THE PERFORMANCE OF COBB 500 BROILERS UNDER VARYING STOCKING DENSITIES

BY

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A RESEARCH REPORT SUBMITTED TO THE SCHOOL OF AGRICULTURAL SCIENCES OF THE UNIVERSITY OF ZAMBIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF AGRICULTURAL SCIENCES

BY

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DECLARATION

THIS THESIS HAS BEEN COMPOSED OUT OF TREMENDOUS INTEREST IN POULTRY AND A LOT OF PRAYER AND HARDWORK. THE WORK IN RECORD HAS BEEN DONE BY MYSELF AND ALL SOURCES OF INFORMATION HAVE BEEN ACKNOWLEDGED.

Mwaka Kayula 2004

ABSTRACT

An experiment using a Completely Randomised Design with four treatments and four replications per treatment was conducted to determine the performance of the Cobb 500 strain of broilers under varying stocking densities (6 , 9, 12 and 15 birds/m^2). The experiment was conducted over a period of 42 days using 168 non-sexed Cobb 500 broilers fed *ad libitum*. Stocking densities were the treatments.

An analysis of variance was used to analyse for the differences in live body weights, weight gain and feed conversion efficiency.

The results showed that there were no significant differences (P>0.05) in average daily gain. The values at 42 days were 55.3, 54.2, 53.5 and 53.1g/day for 6, 9, 12 and 15 birds/m^2, respectively. The feed conversion ratios for the four treatments were not different (P>0.05). Their values were: 1.99, 2.01, 2.02 and 2.03; and the daily feed consumption per bird was not different (P>0.05) at 42 days for all the stocking densities.

These results showed that the stocking density of 15 birds/m^2 is not high enough to cause detrimental effects on the broilers and farmers could stock 15 birds/m^2 for maximum biomass productivity and efficient use of the space available

Key words: Stocking density, live body weight, Biomass productivity, feed consumption, feed conversion ratio.

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DEDICATION

This work is dedicated to my mum and late Dad for the support and encouragement they gave me.

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1.0 INTRODUCTION

1.1 GENERAL

Carbohydrates, proteins, lipids, vitamins and minerals are the food categories that a balanced diet is comprised of. These food constituents are required by the body in the right proportions for healthy growth and development of human beings. Lack of any of these food categories leads to a condition called malnutrition (Chimbanga, 2002).

Protein-rich foods are very expensive and very few people are able to afford them. This makes proteins to be the most limiting nutrient requirement to the majority of the population in Zambia. Sources of protein can be of vegetable or animals origin. Vegetable sources of protein include beans while animal sources include chicken, beef, fish, eggs and milk, to mention but a few.

Chicken is the most popular protein source in Zambia. Traditional chickens are kept for egg as well as meat production and have been part of the Zambian diet for a long time. These chickens require low levels of management and are sources of animal protein. Advances in improving chicken products have resulted in the development of chickens specifically meant for egg or meat production (layers and broilers, respectively) and these require high levels of management.

Zambia has not been left behind in the major advances that have been made world over in improving the products obtained from chicken. In recent years, there has been an increase in hatchery establishments and this has prompted many Zambians to go into poultry production. The poultry industry, if improved, can be a major contributor to the livestock input into the Gross Domestic Product (GDP). At the moment, the livestock industry accounts for 30% of the agriculture industry's contribution to GDP (Ministry of Finance, 2001).

Broiler performance is considerably influenced by genetics, management, nutrition and health. The management factors include: stocking density, temperature control, ventilation, disease control, litter management, lighting control and vaccination. This report endeavours to discuss stocking density as a management factor that can limit the production of Cobb 500 strain of broiler birds.

Stocking density is used as a management tool in the production of good quality meat. Broiler growers rationalize on space so that more profit may be realised per unit area. They base their calculation of stocking density on monetary gain, that is, net returns per unit of floor area rather than per bird started. Provision of adequate floor space for each bird is essential to its growth, health, quality and general well-being. The amount of space to allow is determined by a combination of factors - the weight of the bird at killing age, type of housing, climatic region and time of the year. It is therefore essential to know the exact internal dimension of all houses when deciding their capacity for broiler production (Cobb 500 Handbook, 2000). Overcrowding can only be economically beneficial if high stocking densities do not pose a detrimental effect on the performance of the birds.

Increasing the number of broilers in a given space is a management technique used to reduce costs associated with labour, housing, fuel and equipment. Excessive crowding of broilers can lead to reductions in performance (Shanawany, 1988). Estimates of the correlation of profit potential to increasing stocking density in broilers can be affected either positively or negatively, depending on whether equations are based on a per bird or space per bird basis (Proudfoot, 1973).

Estimates of space requirements for domestic poultry are only a question of production responses and profit to many farmers. Increasing public concern over treatment of domestic species like poultry and the position of animal welfare should be an important issue in the future of animal agriculture and research. It is vital that a larger base of information defining relationships between practical production optimization and animal welfare be available to address such concerns.

