EFFECTS OF BIRD DENSITY ON BROILER PERFORMANCE

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "EFFECTS OF BIRD DENSITY ON BROILER PERFORMANCE" 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,
28- 1 -1985.

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CERTIFICATE

Certified that this thesis, entitled "EFFECTS OF BIRD DENSITY ON BROILER PERFORMANCE" is a record of research work done independently by Sri. T.Linyu under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associate-ship to him.

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Dedicated

to

my parents

CONTENTS

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Introduction

INTRODUCTION

The broiler industry is developing rapidly in India. Though Andhra Pradesh took up broiler raising for the first time in the country as a segment of the poultry industry as early as 1962, it was only in 1978-79 it really caught the imagination of the poultry farmers. Broiler industry is an important sector which could counter the acute shortage of animal protein in the diet, especially in India where the diet is low in animal protein. Increasing the production efficiency of wholesome broiler meat will help fighting malnutrition to a great extent.

The National Commission on Agriculture in its report estimated the demand for poultry meat during 1980 to touch 1,00,000 tonnes, 1,50,000 tonnes in 1985 and 3,00,000 tonnes by 2000 AD. In the case of broilers, the number has been estimated at 17.2 millions for 1985 and 71.8 millions for 2000 AD. The study made by Progressive Agro-Industrial consultants projected demand for broilers as below:

Estimated Demand and supply of meat in India

Year	Demand all meat (tonnes)	Supply of poultry meat (tonnes)	Broilers (tonnes)
1985	1,200,000	150,000	17,000
2000	1,800,000	300,000	71,800

Source : Indian Poultry, Who's Who 1981.

Consumer awareness of the superiority of broiler meat in terms of culinary fitness and profitability has generated production potential for this segment of poultry industry. In 1979, the demand of broilers registered a 100 per cent increase as compared to 1978. Broiler demand and production will continue to rise at a much faster pace than layers have, because broiler meat prices have gone up considerably and have remained stable during the latter half of 1979 and the first half of 1980. The Indian palate got the taste of broilers by 1980.

The increased and quick return on investment, with the considerable lesser risk due to short time span when compared with layers, makes broiler farming very attractive. The expansion of broiler industry coupled with the increasing cost of construction, generated a tendency to increase the stocking density with the view of maximum utilisation of available space. Managemental practices play an important role in economic production of quality chicken. Recent trend has been towards higher stocking densities without impairing performances to off-set the high overhead costs and to obtain higher returns per unit of floor space. Not much work seems to have been done on optimum floor space requirements for broilers in our country.

Environmental effects on poultry production have to be ascertained under different conditions to guage production efficiency. The physical environment is of prime importance and an understanding of the requirement of floor space under different conditions would go a long way in maximum economic utilisation of available space to enhance profitability.

This work, therefore, was designed and undertaken to test the efficacy of rearing broilers in three different density levels during two seasons in a tropical humid type of climate.

Review of Literature

REVIEW OF LITERATURE

Growth rate

Hartung (1953) studied the floor space requirement for broilers using New Hampshire cross-bred strains on 0.5, 0.75, 1.0, and 1.25 sq. ft./bird floor allowances, and observed that as floor space increased there was corresponding increase in body weight.

Brooks et al. (1957) investigated the economic impact of floor space on broiler production. In their study they used White Plymouth Rock broilers and provided floor space allowances of 0.5, 1.0, and 2.0 sq. ft./bird to determine the effect of floor space on weight variation and profit maximization, and concluded that there was a progressive decrease in body weight as floor space per broiler decreased. They further observed that the difference in body weight were relatively small upto 9 weeksand after 9 weeks of age the weight differences between broilers on 1.0 sq. ft. of floor space per bird and the broilers on 0.5 sq. ft./bird floor space became progressively greater. There was a linear relation between weight gain and time.

Siegel and Coles (1958) conducted an experiment on floor space effects, using 2,466 White Rocks reared upto 9 weeks of age. They found that the different floor space treatments of 0.5, 0.75, 1.0, and 1.25sq. ft./bird used in the study had little, if any, effect on body weight.

Brooks <u>et al</u>. (1958) observed that there was a progressive decrease in body weight as floor space per broiler decreased, but these differences in body weight were relatively small upto the 9th week. Hansen and Becker (1960) conducted three experiments and reported that growth rate was decreased as population density increased. This was true with all genotypes and both sexes, males being more responsive to crowding than females.

In a study involving 7500 broiler chicks reared under four different densities throughout the year, Roberts <u>et al</u>. (1951) reported that birds on1sq. ft. floor space each grew well during the fall, winter and spring months whereas during summer months the birds performed better on 1.25 sq. ft. allowances. The data indicated that body weight of birds as a function of strain of the bird is more important than age in determining floor space requirements for optimum growth and development.

Richards and Hamilton (1967) observed that average body weight for 0.7 sq. ft. allowances was highest and significantly greater than the corresponding weights for 0.6 and 1.0 sq. ft. allowance for both males and females during first four weeks.

During subsequent weeks the rank of the 0.9 and 1.0 sq. ft. treatments improved and at 10 weeks average weights were equal or superior to those of 0.6, 0.7 and 0.8 sq. ft. If the concept that there is an optimum density which differs with age is valid, the efficiency of utilization of buildings and equipments and the evenness of flow of birds to market in addition to the growth rate may be improved by increasing the floor space allowance only as the optimum changes, they further opined.

Srinivasan (1968) reported that at the age of 8 weeks, those reared on 0.6 sq. ft. floor space per bird were lighter in weight than those reared on 1.2 sq. ft. floor space per bird. Andrews and Goodwin (1969) reported that the average body weights resulting from 3.7 sq. decimeters of floor space per bird were lower than those on 4.6, 5.6, 6.5 and 7.4 sq. decimeters per bird. Floor space allowances of 4.6 sq. decimeters per bird resulted in lesser broiler weights than broilers with 6.5 and 7.4 sq. decimeters of floor space per bird.

Deaton et al. (1970) investigated the effects of bird density under winter and summer conditions in environmentally controlled house. The results indicated that a density of 279 sq. cm./bird significantly depressed body weight for both the sexes. Hill (1971) reported that the greater the space the better the performance (increased body size). Dorminey *et al.* (1972) reported that there was a trend for body weight gain to decrease as bird density increased.

Bolton *et al.* (1972) studied the effect of stocking density on broiler performance upto 10 weeks of age. A decrease in space allowance from 0.093 sq.m. to 0.047 sq.m. per bird was accompanied by reduced final live weight, the effect on live weight was lesser at 9 weeksand was not significant at 7th or 8th weeks. In broiler experiments of 8 weeks duration, a space allowance of 0.078 sq.m. per bird (0.8 sq. ft. per bird) was found to be more than adequate.

Andrews (1972) reported that as the bird density increased, the body weight of the broilers decreased. Jastrzebski (1972) carried out experiments during three seasons (summer, autumn and winter) to study the population density using Cornish and White Rock birds and reported that body weight was not influenced by bird density, but noted seasonal effects on body weight.

Weaver *et al.* (1973) observed that there were significant differences in body weight at 54 days of age between stocking densities of 502 and 734 sq.cm. Broilers reared at the lower stocking (734 sq.cm) density weighed 1675 g at 54 days of age, and were 50 g heavier than those reared at the higher density (502 sq. cm./bird). Mathur and Reddy (1975) found statistically no significant difference in final weight gain due to differences in floor space provided.

Ram et al. (1976) found that there was no significant difference in final weight between 700 and 450 sq. cm. floor space allotments. Tarrago and Puchal (1977) observed that high stocking rate (18 birds/sq. m. = 555 sq.cm/bird) adversely affected body weight. Parkhurst et al. (1977) reported that broiler performance was unaffected by stocking densities of 0.07 and 0.06 sq.m./bird.

Proudfoot et al. (1979) reporting on an experiment in which broiler chicks were housed at 3.72, 5.55, 7.44 and 9.27 sq. decimeter floor area per bird, observed that increased bird density resulted in a significant linear reduction in body weight of both males and females. Scholtyssek and Gschwindt (1980) opined that stocking rates of 150, 185 and 220 birds/11 sq.m. pen had no effect on growth to 6 weeks of age. Deaton et al. (1981) reported that a growing density of 697 sq.cm. on litter did not adversely affect the body weight at 21 or 49 days.

Stanley (1981) studied the effect of stocking densities of 900, 720, 540 and 360 sq.cm. Weight gains among treatments were affected only after the sixth week of age. Growth was markedly depressed in the groups with the highest stocking densities.

Weaver _et al._ (1982) reported that broilers given more floor space were significantly heavier than birds provided a more restricted floor regimen. Chrappa _et al._ (1982) did not find any significant differences between the densities. Vo (1982) allotted 300, 600 and 900 sq. cm./bird in three different treatments. The results showed that birds reared at the highest density showed a significant reduction (200 g) in 8th week body weight.

Raj _et al._ (1985) compared performance of birds housed at 350, 380, 420 and 470 sq. cm. per bird and found that those housed at 470 sq. cm. per bird registered significant higher weight gains. Kovin'ko (1983) reported that the differences in stocking densities on body weight at 6th week of age were not significant. Body weights of broilers housed at the densities of more than 25 per sq. m. were significantly lower than for densities of 18 - 25 per sq.m.

