THE GROWTH RATE OF POULTRY IN THE HUMID TROPICS.

By

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The necessity of livestock for man is obvious. It is in evidence that improvement of the environmental conditions of these tropical lands should lead to the maximum use of scientific principles in breeding and animal husbandry in the tropical zones.

The single environmental factor involved is, of course, the climate, and all work on animal improvement in the tropics must be carried out with the climate always in mind. Because the climate itself cannot be altered, the primary need is for some explanation of the reactions of different classes and breeds of animals to the tropical environment. Having learnt how the tropical animal behaves, studies can then be carried out to ascertain the reasons. Only then, in the light of such information, can scientific principles be applied.

It is assumed that an animal makes its reflections in the growth and development of its body, and therefore a long-term experiment was started last year by Ensmid (1956) to investigate the growth of animals in Trinidad. Poultry were chosen for ease of handling...
I. INTRODUCTION AND OBJECTS.

The necessity of livestock for the maintenance of fertility in a balanced agricultural programme and for providing a source of protein in the human diet has long been recognised. Much work has contributed to the knowledge of the scientific principles of genetics, nutrition and growth and development in relation to animal husbandry, and the application of this knowledge is now widespread in the breeding and nutrition of improved stock throughout temperate areas.

In most of the tropics however, where the peoples are in the main backward in both thought and deed, the position is vastly different. The indigenous livestock have to exist under conditions of malnutrition, disease and bad management generally, and thus they contribute little to agricultural production. For this reason it is obvious that improvement of the environmental conditions of these tropical stock should precede any direct use of scientific principles of breeding and selection applicable in the temperate zones.

The major environmental factor involved is of course the climate, and all work on animal improvement in the tropics must be carried on with the climate always in mind. Because the climate itself cannot be altered, the primary need is for ample knowledge of the reaction of different classes and breeds of animals to the tropical environment. Having learnt how the stock react, further studies can then be carried out to ascertain the reasons. Only then, in the light of such information, should scientific principles be applied.

Any response that an animal makes is reflected in the growth and development of its body, and therefore a long-term experiment was started last year by Weavind (1953) to investigate the growth of chicks in Trinidad. Poultry were chosen for ease of handling...
of handling and as a cheap means of obtaining a large quantity of data, and measurement was of one characteristic body weight up to the age of 12 weeks.

Yet the environment will affect not only initial growth but also the onset of puberty, the lifetime production, reproduction and above all the efficiency of these processes. Similarly, growth entails not only an overall increase in weight but also a change in the shape and size of every part of the body.

The object of the present study is therefore twofold. Firstly, the rate of growth of the birds as reflected in body weight increases is followed to maturity and beyond. At the same time practical variables such as different feeds and different hatching dates, which are of immediate importance to local agriculture, are introduced and the progress and performance of the birds under such circumstances are noted. The second part of the experiment is chiefly a preliminary investigation of the body development of chicks hatched and reared in the humid tropics. From such fundamental work as this, it is hoped that data will first be accumulated and then compared with similar experiments performed with poultry in temperate countries.

It is only after the reaction of birds to tropical conditions has been thoroughly investigated in this way that recommendations as to the best method of breeding and management can be made. A long journey lies ahead but even the longest must be accomplished step by step.
II. SUMMARY.

1. This work continued the long-term experiment, begun by Weavind (1953) last year, to study rate of chick growth in the wet tropical environment of Trinidad.

2. The practical variables consisted of two local and two imported rations fed to birds on either deep litter or open range.

3. Twelve-week old birds put directly on to open range during the dry season made lower liveweight gains up to maturity than birds put on to deep litter.

4. All birds attained sexual maturity at about 24 weeks old, and thereafter rainfall and humidity appeared the major factors influencing body weight gain in this climate.

5. Average production per bird for the first laying year was 104 eggs.

6. Annual egg production of birds on open range was lower than those on deep litter. This was due to a reduction during the wet season period.

7. Local rations - Marketing Board and Trinidad Stock Feed—continued to produce better growth, as well as more eggs, than the imported Purina and Full-O-Pep feeds. It is suggested that the freshness of the local rations accounted for this.

