VI. OBSERVATIONS UPON THE GROWTH OF YOUNG CHICKENS UNDER LABORATORY CONDITIONS.

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There are not many published records of the use of young chickens as the experimental animals in studies upon the factors concerned in growth and nutrition, but, from a reference to those of recent date, the present author was led to believe that one might rely to some considerable extent upon their suitability for such studies.

When the present work was begun, it was intended to make a full study of the effect of various diets upon tumour growth in the young, growing chick.

The particular tumour which was selected for use was one of the avian neoplasms described by Rous [1910]. This growth, originally found by him in a Plymouth-rock hen, simulates in many respects a spindle-celled sarcoma. It is very suitable for the study of the effect of diet upon tumour growth, on account of its high degree of virulence, its rapid growth, and its great tendency to form metastatic deposits in other parts of the body.

Peculiar interest is also attached to the growth from the fact that it may be transmitted by means of the cell free filtrate from the crushed tumour. For this reason, as well as on other grounds, many workers consider that the growth should be classified as one of the infective granulomata, rather than as one of the true sarcomata.

Whether this is so or not, is a matter which remains as yet undecided. Meanwhile it was felt that the tumour sufficiently simulated a true sarcoma to warrant an investigation along the lines previously mentioned.

At the outset of the work, Dr A. Paine, the Director of the Research Institute, brought to my notice an observation that he had made. He had

been struck by the poor standard of development and nutrition reached by large batches of young chickens reared in the Laboratory animal room from an early age, and, in view of some of the published results from this Laboratory, it was felt that the matter was of sufficient importance to justify an investigation.

It will be useful if reference is made here to some of the earlier research which has been done upon the growth of young chickens and upon the effect of various dietaries upon the growth of Rous' sarcoma grafts which they carried.

Funk [1913] utilised, for a research of this nature, young chicks of the Plymouth-rock strain, which were a fortnight old when observation was begun upon them. They were divided into different batches, which were fed upon different variations of a rice diet. After the elapse of 15 days, each bird received an injection of Rous' sarcoma, and the effect of the diet upon the subsequent development of the tumour graft was then noted.

He found that the young birds, which received as their sole food cooked polished rice, invariably died after some fourteen days without exhibiting any apparent symptoms of beri-beri.

A further series of birds were fed entirely upon cooked "red" (unpolished) rice, and results of apparent importance were obtained upon this batch.

It was found that the chicks remained alive for some four weeks or so without manifesting any sign of further growth. During this period, Funk's control birds, fed upon chicken food, doubled their initial weight.

There is no need to deal here with the results of the dieting upon the injections of tumour material. They are strictly in accordance with the well-known fact that tumour grafts will not flourish well in an ill-nourished host.

Funk apparently kept observation upon his young chicks for a period of only twenty-eight days, a period, however, that he considered sufficiently long for his purpose, in spite of the fact that he realised to some extent the difficulty of rearing the little birds upon such monotonous diets. It is noteworthy that Funk did not observe any appreciable diminution of the appetites of the experimental animals.

In a later publication Funk [1914] corroborates his previous finding, that it is possible to arrest the growth of young chickens by feeding them upon a diet of "red" rice. A photograph is contained in his paper which contrasts very plainly the great difference in size and development of two chickens, one of which had been fed entirely upon a diet of "red" rice, while the other had received normal food.

Subsequently, in collaboration with Macallum, Funk [1914] published the description of extended studies upon the arrest of growth in young chicks. By adding a small ration of cod-liver oil to the diet of "red" rice, Funk and Macallum claim to be able to arrest the growth of young chicks over a much greater length of time than had been previously done upon a diet of "red" rice alone. They give somewhat detailed particulars of an individual bird which was maintained at an almost constant body-weight for a period of no less than five months by this means.

There is also appended to their communication another apparently striking photograph of this particular chick, standing by the side of a normal bird of the same age. It is not, however, stated whether the normal bird, whose photograph is reproduced, was reared in the Laboratory, and from the same series of chicks as the stunted one. In view of the results which will be shown in the present paper this question is one of the greatest importance.

The stunted chick possessed several peculiarities which were noted by Funk and Macallum. They found that the bird failed to develop any of the secondary sexual characteristics of the fowl, its voice is described as that of a four-week-old chick, and apparently the growth and development of the beak and feathers were not retarded to such a degree as was that of the body itself.

The present writer was so much impressed with the importance of the possibility of being able to stunt at will, for comparatively long periods of time, the growth of the young chick, that the preliminary experiments were directed to corroborate this finding, if possible.

Accordingly, in the early summer months of 1915, a large batch of young Plymouth-rock chicks was obtained from a reliable breeding farm in the country. The young birds arrived at the Institute at the age of ten days, and they were at once placed in a heated foster-mother where they were reared until somewhat older and stronger.

