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The Influence of the Protein Level of the Diet on the Growth, Egg Production, Egg-weight, and Mortality of Single Comb White Leghorn Pullets.

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ALTHOUGH many papers have been published on this subject, it was felt that the question was important enough to warrant repetition using local foodstuffs. The rising mortality rate in poultry flocks all over the world is causing considerable anxiety, and very much is being written about the causes. In turn, almost every conceivable factor has been blamed for the present state of affairs. Dry mash feeding, forcing for high egg production, unnatural methods of management, the prevailing systems of breeding, and the hygiene of the farm have all had their share of criticism.

PLAN OF EXPERIMENT.

The nine weeks old Single Comb White Leghorn pullets were divided into three groups and an attempt was made to get them as equal as possible by dividing full sisters into the different groups. Where a particular hen did not have three daughters, half sisters were used to make the division as equal as possible. The pullets were not all hatched at the same time, but with the exception of the oldest lot of pullets, there was not much difference between them. As it happened, the first group had a few more of the oldest pullets, which accounted for the slightly higher production in February, and also the higher average egg weight.

The mash rations used are set forth in Table I.

TABLE I.

Mash Rations.

	Lot I.	Lot II.	Lot III.
Wheat Bran	20	20	20
Pollard	30	30	30
Yellow Maize Meal	40	35	30
Meat and Bone Meal	10	15	20

In addition to the above dry-mash ration, the birds had one feed of grain, viz. crushed yellow maize. The amount of crushed yellow maize was kept the same in all groups, the amount being that consumed by the birds which ate the least. The disadvantages of this method were realized but an attempt had to be made to keep the system of feeding as close as possible to the system in most common usage. Oyster shell and water were supplied *ad lib*, and the fowls had one feed of chopped green lucerne daily.

Results.

The pullets were weighed at nine weeks and at fortnightly intervals thereafter. These weights are given in Table II, and represented graphically in Fig. 1.

Table II.

Bi-weekly Weights of Pullets in Pounds.

Age in Weeks.	Lot I.	Lot II.	Lot III.
	lb.	lb.s	lb.
9	1·14	1·16	1·22
11	1·55	1·60	1·53
13	1·96	1·95	1·89
15	2·37	2·40	2·26
17	2·59	2·70	2·60
19	2·88	2·87	2·83
21	3·08	2·97	3·05
23	3·31	3·30	3·31

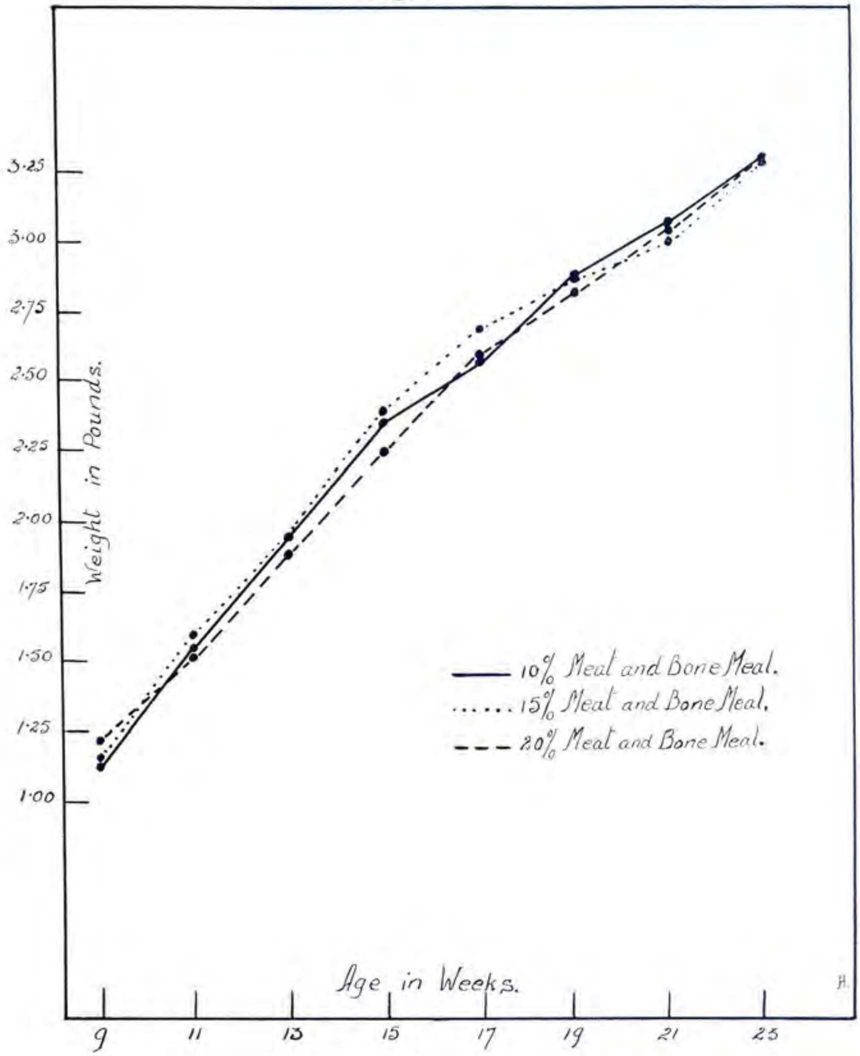
The only conclusion that can be drawn from Table II and Fig. 1 is that all groups grew at almost the same rate. This would indicate that the requirement for protein is lower after the age of eight weeks, and is in agreement with the work of Norris and Heuser (1930) St. John, Carver, Johnson and Brazie (1933), and McConachie Graham and Branion (1935).