The Cobb 500 has a potential productivity of 2.3 kg live weight and a feed conversion ration of 2.0 at 6 weeks if well managed (Cobb 500 Handbook, 2000). When the Cobb 500 is overcrowded, it may not deliver the optimum results. For instance, Shanawany (1988) observed that body weight at 5 weeks declined in a linear manner with increased stocking density.

Overcrowding (overstocking) creates more stress which is indicated by reduced growth rate, increased mortality and culls, poor litter quality and an increase in down grades, hock-burn and breast blisters, lack of flock uniformity and poor feathering, bruising, leg defects, shin damage and poor meat quality. Overstocking increases environmental pressure on the broiler, which in turn reduces profitability. If the stocking density is to be increased, an appropriate increase in feeding and drinking space must be provided and extra care must be taken to maintain the quality of litter and air.

This experiment was conducted to study the performance of the Cobb 500 broilers in terms of live weights, weight gain, feed consumption and feed conversion ratio (FCR) under varying stocking densities under the Zambian conditions. The performances of the Cobb 500 broilers raised at the stocking densities of 6, 9, 12 and 15 birds/m2 were compared to establish the optimum stocking density for the strain. The effects of four varying stocking densities on body weight, weight gain and feed conversion ratio were also compared.

1.2 STATEMENT OF THE PROBLEM

The Cobb 500, being a newly introduced strain in Zambia, has had no research done on it to determine its adaptability to the Zambian conditions. Despite its reported high growth rate, no research has been done to determine the effect of stocking density on its performance under the Zambian conditions. It was therefore, imperative that a research be done to determine the effect of different stocking densities of the Cobb 500 broiler strain on its performance

2.0 LITERATURE REVIEW

The optimum number of growing Cobb 500 broilers per unit floor area range from 18 to 22 birds/m^2 for caged birds while the recommended open housing stocking density is 9-12 birds/m^2 (Unknown, 2000). The 9 birds/m^2 is meant for winter or the cool season, while the 12 birds/m^2 is meant for the hot season or summer (Unknown, 2000).

2.1 Body weight

Bolton *et al* (1972) reported that increasing stocking density results in a reduction in body weight gain over a range of 10-27 birds/m^2. At the intermediate stocking densities of 0.07 and 0.09 m^2 per bird (14.28 and 11 birds/m^2), findings of Proudfoot (1973), Buckland *et al.* (1971) and Parkhurst *et al.* (1977) indicated that body weight of 1.770 and 1.852 kg were similar between highest and lowest densities (25 and 9 birds/m^2). This observation is not in agreement with the findings of Shanawany (1988) which indicated that body weight at 5 weeks declined in a linear manner with increased stocking density. Findings of Weaver *et al.* (1973) indicated that there was a significant improvement in body weight of birds housed at 0.09m^2 (11 birds/m^2) per bird as compared to those housed at 0.04m^2 per bird (25 birds/m^2). Findings of Bolton *et al.* (1972) stated that "in broiler experiments ending at eight weeks, a space allowance of 12.8 birds/m^2 is more than adequate

Findings of Proudfoot *et al.* (1979) suggested that there was a linear increase in body weight with decreasing stocking density at seven weeks. These findings were similar to his earlier findings (Proudfoot, 1973) and those of "Wisman *et al.* (1961) which indicated that high bird stocking densities had a more pronounced detrimental effect (reduced body weight) on body weight.

2.2 Environmental Aspects of Stocking Density

One of the most important consequences of increasing density is the environmental change that occurs within the chicken house. Quinones et al., (1984), Balaji *et al.*, (1976) and Kaitazov, (1976) reported in their findings that an increase in density usually results in corresponding increases in temperature, humidity, carbon dioxide (CO_2), and ammonia (NH_3) levels. High ammonia levels (over 25 to 50 ppm) reduce growth and increase the incidence of breast blisters, hock burns, and foot pad dermatitis (Proudfoot, 1979).

However, the magnitude of the effect of density depends on technical factors (e.g. quality of ventilation and cooling systems) as well as management factors (e.g. litter condition and light programs) (Proudfoot, 1979). This means that increasing the number in a well prepared house can cause fewer negative effects than an increase of similar increment in an out-of-date building with poor technical conditions.

2.3 Social and Aggressive Behaviour

Chickens have a very complex social behaviour. When the birds are maintained in small groups they will usually form a stable "peck order" (or hierarchy) among themselves. The highest number of birds that can maintain a stable hierarchy is unknown, but it seems to be somewhere between 20 and 100 chickens. If the peck order system is established, some chickens will be dominants and others will be subordinates; sometimes organized in a perfect linear dominance hierarchy (Polanco and Lopez, 1984).

Dominants have priority of access to feed and water and nearly all other resources (including mates if they are in mixed mature groups). Although subordinates will have to wait for access to resources, the benefit they receive from this social system is a dramatic reduction in aggressive interaction (Polanco and Lopez, 1984).