Feed consumption

Hartung (1955) found that as the floor space per bird increased there was a corresponding improvement of feed conversion. Brooks _et al._ (1957) investigated the economic impact of floor space on broiler production, using floor space of 0.50, 1.00, 1.50, and 2.00 sq. ft per bird. They found that feed was utilised most efficiently in the pens where the broilers were provided 1.0 and 0.50 sq. ft of floor space per bird. As the total feed input increased after 9 weeks of age, there was a decrease in the units of broiler output per unit of feed input.

Siegel and Coles (1958) ascertained the effects of floor space on broiler performance using 0.5, 0.75, 1.0 and 1.25 sq. ft of floor space per chick and observed that the floor space treatments used had little if any, effect on feed efficiency at 4, 6 and 9 weeks of age.

Brooks et al. (1958) analysed the economic, technical and sampling measurements in broiler floor space requirements. A total of 11,250 White Plymouth Rock birds were used in three trials, with floor space allowance of 0.50, 1.00, 1.50 and 2.00 sq. ft per broiler. The results indicated a better feed utilisation efficiency in the pens where birds had 1.0 and 0.5 sq. ft of floor space each.

Deaton et al. (1967) studied the effect of temperature and density on broiler performance in commercial type houses both under environmentally controlled and uncontrolled conditions. The results indicated that feed efficiency is better at higher temperature. Further they stated that when temperature regimes, specially during the latter part of the growing period, are above 21.1 °C, body weight gain is significantly reduced.

Coligado and Quisenberry (1967) reported that feed efficiency was slightly favoured by higher density. Hill (1971) observed that greater the space the better is the feed efficiency. Derminey <u>et al.</u> (1972) found that feed consumption decreased as bird density increased. Bolton <u>et al.</u> (1972) reported that at 10 week age a decrease in space allowance from 0.093 sq.m. to 0.047 sq.m. per bird was accompanied by reduced feed consumption and increased feed conversion efficiency.

Mathur and Reddy (1975) observed no significant differencesin feed efficiency due to different floor space (450, 700, 950 sq.cm) treatments. Hinners <u>et al.</u> (1975) reported that feed conversion was depressed with highest density (6 birds per 16" x 16" area). Cox and Hinners (1976) found that density did not affect feed efficiency.

Ram <u>et al.</u> (1976) found no significant differences in feed efficiency while testing birds on 450, 700 and 950 sq.cm. per bird. Tarrago and Puchal (1977) studied the effect of stocking rate on the performance of broilers and showed that high stocking rate (18 birds/sq.m = 555 sq. cm/bird) adversely affected feed conversion efficiency.

Parkhurst *et al.* (1977) evaluated the economic feasibility of rearing broilers in environmentally modified vs. conventional houses in densities of 0.07 and 0.06 sq.m per bird, and found that bird density did not influence broiler performance. Mathew *et al.* (1979) observed that feed efficiency was better at higher density in cages and low density on litter. Scholtyssek and Gschwindt (1980) reported that birds stocked at the lowest density (150 birds/11 sq.m.) consumed 9 per cent more feed than those stocked at the other rates, but feed conversion was 6 per cent better at the highest density (220/11 sq.m.) than at the other densities.

Deaton *et al.* (1981) observed that a growing density of 697 sq.cm on litter did not adversely affect feed efficiency at 49 days. Stanley (1981) studied the effect of stocking density on growth rate, feed efficiency, mortality, carcass quality and moisture content of the litter in broilers, on stocking densities of 900, 720, 540, and 360 sq. cm per bird. He reported that feed conversion among treatments were affected only after the sixth week of age. Feed conversion was markedly depressed in the groups with the highest stocking densities.

Weaver *et al.* (1982) found no difference in feed efficiency between broilers provided more floor space and restricted floor space. Chrappa and Peter (1982) reported that feed consumption and feed efficiency between different densities were not significant. Vo (1982) observed that birds reared at the highest density (300 sq. cm/bird) showed a slight improvement in feed efficiency, when compared with the low density group.

Raj et al. (1983) found that the feed conversion ratio increased from 2.72 at 330 sq.cm per bird to 3.06 at 470 sq. cm per bird, although group differences were not significant. Carter and Martin (1983) reported that higher density treatments had highly significant negative effects on feed consumption.

According to Kovin'ko (1983) the consumption of feed per kg gain, on ad lib feeding was 2.52 - 2.63 kg in groups housed at densities more than 25/sq. m Vs 2.46 - 2.49 kg at densities less than 26/sq.m at 7 weeks. At the 8th week, the feed conversion efficiency was poorer in groups housed at densities more than 23/sq.m.

Mortality

Hartung (1955) while reporting the effect of floor space on broiler performance observed that high livability was obtained in 0.50, 0.75, 1.00 and 1.25 sq.ft/bird floor space allotments. Siegel and Coles (1958) observed that the floor space allowance of 0.5, 0.75, and 1.00 and 1.25 sq. ft/bird had little effect on livability upto 9 weeks of age. Coligado and Quisenberry (1967) reported that crowding the birds resulted in increased mortality. Marr *et al.* (1967) observed that per cent mortality increased as the space per bird decreased.

Deaton *et al.* (1967) reported that the density levels of 929 and 650 sq. cm/bird did not affect mortality significantly. Deaton *et al.* (1970) found that floor allowances of 279, 465 and 743 sq.cm/bird affected mortality during high temperature conditions and opined that bird density affects the microenvironment. Hill (1971) linked increased floor space allowance with better performance and reduced mortality.

Dorminey *et al.* (1972) noted that there was a trend for mortality to increase as bird density increased. Feldkamp and Adams (1973) found that mortality rate was not significantly affected by the different bird densities of 330 and 590 sq. cm of floor area per bird.

Mathur and Reddy (1975) observed that the floor treatments of 450, 700, 950 sq. cm/bird did not affect mortality. Hinners *et al.* (1975), Carson *et al.* (1975) and Cox and Hinners (1976) reported increase in mortality percentage consequent to increased bird density. Ram *et al.* (1976) noted no significant difference in mortality levels due to different floor space allowances.

Parkhurst *et al.* (1977) observed significant reduction in mortality in the environmentally modified house, the densities were 0.07 and 0.06 sq. m per bird. Stanley (1981) reported that livability was markedly depressed in the groups with the highest stocking densities.

Husseini *et al.* (1981) also observed mortality increase when density increased in cages. Cunningham and Ostrander (1981) reported that mortality was not affected by population density. Vo (1982) observed that birds reared at high densities exhibited a significant increase in mortality percentage. Carter and Martin (1983) opined that higher density treatments had highly significant negative effect on per cent mortality.

Season

Roberts *et al.* (1961) studied the relationship of floor space to factors influencing broiler growth. The results indicated that birds reared on 1 sq. ft floor per bird grew well during the fall, winter and spring months. However, during summer months the birds required 1.2 sq. ft floor space per bird for efficient growth.

Deaton *et al.* (1967) observed that when temperature regimes, especially during the latter part of the growing period, are above 21.1°C, body weight gain is significantly reduced. A significant density effect on body weight gain is evident at temperatures below 21.1°C. Feed efficiency is better at higher temperatures, but mortality and condemnation were not significantly affected.

Deaton et al. (1970) obtained results under winter and summer conditions in an environmentally controlled house. Males had more leg weakness and breast blisters than females, with a higher mortality when, high temperature and humidity were factors. A density of 279 sq. cm significantly depressed body weight for both sexes. They further observed that bird density affected mortality during high temperature conditions since bird density was found to influence the microenvironment.

Jastrzebski (1972) reported that the seasons clearly did account for an increase of body weight. Parkhurst et al. (1977) investigated a comparison of broilers grown in environmentally modified and conventional housing at different population densities. Body weight and feed conversion significantly improved and mortality was significantly decreased, in the environmentally modified house. Bird density did not influence performance.

Dressing yield

Hartung (1955) graded the individual carcass of each treatment into the Colorado grades and found that as the floor space increased there was an increase in the per cent grade A carcasses. Roberts et al. (1961) observed that there was a significant change in percentage of grade A birds when birds were allowed more floor space.

Deaton et al. (1967) reported that carcass condemnation was not significantly affected by the density levels of 929 and 650 sq. cm/bird. Weaver et al. (1975) investigated the effect of stocking densities of 502 and 734 sq. cm on broiler performance. Methods of rearing included straight-run and unisexual flocks. The results showed that percentage breast trims were significantly higher for males (14.8%) and for the higher stocking densities (5.1%) than for females and the lower densities. Differences among treatments were not significant for breast angle, percentage bruises and condemnations, when processed.

Sethuraman and Kothandaraman (1978) investigated the effect of pre-slaughter fasting and population density on dressing yield of broilers. Floor space given during rearing period had no effect on dressing yield. However, when the birds were reared with increased floor space of 1080 sq. cm and prolonged fasting time, there was reduction in dressing yield.

Proudfoot et al. (1979) reported that increased bird density adversely affected carcass quality. There was a significant increase in the incidence of breast blisters in females with the linear effect approaching significance for males.

Silaev *et al.* (1981) measured carcass weight and carcass weight per sq. m floor area at 6, 7 and 8 weeks of age. It was found that increasing the housing density from 34.5 to 44 birds/sq.m floor area increased the yield of poultry meat per house by 30 per cent without any fall in quality.

