.96) during the first period could be attributed to the lower egg production since the birds were only at the start of the productive cycle. The higher atmospheric temperature that prevailed during that period (Table 2) would also have contributed for this finding as reported by North (1984). Feed efficiencies during the second, third, fourth and fifth periods were statistically comparable and were significantly better than the first period.

1.6. Egg weight.

The mean egg weights (g) as influenced by different floor densities presented in Table 8, on statistical analysis, revealed no significant difference among themselves. The overall mean egg weight (g) for the three groups fell in the normal range. This indicated that the floor densities studied had no significant influence on egg weight. Similar results had been reported by Fox and Clayton (1960), Noles *et al*. (1962), Panda and Mohapatra (1964), Quisenberry and Bradley (1964), Ali and Cheng (1984), Koelkebeck *et al*. (1987) and Lee (1989).

But Chand *et al*. (1977) and Mathew *et al*. (1979) reported an increase in egg weight with decrease in floor space allowance.

Statistical analysis of the data revealed significant difference in mean egg weight from period to period and followed the normal pattern of increase in egg weight during the first year of production. This is in agreement with the reports of Romanoff and Romanoff (1949) and Moran (1986).

Egg weight which was lowest during the first period progressively improved and reached high value of 56.56 and 56.63 g during the fourth and fifth period respectively and is comparable to those reported for this strain cross (Anon., 1992).

1.7. Other Egg Quality Parameters.

1.7.1. Shape Index

The data on mean Shape Index for the different floor density groups during different periods are presented in Table 9. The Shape Indices for the different floor density groups were above 73 and fell in the normal range. The differences among the groups were statistically non-significant, indicating little influence by floor density on Shape Index. This finding is in agreement with the report of Chand et al. (1977).

The period-wise data indicated that the Shape Index in the first period was significantly lower ($P < 0.01$). Shape Indices during second, fourth and fifth periods were comparable and higher than that of the first period. Romanoff and Romanoff (1949) reported an increase in Shape Index with advancement of age. The significantly higher

Shape Index (74.87) recorded during third period is a deviation from normal which could be due to a chance factor. Romanoff and Romanoff (1949) reported that flocks of the same breed of chicken differ greatly in average Shape Index and even within a flock there may be enormous variation.

1.7.2. Shell thickness

The data on mean shell thickness of eggs from birds reared on different floor densities did not reflect any appreciable difference. This suggested that floor space allowance per bird studied did not influence shell thickness. Chand et al. (1977) and Reddy et al. (1981) also reported lack of density effect on shell thickness.

Analysis of period-wise data revealed that the shell thickness during all the periods except fourth period was comparable among each other. The reason for a higher shell thickness obtained during the fourth period could be due to the individual variation of birds from which eggs are selected. Wide variation in shell thickness due to individual difference had been reported by Romanoff and Romanoff (1949).

Pandey et al. (1988) reported an increase in shell thickness between 168 and 224 days and a slight decrease at 280 days of age as observed in this study.

1.7.3. Albumen Index

Overall mean Albumen Indices for the different treatment groups fell in the normal range (Table 11). Analysis of the data obtained on the mean Albumen Index revealed no statistical difference among treatment groups. This finding agrees with those of Fox and Clayton (1980) and Lee (1989).

Contrary to the present finding, Chand et al. (1977) reported an increase in Albumen Index corresponding to a decrease in floor space allowance.

The Albumen Indices during the periods from 25 to 44 weeks of age (I to V period) did not show a definite trend. It tended to increase during the second period and then, showed a declining trend during the third and fourth periods and again increased during the fifth period. These changes were statistically significant ($P < 0.01$). A similar trend of variation in Albumen Index in different months of the year had been reported by Froning and Funk (1958).

1.7.4. Haugh Unit

Haugh Unit values recorded for the different treatment groups are presented in Table 12. The statistical analysis showed that the differences observed among the treatment groups were not significant. It indicated that the difference in floor density did not influence Haugh Unit Score. Similar results were reported by Reddy <u>et al</u>. (1981) and Bhat and Aggarwal (1991).

Though there were statistically significant difference in the Haugh Unit Score among different periods, it did not reveal a definite trend. The present finding is in agreement with the reports of Froning and Funk (1958).

