ADAPTATION OF PROTEIN CONCENTRATES IN THE LAYING RATION

by

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TABLE OF CONTENTS

INTRODUCTION

The adaptation of protein concentrates requires some understanding of the protein requirements. When such concentrates are used, they are the means of supplying nutrients in proper amounts which are not furnished in the other parts of the ration. For the farmer who produces his own grain, the use of protein concentrate is almost a must. The adaptation of a poultry feeding program using such concentrates with home grown grains is a problem vital to all farmers.

The object of this research problem was to compare results of various methods of feeding protein concentrates with grains normally grown on farms for the production of eggs. Such a procedure does more than just affect egg production, it affects the maintenance and health of the bird's body which must be taken care of before egg production begins. Since the food for the embryonic chick must be stored in the egg, there must be some relationship between the diet of the hen and the egg stored food, which would not only affect hatchability, but also the early development of the chick.

This research problem was also designed to test for results which might show a relationship between the growth of the chick and the diet of the hen producing the egg from which the chick was hatched.

REVIEW OF LITERATURE

In adapting protein concentrates to a feeding program, there is involved; first, the composition of the ration and second, the methods of feeding. Since most standard rations contain the essential nutrients, much of the experimental work is involved with methods of feeding.

The various workers who have recorded their findings have approached the subject from various angles. Not all of these will be mentioned here, but enough to substantiate the findings in this experiment.

Callenbach and Murphy (1942) studied the relative effectiveness of six feeding procedures in three experiments. They used a standard laying mash and a high-protein mash. The grain mixture was corn, wheat, and oats. They found that grain fed free-choice constituted the greater part of the diet; that the maintenance of a high total feed intake, rather than a certain balance between grain and mash or high mash consumption, appears to have been the critical feeding factor in the experiment; that feeding a part of the grain in litter helps to keep the litter in better condition than feeding all of the grain in troughs or hoppers; that free-choice of grain feeding permits more efficient use of available labor.

Investigations by Parker and Barton (1947) over a two-year period were conducted with six pens of Rhode Island Red pullets which were fed free-choice mashes or supplements with

22, 33, and 42 percent crude protein and whole grains. The results show that layers fed the 22 and 42 percent supplements laid at about the same rate for the three groups. No appreciable differences were observed in the amount of feed consumed, but more feed was required to produce a dozen eggs in pens fed the 33 percent supplements. As the protein content of the supplement increased, the relative amount of supplement consumed decreased, but the percent of protein in the total ration increased.

The differences in the percentages of hatchability of fertile eggs was somewhat inconsistent, but hatchability was reasonably satisfactory on all three supplements. Feeding the whole grains, yellow corn, wheat, and oats, separately and as a mixture (40-40-20) had no appreciable effect on rate of egg production, egg weight, feed consumption, amount of feed required to produce a dozen eggs, relative amounts of supplement eaten, hatchability, albumen quality of eggs, or rate of mortality. The protein content of the total ration was slightly increased when the grains were fed separately. Also the separate feeding of the whole grains resulted in lighter colored egg yolks. For all pens which were fed the whole grains separately, wheat made up 44 percent of the whole grain consumption, corn 29 percent, and oats 27 percent.

Davidson (1939), of the Michigan Station, conducted three years of work for the purpose of studying the results of high-protein supplement feeding in comparison with the use of the

regular type of laying mash. The results obtained from these trials indicated that there is a possibility of utilizing home-grown grains to better advantage by using a high-protein mash where the quantity raised is in excess of the farm requirements.

The use of a supplement or high-protein mash increases the problem of supplying some of the needed vitamins for certain requirements. Usually it is largely a matter of supplying vitamin D. This may be solved by feeding a wet mash to which the required amount of vitamin D can be added to meet the requirements of the flock, whether for egg production or hatchability.

McClary, Bearse and Miller (1942) summarized the results of their study, of feeding methods for laying hens, by saying that for birds kept on the floor, hopper feeding of both mash and grain results in lower egg production, higher cannibalism mortality and greater feed cost per dozen eggs produced than when all or part of the grain of the ration is litter-fed.

Lee, Scholes and Henry (1944) completed a series of experiments covering two production years to determine the effect of free-choice feeding of grain versus the standard feeding program with limited grain feeding. The results indicated a significant loss of egg production and net return per bird, over feed cost, for Leghorns on the free-choice grain feeding with no significant difference demonstrated for Rhode Island Reds.

It was noted that egg production showed more tendency to decline during periods of hot weather in the pens receiving free-choice grain feeding. Higher grain and lower mash consumption by the birds on free-choice grain emphasized the need of a mash with a higher content of vitamins than necessary for the standard program.

Additional evidence was accumulated to reinforce findings by earlier investigators that about 16 percent protein in the total ration is necessary for top egg production. Results that would be acceptable to the commercial poultryman were obtained at a level of 13 percent where a protein combination of high biological efficiency was used in the ration.

Vondell (1948), at the University of Massachusetts, found that in terms of egg production no one feeding method seemed to have superiority. If anything, the birds in the free-choice pens laid fewer eggs during the hot summer months of July and August, but the percent of production for the year was equal to the others.

Mortality was consistently lower in the all-mash pens and highest in the free-choice pens. This would indicate the need for a special mash when the free-choice method is used. Wet litter was a constant problem during the winter in the all-mash pens. A uniform depth of about six inches of litter was maintained in all pens. The all-mash pens required frequent stirring of the litter to break up the wet, crusty condition.

Robertson, Carver and Cook (1939) compared five different feeding methods at the State College of Washington using 340 White Leghorn pullets in five duplicate lots for nine 28-day periods. The methods of feeding studied were: (a) all-mash, adjusted for the amount of grain usually consumed by birds; (b) a basal mash with grain fed in litter; (c) a basal mash with grain fed in hoppers; (d) a basal mash with grain in litter and supplementary feeding of pellets; (e) free-choice of grains and a high-protein (40 percent) concentrate. Egg production was greatest in lots with free-choice of concentrate and grain, and was lowest in lots fed the all-mash ration.

The hens fed on an all-mash ration laid at the rate of 46.6 percent production; the duplicate lots, where grain was fed in the litter as a supplement to the mash, the hens laid at the rate of 56.7 percent; where grain was fed in the litter supplemented with pellets at the rate of five pounds per 100 birds per day, hens laid at the rate of 55.6 percent; the lots of hens fed the same as the previous lots except that the grain was fed in hoppers laid at the rate of 53.6 percent; the highest production of 59.6 percent was obtained in the duplicate lots that had cracked corn, wheat, and oats, and a 40 percent concentrated mash before them in hoppers at all times.