However, when dealing with large numbers of birds it seems that the establishment of such a peck order is impossible, because it seems that the birds are incapable of individually recognizing every member of the group (required for establishing a peck order). When this happens, conflict or "social tension" is created. As a consequence, dominant chickens will monopolize access to resources, while subordinates cannot obtain access to food or water. This has been the traditional scientific explanation for the reduction in performance seen with increasing densities (Polanco and Lopez, 1984).

2.4 Chicken movement

Movement patterns of chickens have a big influence on the consumption of feed and water and thus might affect the bird's subsequent health and meat quality. Distances traveled by the chickens over the course of one day considerably exceed movements required to simply reach the feed and water, although there is a large variation in locomotion patterns between individual chickens (Guhl, 1958 and Yule, 1974).

Of all the factors that affect the movements of chickens within the house, the age of the birds is very important to consider, especially when the birds are kept at high densities. As age increases (or as they gain weight) the birds move less for shorter distances and spend less time in activities such as pecking or scratching in the litter, which are important for body maintenance (Kruijt, 1964 and Rao *et al.*, 1977).

The research findings cited in the foregoing discussion provide ample evidence to suggest that, although the recommended stocking density of 9 birds/m^2 produces optimal results of 2.3 live body weight and feed conversion ratio of 2.0, the effect of stocking densities in the range of 15 birds/m^2 is not known under Zambian conditions. An experiment therefore was set up to study the effect of different stocking densities (6, 9, 12 and 15 birds/m^2) on growing Cobb 500 broilers fed *ad libitum*.

3.0 JUSTIFICATION

Primarily, stocking density is dictated by balancing economic benefits and performance of the birds. Birds grown under lower stocking densities usually have the best performance, though this does not always translate into higher profits.

High stocking densities with age reduce feed intake per bird. The reduced feed intake is attributed to the reduced drinking and feeding space and increased feed wastage because of competition. This consequently reduces body weight gain.

The stocking density of 9-12 birds/m^2 is recommended for the temperate regions and controlled environments. This stocking density has however, been adopted in Zambia without prior research being done to assess the performance under the Zambian environment. This experiment assessed the performance of Cobb 500 broilers under varying stocking densities in relation to the Zambian environment. The information derived from this study is intended to benefit the poultry farmers at large.

4.0 MATERIALS AND METHODS

4.1 MATERIALS

4.1.1 Birds

A batch of 168 unsexed Cobb 500 broiler chicks were obtained from Hybrid Poultry Farm (Lusaka) and used in an experiment to study the effect of varying stocking densities on feed intake, feed conversion ratio, growth rate and live weights at 6 weeks. Different numbers of chicks were allocated to 16 units at random; the units being the same in their floor area ($1m^2$) to provide stocking densities of 6, 9, 12 and 15 birds/m^2. Each treatment (stocking density) was replicated four times. A Completely Randomised Design (CRD) was used and the experiment was run for 42 days.

4.1.2 Diet

The treatments were subjected to the same feeding regime, the 3-phase feeding regime (starter, grower, and finisher). Feed and water were provided *ad libitum*. The chicks were offered broiler starter mash for the first three weeks, followed by grower mash for one week. Broiler finisher diet, in the form of mash, was fed during the last two weeks (week five and six). The feeds used in the experiment were obtained from Tiger Animal Feeds, Zambia Limited in Lusaka.

4.1.3 Housing

The birds were grown in 16 units each of area 1m^2, excluding the feeding and drinking space, under a deep litter floor system of sawdust. The experiment was conducted during the months of September and October in the year 2003. Each unit had an infra red lamp as the source of heat which was removed at the end of brooding (end of the third week). Two bulbs (240volts, 24 watts) were used for lighting the room in which the 16 units were located. In the first week, feeder trays and bell-type drinkers were used. Each unit was then supplied with a 5 litre conical drinker and a feeder from the second week until the end of the rearing period.

4.1.4 General Management

General bird management was followed in the rearing of the birds and this included vaccinating the birds against Gumboro on the 14th day and New Castle on the 21st day. Vitamins and minerals were supplied to the birds each time major handling of the birds was done (i.e. at vaccinating and weighing the birds), and when changing the feed type. This was to lessen the effects of introduced stresses. Litter was turned every week and wet litter was replaced with dry litter. Clean and fresh water was provided to the birds all the time and drinkers were refilled throughout the period. Feed was provided on trays in the first week and thereafter in feeders up to the end of the experiment.

During the period of rearing, there were many challenges. The footbath had cracks so there was seepage of its contents into the ground. A basin was used instead and this is not a recommended Bio-security measure. In the fifth week, there was an outbreak of Gumboro. The outbreak was attributed to the improper storage of the vaccine and the use of the ND 78 Clone vaccine, which has proved to be ineffective for the strain of Gumboro found in Zambia. The sharing of a weighing scale with other pens that were used for production at the field station contributed to the spread of the disease.