1.7.5. Yolk Index

The overall mean Yolk Index Values (Table 13) obtained during this experiment for the three different treatment groups were within the range reported by Romanoff and Romanoff (1949). The analysis of data to decepher the influence of floor density did not reveal any statistically significant difference thereby indicating that floor space allowance had little influence on this parameter. Bhat and Aggarwal (1991) also could not find any significant effect of stocking density on Yolk Index.

Period-wise data showed that the Yolk Index for the first four periods were comparable and then showed a significant decline during the fifth period. Similar trend of decline of Yolk Index with increasing age of hen was reported by Pandey et al. (1988).

1.8. Mortality.

The mortality rate for all the treatment groups were well within the standard limits and the mortality was not influenced by variation in floor space allowance within the range studied. Strain et al. (1959), Kinder and Stephenson (1962), Noles et al. (1962), Panda and Mohapatra (1964), Eskeland et al. (1977), Reddy et al. (1981), Koelkebeck and Cain (1984), Prasad et al. (1984) and Koelkebeck et al. (1987) had also reported that the differences in floor density levels did not show any significant effect on mortality.

Contrary to the above reports Sharma et al. (1985) and Lee (1989) reported a significant increase in mortality as the floor space allowance decreased.

But, Mathew et al. (1979) in deep litter system and Koelkebeck et al. (1987) in cage system reported a reverse trend of increasing mortality along with an increase in floor space allowance per bird.

1.9. Economics.

The economic advantage and productivity of birds reared under the three floor density levels of 1350, 1575 and 1800 sq. cm. per bird (Table 15) revealed that although egg production per bird was highest in the group provided with 1800 sq.cm. per bird, the return over feed cost per bird and per unit floor space (sq.m.) were lowest in this group. This was essentially due to the significantly higher feed consumption recorded in this group compared to other two groups. The group provided with 1575 sq.cm. per bird were intermediary in their performance both in terms of egg production and economics. But, the group which was provided with 1350 sq.cm. per bird showed positive values of return over feed cost per bird, as well as per square metre floor area. This is of relevance in commercial poultry operation because the farmer is more interested in the net return that he can get rather than the maximum production from the bird.

Therefore the results of the present study revealed that a floor density of 1350 sq.cm. per bird is more economical for commercial layer (ILM 90) production under Kerala condition. Since the study is carried out only during a part of the year, further studies are recommended in other seasons to arrive at a final conclusion.

Summary

In an earlier experiment from this laboratory, it was observed that ILM-90, a commercial strain cross layer developed at Mannuthy Centre of 'AICRP on Poultry for Eggs' required a floor space of 1800 sq. cm. per bird (Anon., 1991). With a view to find out whether further reduction in floor space to reduce the housing cost could be brought about without affecting major productive traits, this experiment was taken up for study.

White Leghorn Pullets (ILM-90) were housed in deep litter pens providing 1350, 1575 and 1800 sq.cm. per bird. For each treatment group five replicates were used. A commercial layer mash was given for all the birds. Feed and water were provided ad lib. Standard routine managemental practices were followed throughout the experimental period.

Egg production, feed consumption, feed efficiency, egg quality traits and mortality were the major criteria considered for the evaluation. The data were collected for five, 28 day periods and were subjected to appropriate statistical analysis.

The results obtained during the course of the study are summarised in Table 16 and detailed as follows.

1. The body weight of the birds at 20th week of age as well as at the termination of the experiment (44th week of age) were statistically similar among the treatment groups at both the stages.

2. The age at sexual maturity as measured by age at first egg and age at 50 per cent production among the three treatment groups were statistically comparable.

3. The mean egg production was numerically superior among birds provided with 1800 sq.cm. per bird. However, the difference between this and the next lower floor space level (1575 sq.cm.) was statistically non significant. The egg production was poorest among birds provided with 1350 sq.cm. per bird but, was statistically similar to the next higher level floor space (1575 sq.cm.) but, significantly lower than those with 1800 sq.cm. per bird.

4. The mean daily feed consumption were significantly different among the three treatment groups and was

highest in group provided with 1800 sq.cm. per bird and lowest in birds provided with 1350 sq.cm. per bird.

5. The feed efficiencies among the groups provided with the three different floor space allowance were statistically homogenous.

6. The egg weight was not influenced by the variation in the floor spaces studied.

7. The other egg quality parameters such as Shape Index, Shell thickness, Albumen Index, Haugh Unit and Yolk Index studied did not show any significant difference due to the three floor space levels employed.

8. The mortality was not different among the three floor space levels provided.

9. The return over feed cost per bird was positive in group provided with 1350 sq.cm. per bird whereas it was negative in the other two lower floor density levels studied.