Graham (1934) found that when pullets are fed ad lib. whole corn, whole oats, and mash, there is considerable variation in the intake of each of these by individual birds. The

intake of any one of these separate feeds by individual birds varies considerably from day to day and week to week. The variation in protein level for individual birds from day to day is very slight. Some birds lay well and gain on 12 to 13 percent protein level while others want, or require, 14 to 15 percent level. Non-laying birds thrive and prepare to lay on an 11 percent protein level. Habit seems to play an important part in the diet of individual birds. Some birds are extremely constant in their protein level intake over a long period. As for example, pullet No. 3 for the first 56 days of the trial balanced her protein at a 13 percent level for all but five days. These results indicate that nutritional requirements are governed by an urge of the organism.

Heiman, Carver and St. John (1936), studying the protein requirements of laying hens, discovered that lots receiving the same ration and kept under the same control presented widely different results. They found that body maintenance required from 12 to 13 percent protein (from plant sources). In the all-mash ration, 14 percent protein was the minimum amount of protein that would maintain body weight and 60 percent production. In the combination mash and grain ration the minimum of 15 percent protein was necessary to maintain body weight and production.

Martin and Insko (1929) made a study with Barred Plymouth Rock and White Leghorn hens to determine the value of protein when fed in an all-mash ration compared with a mash and grain

ration. They found no significant difference as far as egg production was concerned between the two feeding methods. They did notice that when the protein content was lowered there followed a lower egg production. Furthermore there was observed a correlation between body weight and production; that is if body weight dropped, production dropped.

Kennard and Chamberlin (1942) found no appreciable difference in the amounts of protein consumed by groups receiving 22 and 32 percent protein, respectively, in the mash. However, when the consumption of the whole oats and corn was restricted to two hours daily, more mash was consumed but the differences in protein intake were only 1.3 percent. No significant differences in body weights were noted. Egg production was somewhat higher with the higher protein percentages in the ration.

Mehroff (1942) reported on the use of a 32 percent protein concentrate and a scratch-grain mixture, both hopper fed, as compared to a 20 percent protein mash and grain fed in the ratio of 60-40. Mortality in the two lots of birds was about the same. Egg production was practically the same in both lots. He also reported that an all-mash and a mash and grain ration fed in the ratio of 60-40 gave satisfactory results in egg production and livability.

Bird, Haynes, Rubin, and Whitson (1946) noted that the diet of breeders was a factor which affected the viability of the chicks hatched. These investigators observed a marked

increase in the first week mortality of chicks hatched from eggs produced on a soybean oil meal diet which also gave poor hatchability. Modifications of the soybean oil meal diet which improved hatchability of the eggs also improved the viability of the chicks hatched. The parallelism between hatchability and chick viability suggests that the factor (or factors) essential for good hatchability is (are) transmitted from the hen through the egg to the chick. Recently Rubin and Bird (1946) also reported that the unidentified chick growth factor in cow manure was transmitted from the hen through the egg to the chick.

Penquite and Thompson (1936) initiated some experiments to determine whether any relationship existed between the amount of protein fed the hen and the growth of the embryo. These findings were to coincide with those of other workers in that eggs from the hens fed low protein lost more moisture than eggs from high protein fed hens. Embryos from high protein fed hens were heavier from day to day. This suggested that the chick embryo used protein as a source of energy.

Bethke, Kennard, and Pensack (1947) found that the rate of growth of chicks fed a yellow corn-soybean oil meal diet was influenced by the diet of their dams. Growth on a yellow corn-soybean oil meal diet was significantly greater in chicks from hens on a soybean oil meal-fish products diet than in chicks from hens on an unsupplemented soybean oil meal diet.

The inclusion of a 4.0 percent sardine fish meal in the chick diet caused a significantly greater increase in growth in chicks from hens on the soybean oil meal diet than in chicks from dams on the soybean oil meal-fish products diet. Chicks fed the soybean oil meal diet supplemented with 4.0 percent sardine fish meal grow equally well irrespective of whether their dams were fed the soybean oil meal or the soybean oil meal-fish products diet. The results show that sardine fish meal and condensed fish solubles, which increased hatchability, contain a growth factor (or factors) which is (are) transmitted from the hen through the egg to the chick.

MATERIALS AND METHODS

Two hundred and eighty pullets were used in this experiment. They were produced from mating Single Comb White Leghorn males with Hy-Line and crossbred females at the College Poultry Farm. Ninety-three pullets were placed in pen I; 94 in pen II and 93 in pen III. These pullets were placed in the laying house on October 3, 1950, and were weighed at intervals of approximately four weeks, as follows: Nov. 3 (31 days); Dec. 1 (28 days); Dec. 29 (28 days); Jan. 29, 1951 (31 days); Feb. 27 (29 days); March 26 (27 days); April 28 (33 days); and May 25 (28 days). Feed and protein consumption, egg production, body weight and mortality were calculated monthly at the time of weighing.

Feed consumption was calculated on a hen-day basis. The percentage of protein intake was calculated from the total feed consumed during the monthly periods. Egg production was also on a monthly basis. Body weight was the average weight for all hens in one pen for the monthly period. Mortality calculations were based on losses each monthly period. The calculations in Table 4 show the mortality each month in percentage of those on inventory at the beginning of each monthly period.

The pens were in an open front straw loft laying house. Two community nests were provided in each of the three pens. Oyster shell and running water were available at all times. Built-up litter was used in all pens. No artificial lights were used. The birds were confined at all times, and normal farm conditions prevailed as far as possible. Eggs were gathered twice daily.

There was an outbreak of neural lymphomatosis or fowl paralysis which caused a heavier mortality than would normally have been.

The feeds used and the methods of feeding were as follows:

The birds in pen I were fed a commercial laying mash guaranteed to contain 20 percent protein. The mash was kept before the birds in open hoppers at all times. The amount of grain fed approximated the amount of mash eaten. Mixed whole grain consisting of one-third yellow corn, one-third wheat and one-third oats, by weight, was fed in the litter about two

hours before roosting time. The calculated protein content of this mixed grain was found to be 12.04 percent (Table 1). After the experiment was in progress for three months (December 29, 1950), oats became unavailable, and for the remainder of the experiment oats were deleted from the mixed grain. This changed the protein content of the grain (corn and wheat) to 12.05 percent (Table 2).