Sexual Maturity.

The value of the data on sexual maturity (date of first egg) was impaired by a rather severe outbreak of chicken pox. The onset of production was thus retarded in a number of individual cases. On a mash containing ten per cent. meat and bone meal, 63 pullets came into production at the average age of 192·7 days. On the mashes containing fifteen and twenty per cent. meat and bone meal, seventy pullets in each group matured at the average age of 201·6 and 201·5 days respectively.

The level of protein fed did not seem to influence the time of sexual maturity. Heuser and Norris (1933) also stated that the protein level influenced the time of maturity only to a small extent, except in cases where growth was definitely retarded by low protein levels. Winter, Dakin and Bayes (1932) state too that there was no correlation between the level of protein intake and the age at which the first egg was laid.

Fig. I.



EGG WEIGHT.

All eggs produced were weighed to the nearest eighth of an ounce. The object of weighing all eggs was to determine whether any differences existed which could be attributed to the rations, and also to find a more convenient and practical way of determining the annual average egg weights of pullets. Parkhurst (1933), in a rather extensive study of factors affecting egg weight, came to the conclusion that rations varying in protein content did not lead to the production of eggs that differed materially in weight. On the other hand, Heuser (1936) stated that a ration containing 14 per cent. protein was not conducive to the best egg size. Table III gives the monthly average egg weights, standard deviations and standard errors of the mean for the three groups.

TABLE III.

Monthly Average Egg Weights.

Month.	I.				II.				III.			
	No. of Eggs.	Mean.	S.D.	S. Em.	No. of Eggs.	Mean.	S.D.	S. Em.	No. of Eggs.	Mean.	S.D.	S. Em.
February	221	1·59	·136	·0091	217	1·57	·169	·0115	176	1·52	·120	·0090
March	294	1·77	·134	·0078	239	1·69	·164	·0106	466	1·65	·159	·0074
April	375	1·77	·161	·0083	415	1·83	·138	·0068	643	1·84	·128	·0050
May	880	1·89	·164	·0055	986	1·94	·156	·0050	1,020	1·94	·156	·0049
June	893	1·92	·151	·0051	1,006	1·96	·161	·0051	1,151	1·99	·156	·0046
July	975	2·00	·157	·0050	1,122	2·04	·155	·0046	1,306	2·07	·159	·0044
August	1,059	2·05	·142	·0044	1,348	2·07	·144	·0039	1,308	2·09	·150	·0041
September	987	2·06	·138	·0044	1,260	2·08	·152	·0043	1,235	2·10	·154	·0045
October	856	2·01	·143	·0049	1,235	2·08	·153	·0045	1,055	2·08	·168	·0052
November	743	2·03	·154	·0056	1,118	2·12	·147	·0044	1,084	2·11	·176	·0053
December	661	2·05	·145	·0056	943	2·12	·143	·0047	954	2·14	·188	·0061
TOTAL	7,944	1·966	·187	·0021	9,889	2·023	·175	·0018	10,398	2·203	·205	·0020

From April to the end of the year, groups 2 and 3 produced heavier eggs than group 1. The difference between 1 and 2 is ·057 ± ·0029. The difference is 20 times as large as the Standard error of the difference, and there can thus be no doubt as to the significance of this difference. 15 and 20 per cent. meat meal in the ration produced eggs of the same size, but 10 per cent. caused a significant decrease in egg size.