Table 16. Summary of performance of birds reared under different floor densities.

Parameters	Floor densities		
	1350 sq.cm/ bird	1575 sq.cm/ bird	1800 sq.cm/ bird
1. Body Weight at 20 week (g)	886.90±7.27	882.94±15.35	886.27±10.43
2. Age at first egg (days)	153.20±2.35	152.00±2.19	157.00±1.48
3. Age at 50 per cent production (days)	185.00±2.61	187.40±3.12	183.4±2.29
4. Hen-housed egg production (%)	57.94^{a}±2.28	59.34^{ab}±2.68	61.90^{b}±2.37
5. Mean daily feed consumption/bird(g)	109.32^{a}±2.96	116.51^{b}±3.15	123.08^{c}±3.21
6. Feed efficiency (kg feed/dozen eggs)	2.31±0.06	2.44±0.09	2.45±0.08
7. Mean egg weight during 24-44 week(g)	53.86±0.64	53.27±0.68	53.31±0.86
8. Shape Index	73.48±0.28	73.88±0.31	73.64±0.30
9. Mean shell thickness (mm)	0.38±0.002	0.38±0.003	0.38±0.003
10. Albuman Index	0.091±0.003	0.090±0.003	0.091±0.003
11. Haugh Unit	83.24±0.93	83.00±0.95	83.68±0.97
12. Yolk Index	0.431±0.002	0.432±0.002	0.432±0.002
13. Mean body weight at 44 week (g)	1411.80±20.14	1426.12±13.56	1400.80±18.73
14. Return over feed cost per bird in 140 days (Rs)	+0.54	-2.64	-3.82
15. Return over feed cost per sq.m. floor area in 140 days (Rs)	+4.00	-16.64	-21.26

Means bearing same superscript in a row do not differ significantly.

From the trend of egg production of the birds in this study it appears that the commerical hybrid layer ILM-90 deliver better performance with 1575 and 1800 sq.cm. per bird than with 1350 sq. cm. per bird. But other economic parameters like feed consumption, feed efficiency and economics of production favour the group provided with 1350 sq. cm. per bird. So, on economic consideration, about which a farmer is more concerned with, a floor density of 1350 sq. cm. per bird seems to be more suitable for ILM-90, the hybrid layer developed at 'AICRP on Poultry for Eggs', Mannuthy.

References

REFERENCES

Ali, A. and Cheng, K.M. (1984). Influence of flock size and density upon the performance of chickens. Poultry Adviser. XVII (VIII): 21-26.

Anitha, P. (1991). Effect of housing system on protein and energy requirements of White Leghorn. M.V.Sc. Thesis submitted to the Kerala Agricultural University, Trichur.

Anon., (1990). Indian Poultry Industry Year Book 1990. ed. S.P. Gupta, A-25, Priyadarshini Vihar, Delhi.

Anon., (1991). Annual Progress Report 1990-91. All India Co-ordinated Research Project on Poultry Housing and Management, Mannuthy Centre, Kerala Agricultural University, Mannuthy, Thrissur.

Anon., (1992). Annual Progress Report 1991-92 and Consolidated Report 1977-92. All India Co-ordinated Research Project on Poultry for Eggs, Trichur Centre, Kerala Agricultural University, Mannuthy, 680 651.

A.O.A.C. (1970). Official Methods of Analysis. Association of Official Agricultural Chemists, 11th edn., Washington, D.C.

*Bhat, G.A. and Aggarwal, C.K. (1991). Effect of two stocking densities and cage level on egg quality and plasma alkaline phosphatase level of White Leghorn pullets. Anim. Breed. Abstr. 59(10): 7146.

Bureau of Indian Standards (1972). Indian Standard Code of Practice for Poultry Housing. Manak Bhavan, 9 Bahadurshah Zafar Marg, New Delhi.1.

*Bressler, G.O. and Maw, A.J.G. (1967). High density and environmental control key to efficient egg production. Anim. Breed. Abstr. 35(3): 2990.

Carpenter, K.J. and Clegg, K.M. (1956). The metabolizable energy of poultry feeding stuffs in relation to their chemical composition. J. Sci. Fd. Agric. 7: 45-51.

Chand, D. and Razdan, M.N. (1976). Effect of housing conditions and month of the year on egg production, feed consumption, mortality and weights of various organs at slaughter after complete pullet year production. Indian J. Anim. Sci. 46(9): 497-502.