This was done as several preliminary experiments had shown that very young chicks are too delicate to be fed with unnatural dietaries.

The birds were strong and healthy when brought in, and, during the whole of the time that they were being hardened off in the foster-mother, they ate their food well. They were weighed regularly, and observation both of these weights and of their general appearance warranted the assumption that they would develop into healthy vigorous chickens.

It might be mentioned here that the foster-mother was constructed of wood, and the heating regulated so that as time elapsed the young birds

might be gradually hardened off. The floor was covered with a layer of fine sand and grit.

The diet supplied to the birds during this period was mainly a special chick-food, chopped egg and bread crumbs, and fresh green food.

After having been in the foster-mother for a month, the birds were divided into four batches, each of which was placed in a separate pen. The pens were large and well ventilated, provided ample room for exercise, and possessed a covered-in end, fitted with a warm sleeping shelter. The floors of the pens were covered with coarse sand, shell mixture and sawdust. The animal-room, in which the pens were kept, is large and airy, and has been constructed upon scientific principles for the housing of experimental animals under as natural conditions as possible.

Chart I. Growth curves of chicks fed upon a diet of cooked "black" rice.
x marks commencement of diet.

At this point in the investigation all the young birds were in good health as far as could be judged. They continued to eat well and the weekly increment of body-weight was satisfactory. All four batches were fed normally in the pens for a fortnight, receiving chicken-food, corn, meal and fresh green vegetables.

It was towards the end of this fortnight that the first cases of indisposition occurred. One or two of the chicks showed signs of weakness, particularly in the legs, and in these cases it was noted that the increase in body-weight was not as satisfactory as it had been.

Particular notice was not, however, paid to these birds, as it was considered that they might be exceptional cases.

They were accordingly weeded out, and the remaining chicks were placed upon various diets. One group received as sole source of nutriment cooked polished rice, a second was fed entirely upon cooked "red" (unpolished) rice, a third batch was given another variety of unpolished rice, namely, "black" rice, in the cooked state, whilst the fourth and last group was maintained on normal food. Daily observation was made on the birds,

and they were weighed at intervals of four days. The birds which were fed upon "white" polished rice behaved in the manner that was expected. They almost immediately failed to register an increase in body-weight, then followed a period of rapid decline and finally death (Chart II). Failure of appetite did not seem apparent during the decline, until in the latter stages. There is little need to comment upon the results obtained in this series of birds, for the results are but a corroboration of those which have been published by a considerable number of workers.

Chart II. Growth curves of chicks fed upon diet of cooked "white" rice.
x marks commencement of diet.

The second group of birds, which were given "red" rice alone, were watched with particular interest in view of the findings of Funk which have been referred to.

Chart III. Growth curves of chicks fed upon diet of cooked "red" rice.
x marks commencement of diet.

It was found, on an examination of the body-weights of the chicks in this batch, that growth was in many cases suspended shortly after the commencement of the feeding. Many of the birds did maintain an almost constant body-weight for periods of time varying from twenty to eighty days (Chart III). It was, however, soon obvious that the chicks were far from being in a healthy condition. The observations of Funk and Macallum with regard to the absence of any development of the secondary sexual characteristics and of the voice, and the comparative overgrowth of beak and feathers of these chicks, were confirmed. Many of them showed a

weakness in the legs and they all presented a ruffled appearance. Again, as in the case of the animals fed upon "white" rice, no apparent failure of the appetite was observed until a few days before death, which usually occurred after a rapid decline, following the period during which maintenance was marked.

Post-mortem examination of the chicks which died in this batch failed to reveal many apparent abnormalities. The birds were emaciated and there was a poverty of blood in the organs, the majority of which were atrophic; particularly was this the case with the thymus and the spleen.

Chart IV. Growth curves of control chicks, showing early failure.

The third series of chicks, fed upon "black" rice, reacted to the diet in a very similar manner to those which had received "red" rice. This is a matter for no surprise when one considers that the two diets are very similar. If anything, the period during which growth was stunted was shorter, and the final decline more rapid than in the case of the chicks fed upon "red" rice (Chart I).

The really interesting results of the work, however, followed, strangely enough, from a study of the remaining batch of chicks which had been retained upon normal diet, to act as control animals to the other three groups (Chart IV).

Mention has already been made of the one or two cases of weakness which were observed before the chicks were placed upon special diets.

It was now found that further similar cases occurred with increasing frequency amongst the control birds. Taken collectively, the batch began to present the same ruffled appearance and weakness in the legs as those which were fed solely upon rice diets, while few of them continued to put on weight.