Stanley (1981) studied the effect of stocking density on growth rate, feed efficiency, mortality, carcass quality and moisture content of litter in broilers. Carcass quality as determined by the number of breast blisters, was 42 per cent in the groups with the highest stocking density (360 sq. cm/bird) as compared with 10.3 per cent in the groups with the lowest stocking density (900 sq. cm/bird).

Litter evaluation

Hartung (1959) reported that litter moisture content decreased rapidly as the space increased. Siegel and Coles (1958) observed that the litter conditions were satisfactory under floor space treatments of 0.50, 0.75, 1.00 and 1.25 sq.ft/bird. Roberts *et al.* (1961) observed the per cent moisture in the litter decreased where birds were less crowded. Mathur and Reddy (1975) reported that the moisture content of the litter significantly varied between the floor treatments of 450, 700, 950 sq. cm both at 8 and 12 weeks of age.

Ram *et al.* (1976) noted that the moisture content of the litter significantly varied between different floor treatments both at 8 and 12 weeks of age indicating an inverse relationship between moisture content and population density. Mathur and Reddy (1975) and Ram *et al.* (1976) observed that it was difficult to keep the litter in workable condition when floor space allowances were reduced. Stanley (1981) observed the moisture content of the litter increasesprogressively as the stocking density increased.

Materials and Methods

MATERIALS AND METHODS

Two experiments were carried out at the University Poultry Farm attached to the Department ofPoultry Science of the College of Veterinary & Animal Sciences, Mannuthy. The trials were to ascertain the performance of commercial broilers reared in three different density levels, in two seasons, to determine the optimum space requirement for broilers under the Agro-climatic conditions existing in Kerala. Day-old commercial broiler chicks were purchased from the Regional Poultry Farm, Chatamangalam, Kozhikode. The first experiment was conducted during the summer season (April - May) and the second during monsoon season (June - July).

Experiment I

In this trial, 700 day-old, straight-run commercial broiler chicks were brooded together under infra red brooding system upto four weeks of age. The litter material used was wood-shavings, which was spread over the floor in about 7 cm thickness. The day-old chicks were protected against Ranikhet disease using RDF vaccine by occulo-nasal instillation. The chicks were wing banded and individually weighed. Feed and water were provided ad lib. Commercial broiler starter mash was fed from 0 - 6 weeks of age followed by a broiler finisher mash till the completion of the experiment. The proximate composition of the feeds used is furnished in Table 1.

Table 1. Proximate composition of Starter and Finisher diets.

Factor	Starter (%)	Finisher (%)
Dry matter	92.5	92.2
Crude protein	25.2	24.0
Ether extract	5.5	6.1
Crude fiber	2.1	3.5
Total ash	11.1	8.5
Acid Insoluble Ash	3.9	2.8

The feed consumption was recorded during the brooding period separately. The air temperature and relative humidity inside the pens were recorded daily throughout the experiment.

At the age of four weeks, the chicks were weighed individually and randomly distributed into three treatment groups as follows:

	Treatment	Floor space allowance
Group I	Low density treatment	1114 sq. cm/chick
Group II	Medium density treatment	929 sq. cm/chick
Group III	High Density treatment	743 sq. cm/chick

Each treatment group was assigned one replicate each. The average body weight of all the treatment groups were adjusted to approximately equal. Birds numbered 85,100 and 125 in the low, medium and high density groups respectively. Except for the floor space allotment, all other managemental practices were the same for all the treatments. Data on individual body weight and feed consumption for each group were collected at weekly intervals upto 8 weeks.

Observations were also made on mortality and behavioural pattern among the different treatments. Microclimatic variables of air temperature and relative humidity were recorded. When mortality occurred, dead ones in each group were replaced by birds of almost identical weights from a group of extra birds maintained separately, with a view to keep the floor space allowances constant. Samples of litter were taken and identical quantities (50g) were weighed out and moisture per cent was ascertained by weighing after complete drying.

At the end of 8 week period, 3 males and 3 females were randomly selected from each replicate and slaughtered to study the processing yields. The birds were fasted for nine hours prior to slaughter, during this period water was provided ad lib. The birds were killed by the outercut method. Bleeding time of one minute was allowed after killing the birds by placing them in a bleeding funnel. Dressing and evisceration was done as per the standard procedures.

Experiment II

This experiment was similar to Experiment I except that this trial was run during the monsoon season of June - July. Floor space allowances, and managemental practices were identical for both experiments. Due to an unexpected shortage of broiler chicks, the treatment allotments of this experiment numbered 52, 63 and 79 for the low density, medium density and high density groups. There was no change in the floor space allowances per bird which remained 1114 sq. cm, 929 sq. cm and 743 sq. cm in this experiment also. The variable factor between the two experiments was season. Data collection, evaluation and processing for different parameters were carried as laid out under Experiment I.

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

Results

RESULTS

Experiment I

This experiment was carried out during the warm season of April and May. The climatic variables of temperature, relative humidity, precipitation, and air velocity for the season are presented in Table II. The mean weekly maximum temperatures were 34.7, 35.7, 34.3, 33.1, 34.6, 35.3, 34.4, 34.6°C and the mean relative humidity percentages were 75.2, 67.3, 73.9, 74.8, 70.5, 68.2, 71.3, 70.2 respectively for the period under study. The maximum ambient temperature was registered during the second week of the experiment. The maximum relative humidity percentage was observed during the first week.

The mean weekly body weights and the gains for 4th to the 8th week of age are presented in Table III the analysis of variance in Table IV and the graphic representation in Figure 1. The mean 8th week body weights registered for the treatment groups were 1054, 1014 and 1013 g respectively for low, medium and high densities. Though the growth rate did not reflect statistically significant difference between treatments, the low density group exhibited numerical difference from medium and high density groups.

Table II. Mean Climatic Variables April - May. Experiment I

Week	Temperature °C Maximum	Temperature °C Minimum	Relative humidity %	Precipitation mm	Air velocity km ph
I	34.7	25.2	75.2	2.58	5.42
II	35.7	24.8	67.5	0.77	6.85
III	34.3	24.1	73.9	1.24	5.57
IV	33.1	24.8	74.8	0.51	5.57
V	34.6	26.4	70.5	0.00	6.28
VI	35.3	26.2	68.2	0.00	6.00
VII	34.4	25.7	71.5	1.51	6.85
VIII	34.6	25.6	70.2	1.40	6.85

Table III. Mean weekly body weights and weekly gain in g Experiment I.

Week	Low density 1114 cm^2/bird		Medium density 929 cm^2/bird		High density 743 cm^2/bird	
	body wt.(g)	gain (g)	body wt.(g)	gain (g)	body wt. (g)	gain (g)
IV	374		375		375	
V	533	159	541	166	543	168
VI	719	186	719	178	695	152
VII	857	138	850	131	859	164
VIII	1054	197	1014	164	1013	154

Table IV. Analysis of variance for weekly gains Experiment I.

Source	df	SS	MSS	F
Replicate	1	2	2	0.004
Treatment	2	588.05	294.03	0.65 NS
Week	3	3086.92	1028.97	2.28
Error	17	7645.65	449.74	
Total	23	11322.62		

NS = Not Significant.

The mean weekly feed consumption from 4th to the 8th week is presented in Table V (a) the analysis of variance for feed consumption is presented in Table V (b) and the graphic representation in Figure 2. The feed consumption did not differ significantly between treatments. The overall feed consumption per bird for low, medium and high density groups were 3355, 3303 and 3205 g respectively. The highest feed consumption was observed in the 7 week for all the treatments.

The percentage of ready-to-cook yield at 8th week of age is presented in Table VI. The percentages for the low, medium and high density groups were 69.4, 69.1 and 68.7 respectively. The pooled analysis of variance for the Experiment I & II are presented in Table VII. The results on the per cent dressed yields showed statistically no significant difference between the different treatments. However, there was numerical advantage for the low density group when compared with the medium density group and the high density group.