The birds in pen II were fed, free-choice, a 26 percent protein commercial mash (balancer) in open hoppers. The grains consisted of the same as used in pen I and were fed free-choice in open hoppers.

Those in pen III were fed a special mash in open hoppers which was available to the birds at all times. During the first three months, no grain was fed to this pen. This special mash consisted of 50 percent, by volume, of a 26 percent protein commercial mash (balancer) and 50 percent, by volume, of ground yellow corn, ground wheat and ground oats. The calculated protein content was 18.62 percent (Table 3). Protein content was calculated from values recommended by the National Research Council in their revised publication dated March, 1950.

On November 17, 1950, eight White Leghorn males were placed in each pen, preparatory to saving hatching eggs.

After this experiment had been in progress for approximately three months (December 29, 1950), oats became unavailable and were deleted from the above mentioned special mash mixture.

No other grains were used to replace the oats. This changed the calculated protein content to 18.33 percent (Table 3).

At the same time (December 29, 1950), the ration was changed for pen III. The mash mixture (consisting of 50 percent balancer, 50 percent ground yellow corn and ground wheat) containing 18.33 percent protein was continued being fed in open hoppers and the same grain mixture as used in pen I and pen II was fed in the litter in the late afternoon. The amount of grain fed approximated the amount of mash consumed (Table 2).

During the period of December 22 to 29, 1950, eggs were saved from all three pens for hatching purposes. Only select hatching eggs were placed in one of the College Poultry Farm's mammouth incubators. On January 18, 1951, 155 chicks were hatched from eggs produced by pen I; 142 chicks from eggs produced by pen II; and 138 chicks from eggs produced by pen III.

One-half of the chicks from each pen were brooded together. This made two lots of chicks and each lot was fed a different ration. Lot I was fed a control chick starting mash, and lot 2 a high efficiency feed. No grain was fed to either lot after the first three days. Fresh water and grit were available to the chicks at all times. They were individually weighed every two weeks until they were six weeks of age, at which time this part of the experiment was concluded. The rate of growth, feed consumption and mortality were calculated at each of the three weighing periods. The control and high efficiency starting ration was composed of the following:

Chick Rations

	Percent Protein	"A" High Efficiency in pounds	"B" Control Diet in pounds
Ground Yellow Corn	8.6	61.0	31.5
Wheat Shorts	16.9	-	20.0
Wheat Bran	16.9	-	5.0
Ground Oats	12.0	-	10.0
Dehydrated Alf. Meal	17.0	1.0	5.0
Meat and Bone Scraps	50.0	2.5	5.0
Fish Meal	60.0	2.5	2.5
Soybean Oil Meal	44.0	30.0	19.0
Steam Bone Meal	6.0	1.0	-
Calcium		1.0	1.0
Salt		0.5	0.5
		Grams	Grams
Manganese		25	15
Delsterol		40	40
Calcium Pantothenate		1	1
Riboflavin		5	5
Prot. A		100	100
Vit. B_{12} (Merck 626)*		23	23
Choline Chloride (25% mix.)		36	36
		230 = 0.5	220 = 0.5
Total		100.0	100.0
Percent protein in ration		21.35	21.28

* Contains 12.5 mg Crystalline Vitamin B_{12} and 2 gm of Crystalline Procaine Penicillin Hydrochloride per pound of feeding sypplement.

RESULTS

Feed Consumption

One of the purposes of this experiment was to duplicate as nearly as possible farm feeding conditions. This meant

that for those hens receiving controlled amounts of grain that they should be fed about the same amount of grain as mash consumed. It will be noted from Table 4 that very seldom was this mash-grain ration balanced for any month. The reason is explainable. At the end of each month, when calculations were made, if it appeared that the mash-grain proportion was out of balance, the amount of grain fed for the succeeding month would be changed.

In pen I, where grain was fed in the litter, it was noted that in all months, except three, the consumption of mash was below the average for the three pens, and for all but two months, the consumption of grain was below the average for the three pens, but when the total average consumption of grain and mash of the three pens was considered, pen I became the average and consumed .2437 pound daily per hen (Table 4).

In pen II, where the hens were fed grain mixture free-choice, different results were observed. They consumed about one-half as much mash as grain. This is in agreement with the findings of Callenbach and Murphy (1942), and Lee, Scholes and Henry (1944). It was noted that the order of choice was wheat, corn and oats. This finding is not in accord with Parker and Barton (1947) who placed the order of grain choices as wheat, oats and corn. The total average monthly feed consumption of .2348 pound daily per hen was the lowest of the three pens (Table 4).

In pen III there were two methods of feeding employed. For the first three months, the birds were fed only the mash mixture. The succeeding five months, grain was fed in the litter. This change in method of feeding made a noticeable change in protein intake. For the eight months of the experiment they consumed the greatest total average amount of feed daily per hen of the three pens.

It is also noted from Table 4 that during these first three months, an average of .2252 pound of mash was consumed by each hen daily but that after grain was added to the ration the daily consumption of feed per hen increased to .2774 pound.

Adaptation of Protein

In considering the protein intake during this experiment, it will be noted from Table 4 that in the case of each pen there was a variation from month to month. This protein intake is determined by the volume of the grain and mash consumed. At no time in either of the three pens was the same amount of total feed consumed nor was the proportion of mash to grain the same. Therefore, the percentage of protein consumed varied from month to month in all pens. The percentage of protein consumed from the feed in pen I was above the 15 percent recommended by the National Research Council for egg production in all months but two. The eight months' average for protein intake was lowest in pen I of the three pens, it

being 15.7 percent.

In pen II, where free-choice of mixed grains was fed, it was found that the birds consumed more than two times as much mixed grains as mash. For the eight months' period their average protein intake was 16.8 percent. This was the highest total average protein intake of the three pens.

It was found that they were able to balance their protein intake without as wide a variation as in the case of the other two pens. This fact coincides with the results obtained by Fangus and Kallmann (1933), Graham (1934), Kennard and Chamberlin (1942), and Parker and Barton (1947).