Chand, D. Razdan, M.N. and Georgie, G.C. (1977). Effect of housing conditions of the gross components of eggs and egg quality indices in White Leghorn. Indian J. Poult. Sci. 12(2): 36-40.

Clegg, K.M. (1956). The Application of anthrone reagent to the estimation of starch in cereals. J. Sci. Fd. Agric. 7: 40-44.

*Eskeland, B., Bjornstad, S. and Hvidsten, H. (1977). Effect of population density, group size, type of housing and beak trimming on the performance of hens in cages and pens. Anim. Breed. Abstr. 45(12): 7298

Esmay, M.L. (1969). Principles of Animal Environment. The AVI Publishing Company, INC, West Port, Connecticut, p. 186, 190.

Fox, T.W. and Clayton, J.T. (1960). Population size and density as related to laying house performance. Poult. Sci. 39(4): 896-899.

Froning, W. and Funk, E.M. (1958). Seasonal variation in quality of eggs laid by caged layers and their sisters on the floor. Poult. Sci. 37(1): 215-223.

H.M.S.O. (1976). Her Majesty's stationary office,Bulletin No. 212. The Climatic Environment of Poultry Houses. HMSO, London, pp. 12-13.

*Hyre, H.M., Johnson, J.R. and McClung, M.R. (1968). Influence of density on production traits of laying hens. Anim. Breed. Abstr. 36(2): 1959.

*Kinder, Q.B. (1960). Floor space studies with laying hens. Poult. Sci. 39(5): 1264-1265.

Kinder, Q.B. and Stephenson, A.B. (1962). Floor space studies using slat floor and litter floor for laying hens. Poult. Sci. 41(5): 1394-1400.

Koelkebeck, K.W., Amoss, M.S. and Cain, J.R. (1987) Production, physiological and behavioural response of laying hens in different management environments. Poult. Sci. 66(3): 397-407.

Koelkebeck, K.W. and Cain, J.R. (1984). Performance, behaviour, plasma corticosterone and economic returns of laying hens in several management alternatives. Poult. Sci. 63(11): 2123-2131.

Kothandaraman, P. (1985). Environment and poultry production. Poultry Guide. 22(6): 61-79.

Lee, K. (1989). Laying performance and fear response of White Leghorns as influenced by floor space allowance and group size. Poult. Sci. **68**(10): 1332-1336.

Logan, V.A. (1965). Influence of cage Vs floor density and dubbing on laying performance. Poult. Sci. **44**(4): 974-979.

Mathew, P.V., Siddiqui, S.M. and Reddy, C.V. (1979). Effect of floor and cage housing in relation to stocking density on the performance of layers. Indian J. Anim. Sci. **49**(10): 822-827.

Mc Dowell, R.E. (1972). Improvement of Livestock Production in Warm Climates. W.H.Freeman and Company, San Fransisco, Ist edn. p. 32.

Mench, J.A., Van Tienhoven, A., Marsh, J.A., Mc Cormick, C.C., Cunningham, D.L. and Baker, R.C. (1986). Effects of cage and floor pen management on behaviour, production and physiological stress responses of laying hen. Poult. Sci. **65**(6): 1058-1069.

Mohan, B., Mani, V. and Ramakrishnan, M. (1991). Influence of floor space and literacy level of the farmers on egg production. Poultry Adviser. **24**(8): 47-49.

Moran, E.T.(Jr.) (1986). Egg quality and hen performance responses to protein-calcium deficiency, cafeteria feeding and cage density. Poult. Sci. **65**(6): 1153-1162.

Muller, W.J. (1961). The effect of constant and fluctuating environmental temperatures on the biological performance of laying pullets. Poult. Sci. 40(6): 1562-1571.

Noles, R.K., Driggers, J.C., Laurent, C.K. and Page, W.O. (1962). Floor space requirements of S.C. White Leghorn hens. Poult. Sci. 41(3): 887-891.

North, M.O. (1984). Commercial Chicken Production Manual. AVI Publishing Company, INC, Westport, Conneticut. 3rd edn.

Panda, N.C. and Mohapatra, K.N. (1964). Floor space requirement for Rhode Island Red laying hens. Indian Vet. J. 41(4): 280-284.

Pandey, N.K., Mahapatra, C.M., Verma, S.S. and Sharma, R.D. (1988). Observations on egg quality traits in strain and breed crosses of chicken and their association with age. Indian J. Anim. Sci. 58(6): 705-709.