The per cent mortality of the different treatments are given in Table VIII and the pooled analysis of variance for mortality for Experiment I & II are furnished in Table IX. The per cent of mortality for low, medium and high density

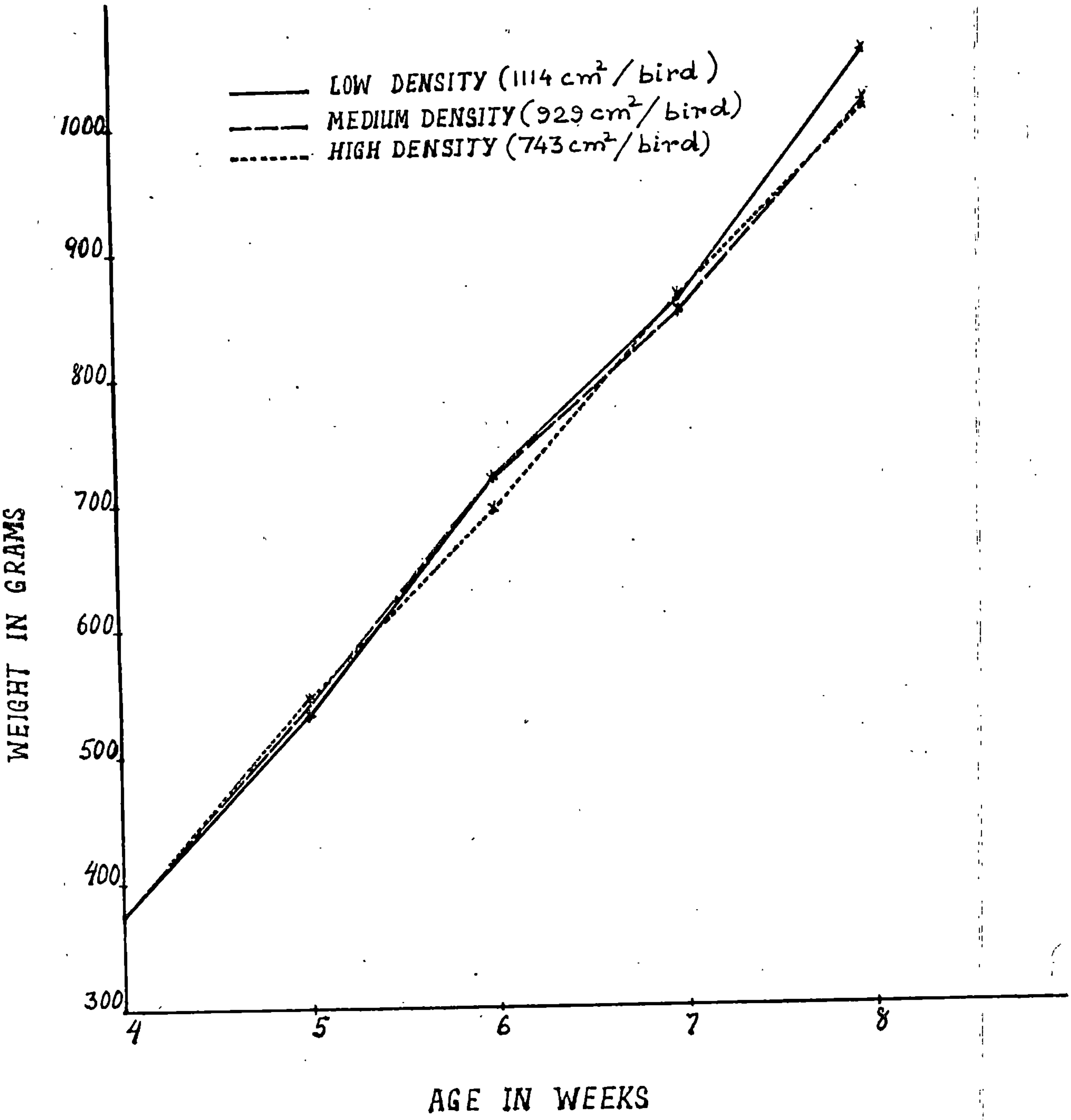

FIG. 1 GROWTH PATTERN OF BROILERS
• EXPERIMENT 1 •

Table V(a). Mean weekly feed consumption (g/bird/week. Experiment I.

Week	Low density 1114 cm^2/bird	Medium density 929 cm^2/bird	High density 743 cm^2/bird
0 - IV	748.0	748	748
V	491.5	476	476
VI	637.5	633	592
VII	739.0	734	725
VIII	739.0	712	664
Cumulative total	3355.0	3303	3205

(0 - 4 weeks feed consumption is the average of all birds brooded together before allotment).

Table V(b). Analysis of variance for weekly feed consumption Experiment I.

Source	df	SS	MSS	F
Replicate	1	8.0088	8.0088	
Treatment	2	1328.12	664.06	0.84 NS
Week	2	96192.12	48096.06	61.3 *
Error	12	9415.87	784.65	
Total	17	106929.12		

NS = Not Significant.

* = Significant ($P < 0.05$)

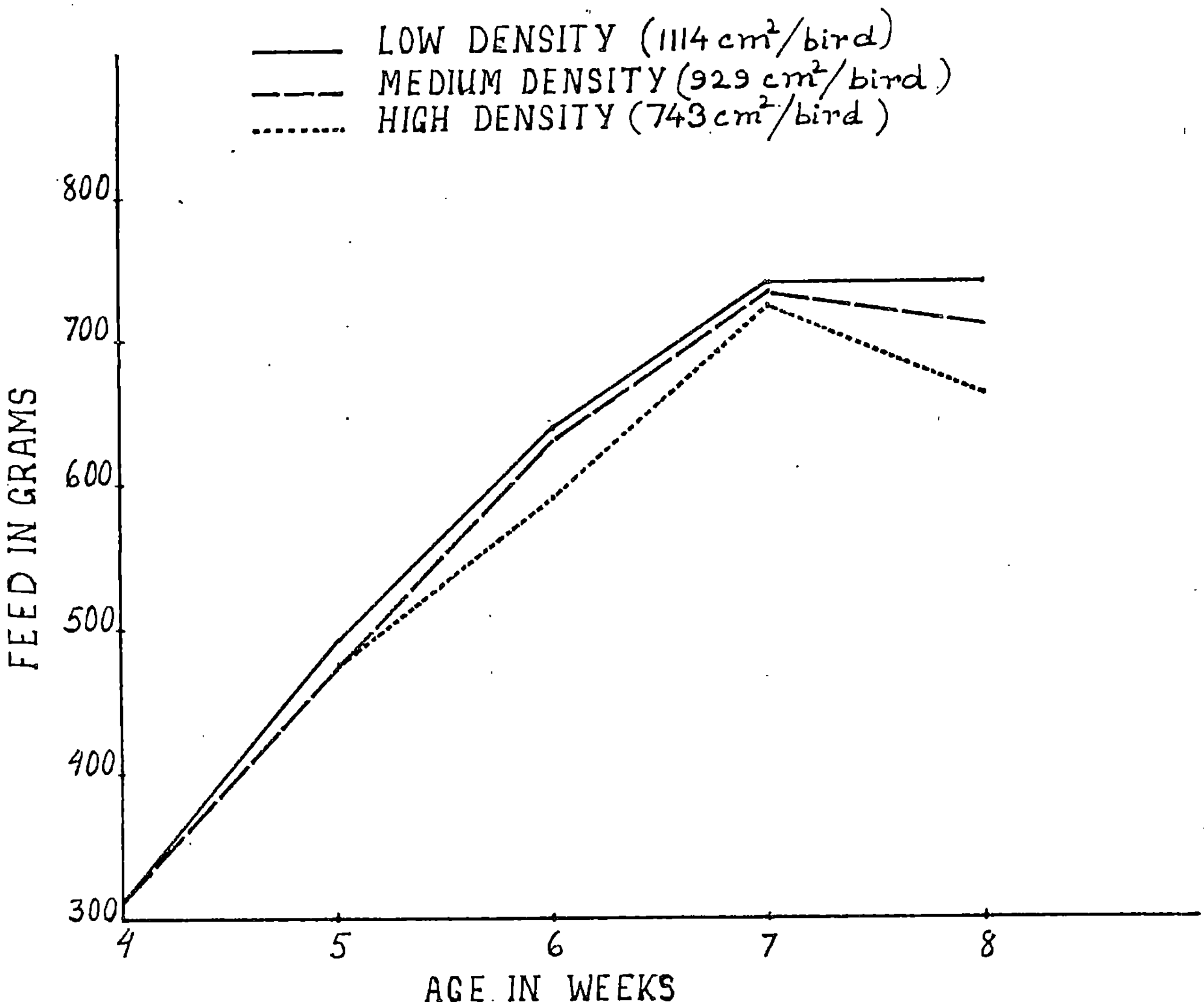

FIG.2 THE MEAN WEEKLY FEED CONSUMPTION OF BROILERS (g/bird/week)

• EXPERIMENT 1 •

Table VI. Per cent ready-to-cook yield Experiment I and II.

Treatment	Per cent ready-to-cook yield	
	Experiment I	Experiment II
I Low density 1114 cm^2/bird	69.49	72.25
II Medium density 929 cm^2/bird	69.12	72.14
III High density 743 cm^2/bird	68.71	72.55

Table VII. Adjusted analysis of variance for per cent ready-to-cook yield Experiment I and II.

Source	df	MSS
Season adjusted	1	123.2592 **
Treatment adjusted	2	0.80502
Interaction	2	1.27095
Within sub-class	48	4.265175

** Highly significant ($P \leq 0.01$)

Table VIII. Per cent mortality Experiment I & II.

Treatment	Per cent mortality	
	Experiment I	Experiment II
I Low density 1114 cm^2/ bird	3.50	00
II Medium density 929 cm^2/ bird	3.50	00
III High density 743 cm^2/ bird	1.58	00

Table IX. Analysis of variance for per cent mortality Experiment I and II (After aresine transformation.

Source	df	MSS
Replication	1	3.091
Season	1	220.420 **
Treatment	2	3.449
Interaction	2	3.449
Error	5	5.477
Total	11	

** Highly significant ($P \angle 0.01$)

Mean table for comparison between seasons and between treatments

Treatments →	I	II	III	Mean
Season I	10.12 (3.1)	10.76 (3.5)	7.21 (1.55)	9.38 (2.65)
Season II	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)
Mean	5.45 (0.90)	5.785 (1.0)	4.01 (0.49)	

(Values in the parentheses denote retransformed mean values) treatments were 3.50, 3.50 and 1.58 respectively indicating that the different floor space treatments had no significant effect on mortality.