In pen III, where the hens were fed an all-mash ration for the first three months, their protein intake was 18.6 percent. After the first three months and for the balance of the experiment, when mixed grain was added to the ration, the protein content dropped to the lowest of the three pens, or an average of 15.2 percent for the five months. For only one of these last five months was the monthly average percent of protein intake above the 15 percent recommended by the National Research Council. This high protein intake for the one month can be accounted for by referring to Table 4. It will be noted that during this month there was 30 to 40 percent less grain and a correspondingly larger amount of mash consumed by this pen. It might be said that there were four levels of protein intake. First the balanced or control group receiving an average of 15.7 percent, the free-choice group with an

average intake of 16.8 percent, and all-mash group getting an average of 16.5 percent, and this same group for five months, with grain, getting 15.2 percent. These various conditions on the adaptation of protein have their reflections on the outcome of this experiment as will be pointed out under the discussion.

Production

One of the basic purposes of this experiment was to study results in terms of production. In this study, production could be considered from two viewpoints, eggs and baby chicks. Under another heading baby chicks will be discussed. Egg production in this experiment started low. However, from a breeding standpoint, the pullets were Leghorns crossed with Hy-Lines, and had not all reached sexual maturity at the time of starting this experiment. It is believed that the outbreak of fowl paralysis was a contributing factor to the low egg production.

The total average percent production was the highest of the three pens in pen I (Table 4). It was noticed that in this pen production reached the high level of 62.7 percent and 64.5 percent for March and April. Pen I consumed the average amount of feed, with the lowest eight months' average of protein intake, yet they were the highest in egg production.

In pen II where grain was fed free-choice, egg production

for the eight months averaged slightly below the average of the three pens. It is to be noted in Table 4 that in comparing February and March that there was an increase in feed consumption from .2710 to .2950 pound per bird per day, and an increase in protein intake from 16.6 percent to 17.2 percent, resulting in an increase in production from 51.6 percent to 63.8 percent.

In comparing the next two months, April and May, there was a drop of from .2560 to .1930 pound of feed per bird per day, protein intake increased from 16 percent to 19 percent and egg production increased from 43 percent to 57.9 percent for the months concerned.

Again referring to Table 4, in pen III for the first three months where the all-mash ration was fed containing 18.6 percent protein, the percent production was slightly higher than the average of the three pens for the three months, but when grain was fed, reducing the percentage of protein intake, production dropped below the five months' average and for the experimental period production average was the lowest of the three pens.

Body Weight

A study of Table 4 reveals that there was very little variation in body weight between the birds in all three pens.

There appeared to be no correlation between body weight

and feed consumption, protein intake or egg production. This was not surprising since the birds are expected to maintain body weight from their feed intake before much of it is used for the production of eggs.

Mortality

Because of the outbreak of fowl paralysis, significance of mortality data cannot be considered in this experiment. Calculations from Table 5 reveal that for the eight months there was a total mortality in pen I of 59.1 percent, in pen II of 65.1 percent and in pen III of 61.3 percent. Data recorded during the experiment as listed in Table 4 show the mortality by months in percentage of those birds on hand at the beginning of that month. It is to be noted that during the last six months of the experiment there was a gradual increase in monthly percentage of mortality.

Hatchability

It has long been accepted that hatchability is a transmittable character. A part of this may be a genetic factor, but to a large extent it is controlled by the ration of the breeding hens. This is the findings of Bird et al. (1946).

Eight males were placed in each pen and from all appearances this number provided satisfactory fertility. Males were

not rotated among the pens. Table 6 reveals only slight variation in hatchability of the three pens.

Transmittal Factors to the Chick

If causative factors for mortality are transmitted, the ration fed the chick can be ruled out. In this experiment, the overall percentage mortality among those fed the high efficiency ration was 8.8 percent against 8.2 percent for those fed the control diet.

The total percent mortality between the offspring from the different pens is to be considered. From pen I the total chick mortality was 5 percent; from pen II, 9 percent; and from pen III, 11.6 percent. It is to be remembered that the hens in pen I were receiving a 20 percent commercial laying mash and mixed grains fed daily in the litter when the eggs were being produced from which the above chicks were hatched. The hens in pen II were receiving the 26 percent balancer mash and mixed grain fed ad lib., and the hens in pen III were receiving an all mash ration containing 18.6 percent protein as their entire ration when the eggs were being produced from which the above mentioned chicks were hatched. Just why the offspring from pen I suffered the least mortality cannot be explained unless there was a livability factor in something the hens in pen I ate in addition to the grains and mash.

In comparing the total growth gains between those fed

ration "A" and ration "B", it will be noted by calculations from Table 7 that the total average individual gain on ration "A" was 498.3 grams compared with the total average individual gain of 493.0 grams on ration "B".

The two-week period gain as shown in Table 7 for the progeny from each pen on each ration, when averaged, reveals the following:

Ration "A"	Pen I (grams)	Pen II (grams)	Pen III (grams)
1st two weeks	103	94	73
2nd two weeks	202	166	231
3rd two weeks	223	228	175
Total, 6 weeks	528	488	479
Ration "B"			
1st two weeks	133	96	103
2nd two weeks	162	189	169
3rd two weeks	184	225	218
Total, 6 weeks	479	510	490

It will be noted that the chicks from pen I show the greatest 6 weeks' total gain on ration "A" and the lowest on ration "B". The chicks from pen II show the greatest gain on ration "B" and the chicks from pen III show the lowest gain on ration "A". It will be noted by adding the 6 weeks' total gain on Ration "A" and "B" that the greatest total gain was from the offspring of pen I.

It will be observed from Table 8 that the individual average weight of the female progenies from pen I exceeded those from

pens II and III. The average weight of the male progenies from pen I had a very slight gain over those from pens II and III.

Data recorded in Table 9 reveal a comparative average weight per chick of 1.42 pounds for the offspring from pen I; 1.19 pounds for the offspring from pen II and 1.15 pounds for the offspring from pen III. This confirms the findings of Bethke et al. (1946) that there are certain growth factors transmitted through the egg to the chick and in this experiment it is probably from the method of feeding in deep litter that the hens in pen I have picked up certain amounts of vitamin B_{12} known to be in the litter. The hens in the other pens did not eat from the litter and did not get this vitamin or growth substance. (It is to be remembered that the hens in pen III were fed an all-mash ration of 18.6 percent protein while the hatching eggs were being produced and were not fed grain in the litter until after all hatching eggs had been set in the incubator).