Another challenge was in maintaining the right temperature in the house. This was difficult as the thermometer was not working. Adjustment of windows and the infra red lamps were used for maintaining the temperature within a small range. The most important indicator for temperature adjustments were the chicks themselves. According to the Tamba Farms Production Journal (1993), if the chicks huddled together, it meant that the heat was inadequate, while if they were very scattered and huddling against the surrounding, this indicated that the heat was too much. If the temperature was right, the chicks would be evenly spread all over the house, active and consuming feed.

4.2 DATA COLLECTION

4.2.1 Body-weight

An average weight of the chicks was recorded just before they were randomly allocated to the 16 units. The birds were weighed individually every week and the average weights for the birds in each unit were recorded. The weekly weighing of the birds was done every Friday in the morning.

4.2.2 Feed consumption

The feed given to the birds was weighed and the remaining feed in the feeder after 24 hours was also weighed. The weighing of the feed was done every day at noon and feed consumed in a day was obtained as a difference between the amount given and the amount left in the feeder on the following day. To obtain daily feed intake per bird, the feed consumed in a unit per day was divided by the number of birds in that unit.

4.3 STATISTICAL ANALYSIS

Differences between treatments were established by an analysis of variance (Steel and Torrie, 1980) for a Completely Randomised Design (CRD) for an experiment with four treatments and four replications using Genstat Computer package. The analysis was in terms of the effect of the treatments (stocking densities) on live weights, growth rate, feed intake and feed conversion ratio. Least Significant Differences (LSD) was used to test the means where analysis of variance indicated significant differences.

5.0 **RESULTS AND DISCUSSION**

5.1 MORTALITY

Total mortality of 11.9% was experienced due to the outbreak of Gumboro in the fifth week. The disease was confirmed by post mortem investigations carried out at the School of Veterinary Medicine and at Hybrid Poultry Farm. This disease was attributed to the bad storage and wrong use of ND 78 Clone vaccine which is not effective for the strain of Gumboro found in Zambia (Personal communication; Bio-Security Division, Hybrid Poultry Farm, Lusaka). Weaver *et al*, (1979); Shanawany, (1988) and Parkhurst *et al.*, (1977) reported in their findings that broiler mortality is not affected by stocking density.

5.2 FEED CONSUMPTION

Feed consumption was analysed for variance. There were no differences (P>0.05) in feed intake in the second and third weeks. In the fourth, feed intake was highly significant. The difference was between treatment 4 and the rest. The difference was attributed to the invasion of the Gumboro disease which first affected birds in treatment 4.

Total feed consumption showed no differences (P>0.05) in the at the end of the 6-week period (Appendix1). At 21 days, consumption in treatments 1, 2, and 3 was similar and at 28 days (145.35, 144.99, 143.41 g per bird per day respectively), treatments 1 and 3 were similar. Treatments 2 and 4 were similar at 28 days different from treatments 1 and 3.

There were no differences among the treatments in the total feed consumption (table 1).

Table 1: Average daily feed intake (g/bird/day)

WEEK	TREATMENT			
	1	2	3	4
1	28.75^{a}	28.75^{a}	28.75^{a}	28.75^{a}
2	64.61^{b}	58.00^{b}	61.85^{b}	58.21^{b}
3	106.46^{c}	107.96^{c}	99.37^{c}	100.95^{c}
4	145.35^{d}	144.99^{d}	143.41^{d}	139.46^{e}
5	171.70^{f}	173.81^{f}	172.79^{f}	171.44^{f}
6	153.82^{g}	152.31^{g}	151.99^{g}	159.45^{g}

* The lower feed consumption in the last week in all the treatments was attributed to the birds' infection by Gumboro disease.

The feed consumption values for each treatment were not different (P>0.05) at the end of the experiment. Average daily intake was not significantly different in the all the treatments (4694.8, 4660.7, 4607.1 and 4607.8 grams). The feed intake values in the sixth week were low and this was attributed to the infection by Gumboro disease which depressed consumption.

5.3 LIVE BODY WEIGHTS

The effect of varying stocking density on body weight is presented in Table 2 below.

Table 2: The effects of stocking density on the live body weight of Cobb 500 chicks[1]