The moisture content of litter at the end of 8th week is shown in Table X and the analysis of variance for pooled data of Experiment I & II is presented in Table XI. There was significant difference ($P < 0.05$) between all the treatments. The per cent of litter moisture content for low, medium and high density treatments were 21.70, 29.67 and 32.52 respectively. The high density pens of 743 sq cm per bird had the highest moisture content.

Experiment II

This experiment was carried out during the monsoon season of June - July. The climatic variables of temperature, relative humidity, precipitation, air velocity for the season are presented in Table XII. The mean weekly maximum temperatures were 29.1, 29.1, 28.3, 28.2, 27.9, 28.6, 27.6, 29.6°C and the mean relative humidity per cent were 82.5, 83.1, 85.9, 87.5, 86.4, 86.3, 89.5 and 82.2 respectively for Ist to the 8th week. The maximum ambient temperature was registered during the 8th week. The maximum relative humidity per cent was recorded during the 7th week of the experiment.

Table X. Per cent litter moisture content Experiment I and II.

Treatments	Litter moisture content (%)	
	Experiment I	Experiment II
I Low density 1114 cm^2/ bird	21.70	32.55
II Medium density 929 cm^2/ bird	29.67	40.99
III High density 743 cm^2/ bird	32.52	43.23

Table XI. Analysis of variance for litter moisture content Experiment I and II.

Source	df	MSS
Replication	1	1.920
Season	1	135.475 **
Treatment	2	48.875 *
Season x Treatment	2	0.1181
Error	5	0.6006
Total	11	

** Highly significant ($P \angle 0.01$)

* Significant ($P / 0.05$)

Mean table for comparison between seasons and between treatments

	Treatment I	Treatment II	Treatment III	Mean
Season I	27.765 (21.7)	33.02 (29.7)	34.775 (32.5)	31.853 (27.85)
Season II	34.785 (32.5)	39.815 (41.0)	41.12 (43.12)	38.573 (38.85)

(Values within the parentheses denote retransformed mean values).

Table XII. Mean climatic variables - June -July
Experiment II

Week	Temperature °C		Relative humidity %	Precipitation mm	Air velocity km ph
	Maximum	Minimum			
I	29.1	23.0	82.5	20.9	4.42
II	29.1	22.8	88.1	40.8	6.00
III	28.3	22.2	85.9	29.3	5.00
IV	28.2	22.7	87.5	18.1	5.00
V	27.9	22.7	86.4	31.1	5.71
VI	28.6	23.0	86.3	25.9	5.71
VII	27.6	22.2	89.5	37.3	5.71
VIII	29.6	23.3	82.2	3.3	5.42

The mean weekly body weights and the gains from 4th to the 8th week are enumerated in Table XIII (a) the analysis of variance in Table XIII (b) and the graphic representation in Figure 3. The results indicated that as the floor space per bird increased there was a corresponding increase in weight gain. All treatments exhibited statistically significant differences. The average 8th week body weights for low, medium and high density groups were 1656, 1631, and 1539 g respectively. The trend of body weight gain was in the same pattern for all the three treatments. The maximum body weight gain was in the 6th week for all the treatments, the gains for low, medium and high density groups were 306, 302 and 290 g respectively. In the 7th week there was a downward deflection in weight gain for all the treatments. In the 8th week, the weight gain improved in low and medium density groups but in the high density group it was equal to the 7th week. The birds grown on low density pens had the highest weight gain. The birds on medium and high density treatments had a slightly better weight at 5th week of age but the difference between the treatments widened as age progressed, with the bird on low density treatment returning higher weights.

The mean weekly feed consumption from 4th to the 8th week are given in Table XIV(a) the analysis of variance in Table XIV (b) and the graphic representation in Figure 4.

Table XIII(a). Mean weekly body weights and weekly gain in g Experiment II.

Week	Low density 1114 cm^2/bird		Medium density 929 cm^2/bird		High density 743 cm^2/bird	
	Body wt.(g)	gain (g)	body wt.(g)	gain(g)	body wt.(g)	gain (g)
IV	530		529		529	
V	793	263	788	259	789	260
VI	1099	306	1090	302	1079	290
VII	1368	269	1355	265	1334	255
VIII	1656	283	1631	276	1589	255

Table XIII(b). Analysis of variance for weekly gains Experiment II.

Source	df	SS	MSS	F
Replicate	1	87.95	87.95	0.840
Treatment	2	1081.575	540.787	5.16 *
Week	3	5910.866	1970.288	18.831
Error	17	1778.709	104.629	
Total	23	8859.1		

* Significant (P ∠ 0.05)

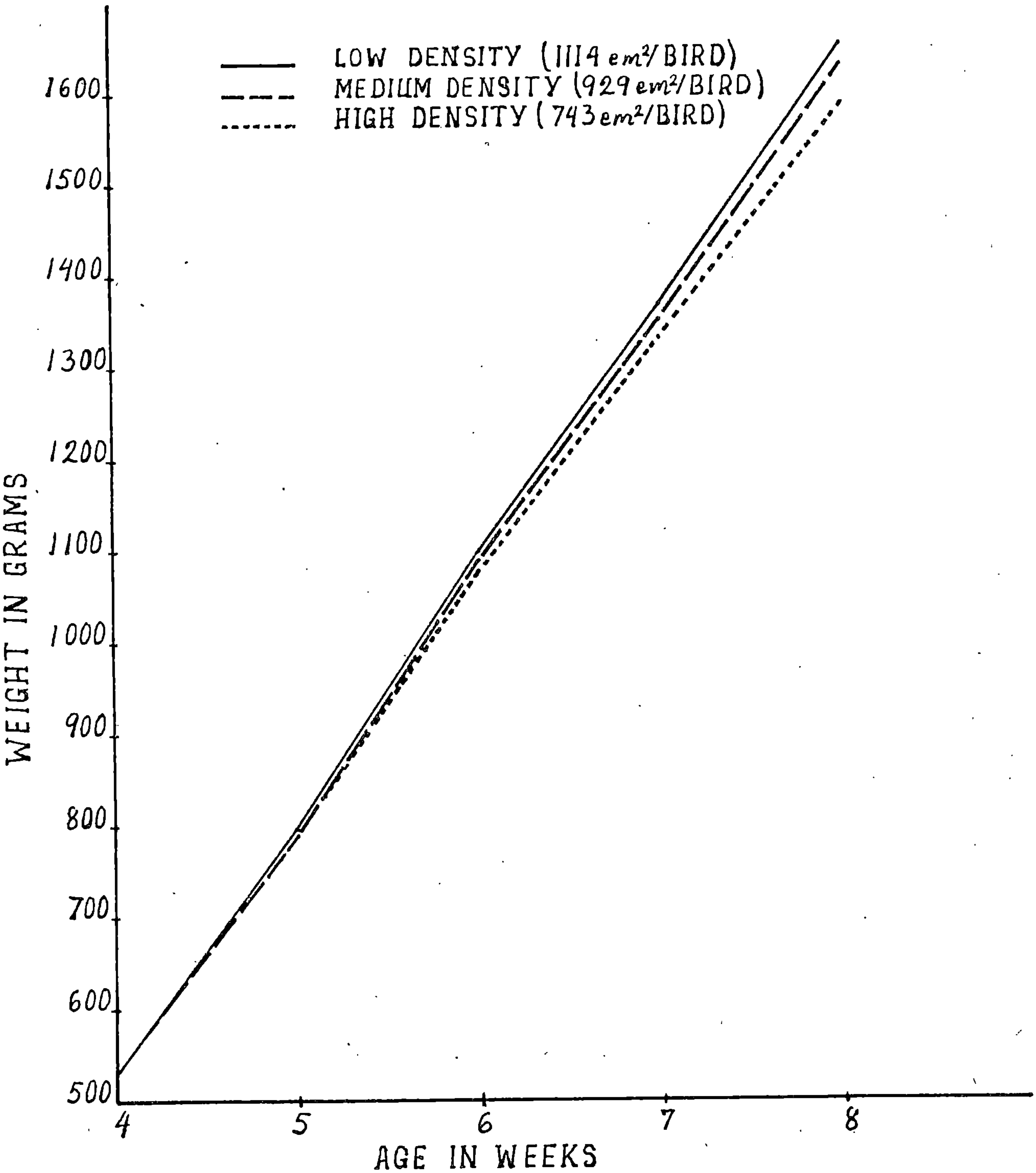

FIG.3 GROWTH PATTERN OF BROILERS

• EXPERIMENT 2 •

Table XIV(a). Mean weekly feed consumption (g/bird/week) Experiment II

Week	Low density 1114 cm^2/bird	Medium density 929 cm^2/bird	High density 743 cm^2/bird
0-IV	980	980	980
V	601	603	603
VI	738	723	730
VII	752	775	749
VIII	977	916	878
Cumulative Total	4048	3997	3940

(0 - 4 weeks feed consumption is the average of all birds brooded together before allotment)

Table XIV(b). Analysis of variance for weekly feed consumption Experiment II

Source	df	SS	MSS	F
Replicate	1	0.2244	0.2244	
Treatment	2	3537.45	1768.72	2.03 NS
Week	2	59886.78	29943.39	34.43
Error	12	10435.33	869.61	
Total	17	73859.78		

NS = Not Significant.