DISCUSSION

It is generally accepted that for greater feed consumption there should be greater production. In this experiment pen I had the highest total average monthly production of 47.7 percent (Table 4), in comparison with the low pen whose average monthly production was 40.9 percent. It cannot be determined

in this experiment the cause for this. The birds in pen I were fed mixed grain in the litter daily and they might have received some nutrients from the deep litter which would have affected production. It is an established fact that there is a certain amount of vitamin B_{12} in deep litter and this vitamin is a factor in egg production. The birds in pen III also were fed mixed grain in the deep litter for the last five months of this experiment and their average monthly production was only 40.9 percent. The birds in pen II exceeded all others in the percentage of protein consumed and their production was very close to the highest average. The protein allowance for laying hens recommended by the National Research Council is 15 percent. It is not expected that egg production would be adversely affected with a protein content above this allowance.

The birds in pen II, which is the one having free-choice grain and mash feeding, not only balanced their diet as far as protein content was concerned, but maintained production slightly below the average of the three pens. It was noted that the 26 percent mash (balancer) provided approximately one-third of their feed intake. This would mean that such a balancer should contain more of the other nutrients not provided by the grains fed than a mash where 50 percent of the feed intake is mash and the other 50 percent grain.

The various feeding methods affected the protein intake. Pen I received approximately 50 percent of the 20 percent protein mash and 50 percent mixed grains containing about 12.05

percent protein which averaged for the experiment a 15.7 percent protein intake. Pen II, getting about one-third of their protein intake from the 26 percent balancer and about two-thirds from the mixed grains which contained about 12.05 percent protein, averaged for the experiment a protein intake of 16.8 percent. Pen III presented a different problem. Normally feeds are balanced by weight. In the case of the birds in pen III, the mash of their ration was balanced by volume. For the first three months of the experiment their mash consisted of 50 percent by volume of 26 percent balancer and 50 percent by volume of mixed ground grains containing approximately 12.05 percent protein. By calculation their entire protein intake for the first three months was 18.6 percent. Production for these three months was near the three pen average. For the last five months while grain was added to their ration, it is to be understood that these birds were actually getting 75 percent of their feed as grain and 25 percent as balancer mash mash and it was during this time that there was a gradual decline in egg production. It is to be expected that there were deficiencies in other nutrients not supplied by the grains.

The question arises whether one hen stores in her egg, feed which can be used by her offspring to an advantage over the offspring from another hen? Bethke et al. (1947) found that this was possible under certain conditions with certain nutrients. In this experiment, when one-half of the chicks from each pen were fed a normal starting ration and the other

half fed a high efficiency ration, it is revealed in Table 7 that the offspring from pen I produced the greatest growth. The offspring from pen III produced the least growth of the three pens. This is hard to explain since the hens in pen III at the time when hatching eggs were being produced were receiving a mixed mash ration containing 18.6 percent protein. It is postulated that there was a growth factor in the deep litter which was used by the hens in pen I and transmitted to the chicks through the egg. This was not the case with pen III since they were receiving only ground grains mixed with the 26 percent balancer mash at the time the hatching eggs were produced. In calculating the feed efficiency from the data in Tables 7, 8, and 11 of the progeny from pens I, II and III on the high efficiency ration and the control ration, the following results were obtained for the six weeks' period.

Feed Efficiency	High Efficiency Ration	Control Ration
Pen I Progeny	2.57	3.00
Pen II Progeny	2.72	2.95
Pen III Progeny	2.85	2.91

This means that it took the above number of pounds of feed to produce one pound of chick weight. It is expected that these results are higher than the normal because of the method of feeding the chicks. They were fed in open hoppers and no recognition was made for any feed that might have been wasted from the hoppers.

SUMMARY

The adaptation of protein concentrates in the laying ration involves two main studies: First, that of balancing the ration with proper essential nutrients, and second, applying the proper method of feeding the rations.

In considering the feed consumption of all three pens it appears that in pen I there was a ratio of mash to grain of 1:1 and the amount of feed consumed per hen per day became the average for the three pens. In pen II the ratio of mash to grain was 1:2 and the feed consumption per hen per day was the least of the three pens. In pen III when the ration consisted only of a mixed mash, the average consumption per hen per day was .22 pound, but when grain was added to the ration the consumption was increased to .25 pound per day per hen.

The adaptation of protein in this experiment was dependent to a large extent on the methods of feeding. In pen I the 15.7 percent protein in the feed exceeded the recommended allowances of the National Research Council and appeared to be adequate for satisfactory results. In pen II the birds were able to balance the protein intake from their ration on a computed level of 16.8 percent, a higher percent of protein intake than either of the other two pens. The birds in pen III when their ration consisted of only mixed mash, containing 18.6 percent protein, apparently were able to maintain body weight but production was low. When grain was added to their ration the

protein content changed to 15.2 percent. The immediate increase in production indicates that the feeding of the grain in the litter added some unknown nutrients to the ration.

Considerating egg production over the eight months' period, the birds in pen I consistently maintained the highest rate of the three pens. The rate of production of the birds in pen III was the lowest of the three pens.

In this experiment it appears that there were sufficient nutrients in the feed furnished all three pens to satisfactorily maintain body weight. There was no correlation between body weight and feed consumption, protein intake or egg production.

The significance of mortality data cannot be considered in this experiment because of an outbreak of a disease in all three pens.

There was a slight variation in hatchability between the three pens.

The transmittable factors from the dam, through the egg, to the chick were measured in terms of mortality and growth. Each of these terms was considered from the ration fed the chicks and the rations fed their dams. There was no explanation for the higher mortality among the chicks fed the high efficiency ration. The mortality of the offspring from pen I being 5 percent, from pen II being 9 percent and from pen III being 11.6 percent lends to the conclusion that the chick offspring from pen I were better able to live in their environ-

ment. In considering the growth factors of the chicks fed on the two rations there seems to be but slight difference in favor of those fed the high efficiency ration. In considering the growth factors of the progenies of pen I, pen II and pen III, it is postulated that reason for the offspring from pen I exceeding the offspring from pen II and pen III in growth was that the birds in pen I obtained nutrients from being fed grain in the litter which was transmitted to their offspring through the egg. The hens in the other two pens were not fed grain in the litter and consequently did not receive these extra nutrients.

CONCLUSIONS

All conclusions from this experiment are arrived at from narrow margins of evidence and should not be considered as statistically significiant.