*Petersen, V.E. (1978). Effect of two housing systems on laying hens. Anim. Breed. Abstr. 46(6): 2991.

*Pokrovskii, V.A. (1957). Stocking rates in hen houses. Anim. Breed, Abstr. 24(2): 923.

Prasad, R.V., Reddy, S.J. and Rao, P.V. (1984). Influence of housing systems and protein levels on production traits and nutrient utilization in layers. Indian J. Poult. Sci. 19(1): 34-39.

*Quisenberry, J.H. and Bradley, J.W. (1964). Effects of bird density on performance of egg production stock. Poult. Sci. 43(5): 1354.

Rao, R.M., Reddy, S.J. and Rao, P.V. (1983). Influence of housing systems and protein levels on productive traits in chicken. Indian J. Poult. Sci. 18(1):1-8.

Reddy, N.D., Varadarajulu, P., Siddique, S.M. and Reddy, S.J. (1981). Production performance of egg type chicken under different housing systems. Indian. J. Poult. Sci. 16(4): 318-323.

Roland, D.A. (Sr). (1979). Factors influencing shell quality of ageing hens. Poult. Sci. 58(4): 774-777.

Romanoff, A.L. and Romanoff, A.J. (1949). The Avian Egg. John Wiley and Sons, INC, New York. Chapman and Hall Limited, London.

*Samalo, S. and Sathe, B.S. (1976). Studies on the effect of increasing the bird density and protein level on the performance of layers kept on floor and in cages. Anim. Breed. Abstr. 44(9): 4454.

Sharma, M.L., Shingari, B.K. and Ichhponani, J.S. (1985). Effect of bacitracin feeding on the requirement of floor space in laying hens. Indian J. Poult. Sci. 20(3): 223-224.

Siegel, H.S. (1959). Egg production characteristics and adrenal function in White Leghorns confined at different floor space levels. Poult. Sci 38(4): 893-898.

Snedecor, C.W. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Company, Calcutta, 6th edn.

Somanathan, V.L. (1980). Bio-climatological studies on dry matter intake and water consumption of growing livestock. M.V.Sc. Thesis submitted to the Kerala Agricultural University, Trichur.

*Strain, J.H., Phillips, R.E. and Sams, J.R. (1959). Floor and feeder space requirements for laying hens. Poult. Sci. 38(5): 1251-1252.

* Originals not consulted.

Appendices

APPENDIX I

Analysis of Variance for 20th week body weight

SOURCE	DF	SS	MS	F
Treatment	2	46	23	3.475195E-02
Error	12	7942	661.8333	

APPENDIX II

Analysis of Variance for 44th week body weight

SOURCE	DF	SS	MS	F
Treatment	2	1610	805	.5137205
Error	12	18804	1567	

APPENDIX III

Analysis of Variance for age at first egg

SOURCE	DF	SS	MS	F
Treatment	2	68.1250	34.0625	1.6297
Error	12	250.8125	20.9010	

APPENDIX IV

Analysis of Variance for age at 50 per cent production

SOURCE	DF	SS	MS	F
Treatment	2	40.5625	20.28125	.5577199
Error	12	436.375	36.36458	

APPENDIX V

Analysis of Variance for Hen-housed egg production

SOURCE	DF	SS	MS	F
Treatment	2	201.90630	100.95310	3.2506*
Period	4	8670.87500	2167.71900	69.7991**
Interaction	8	169.53130	21.19141	0.6546
Error	60	1942.31300	32.37188	

CD for treatment means comparison 3.152474

CD for period means comparison 4.069826

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX VI

Analysis of Variance for feed consumption

SOURCE	DF	SS	MS	F
Treatment	2	2366.50000	1183.25000	15.0308**
Period	4	12026.81000	3006.70300	38.1942**
Interaction	8	401.81250	50.22656	0.6087
Error	60	4951.25000	82.52084	

CD for treatment means comparison 5.019052

CD for period means comparison 6.479568

** Significant at 1 per cent level

APPENDIX VII

Analysis of Variance for feed efficiency

SOURCE	DF	SS	MS	F
Treatment	2	0.31110	0.15555	2.1105
Period	4	5.97324	1.49331	20.2618**
Interaction	8	0.60455	0.07557	1.0288
Error	60	4.40710	0.07345	