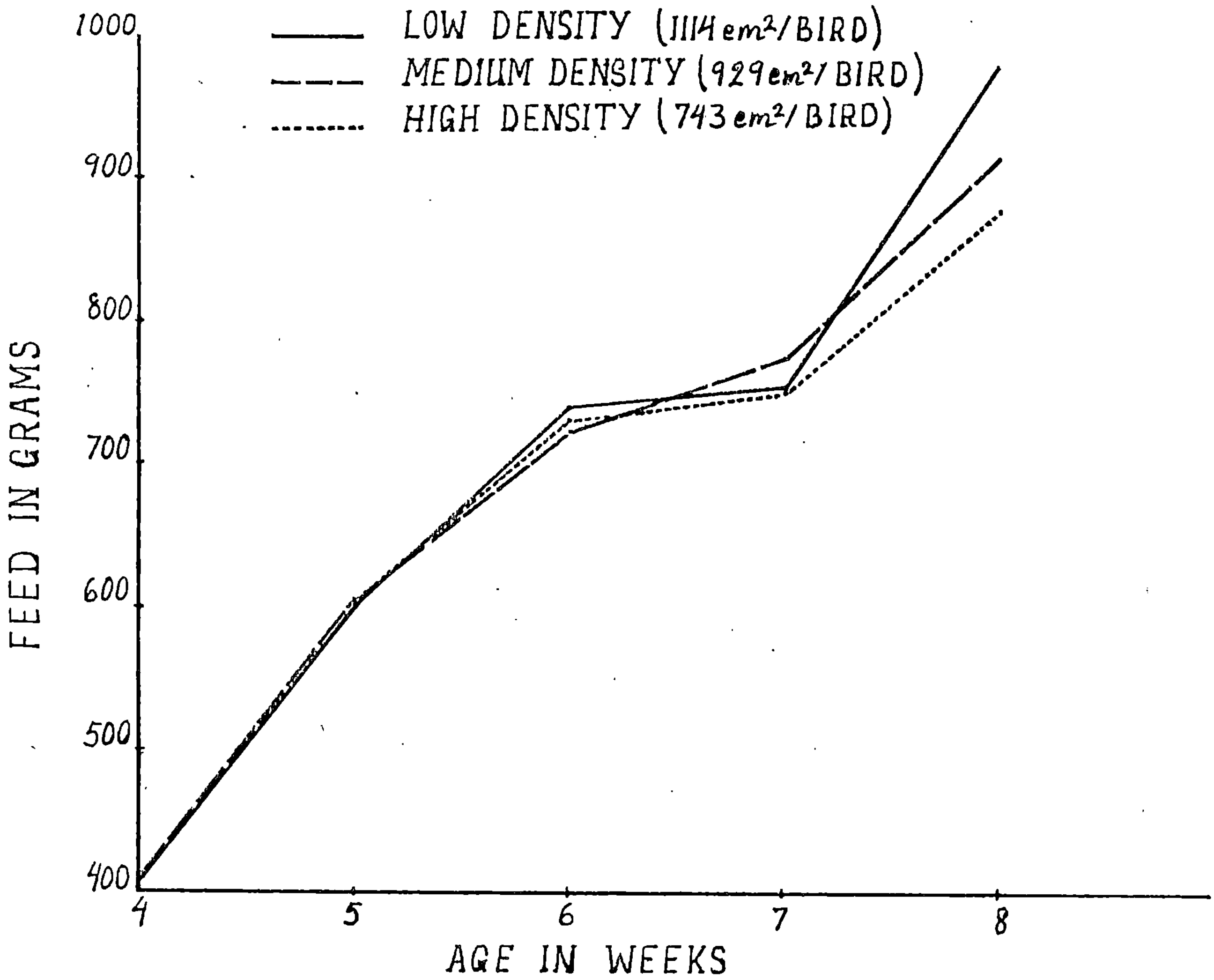

FIG.4 THE MEAN WEEKLY FEED CONSUMPTION OF BROILERS (g/bird/week) EXPERIMENT 2

The feed consumption rates tend to show more or less the same trend with only slight difference till the 7th week. During the 8th week, feed consumption varied in a wider range. The low, medium and high densities had the highest, medium and lowest feed consumption rates during the 8th week. The maximum feed consumption was observed during the 8th week for all the treatments. The feed consumption during the 5th week was a little higher for medium and high density groups than the low density group. In the 6th week the low density group consumed more than high density followed by the medium density group. But in the 7th week the medium density group consumed more feed than the other two treatments, which though slightly different did not reflect statistically significant differences.

The ready-to-cook yields at 8th week of age are presented in Table VI and the pooled analysis of variance for Experiment I and II is presented in Table VII. The per cent ready-to-cook yields for low, medium and high density groups were 72.25, 72.14 and 72.55 respectively. No significant differences were observed in the dressed yields of broilers reared on different density treatments. The results on carcass yields indicated that birds reared on floor space of 1114,929 and 743 sq. cm per bird did not affect the carcass yields, during the monsoon season. There was no mortality from 4th to the 8th week of age.

The moisture content of the litter at the end of 8th week is given in Table X and the pooled analysis of variance for Experiment I and II for the factor in Table XI. The percentage of litter moisture content for low, medium and high density groups were 32.55, 40.99, and 43.23 respectively. Significant differences ($P \angle 0.05$) were observed between all the three different treatments.

Comparison between Experiment I & II

Since Experiment I and Experiment II were conducted during two distinct seasons of the year, a comparison was made pooling the data for ascertaining the seasonal effects on performance results. The analysis of variance for growth is presented in Table XV. The mean 8th week body weights registered for the treatment groups were 1054, 1014, and 1013 g respectively for low, medium and high densities during summer, and the mean 8th week body weights registered for the treatment groups during monsoon season were 1656, 1631, and 1589 g respectively for low, medium and high densities.

The monsoon season crop had shown significantly higher growth ($P \angle 0.01$) than summer season. From 4th to the 8th week, the monsoon season birds were higher in body weight gain in all the different treatments. The body weight difference

Table XV. Pooled data analysis of variance for growth rate Experiment I and II.

Source	df	SS	MSS
Season	1	147491.51	147491.51 **
Week	3	7087.30	2362.42 *
Treatment	2	150 2.42	751.21 *
Season x week	3	1916.44	638.81 *
Season x treatment	2	217.90	108.75
Treatment x week	6	3061.68	510.28
Error	30	6395.94	213.20
Total	47	167673.18	

** Highly significant (P ∠ 0.01)
* Significant (P ∠ 0.05)

between the two seasons for low, medium and high densities at 8th week were 602, 617 and 576 g respectively. The high density group (743 sq. cm/bird) and medium density group (929 sq. cm/bird) differ significantly ($P < 0.05$) from the low density (1114 sq. cm/bird) group.

Low density with a floor space of 1114 sq. cm per bird exhibited significantly higher growth than medium (929 sq. cm/bird) and high (743 sq. cm/bird) treatments in both the seasons. In summer, growth rate in 6th to the 7th week is significantly lower than that of other weeks which are homogenous. In monsoon season, growth rate in 5th to the 6th week is significantly higher than that of other weeks which are homogenous.

The pooled analysis of variance for feed consumption for Experiment I and II are given in Table XVI. The overall feed consumption during summer season for low, medium and high density groups were 3355, 3303 and 3205 g respectively and the corresponding figures for monsoon season were 4048, 3997 and 3940 g. The difference between the two seasons for low, medium and high density groups were 693, 694 and 735 g respectively. Monsoon season had shown significantly higher feed consumption than the summer season. During summer season, 5th to 6th week feed consumption was significantly higher than

Table XVI. Pooled data analysis of variance for food consumption Experiment I and II.

Source	df	SS	MSS
Season	1	9408.99	9408.99 **
Week	2	33378.72	16689.36 **
Season x week	2	122700.17	61350.08 **
Treatment	2	4354.59	2177.30 *
Season x Treatment	2	511.18	255.60
Treatment x week	4	10354.78	2588.70 *
Error	22	9489.66	431.35
Total	35	190197.89	

** Highly significant (P ∠ 0.01)
* Significant (P ∠ 0.05)

other weeks, and 7th to 8th week consumption was very low. In monsoon season, there was significant difference between all the weeks, 7th to 8th week showed highest consumption, and 6th to 7th week the lowest.

During summer season, low and medium density groups feed consumption was homogenous but significantly different from high density group, which returned the lowest feed consumption. During monsoon season, significant difference between low, medium and high density groups were observed, low density registering highest feed consumption and the high density the lowest consumption.

The ready-to-cook yield percentages between seasons differed highly significantly. Percentages for summer season were 69.49, 69.12 and 68.71 for low, medium and high density groups respectively, while the corresponding figures were 72.25, 72.14 and 72.59 during the monsoon season (Table VI and VII).

The litter moisture content were 21.70, 29.67 and 32.52 per cent for summer for the low, medium and high density groups respectively. The corresponding respective figures for the monsoon season were 32.55, 40.99 and 43.23 per cent. There existed highly significant ($P \angle 0.01$) difference between seasons (Table X and XI).