Part-time Records of Egg Weight and Annual Average Egg Weight.

Several investigators have attempted to arrive at a suitable average annual egg weight by means of short time records.

Funk and Kempster (1934) found that the age and body weight at sexual maturity influenced the weight of the first ten eggs laid, but this was not closely correlated with the maximum and average egg weights.

In a study of Egg Laying Test records, Ginn (1932) found that a fairly reliable estimate could be obtained by weighing two eggs per month.

Godfrey (1933) stated that an approximation of the annual mean egg weight could be obtained from a knowledge of the average weight of the first ten eggs, the body weight when the first egg was laid, and the age at which laying commenced. A more reliable estimate was obtained by weighing all eggs laid the first four days of each month, and the best estimate was obtained by weighing the eggs on one specified day of the week throughout the first laying year.

Jull and Godfrey (1933) found that the minimum average of the first ten eggs, in order that birds should give standard eggs later on, varied with different flocks.

Wilson and Warren (1934) found that the month when pullets started to lay was important in estimating whether a bird would achieve the standard two ounce egg later. The later a bird starts to lay, the higher should be the average weight of the first ten eggs.

The average weight of the first ten eggs, and the estimate of egg size later, are important in cases where pullets are destined for egg laying tests. For ordinary breeding purposes, however, the disadvantage is that pullets do not start to lay at the same time, and egg weighing must thus be extended over three or four months. Furthermore, many pullets are inclined to lay a few eggs on the floor when they first start to lay. Weighing eggs for a few days a month or one day every week will also be rather a tedious procedure by the end of the year. To be of the greatest practical use, short period testing should be over as soon as possible and be done when most birds are in production.

In order to arrive at such a period the monthly average egg weight was correlated in South Africa with the annual average, and the regression formulae calculated. Table IV gives the coefficients of correlation, the number of individuals involved, and the regression formula in which X is the average egg weight for the year and Y is the average egg weight for the corresponding month.

TABLE IV.

Month.	Coefficient of Correlation.	n.	Regression formula.	$100r_2$.
May	·774 ± ·026	107	X = ·7356 Y + ·59	59·91
June	·778 ± ·023	123	X = ·8136 Y + ·42	60·53
July	·829 ± ·018	132	X = ·9436 Y + ·08	68·72
August	·901 ± ·011	135	X = ·928 Y + ·11	81·18
September	·877 ± ·013	134	X = ·8932 Y + ·17	76·91
October	·852 ± ·016	134	X = ·8458 Y + ·29	72·59
November	·892 ± ·012	134	X = ·892 Y + ·16	79·57
December	·858 ± ·016	128	X = ·782 Y + ·38	73·62

The monthly average weight is quite closely correlated with the annual average egg weight. The coefficient increases as the season advances and is at a maximum in August; from this time to the end of the year, there is an irregular decline.

The irregularity during early summer (November in South Africa) is probably due to climatic conditions.

The last column of Table IV gives the percentage variation in the total egg weight which can be established from average egg weights determined over periods of one month. Judging from this, one must conclude that either August or September or November in South Africa would be the best month to weigh eggs for computing annual average pullet egg weights.

EGG PRODUCTION.

The percentage production on a hen-day-basis from February to December is given in Table V and the same data are illustrated in Fig. 2.

TABLE V.

Month.	I.	II.	III.
February	15·1	15·3	12·6
March	20·6	15·9	32·4
April	17·3	17·6	27·3
May	42·0	40·4	43·8
June	45·7	42·9	52·8
July	50·5	47·4	57·8
August	59·5	59·6	60·2
September	63·5	62·3	62·1
October	60·7	61·5	55·3
November	53·4	60·3	60·3
December	58·2	56·0	56·8
TOTAL	43·6	44·5	48·5