Only one particularly strong chick continued to grow at a rate at all approximating to normal. There were, on the other hand, several cases of arrest of growth over considerable periods of time, followed occasionally by a slow resumption of a very subnormal rate of growth, or, as was the case

with the majority, by a rapid decline and death (Pl. I, photo. 2). Few of these birds lived longer than 120 days, which is little better than those which had been fed solely upon "red" rice.

Chart V. Curves showing failure of young chicks reared upon earth surface.

Even the one bird referred to above did not maintain its superior rate of growth for long. After fourteen weeks it arrived at its maximum body-weight of 500 g. and it was then a fairly strong chick (Pl. I, photo. 1). Subsequently it maintained its body-weight for some few weeks after which it declined in the same way as had done the other birds of this group.

The results obtained in the series of experiments may be tabulated in the following form:

No. of chicks in batch	Diet	Average length of life, days	Average maximum body-weight attained, g.	Average weight at death, g.
12	normal	123	256	216
12	"white" rice	65	107	91
12	"red" rice	82	167	100
12	"black" rice	76	162	113

From these average results it will be seen that the consequences of feeding "red" rice to young chicks is not much more detrimental to the nutrition of the animal than if one retains the bird on normal food.

The failure of the normal birds to grow and develop was at first attributed to possible defects in the condition of keeping or feeding. Thus, poultry-keepers sometimes consider that weakness in the legs is due to a deficiency of fresh meat in the diet. It was therefore attempted to rear a batch of young chicks upon normal food, giving them in addition a ration of fresh

meat daily. The birds ate the meat greedily, but did not respond to the change, and the effort to raise them was no more successful than before.

It was then thought that if the young birds were reared upon a more natural surface they might thrive more satisfactorily. Accordingly, two batches were reared separately, one being brought up upon a surface of sawdust and coarse sand, scattered on the floor of the cage (Chart VI); whilst the other group was provided with a surface of fresh earth and grass, which was frequently changed (Chart V).

Chart VI. Curves showing failure of young chicks reared on a surface of sawdust and sand.

Observation upon both batches was made as before, but very little improvement was noted in those reared under the more natural conditions. Certainly, as is seen from the tabulated results, they lived on the average somewhat longer, and attained a slightly greater maximum body-weight, but the usual symptoms of weakness, which have been described, made themselves apparent sooner or later and the chicks declined and died.

No. of chicks in batch	Reared upon	Average length of life, days	Average maximum body-weight attained, g.	Average weight at death, g.
12	Sand and sawdust	80	173	168
12	Earth and grass	93	239	229

Post-mortem examination of a large number of these "normal" chicks did not bring to my notice any particular point of interest. The bodies were without exception greatly emaciated. The organs were usually small and anaemic. During life this apparent poverty in blood was striking. The

combs and eyelids of the chicks were peculiarly bloodless, being of a dead white colour, as contrasted with the deep red colour possessed by the combs and eyelids of normal fowls of an equal age.

The results were of so striking a nature, and of such great importance in a consideration of the value that should be placed upon results of previous investigations carried out upon young chickens, that the experiments which have been described were repeated upon a further batch of young Plymouth-rock chicks.

This series were hatched out from eggs in the Institute, and were thus under observation from their birth. They were a strong healthy brood when born, and they were carefully reared in the foster-mother until five weeks old. They were then divided into similar batches to the other series, placed out in pens, and fed upon similar dietaries.

The results obtained were identical in every way with those which have already been described. The onset of the symptoms of weakness was, however, earlier in every case, and consequently the birds did not live so long or attain so great a weight.

No. of chicks in batch	Diet	Reared upon	Average length of life, days	Average maximum weight attained, g.	Average weight at death, g.
10	normal	earth	81	202	171
10	normal	sand	74	187	165
10	"red" rice	"	45	103	87
10	"white" rice	"	41	108	80
10	"black" rice	"	47	112	80

There now seemed every reason to believe that the observation communicated to me by Dr Paine was substantiated by facts, and that it was indeed a matter of difficulty to rear young chickens at all under the artificial conditions of an indoor animal-room.

While this work had been in progress, it was observed that a batch of Plymouth-rock hens which had been brought into the Institute at the age of six months were continuing to grow at a normal rate and appeared in every way healthy and strong. This observation suggested that an investigation into the effect of the age at which the young chickens were brought into the unnatural surroundings upon their subsequent development might yield useful data, particularly as large numbers of full-grown birds have been kept for long periods of time, under the same unnatural surroundings, without in any way showing any tendency to decline. Even egg production occurs in these full-grown fowls at a normal rate.