CD for treatment means comparison 0.1535717

CD for period means comparison 0.1982602

** Significant at 1 per cent level

APPENDIX VIII

Analysis of Variance for egg weight

SOURCE	DF	SS	MS	F
Treatment	2	5.45313	2.72656	1.0493
Period	4	796.64060	199.16020	76.6488**
Interaction	8	19.23438	2.40430	0.9162
Error	60	157.45310	2.62422	

CD for treatment means comparison 0.9118501

CD for period means comparison 1.177193

** Significant at 1 per cent level

APPENDIX IX

Analysis of Variance for Shape Index

SOURCE	DF	SS	MS	F
Treatment	2	2.06250	1.03125	0.8060
Period	4	73.62500	18.40625	14.3865**
Interaction	8	4.62500	0.57813	0.4211
Error	60	82.37500	1.37292	

CD for treatment means comparison 0.639853

CD for period means comparison 0.8260466

** Significant at 1 per cent level

APPENDIX X

Analysis of Variance for Shell thickness

SOURCE	DF	SS	MS	F
Treatment	2	0.00004	0.00002	0.2194
Period	4	0.00382	0.00096	10.4637**
Interaction	8	0.00013	0.00002	0.1636
Error	60	0.00608	0.00010	

CD for treatment means comparison 5.405192E-03

CD for period means comparison 6.978072E-03

** Significant at 1 per cent level

APPENDIX XI

Analysis of Variance for Albumen Index

SOURCE	DF	SS	MS	F
Treatment	2	0.00002	0.00001	0.1096
Period	4	0.00668	0.00167	17.3079**
Interaction	8	0.00030	0.00004	0.3645
Error	60	0.00626	0.00010	

CD for treatment means comparison 5.556723E-03

CD for period means comparison 7.173699E-03

** Significant at 1 per cent level

APPENDIX XII

Analysis of Variance for Haugh Unit

SOURCE	DF	SS	MS	F
Treatment	2	5.93750	2.96875	0.2171
Period	4	694.18750	173.54690	12.6920**
Interaction	8	57.81250	7.22656	0.4972
Error	60	872.00000	14.53333	

CD for treatment means comparison 2.091791

CD for period means comparison 2.70049

** Significant at 1 per cent level

APPENDIX XIII

Analysis of Variance for Yolk Index

SOURCE	DF	SS	MS	F
Treatment	2	0.00002	0.00001	0.0755
Period	4	0.00133	0.00033	2.7651*
Interaction	8	0.00056	0.00007	0.5487
Error	60	0.00760	0.00013	

CD for treatment means comparison 6.195187E-03

CD for period means comparison 7.997953E-03

* Significant at 5 per cent level

EFFECT OF FLOOR DENSITY ON PRODUCTION PERFORMANCE OF COMMERCIAL HYBRID LAYERS

By

A. G. GEO

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
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1992

ABSTRACT

In order to prescribe optimum floor space allownace for the commercial hybrid layer (ILM-90) released from Mannuthy Centre of the 'AICRP on Poultry for Eggs' with the ultimate objective of reducing housing cost and achieving better labour efficiency, a study was carried out to evaluate its production performance on three different floor densities under deep litter system of rearing.

The floor densities evaluated were 1350, 1575 and 1800 sq.cm.per bird. Each group was assigned to five replicates and mean body weight at 20 weeks of age were kept uniform for all the replicates. Except for the difference in floor densities, all the managemental practices followed were uniform for the different treatment groups. Feed and water were given _ad lib_. The data were recorded for five, 28 day periods.

Body weight at 44th week of age and Age at fifty per cent production were not significantly influenced by the difference in floor densities. There was an increase in egg production as the floor space allowance per bird was increased and this increase was significant ($P < 0.05$) for the group provided with 1800 sq. cm. per bird than that of

group provided with 1350 sq. cm. per bird. Feed consumption progressively increased as the floor space allowance increased and this increase was highly significant ($P < 0.01$). But, the differences in feed efficiency among different groups were not statistically significant. Egg weight and other egg quality parameters such as shape Index, shell thickness, Albumen Index, Haugh Unit and Yolk Index were not affected by difference in floor space allowances. Mortality was also not found to be influenced by the difference in floor densities.

Though the birds reared with a floor space of 1800 sq.cm. per bird showed higher egg production, the lower feed consumption, numerically higher efficiency of feed conversion and positive returns in terms of economics of production indicated that a floor density of 1350 sq.cm. per bird is more economical for the hybrid layer ILM-90 under Kerala condition.