Fig. II

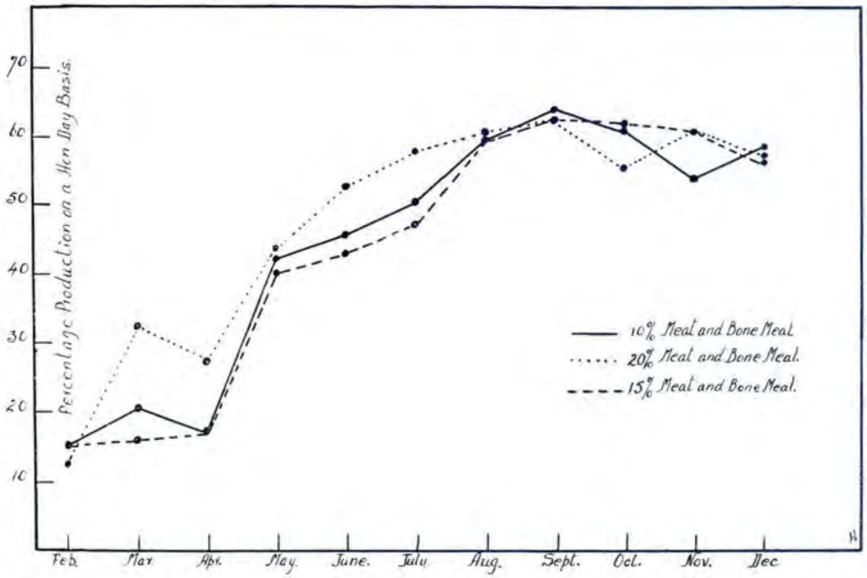


Table VI gives the average egg production, standard deviation, and standard error of the mean for all birds in each group which completed the experiment. Birds with records of less than 100 eggs were excluded due to the possibility of such birds suffering from some organic disease. Thus 5 birds in group 1, 10 birds in group 2, and 5 birds in group 3 were excluded. Among the birds excluded were a few that showed excessive broodiness, their low production being due partly at least, to a poor genetic make-up.

TABLE VI.

Group.	Mean.	Standard Deviation.	Standard Error of Mean.	No. of Individuals.
I..........................	159·5	22·8	4·03	32
II..........................	153·0	24·0	3·57	45
III..........................	163·0	33·6	4·66	52

An examination of Tables V and VI reveals no significant group difference in egg production. During March and April, there was a slight difference in favour of group 3, but the production of all groups was below normal then, due to an outbreak of chicken pox. It might have been that groups 1 and 2 were more susceptible, or that group 3 was more resistant to the virus. (At this stage it is of interest to consult the mortality records).

We conclude that under the conditions of this experiment, mash rations containing 10, 15 and 20 per cent. meat and bone meal, fed in conjunction with approximately equal quantities of crushed yellow maize, do not influence markedly the number of eggs produced by pullets during their first laying year.

Mortality.

Table VII gives an analysis of the mortality records. The most striking fact is the abnormally high death rate in each group.

Prolapse of the oviduct, with or without pickout, was the main cause of death. Many cases were found dead and eviscerated and it is presumed that cannibalism was incited by protrusion of the oviduct. In most cases, the birds were found before they were eviscerated, but these usually developed severe salpingitis and died or had to be killed, only a few recovering. Slightly more than 40 per cent. of the total mortality was due to this cause. Most interesting and important is a comparison of the prolapse-rates in the three groups. Very few cases occurred in the group receiving the highest percentage of meat and bone meal in the mash.

Table VIII suggests a seasonal incidence of prolapse, most cases occurring in spring. In group 1, two cases occurred immediately after the onset of laying. In group 2, one case occurred in April on the day the later hatched pullets were put in permanent quarters. Possibly this shifting exerted some influence. From July till the end of the year, this group had a regular mortality of two per month. In group 3, one early case occurred in May and the other two late in December.

Table VII.

Cause of Death.	10 Per cent. Meat and Bone Meal.		15 Per cent. Meat and Bone Meal.		20 Per cent. Meat and Bone Meal.	
	Number Died.	Percentage of total Mortality.	Number Died.	Percentage of total Mortality.	Number Died.	Percentage of total Mortality.
Prolapse of oviduct with or without pickout	22	56·4	13	48·1	3	12·5
Lymphoid Leucosis	8	20·5	3	11·1	5	20·8
Erythroleucosis	—	—	—	—	1	4·2
Other tumours	2	5·1	2	7·4	1	4·2
Neurolymphomatosis	2	5·1	3	11·1	1	4·2
Yolk Peritonitis	1	2·6	1	3·7	1	4·2
Fatty degeneration of liver	—	—	1	3·7	2	8·3
Cysts of Mullerian Duct	—	—	—	—	3	12·5
Accidental	—	—	—	—	2	8·3
All other causes	4	10·3	4	14·8	5	20·8
Total	39	100·0	27	99·9	24	100·0
Original No. of birds	78		82		78	
Percentage Mortality	50·0		32·9		30·8	

In these experiments the pullets were on their particular rations from the age of nine weeks. Were prolapse the result of a deficiency associated with the animal protein supplement, one would expect cases to occur first in the birds that were unable to build up reserves in their bodies before the onset of egg production.