In considering feed consumption it appears that the volume of feed consumed by laying hens may be influenced by the method of supplying the feed to them. The consistency of the feed may be another factor as it was demonstrated in this experiment that mixed grains were more palatable than mash.

The adaptation of protein as demonstrated in this experiment lends to the conclusion that a total intake of protein at or above the recommended allowances of the National Research Council is satisfactory for body weight, growth and production.

It has further been demonstrated that when laying hens are fed mash and grain ad lib., they are able to balance the protein intake from these feeds to satisfy their protein requirements.

Better production is possible when laying hens are fed mash and grain in the ratio of 1:1 with the mash hopper-fed and the grain fed daily in the litter. Production can be adversely affected when the protein content of the feed is satisfactory and other nutrients are furnished in amounts below minimum.

This experiment furnished no satisfactory evidence to warrant conclusions on the effect of body weight, mortality or hatchability.

There appears to be no transmittable factors that would cause a chick to grow better on a high efficiency ration than on a standard ration as used in this experiment. It appears that there were transmittable factors for growth from the birds in pen I to their offspring.

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LITERATURE CITED

Bethke, R. M., D. C. Kennard, and J. M. Pensack.
The influence of hen's diet upon growth of progeny. Poultry Science. 26: 128-131. 1947.

Bird, H. R., S. K. Haynes, Max Rubin, and D. Whitson.
Effectiveness of dietary supplements in increasing hatchability of eggs and viability of progeny of hens fed a diet containing a high level of soybean oil meal. Poultry Science. 25: 285-293. 1946.

Callenbach, E. W., and R. R. Murphy.
Feeding systems for laying hens. Pennsylvania Agr. Expt. Sta. Bul. 425. March, 1942.

Davidson, J. A.
The use of high-protein laying mashes. Michigan Agr. Expt. Sta. Quarterly Bul. 22. No. 2. 1939.

Fangus, R., and E. Kallmann.
Boliobige autnahme von eiweissfutter bei legehuhnern als eiweissparende futterungstechnik. Arch. F. Geflugelk 7: 1-10. 1933.

Graham, J. C.
Individuality of pullets in balancing the rations. Poultry Science. 13: 34-39. 1934.

Heiman, V., J. S. Carver, and J. L. St. John.
The protein requirements of laying hens. Washington Agr. Expt. Sta. Bul. 331. 1936.

Kennard, D. C., and V. D. Chamberlin.
Rations and methods of feeding White Leghorn pullet layers. Ohio Agr. Expt. Sta. Bimonthly Bul. 214: 10-16. 1942. Ohio Agr. Expt. Sta. Record 87: 260. 1942.

Lee, C. E., J. C. Scholes, and C. L. Henry.
The effect of free-choice grain feeding on egg production, food consumption, body weight and egg quality. Poultry Science. 23: 360-370. 1944.

Martin, J. Holmes, and W. M. Insko, Jr.
Feeding trials with laying hens. Kentucky Agr. Expt. Sta. Bul. 294. 1929.

McClary, C. F., G. E. Bearse, and V. L. Miller.
A study of feeding methods of laying hens. Report of Agr. Res. and other Activities of the Western Washington Expt. Sta. December, 1942.

Mehroff, N. R.
Poultry research marches on. Florida Poultryman and Stockman. p. 16. November, 1942.

Parker, J. E., and O. A. Barton.
Free-choice feeding of laying hens. North Dakota Agr. Expt. Sta. Bul. 345. 1947.

Penquite, Robert, and R. B. Thompson.
Growth of chick embryos from hens fed different protein levels. Poultry Science. 15: 8. 1936.

Robertson, E. I., J. S. Carver, and J. W. Cook.
Methods of feeding laying hens. Washington Agr. Expt. Sta. Bul. 381. 1939.

Rubin, Max, and H. R. Bird.
A chick growth factor in cow manure. II. The preparation of concentrates and the properties of the factor. Jour. Biol. Chem. 163: 387-392. 1946.

Subcommittee on poultry nutrition: W. W. Cravens, chairman, H. J. Almquist. R. M. Bethke, H. R. Bird, L. C. Norris. Recommended nutrient allowances for domestic animals. No. 1. Recommended nutrient allowances for poultry. National Research Council, 2101 Constitution Avenue, N.W. Washington 25, D. C. Revised March, 1950.

Vondell, John H.
Methods of feeding layers and breeders. Poultry Science. 27(5): 531-535. 1948.

APPENDIX

Table 1. Protein content of grain mixture including oats.

	Protein percent	Lbs. protein in feed
100 lbs. Yellow corn	8.9	8.9
100 lbs. Wheat	15.2	15.2
100 lbs. Oats	12.0	12.0
300 lbs.		36.1

Protein content of this grain mixture is 12.04 percent

Table 2. Protein content of grain mixture excluding oats.

	Protein percent	Lbs. protein in feed
100 lbs. Yellow corn	8.9	8.9
100 lbs. Wheat	15.2	15.2
200 lbs.		24.1

Protein content of this mixed grain is 12.05 percent

Table 3. Protein content of ground grains with balancer, with and without oats, measured by volume.

	Net wt. of measure when full	Percent protein content	Lbs. protein in each full measure
		With oats	
Ground yellow corn	46 lbs.	8.9	4.094
Ground wheat	48 lbs.	15.2	7.296
Ground oats	35 lbs.	12.0	4.200
Balancer mash	38 lbs.	26.0	9.888
Balancer mash	38 lbs.	26.0	9.888
Balancer mash	38 lbs.	26.0	9.888
Total	243 lbs.		45.254
Calculated protein content of this mash is 18.62 percent			
		Without oats	
Ground yellow corn	46 lbs.	8.9	4.094
Ground wheat	48 lbs.	15.2	7.296
Balancer mash	38 lbs.	26.0	9.888
Balancer mash	38 lbs.	26.0	9.888
Total	170 lbs.		31.166
Calculated protein content of this mash is 18.33 percent			

Table 4. Summary of results showing feed and protein consumption, production, body weights and mortality.