For the purpose of this research a large number of young Plymouth-rock

chicks were hatched out in the country and were then brought into the Institute after various periods of time. Observation was kept on them closely after they had been brought into the artificial conditions and the results have been tabulated as follows (Chart VII):

No. of chicks in batch	Age brought in, days	Average length of life, days	Average maximum body-weight, g.	Average weight at death, g.	Remarks
20	0	77	197	168	All died exhibiting signs of extreme malnutrition
16	4	86	206	198	ditto
25	7	84	233	184	ditto
12	10	123	256	216	ditto
12	21	152	307	290	Symptoms not so severe, yet all died from malnutrition
8	28	160	320	300	ditto
10	42	6 yet alive after 205 days	497	—	Poorly nourished and ill developed. Six yet alive, but all declining rapidly

The ten birds in the last group have resisted the unfavourable influences of the unnatural surroundings longer than any other batch have done. They have never presented, even at the time when they registered a maximum body-weight, a strong appearance.

During the period of decline they have not shown the symptoms of

weakness to anything like the same extent as did the first four batches, nor did they possess the pallor of the comb and eyelids which was so characteristic of the earlier groups of birds.

We now come to a consideration of the results which have been obtained. Firstly, it is felt that the young chick is not a suitable subject upon which to conduct experiments in the study of growth, at any rate, when it is kept under artificial conditions. The difficulty of rearing young fowls indoors is, I believe, realised by poultry-farmers generally, so much so in fact, that it is seldom attempted by them.

An explanation of the cause of the failure has not yet suggested itself. No dietary deficiency can be held as responsible, for the diet supplied to the experimental chicks in the normal batches was in every way similar to that successfully employed to rear chicks in the open air. An attempt to supply one of the conditions, under which fowls are normally reared, was made when fresh earth and grass were given to provide a surface for the young birds to run upon.

They certainly made use of the soil, scratching it over and picking out small insects and other tasty morsels all day long. And yet, despite the fact that the earth was changed frequently, this group of birds reached but a slightly better standard of development than did a similar batch, which had a surface of sawdust and grit to run upon.

In the light of these facts we must admit that there are other factors than an adequate diet, which must be supplied to the growing chick, in order that it may complete its normal growth when under conditions such as are described.

If we submit the results which have been published by Funk, and by Funk and Macallum, upon growth in young chicks, to a criticism directed along these lines, we are forced to conclude that they now have a much smaller value.

It is unjustifiable to deduce results from the feeding of an experimental animal upon a certain diet, unless the control animals, which are fed normally, behave in a normal manner. In the present case, it has been shown that young chicks may be fed upon a normal dietary—which under better surroundings would suffice to produce a normal development—and yet suffer from severe forms of malnutrition.

We know well that there was no reason to expect the batches fed upon cooked “white” rice to behave in any manner other than they did, for it is definitely established that “white” rice is an inadequate diet in many respects.

It is however considered that it is unwise to draw any conclusions from the results obtained in dieting birds upon "red" rice. Although it is true that many of the birds which were fed in this manner, in this series of researches, did show a period during which arrested growth was a prominent feature; yet, many similar cases have been observed in the control chicks fed on normal food.

The photographs shown in this communication demonstrate that arrested growth may occur in normally fed chicks to almost as striking a degree as in the case recorded by Funk and Macallum.

The previous work of the authors just referred to, on growth in young chicks, therefore affords no satisfactory evidence of the existence of any accessory substances or, as Funk prefers to call them, "vitamines."

Needless to say, no attempt was made to carry out the proposed scheme of investigation into the effect of diet upon tumour growth in the young growing chick, nor will such an attempt be made in this Institute until it has been found possible to rear young birds indoors to a satisfactory standard of nutrition.

The observations reported in the present communication may, at first sight, seem incomplete without containing a more exhaustive enquiry into the cause which underlies the early failure of the young chickens. The advisability of carrying out such an investigation was, however, fully considered at the time, but it was felt that such a study would lead too far away from those problems which are, at the present time, engaging the activities of this Institute.

It is for this reason, therefore, that the results that were obtained have been communicated in their somewhat incomplete form.

SUMMARY.

1. It has been found impossible to rear, to a satisfactory degree of development, young chicks kept under the artificial conditions prevailing in this Laboratory.

2. The age at which the chick is brought under the influence of these artificial conditions is apparently the chief determining factor in its subsequent development, other conditions being the same.

REFERENCES.

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Photograph 1. *Chick 1 A*, fed upon normal food, age 14 weeks, weight 500 g. At the time that this photograph was taken, this bird was at its prime. Nevertheless, the comb and eyelids were very pale and the bird was not strong. This chick remained at a body-weight of about 500 g. for nine weeks before it declined and died.

Photograph 2. *Chick 207 A*, age 12 weeks, weight 147 g. This bird was also fed upon normal food and belonged to the same hatch as No. 1 *A*. It fed well, and seemed quite as strong as the bigger bird, despite its ill-developed appearance. The overgrowth of the wing feathers may be noted in this case. This chick remained at an almost constant body-weight for 80 days before it declined and died. Both photographs are on same scale.