TABLE VIII.

Month.	I.	II.	III.
February	2	—	—
March	—	—	—
April	1	1	—
May	1	—	1
June	—	—	—
July	3	2	—
August	4	2	—
September	6	2	—
October	3	2	—
November	2	2	—
December	—	2	2
TOTAL	22	13	3

Other factors which might exert some influence on the incidence of prolapse are: size of egg, rate of production, and age at first egg. The potential influence of these factors has been investigated as far as possible with the available data.

Table IX gives the average weight of the first ten eggs laid by all birds and those that suffered from prolapse. The birds in group 1 that suffered from prolapse laid slightly heavier eggs, but the difference is not significant. In group 2, the average weights were practically the same. In group 3, the three cases laid slightly smaller eggs, but the numbers are too small for comparison.

It would thus appear that egg size has no real influence on the incidence of oviducal prolapse. Only in one case, Hen A. 46, could prolapse be attributed to an abnormally large egg; protrusion accompanied the laying of the first egg which weighed 2·50 ounces. The average weight of the last egg laid by birds that died from prolapse was 2·01, 1·99 and 1·88 ounces respectively in the three groups. These weights do not differ materially from the annual averages given in Table III.

TABLE IX.

Prolapse and Egg Size.

Average of first 10 eggs.	I.	II.	III.
All birds	1·771	1·818	1·798
Prolapse birds	1·798	1·807	1·708
Difference	·027	·011	·090

The average age at sexual maturity, of birds with prolapse, was 190, 200 and 186 days for each group respectively. This does not seem materially different from the average ages at sexual maturity of all pullets, namely 192·7, 201·6 and 201·5 days for groups 1, 2 and 3 respectively.

The rates of production of birds suffering afterwards from prolapse was 59·3, 63·1 and 62·7 per cent for groups 1, 2 and 3 respectively. The rate was calculated from the time of the first egg to the time the prolapse occurred. Unfortunately these figures cannot be compared with any other general figure from the available data; however, they cannot be considered to be above the average, The idea of prolapse being due to exhaustion following heavy egg production would thus appear to be ill founded.

The popular literature always mentions cannibalism as being due to overcrowding; but in this case only 80 birds were placed in a house with 400 square feet of floor space (the regular allowance being 4 square feet per bird).

Other factors conceivably favouring the incidence of prolapse are tumours, weakness from any cause, spasms of smooth muscle, inflammation of the oviduct or cloaca, and an inherited predisposition.

When the affected bird is eviscerated by the fowls, the oviduct and intestines are lost and one cannot determine whether the bird was suffering from tumours or inflammation of the oviduct, etc.

Inherited factors were controlled as far as possible, each group having a full- or half sister. The hereditary make-up may play a rôle due to the interaction of genes and environment, but no confirmatory evidence of this was found.

Considering all the possibilities, the most plausible explanation of oviduct prolapse seems to be a nutritional deficiency. Perhaps an hereditary predisposition is also at work.

(Some families had more cases of prolapse than others but the figures were too small to permit definite conclusions.) The anti-prolapse factor seems to be associated with the protein supplement. Work to prove or disprove this is in progress.

Little need be said about the other cause of mortality, except that neoplasia were far too common. Infectious diseases and parasites were completely absent due to strict sanitation.

Conclusions.

1. The growth of pullets from nine weeks to maturity was the same on mash rations containing 10, 15 and 20 per cent. meat and bone meal, when fed in conjunction with crushed yellow maize as grain.

2. There was no significant difference in egg production which could be attributed to the different rations.

3. Birds receiving 15 and 20 per cent. meat and bone meal in the mash laid significantly larger eggs than birds receiving 10 per cent. meat and bone meal.

4. Prolapse of the oviduct occurred more frequently in the two lower protein supplement groups. The view is advanced that a nutritional deficiency, modified possibly by an hereditary predisposition, is responsible for the cases of prolapse.

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