Discussion

DISCUSSION

Experiment I

Season

The climatic variables indicatedthat the period of April May can be classed as warm and relatively humid. Thermal environment existing during this periodwas not conducive for poultry as indicated by the ambient temperature and the high humidity rates. The optimum thermal zone recommended for better production for broiler is in the range of 18 and 24.0°C (H.M.S.O. 1976). Since the ambient temperature during the periodwas consistently much above the upper limit of the recommended zone, birds reared during this period experience considerable amount of thermal stress. Suitable managemental practices are indicated to improve comfort conditions when birds are reared during this period. This is consistent with the findings of Deaton et al. (1967), Deaton and Reece (1970) and Nair (1983) for this periods under tropical climates.

Growth rate

On a comparison of the 8th week body weights between the treatments, it was observed that the birds on low density treatment (1114 sq. cm/bird) returned numerically better weights than the medium density (929 sq. cm/bird) and the high density (743 sq. cm/bird) groups. The increased floor space allowances apparently had alleviated the environmental stress contributing to an improvement in comfort conditions. A reduction in social tension due to availability of increased dispersal facility might also have contributed for the better performance of the low density group. It would be natural that availability of floor space would reduce individual interactions paving way for stabilisation in the flock. Better performances for low density flocks were reported by Hartung (1955), Hansen and Becker (1960), Roberts et al. (1961), Hill (1971), Weaver et al. (1982), and Raj et al. (1985).

The results of this study therefore indicates a trend of better performance by birds under increased floor allowances suggesting that density reduction during summer months of a hot humid type of tropical climate improves broiler performance.

Feed consumption

A perusal of the data on the mean weekly feed consumption (g/bird/week) do not reflect statistically significant differences between treatments. But, here again, the trend of increase in feed consumption is evident corresponding to a decrease in bird density. Generally, feed consumption goes down during hot season and to conteract this voluntary anorexia, many nutritional, environmental and managemental manipulations are reported and practiced (Clark, 1981). The trend of increased feed consumption in this experiment consequent to density reduction could well be exploited as a means of maintaining better production during the hot summer months. This is in agreement with the finding of Tarrago and Puchal (1977).

Per cent ready-to-cook yield

The data on per cent ready-to-cook yield of broilers reared under low density, medium density and high density do not reflect any appreciable difference suggesting that increased floor space allowance per bird do not influence dressing yield. The carcasses were not graded and therefore, the effect of density on carcass grade could not be evaluated. It can be presumed that increased density may contribute to social strife and hence this aspect needs detailed evaluations. Hartung (1955), Roberts _et al_. (1961), Deaton _et al_. (1967), Sethuraman and Kothandaraman (1978) also reported lack of density effects on dressing yields of broilers. A perusal of the literature presents conflicting reports on the effect of density on carcass grades and there is further scope of investigation on this aspect.

Per cent mortality

From the data on the mortality percentage it is difficult to ascribe treatment effects. The per cent mortality for all the treatments are well within the standard limits. It is impossible, therefore, to attribute any link between per cent mortality and density levels as far as this experiment is concerned.

Per cent litter moisture content

The litter moisture content exhibited statistically significant difference between the three density treatments. While the low density (1114 sq. cm/bird) returned 21.7% the medium density group (929 sq. cm/bird) 29.6% and the high density group (743 sq. cm/bird) 32.5% exhibiting a direct connection between bird density levels and litter moisture content. This is quite understandable as there is considerable moisture output in the respiratory process of chicken especially in increased ambient temperatures. At temperatures above 26°C, chicken heavily resort to evaporative cooling by way of panting as the main medium for thermoregulation. As density levels increase, evaporatory moisture accumulates contributing to elevated litter moisture percentages. This observation is in agreement with the findings of Hartung (1955), Roberts et al. (1961), Mathur and Reddy (1975), Ram et al. (1976) and Stanley (1981). The results of this study is perfectly in agreement with the observations of Mathur and Reddy (1975) that at lower floor space allowances it was difficult to keep the litter in workable conditions. It is evident therefore, from the results of the study that there exists a direct relationship between litter moisture content and population density. Ram et al. (1976) also made similar observations. It is, therefore, appropriate to presume that lowering density levels would be an advantageous managemental practice to keep good litter conditions.

Experiment II

Season

This trial was conducted during the Southwest monsoon season of June - July. A perusal of the climatic variables of ambient temperature, relative humidity, precipitation and air velocity indicated that the climatic profile of the season was reasonably conducive for poultry production. The mean maximum temperature during this season varied between 27.6 and 29.6 °C, only, and the mean minimum temperature between 22.2 and 23.3 °C, thereby registering low amplitudes. The relative humidity percentage varied between 82.2 and 89.5. This season is characterised by a fair amount of precipitation registering a minimum of 3.3 mm and the maximum of 40.8 mm. This precipitation had accounted for the increased levels of relative humidity recorded during the season. The increase in the humidity percentages have been considerably off set by the decrease in the ambient temperature from the point of view of bird comfort.

Growth rate

The respective 8th week body weight registered by broilers in this trial were 1656, 1631, 1539 g for the low density (1114 sq. cm/bird) medium density (929 sq.cm/bird) and high density (743 sq.cm/bird) treatments. The different density treatments differed significantly ($P < 0.05$) between them denoting density influence on body weight gains. Body weight gains exhibited improvements consequent to a decrease in density levels. A depression in growth rate and better growth performance consequent to an increase and decrease respectively in density levels has been reported by Srinivasan (1968), Andrews and Goodwin (1969), Deaton et al. (1970), Hill et al. (1971) Bolton et al. (1972), Weaver et al. (1982) though Chrappa et al. (1982) did not observe any significant difference between densities. From the results of this experiment it could be concluded that decrease in density levels contribute to better growth performances.

Feed consumption

The mean weekly feed consumption for this experiment did not reflect significant differences. The trend of increased feed consumption could be observed consequent to a decrease in bird density. The differences reflected on feed consumption between the density treatments followed the same trend for both the experiments. It can be presumed, therefore, that density levels tried in this study do not significantly affect feed consumption per se.

Per cent ready-to-cook yield

Per cent ready-to-cook yield between treatments did not reflect significant differences, though the percentages were higher in this experiment compared to the earlier experiment. Since both the experiments did not reflect differences between treatments, it could be presumed that density levels do not have any influence on ready-to-cook percentages. Sethuraman and Kothandaraman (1978) also reported lack of effect of density levels on broiler carcass yield. Many workers had reported density effects on carcass grades (Hartung 1955, Roberts et al. 1961, Deaton et al. 1967, Weaver et al. 1973). The effects of density levels on carcass grades and on condemnation were not evaluated in the study since effort was made on the quantum aspect only.

Per cent litter moisture content

Per cent litter moisture content between treatments significantly differed ($P < 0.05$) in this experiment. Low density treatment (1114 sq. cm/bird) had the lowest litter moisture percentage of 32.55, the medium density treatment (929 sq. cm/bird) had the next higher percentage of 40.99 and the high density (743 sq.cm/bird) group returned the maximum percentage of 43.23. The difference between treatments reflects significant effect of density levels on litter moisture content. As bird density increased, litter moisture also increased thereby constituting a serious health hazard for broilers as moist litter is always a fertile breeding ground for pathogenic organisms. Mathur and Reddy (1975), Ram et al. (1976) and Stanley (1981) had also reported increase in litter moisture consequent to increased density levels. This is to be expected as the number of birds increased per unit of floor space, there will be increased moisture output per unit of litter space by way of droppings and repiratory moisture output. This finding have, added importance specially in humid tropical climates. Density reduction, therefore, could be practiced as a managemental measure to keep down litter moisture content, thus maintaining better hygienic conditions in poultry houses.

Comparison between Experiment I & II.

The two experiments were conducted in two distinct seasons in a tropical monsoon type of climate as prevalent in Kerala. The experiments were identical in all respects but for the season. Experiment I was conducted during the warm season of April - May and Experiment II during the monsoon season of June - July. Since the climatic variables of both the seasons show distinct variations, it would be worthwhile to ascertain how much season had influenced the performance of broilers under the various density levels tried.

An evaluation of the climatic data of the two seasons indicatedthat the ambient temperature and relative humidity per cent exhibited considerable variations between the seasons.

The first season (Experiment I, April - May) recorded a mean maximum ambient temperature of 34 °C and the mean minimum of 25.35 °C the mean relative humidity per cent of 72.1, a total precipitation rate of 8.01 mm and a mean air velocity of 6.17 kmph during the period of the experiment. The mean figures registered during the second season (Experiment II, June - July) for the above variables were 28.55, 22.73 °C, 85.05 per cent, 204.7 mm and 5.37 kmph respectively. The range of temperature difference exhibited between season I and II, is 5.45 °C, whereas the first season registered a relative humidity percentage of 72.1, the second season registered 12.9% higher. There was scant precipitation (8.01 mm) only in the first season whereas in the second season had 204. 7 mm of rainfall. There was only a difference of 0.8 kmph in the air velocity between the first and the second season. Birds depend upon evaporative cooling as the main means of thermoregulation beyond 26 °C and as the ambient temperature increases further the dependency on this means becomes heavier and critical. Density levels become an important factor at this stage, as the density increases water moisture output along with sensible heat loss would make the microenvironment highly stressful. Deaton et al. (1970) observed similar trends. A reduction in environmental temperature by a few degrees would go a long way in easing the situation. The lower temperature existing during the second season as a result of the increased precipitation would have contributed in making the season more conducive for birds.