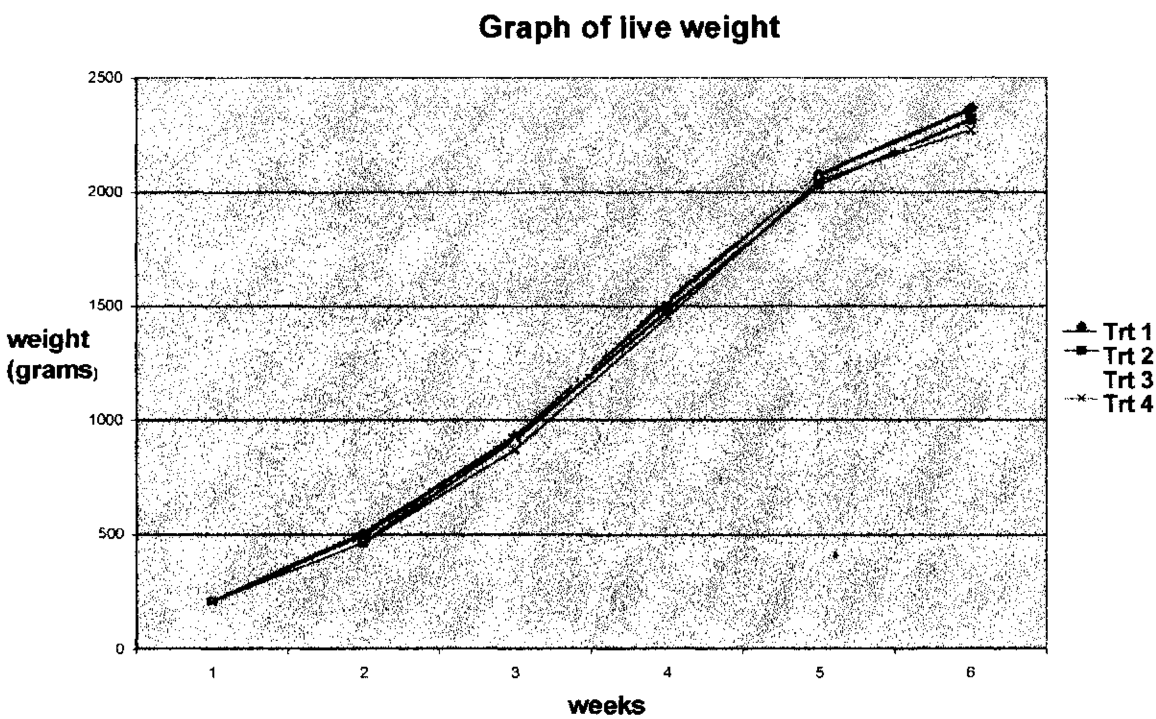
Density	Body weight (grams)			
Birds/m^2	3wks	4wks	5wks	6wks
6	925.2^a	1513^b	2057^c	2362^d
9	915.4^a	1480^b	2023^c	2316^d
12	914.2^a	1529^b	2091^c	2285^d
15	870.3^a	1451^b	2046^c	2272^d
ANOVA summary		Probability		
Source of variation		0.05		
Density				

[1]Values represent the mean of four replicates
Same superscripts represent weights which are similar

The results indicate that mean live body-weights for all the treatments were not different (P>0.05) at any point of growth (Appendix 1). At 5 weeks, body weights were similar for all the stocking densities. This observation is not in agreement with Shanawany (1988) who observed that body weight at five weeks declined in a linear manner with increased stocking density, or with Weaver *et al.* (1982), who observed that the 4-week body weight of birds stocked at 0.07m^2 per bird (14.28 birds/m^2) were significantly decreased in comparison with that of lower densities ($0.11m^2$ per bird or 9 birds/m^2). At 4 weeks, birds stocked at $0.07m^2$/bird are large in size and the large size reduces the feeding space available. This creates competition resulting in reduced feed intake which is reflected in the decreased body weights.

Shanawany (1988) suggested that body weight at six weeks depended on a curvilinear function of density, with very little difference in weight between the density rates of 0.03-$0.1m^2$ per bird (Figure 1). The results obtained in this experiment are in agreement with Shanawany (1988) curvilinear function of density.

FIGURE 1: Live weight per day vs. time



5.4 WEIGHT GAIN

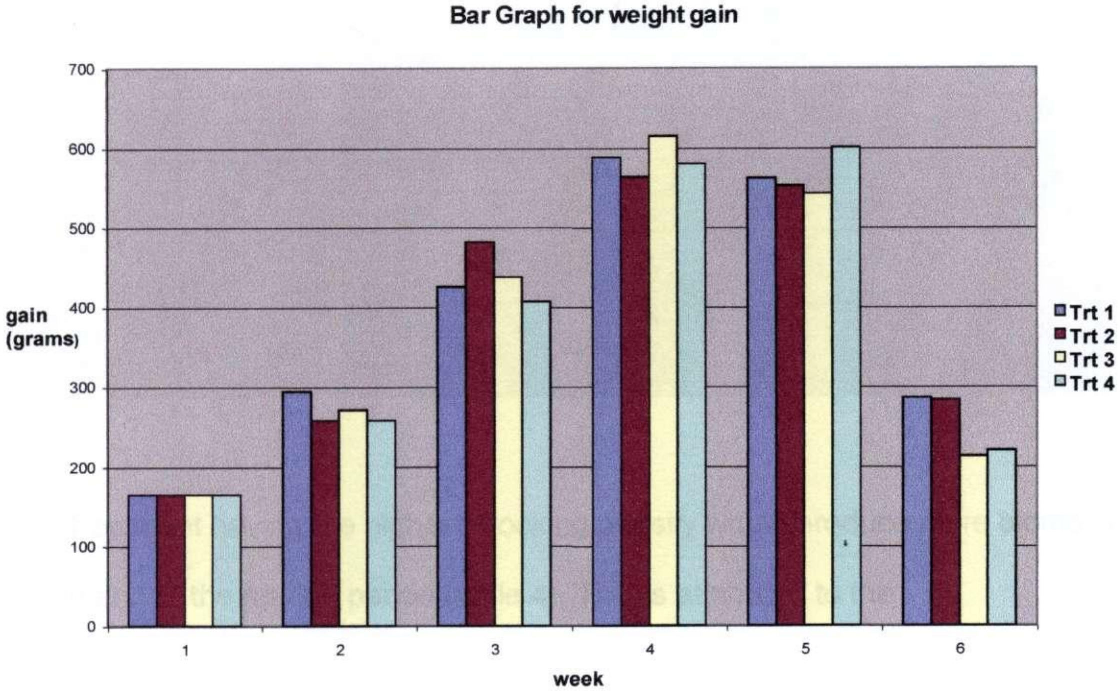
The analysis of weight gain (appendix 1) indicated no difference (P>0.05) for all treatments in all the weeks (table 3; figures 2 and 3).