	Pen no.	No. hens started	Oct. 1950	Nov. 1950	Dec. 1950	Jan. 1951	Feb. 1951	March 1951	April 1951	May 1951	Total average
Mash consumption per hen day, in pounds	I	93	.0726	.1340	.1700	.1290	.1390	.0670	.0810	.1250	.1147
	II	94	.0455	.0675	.0760	.0830	.0890	.1090	.1740	.0960	.0800
	III	93	.1698	.2740	.2320	.1436	.1330	.1210	.1200	.2030	.1745
Average			.0959	.1585	.1593	.1185	.1203	.0990	.0916	.1413	.1232
Grain consumption per hen day, in pounds	I	93	.0890	.1410	.1000	.1260	.1230	.1320	.1780	.1430	.1290
	II	94	.1254	.1730	.1720	.1210	.1820	.1860	.1820	.1970	.1741
	III	93	-	-	-	.1884	.1160	.1290	.1460	.0870	.1333
Average			.1072	.1570	.1360	.1451	.1403	.1490	.1687	.1090	.1455
Total feed consumption per hen day, in pounds	I	93	.1616	.2750	.2700	.2550	.2620	.1990	.2590	.2680	.2437
	II	94	.1709	.2405	.2480	.2040	.2710	.2950	.2560	.1930	.2348
	III	93	.1696	.2740	.2320	.3320	.2490	.2500	.2660	.2900	.2578
Average			.1674	.2632	.2500	.2637	.2607	.2480	.2603	.2503	.2438
Percent protein consumed from feed	I	93	15.6	15.9	17.0	16.1	16.3	14.7	14.5	15.8	15.7
	II	94	15.8	15.9	16.3	17.7	16.6	17.2	16.0	19.0	16.8
	III	93	18.6	18.6	18.6	14.7	15.4	15.1	14.8	16.4	16.5
Average			16.6	16.8	17.3	16.2	16.1	15.7	15.1	17.0	16.3
Percent production	I	93	17.1	22.4	44.2	60.8	52.2	62.7	64.5	57.8	47.7
	II	94	22.0	25.0	38.2	56.2	51.6	63.8	43.0	57.9	43.7
	III	93	21.6	28.5	37.9	56.9	52.6	50.4	33.0	46.1	40.9
Average			20.3	25.0	40.1	58.0	52.1	59.0	46.8	57.9	44.1
Average body weight, in pounds	I	93	3.78	4.21	4.44	4.08	4.36	4.22	4.57	4.39	4.26
	II	94	3.74	4.04	4.19	4.05	4.24	4.18	4.08	4.55	4.13
	III	93	3.95	4.35	4.33	4.15	3.89	4.02	3.94	3.98	4.08
Average			3.82	4.20	4.32	4.09	4.16	4.14	4.20	4.31	4.16
Percent of mortality of those on hand at the beginning of each period	I	93	7.5	6.9	9.8	8.2	8.7	9.5	21.8	11.6	10.5
	II	94	5.2	9.0	11.0	15.0	9.5	10.7	20.4	5.7	10.8
	III	93	7.5	6.9	15.0	10.2	9.9	5.4	15.2	7.7	9.7
Average			6.8	7.6	11.9	11.1	9.4	8.5	19.1	8.3	10.3

Table 5. Experimental data from Pens I, II and III taken at approximately four-week intervals.

Beginning date Oct. 3, 1950: Date of calculation	Nov. 3, 1950	Dec. 1, 1950	Dec. 29, 1950	Jan. 29, 1951	Feb. 27, 1951	March 26, 1951	April 23, 1951	May 25, 1951
Pen I								
Average number hens	86	81	73	69	63	54	43	38
Hen days (for egg prod.)	2863	2220	2206	2216	1950	1449	1205	1262
Male days	-	112	173	155	145	180	168	192
Fowl days (for feed con.)	2863	2332	2379	2371	2095	1629	1373	1554
Total egg production	491	498	976	1348	1018	908	778	729
Total weight females lbs.	330.3	307.6	309.6	306.3	263.4	230.4	187.1	171.6
Mash consumption lbs.	208	313	405	306	292	109	112	195
Grain consumption lbs.	255	329	236	301	259	216	244	223
Total feed con. lbs.	463	642	641	607	551	325	356	418
Pen II								
Average number hens	89	81	71	62	56	44	35	33
Hen days (for egg prod.)	2813	2345	2190	2137	1792	1281	1296	951
Male days	-	112	210	210	189	189	231	168
Fowl days (for feed con.)	2813	2457	2400	2347	1981	1470	1527	1119
Total egg production	619	587	837	1202	925	818	558	494
Total weight females lbs.	329.3	306.5	294.6	263.3	228.9	190.2	147.7	135.6
Mash consumption lbs.	128	166	184	196	178	161	113	107
Grain consumption lbs.	353	427	415	285	362	274	279	108
Total feed con. lbs.	481	593	599	481	540	435	392	215
Pen III								
Average number hens	86	80	68	61	55	46	39	36
Hen days (for egg prod.)	2783	2160	2124	1997	1707	1324	1401	1033
Male days	-	112	224	216	174	168	165	140
Fowl days (for feed con.)	2783	2272	2348	2213	1881	1492	1566	1173
Total egg production	603	616	805	1138	899	668	463	477
Total weight females lbs.	329.9	316.3	296.2	268.8	229.6	196.8	158.5	142.1
Mash consumption lbs.	472	624	544	318	250	181	188	239
Grain consumption lbs.	-	-	-	417	217	193	230	103
Total feed con. lbs.	472	624	544	735	467	374	418	342

Table 6. Hatchability records.

Pen	Eggs set	Infertile eggs	Fertile eggs	Dead germ	Dead embryo	Cull chicks	Number vigorous chicks	Percent hatchability of fertile eggs
I	180	12	168	1	11	1	155	86.3
II	180	14	166	3	15	6	142	85.5
III	180	21	159	8	12	1	138	86.8

Table 7. Chick growth.

Ration*	Off-spring from pen	1st and 2nd week (16 days) Mortality percent	1st and 2nd week (16 days) Av. individual gain for period in grams	1st and 2nd week (16 days) Daily food consumption in pounds per chick	3rd and 4th week (14 days) Mortality percent	3rd and 4th week (14 days) Av. individual gain for period in grams	3rd and 4th week (14 days) Daily food consumption in pounds per chick	5th and 6th week (14 days) Mortality percent	5th and 6th week (14 days) Av. individual gain for period in grams	5th and 6th week (14 days) Daily food consumption in pounds per chick
A	1	4	103	.0303	4	202	.0865	0	223	.1086
A	2	3	94	.0303	3	166	.0865	1	228	.1086
A	3	7	73	.0303	1	231	.0865	3	175	.1086
B	1	0	133	.0310	2	162	.0879	0	184	.1274
B	2	3	96	.0310	7	189	.0879	1	225	.1274
B	3	2	103	.0310	3	169	.0879	6	218	.1274

* Ration A - High Efficiency; Ration B - Control

Table 8. Six week weights by sexes.