A comparison of the performance of broilers between the two seasons showed that the birds in the second season had attained better growth rates and final body weights irrespective of the treatments. In the first season, the final body weights returned by the low density, medium density and high density treatment groups were 1054, 1014, 1013 g respectively, whereas the figures were 1656, 1631, 1589 g for the corresponding treatment groups during the second season. The difference exhibited between seasons is highly significant ($P < 0.01$). This clearly shows that the highly significant better performance exhibited by the birds in the second experiment is to a large measure attributable to seasonal influence. This finding is in agreement with the findings of Roberts et al. (1961), who observed better performances for birds during the cooler months on all the density levels tried. Deaton et al. (1970) and Parkhurst et al. (1977) and Jastrzebski (1972) also could observe definite positive seasonal effects on body weights.

A comparison of the data on feed consumption between the experiments revealed highly significant difference ($P < 0.01$) between seasons. The birds under different levels of density treatments during the second season consumed significantly more feed than those in the corresponding treatments in the first season indicating a marked seasonal effect. This is consistent with the findings of Hill (1971), Dorminey et al. (1972), Bolton *et al.* (1972), Hinners *et al.* (1975), while Mathur and Reddy (1975), Ram *et al.* (1976) found no significant differences in feed utilisation due to density levels. Speaking in terms of feed efficiency it is an accepted scientific fact that reduced feed consumption and increased feed efficiency goes together. But standard broiler outputs is accompanied by optimum feed consumption. The results of the experiments clearly indicate that a conducive thermal environment does stimulate feed consumption thereby contributing to better performance. It could, therefore, be presumed that the monsoon season does stimulate increased feed consumption and decreased density levels also do contribute to an increase in feed consumption.

The data on mortality percentages do not throw any light on the effect of season on treatment, while there were a few mortalities in the first experiment, there were none in the second experiment. The absence of mortality in the second experiment do not indicate any specific effect attributable to any factor. Even though the litter condition was much worse in the second experiment than the first, the lack of mortality in this experiment can only be considered as a chance occurrence. Since the mortality per cent in the first experiment is within reasonable limits, it could be assumed that there is hardly any effect attributable to treatment or season on this factor.

The analysis of variance of mortality data reveals highly significant effect of season on the percentage, but no cognizance need be taken of this as this is only a mathematical quantumisation of the presence or absence of a reasonably normal biological occurrence. The effect of the first and second season on litter moisture content presents interesting findings. The per cent litter moisture content differs significantly ($P < 0.05$) between treatments and highly significantly ($P < 0.01$) between seasons.

In the first experiment during Season I, low density, medium density and high density treatments had litter moisture contents of 21.7, 29.67, 32.52 per cent respectively and the corresponding figures for treatments in the second experiment during Season II were 32.55, 40.99 and 43.25 per cent respectively indicating highly significant ($P < 0.01$) differences. A comparison of the treatments between experiments I and II reveals that the low density treatment of Experiment II had 10.8 per cent more moisture than the same treatment of Experiment I, the medium density group of experiment II had 11.3 per cent higher moisture content than the corresponding treatment of the experiment I and high density group had 10.7 per cent more of litter moisture content than the corresponding treatment group of Experiment I.

A close perusal of these figures gives the indication that roughly 10 per cent increase in litter moisture can be expected during the monsoon season than in the dry season. It is also found that as density levels increased, there is proportionate increase in litter moisture content. The findings on litter moisture contents are in agreement with Mathur and Reddy (1975), Ram et al. (1976) and Stanley (1981). Hartung (1955), Siegel and Coles (1958), Roberts et al. (1961) had also observed earlier that moisture in the litter decreased consequent to a decrease in bird density. This finding will be useful in poultry litter management in humid climates.

The per cent ready-to-cook yield between seasons exhibited highly significant differences, whereas between treatments there were no significant difference, clearly indicating a marked seasonal effect. It is not possible to reason out this effect precisely but could be presumed that the higher edible yield may be a consequence of the overall better performances of the birds in the second season. It may be recalled here that the 8th week body weights were markedly high in the second experiment than the first. The lack of any treatment effect on this factor also points to the fact that better carcass yields reflected in Experiment II are due to the generally improved body weights of the birds in this experiment.

Summary

SUMMARY

Two experiments were conducted during the summer (April - May) and monsoon (June - July) seasons to study the effects of bird density on broiler performance. Three density levels of 1114, 929, and 743 sq cm per bird were tried involving a total number of 1009 commercial broilers. The experiments were identical in all respects except for season.

Perusal of the climatic data of the first experiment revealed that ambient temperature was well above the recommended range for better broiler performance. Performance data indicated that birds on low density treatments (1114 sq cm/bird) had higher body weight gains though the difference between treatments were not statistically significant. The feed consumption, per cent ready-to-cook yields and per cent mortality did not exhibit statistically significant difference between the density treatments. The per cent litter moisture did differ significantly ($P < 0.05$) between the three density treatments, the upward gradation sequence being Low, Medium and High density groups in that order.

The climatic data of the second experiment reflected a reduced temperature and slightly higher humidity levels. The data on body weight gains between treatments exhibited statistically significant ($P < 0.05$) differences. The upward

gradation in body weight gains being High, Medium and Low density treatments in that order. The high density treatment group had the lowest weight gain compared to the medium and low density groups. There existed no significant difference in feed consumption between treatments. However, a trend towards decreased feed consumption as population density increased, was evident. Per cent ready-to-cook yield did not reflect statistical significance. Per cent litter moisture content exhibited statistically significant ($P \angle 0.05$) differences between treatments.

A comparison of the data between experiments revealed that the climatic profile was more hostile during the first experiment. The monsoon season reared birds in the second experiment returned significantly ($P \angle 0.05$) better body weights in all treatments. Feed consumption data between the experiments were statistically significant ($P \angle 0.01$). The birds in the second experiment consumed significantly more feed than those in the first experiment. Data on mortality percentages did not reveal any seasonal effect. While there were a few mortalities in the first experiment, there were none in the second experiment. The mortality in the first experiment were due to usual causes and within limits. The per cent litter moisture content between the experiments revealed highly significant ($P \angle 0.01$) differences. Approximately 10% increase in litter moisture content was noticed in the second experiment (monsoon season) for all treatment groups compared to the first experiment (summer season). Per cent ready-to-cook yield also exhibited highly significant differences ($P \angle 0.01$) between seasons.

CONCLUSIONS

1. Summer season (April - May) presents a hostile climatic profile for broilers when compared to the monsoon season (June - July).

2. Broilers perform better with increased floor space allowance of 1114 sq cm/bird during both seasons. While 929 sq cm/bird seems to be optimum for monsoon season, 1114 sq/bird is indicated for warm periods.

3. Broilers reared during monsoon season (June - July) perform significantly better than those reared during summer (April - May). Applying methods to alleviate thermal stress during summer could improve performance. Controlled studies are indicated on this aspect.

4. Feed consumption is not materially affected by bird density, but birds reared during monsoon season tends to consume more feed.

5. Litter moisture content and density levels are directly related. Litter moisture per cent increases, as density levels increase. Approximately 10 - 15 per cent more litter moisture could be expected during monsoon season independent of bird density.

6. Density levels do not influence ready-to-cook yields. Distinct seasonal effects on yields could be expected. Yield improves during monsoon season. Controlled studies are indicated to ascertain density effects on broiler carcass grades and condemnations.

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EFFECTS OF BIRD DENSITY ON BROILER PERFORMANCE

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ABSTRACT OF A THESIS

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ABSTRACT

Two experiments were conducted during summer (April - May) and monsoon (June - July) seasons, to study the effects of bird density on broiler performance. Three density levels of 1114, 929 and 743 sq cm/bird were tried. The experiments were identical in all respects except for season.

The climatic variables during the first experiment was not favourable when compared to the second experiment. Data on weight gain revealed no significant difference between the three treatments. However, broilers reared with a floor space allowance of 1114 sq cm/bird had higher final body weight. The feed consumption, ready-to-cook yields and per cent mortality did not exhibit statistically significant differences between the density treatments. The per cent litter moisture did differ significantly ($P \angle 0.05$) between the three density treatments. The high density group had the highest followed by medium and then low density treatment.

The climatic variables during the second experiment reflected of more comfortable conditions for the birds. Data on body weight gains between treatments exhibited statistically significant ($P \angle 0.05$) differences. The low density group had the highest weight gains followed by medium density group. The high

density group had the lowest weight gain. There was no significant difference in feed consumption between treatments. Per cent ready-to-cook yield did not differ significantly. Per cent litter moisture content exhibited statistically significant (P/_0.05) difference between treatments.

Data on weight gain and feed consumption between the two experiments revealed statistically significant difference. The monsoon reared birds gained higher body weight and consumed more feed in all treatments. Mortality percentages did not reveal any seasonal effect. Approximately there was an increase of 10% litter moisture in monsoon season for all the treatment groups. Per cent ready-to-cook yield revealed statistically significant difference between the two seasons.