Table 3: Average weight gain (g/bird/week)

WEEK	TREATMENT			
	1	2	3	4
2	272.4^{a}	258.0^{a}	271.8^{a}	258.0^{a}
3	447.8^{b}	452.4^{b}	435.9^{b}	421.3^{b}
4	558.2^{c}	564.1^{c}	614.9^{c}	580.5^{c}
5	563.0^{d}	553.0^{d}	543.0^{d}	601.0^{d}
6	286.0^{e}	284.0^{e}	213.0^{e}	220.0^{e}

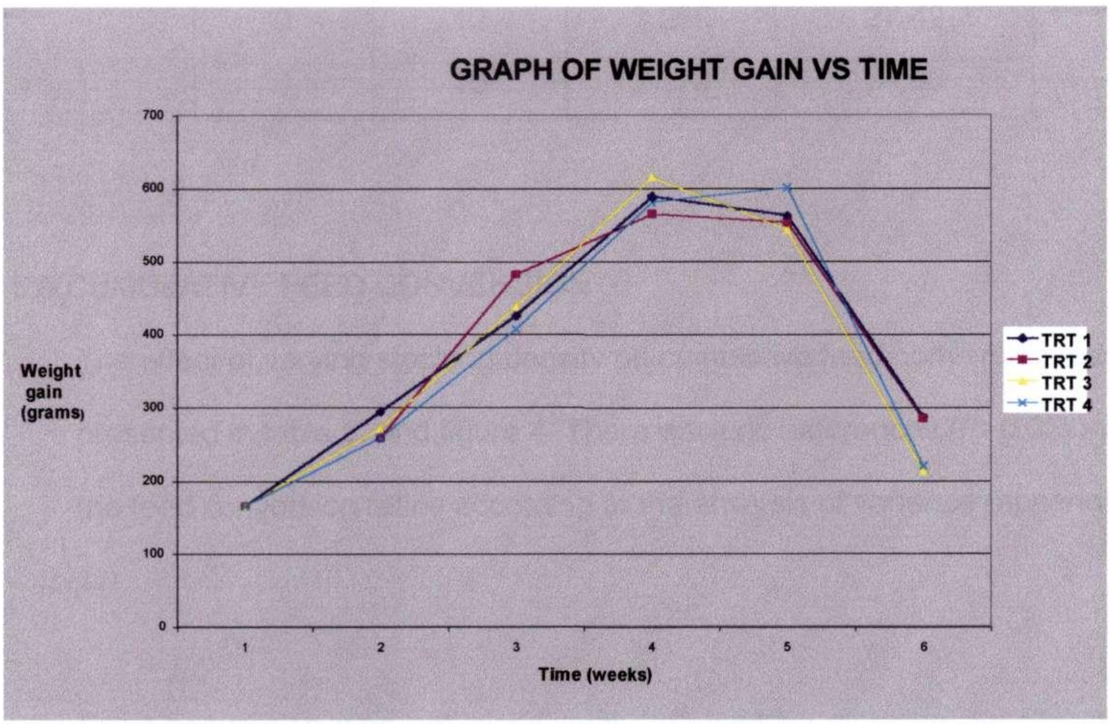
*Numbers with the same superscript are not significantly different (P>0.05)

Figure 2: Bar graph of average weight gain vs. time



The lack of significance in growth among the stocking densities used means that when the growth rates are similar. At the end of fourth week, treatment 3 had the highest weekly gain of 614.9 g/bird but it was not significant (P>0.05) and the gain in all the treatments declined sharply during the sixth week. This decline in live weight gain was attributed to the Gumboro attack in the early fourth week proceeding into the fifth week (figure 3).