Ration	Progeny: Pen I No. F*	Pen I Av. wt. lbs.	Pen I No. M*	Pen I Av. wt. lbs.	Pen II No. F*	Pen II Av. wt. lbs.	Pen II No. M*	Pen II Av. wt. lbs.	Pen III No. F*	Pen III Av. wt. lbs.	Pen III No. M*	Pen III Av. wt. lbs.
A	39	1.13	32	1.40	30	1.00	45	1.30	32	1.00	29	1.30
B	33	1.14	43	1.20	35	1.10	33	1.30	35	1.07	26	1.30

* F = Female chickens; M = Male chickens

Table 9. Progeny weights by pen from both feeding experiments of chicks, day old and six weeks of age.

	Pen					
	I		II		III	
	No.	Average weight	No.	Average weight	No.	Average weight
Day old chicks	155	37 gm	142	36.2 gm	138	35.5 gm
At 6 weeks						
Females	72	1.135 lb.	65	1.05 lb.	67	1.04 lb.
Males	75	1.69 lb.	78	1.30 lb.	55	1.30 lb.
Average		1.42 lb.		1.19 lb.		1.15 lb.

Table 10. Chick data on Ration "A", High Efficiency, and Ration "B", Control.

Line	Dates of period	Jan. 18, 1951 to Feb. 3, 1951			Feb. 3, 1951 to Feb. 17, 1951			Feb. 17, 1951 to March 3, 1951		
	Offspring from Pen No.	I	II	III	I	II	III	I	II	III
					Ration A					
A	No. beginning of period	77	70	69	74	68	64	71	66	63
B	Mortality during period	3	2	5	3	2	1	0	1	2
C	No. end of period	74	68	64	71	66	63	71	65	61
D	Total weight beg. of period, g	2845	2485	2444	10408	8878	6950	24289	19522	21338
E	Total wt. of those died, g	274	150	460	908	574	253	-	296	678
F	Total wt. end of period, g	10408	8878	6950	24289	19522	21338	40134	34482	31508
G*	Weight gain in g	7837	6543	4970	14789	10238	14641	15845	14960	10848
H	$\bar{x}$ wt. beginning period in g	37	36	35	140	130	108	342	296	339
I	$\bar{x}$ wt. end of period in g	140	130	108	342	296	339	565	530	517
F#	$\bar{x}$ gain during period in g	103	94	73	202	166	231	223	228	175
					Ration B					
A	No. beginning of period	78	72	69	78	70	67	76	65	65
B	Mortality during period	0	2	2	2	5	2	0	1	4
C	No. end of period	78	70	67	76	65	65	76	64	61
D	Total wt. beg. of period, g	2885	2555	2458	13278	9248	9276	25197	20884	19976
E	Weight of those died, g	0	187	182	567	1121	454	0	321	1228
F	Total wt. end of period, g	13278	9248	9276	25197	20884	19976	39225	35094	32507
G*	Weight gain in g	10393	6880	7000	12486	12757	10940	14028	14531	13759
H	$\bar{x}$ wt. beginning period in g	37	36	35	170	132	138	332	321	307
I	$\bar{x}$ wt. end of period in g	170	132	138	332	321	307	516	548	532
J#	$\bar{x}$ gain during period in g	133	96	103	162	189	169	184	225	218

* G = F-D+E
\# J = G/(C+B/2)

Table 11. Chick feed data for Ration "A", High Efficiency, and Ration "B", Control.

Line	Period	Jan. 18, 1951 to Feb. 3, 1951 (16 days)	Feb. 3, 1951 to Feb. 17, 1951 (14 days)	Feb. 17, 1951 to March 3, 1951 (14 days)
		Ration "A"		
A	Total feed consumed, lbs.	96	246	302
B	No. chicks died	10	6	3
C	No. chicks on hand end period	206	200	197
D*	Chick days	3165	2842	2779
E#	x for daily feed con., lbs.	.0303	.0865	.1086
		Ration "B"		
A	Total feed consumed, lbs.	101	259	363
B	No. chicks died	4	99	5
C	No. chicks on hand end period	215	206	201
D*	Chick days	3255	2947	2849
E#	x for daily feed con., lbs.	.0310	.8790	.1274

* D = (C + B/2) x No. days. # E = A/D.

ADAPTATION OF PROTEIN CONCENTRATES IN THE LAYING RATION

by

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B. S., Oklahoma A & M College,
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The purpose of this experiment was to make a study of the protein adaptations for laying hens in the production of eggs, hatchability, body weight and transmittal factors to their offspring.

Two hundred eighty pullets from Single Comb White Leghorn males and Hy-Line females were placed in three pens. Pen I was fed a 20 percent protein mash with an equal amount of mixed grains fed in the litter. Pen II was fed a 26 percent protein mash balancer with mixed grain fed free-choice. Pen III was fed an all-mash diet for the first three months of the experiment, consisting of 50 percent by volume of 26 percent protein balancer, and 50 percent by volume of ground yellow corn, ground wheat and ground oats. During the last five months of this experiment the birds were fed this same mash mixture less oats with equal amounts of mixed grain fed daily in the litter.

During the experiment, oats became unobtainable and were removed from the ration.

The birds in Pen I, on a 15.7 percent total protein diet, produced the best results from the standpoint of egg production and body weight.

The birds in Pen II were able to balance their diet for the protein requirements. (For the eight months the protein content of their total feed averaged 16.8 percent.)

In Pen III satisfactory results were obtained for the first three months, but when additional grain was added to the

ration there was a gradual decline in egg production.

The protein content in the diet appeared to have no effect on hatchability.

Four hundred thirty-five baby chicks were hatched from these three pens. One-half of the progeny from each pen were fed to six weeks of age on a high efficiency type ration and the other half were fed on a control ration.

The progeny from Pen I had made the best growth at six weeks of age (averaging 1.42 lbs., 1.19 lbs., 1.15 lbs. for Pens I, II, and III, respectively). It is believed that the hens in Pen I received certain vitamins (B_{12}) and other nutrients from the feeding of grain in the litter which was transmitted as a growth factor through the egg to the chick.