Figure 3: Gain in weight vs. time



The treatment having the highest stocking density would produce more biomass at the end of the rearing period (table 4). This is attributed to the fact that there would be more efficient utilization of feed (low FCR) in the highly stocked treatments as there is little room for wastage. However, this was not the case in the current study.

Table 4: Biomass production

Treatment	Number of birds/m^2	Weight (kg)	Biomass (kg/m^2)
1	6	2.362	14.17
2	9	2.316	20.84
3	12	2.285	27.42
4	15	2.272	34.08

5.5 CUMULATIVE FEED CONVERSION

The effect of varying stocking density on cumulative feed conversion ratio is presented in table 5. and figure 4. There were no differences ($P>0.05$) in the feed conversion ratios according to the analysis of variance (appendix 1).

Feed conversion was not significantly affected by stocking density at six weeks. Other studies confirm this observation (Buckland *et al.*, 1971; Packhurst et al., 1977; Proudfoot *et al.*, 1979; Weaver *et al.*, 1982). Birds in treatment 3 tended to utilise feed better as they ate less but had similar live body weights with the birds in treatments 1, 2 and 4.

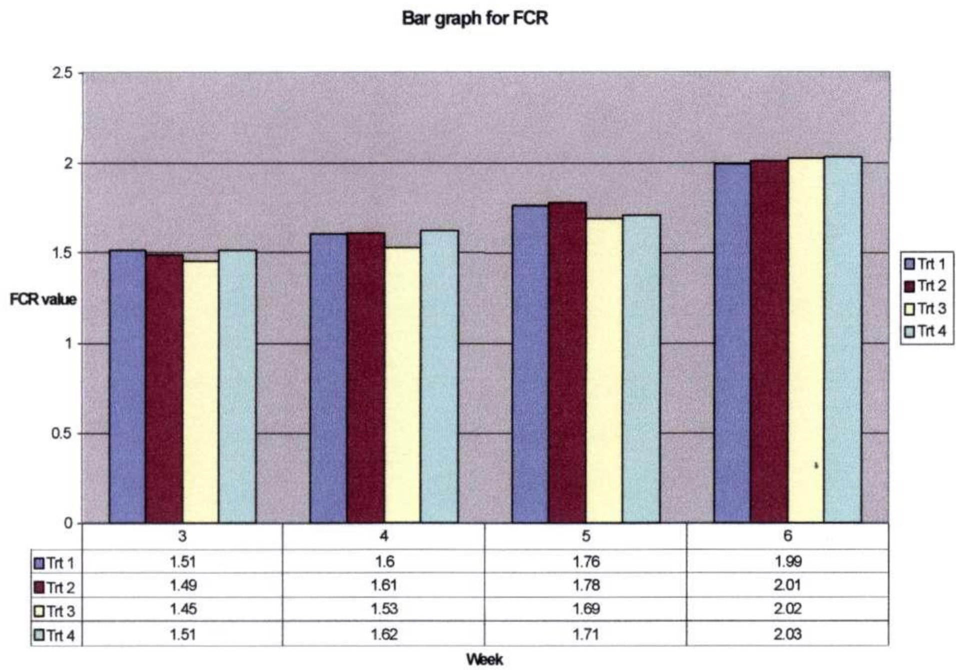
Table 5: The effects of stocking density on the cumulative feed conversion ratio for Cobb 500 chicks[1]

Density	FCR			
Birds/m^2	3wks	4wks	5wks	6wks
6	1.51	1.60	1.76	1.99
9	1.49	1.61	1.78	2.01
12	1.45	1.53	1.69	2.02
15	1.51	1.62	1.71	2.03

ANOVA summary	Probability
Source of variation	0.05
Density	

[1]Values represent the mean of four replicates

Figure 4: Cumulative Feed Conversion Ratio



The analysis of variance (appendix 1) showed that feed conversion ratio in the fourth week was highly significant. The feed conversion ratios for treatments 1, 2, 3, and 4 were 1.76, 1.80, 1.64 and 1.48g respectively. This difference was attributed to the significance ($P<0.05$) in feed intake in the forth week.

6.0 CONCLUSION

The experiment conducted agrees with other previously conducted experiments that concluded that body-weight at six weeks depended on a curvilinear function of density, with very little difference in weight at the various stocking densities.

At stocking densities of 6, 9, 12 and 15 birds/m^2, there were no differences in live body weight-gain. The lower feed intake for treatments 3 and 4 can be attributed to the little feeding space available to the birds which meant they ate less. The body weights at the end of the experiment were not different for all the treatments.

The experiment showed that there was no difference among the treatments feed conversion ratio and this is supported by the similarities in the live body weight gain.

With these results obtained, it can therefore be said that the Cobb 500 can reared to the Zambian conditions and the stocking density of 15 birds/m^2 is suitable. There is however need to establish performance at densities higher than 15 birds/m^2 under the Zambian conditions.

7.0 RECOMMENDATIONS

The results obtained in this experiment indicated that Zambian farmers can stock 15 birds per square meter for maximum biomass productivity and efficient use of the space available. There is also need for more research to be done in Zambia in the same line with varying stocking densities higher than 15 birds/m^2 to establish the optimum stocking density for the Cobb 500 broiler strain under Zambian climatic conditions.

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APPENDIX 1

ANALYSIS OF VARIANCE (ANOVA TABLES)

Live weight at 21 days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	7185.	2395.	0.129	
Residual	12	12477.	1040.		
Total	15	19662.			

****

CV 3.6%
Not significant at P>0.05

Live weight at 28 days

Source of variation	d.f.	s.s.	m.s.	F.pr	significance
Density	3	14731.	4910.	0.151	
Residual	12	27785.	2315.		
Total	15	42517.			

****

CV 3.2%
Not significant at P>0.05

Live weight at 35 days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	9660.	3220.	0.594	
Residual	12	58740.	4895.		
Total	15	68400.			

CV 3.4%

Not significant at P>0.05

Live weight at 42 days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	19297.	6432.	0.719	
Residual	12	169660.	14138.		
Total	15	188957.			

CV 5.1%

Not significant at P>0.05

Feed Consumption at 21 Days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	66762.	22254.	<.001	**
Residual	12	14272.	1189.		
Total	15	81033.			

****

CV = 3.0%

**Significant at P<0.05

Feed consumption at 28 Days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	285131.	95044.	<.001	**
Residual	12	35354.	2946.		
Total	15	320485.			

****

CV 2.5%

**Significant at P<0.05

Feed consumption at 35 days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	298923.	99641.	<.001	**
Residual	12	82319.	6860.		
Total	15	381242.			

****

CV 2.5%

**Significant at P<0.05

Feed consumption at 42 Days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	355229.	118410.	0.077	
Residual	12	484449.	40371.		
Total	15	839678.			

****

CV 4.6%

Not significant at P>0.05

Cumulative FCR at 42 Days

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	0.037969	0.012656	0.150	
Residual	12	0.071375	0.005948		
Total	15	0.109344			

****

CV 4.0%

Not significant at P>0.05

Feed intake (week 2)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	792.8	264.3	0.643	
Residual	12	5527.6	460.6		
Total	15	6320.3			

****

CV 8.1%

Not significant at P>0.05

Weight gain (week 2)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	5920	1973.3	0.015	
Residual	12	4460.9	371.7		
Total	15	10380.8			

****

CV 4.5%

Not significant at P>0.05

Feed conversion Ratio (week 2)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	0.01762	0.0587	0.715	
Residual	12	0.015323	0.01277		
Total	15	0.17084			

****

CV 7.0%

Not significant at P>0.05

Feed intake (week 3)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	10216.1	3405.4	0.053	
Residual	12	11994.6	999.5		
Total	15	2210.7			

****

CV 4.4%

Not significant at P>0.05

Weight gain (week 3)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	2320.1	773.4	0.257	
Residual	12	6054.2	504.5		
Total	15	8374.2			

****

CV 5.1%

Not significant at P>0.05

Feed Conversion Ratio (week 3)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	0.01702	0.00567	0.707	
Residual	12	0.14418	0.01201		
Total	15	0.16119			

****

CV 6.6%

Not significant at P>0.05

Feed intake (week 4)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	77823.1	25941.0	<0.001	**
Residual	12	9086.1	757.2		
Total	15	86909.2			

****

CV 2.8%

Significant at P<0.05

Weight gain (week 4)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	5383.5	1794.5	0.107	
Residual	12	8541.6	711.8		
Total	15	13925.1			

****

CV 4.5%

Not significant at P>0.05

Feed Conversion Ratio (week 4)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	0.246025	0.082008	<0.001	**
Residual	12	0.014418	0.01201		
Total	15	0.16119			

****

CV 5.0%

**Significant at P<0.05

Feed intake (week 5)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	691	230	0.973	
Residual	12	377.44	3145		
Total	15	38435			

****

CV 4.6%

Not significant at P>0.05

Weight gain (week 5)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	7637	2546	0.623	
Residual	12	50268	4189		
Total	15	57905			

****

CV 11.5%

Not significant at P>0.05

Feed Conversion Ratio (week 5)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	0.10665	0.03555	0.430	
Residual	12	0.43035	0.03586		
Total	15	0.53700			

****

CV 8.8%

Not significant at P>0.05

Feed intake (week 6)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	2526	842	0.990	
Residual	12	279064	23255		
Total	15	3281590			

****

CV 14.4%

Not significant at P>0.05

Weight gain (week 6)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	18774	6258	0.682	
Residual	12	146844	12237		
Total	15	165618			

****

CV 44.1%

Not significant at P>0.05

Feed Conversion Ratio (week 6)

Source of variation	d.f.	s.s.	m.s.	F pr.	Significance
Density	3	24.96	8.32	0.629	
Residual	12	0.43035	167.02		
Total	15	191.98			

****

CV 69.1%

Not significant at P>0.05