8. Hatchability of fertile eggs over a sample period of two months was 68.5%.

9. Average egg weight for all laying birds was 22.4 ounces per dozen, mature birds giving smaller eggs during intensive laying periods.

/- PART 2.
This year three groups of chicks were hatched in the mid-season and, besides body weight, three external body measurements were taken on one group from hatching date to twelve weeks of age.

Growth this year was superior to that of birds hatched at the same time last year.

The minor inflection which occurs at five weeks in the growth rate curve of chicks hatched in the dry season was delayed three weeks in birds hatched in December this year.

The correlations between body weight and shank length and body weight and body depth were highly significant at intervals after one week's growth up to twelve weeks of age. The correlations between body weight and keel length were also significant but tended to decrease with age up to twelve weeks.

Brody (1937) and others have confirmed that for poultry in temperate countries the age of puberty is twelve weeks, but because the pubertal inflection did not occur within the twelve weeks encompassed by his data, Nævind (1953) concluded that chicks mature later in the tropics. However it will be shown in subsequent sections that even in the tropics twelve weeks is actually the age of attaining puberty for poultry.
III. REVIEW OF LITERATURE.

The collection and analysis of information concerning animal growth has been continuing for many years, and various patterns and approaches have been followed to explain this complex biological process. Hammond (1932) has established without doubt that growth is essentially two processes; firstly an increase in body weight and secondly a change in the shape and conformation of both external and internal body parts. The former he called "growth" and the latter "development." Rate of growth is most commonly measured by the change in body weight per unit of time and the growth curve of any organism is characteristically sigmoid in shape.

Brody (1927) states that although minor inflections occur at frequent intervals to indicate different physiological attainments, growth curves may be divided into two main segments with a major inflection at the division. The first segment is one of increasing slope, representing a period of self-acceleration when the rate of growth tends to be proportional to growth already made. The second segment of the curve is one of decreasing slope during which the rate is proportional to growth yet to be made, and Brody terms this the self-inhibiting phase. The major inflection between the two segments occurs at sexual maturity and thereafter, as Weavind (1953) points out, the development of the animal is under the domination of the environment.

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Nevertheless the other minor inflections which mark stages in developmental maturity can be delayed by unfavourable conditions of environment. For example, Weavind (1955) found an inflection occurring at five weeks old in the growth rate curve of chicks hatched in the wet season, whereas the same inflection in dry-season birds was delayed until eight weeks of age. In other words, the reaction of the birds to the unfavourable conditions of dry-season hatching was indicated by a three-week delay in reaching the stage of maturity that this inflection represents.

Much work has been done on the growth of poultry in temperate climates but little has been carried out under such tropical conditions as Trinidad possesses, and this must be borne in mind when comparisons are made. At the same time one must remember that growth involves not only an increase in weight but also such aspects as maturity, the onset and lifetime course of production and its persistence.

The age at which the first egg is laid has been used for many years to measure time of sexual maturity (Lerner and Taylor, 1937) (Waters, 1937), but the precise date of the onset can be profoundly affected by environmental factors such as plane of nutrition (Wilson, 1954) and climate (Hammond, 1940). Brody (1927) put it for most breeds at 20 - 24 weeks, whilst Hays (1951) found that the average age at maturity was 198 days with extremes varying from 160 to 250 days. On the other hand work in Ceylon, which is at roughly the same latitude as Trinidad, shows the average age of Rhode Island Red hens at first egg to be 255 days, or 36 ½ weeks. (Mahadevan, 1954).

Maximum body weight, or the attainment of physical maturity, appears to coincide with maximum egg weight at about ten months of age (Waters, 1937) but here again environment will play a big part.
The effect that climate may have on the process of normal growth has already been stressed, and this aspect obviously assumes particular importance in the tropics. Hammond (1954) states that the heat of the tropics is likely to affect hens more than the cold of temperate climates; but it is by no means clear that temperate breeds cannot thrive in hot countries, for in the latter some flocks give very reasonable yields.

Kempster (1941) in Missouri related average monthly temperatures, percentage humidity and sunshine to pullet gains and, of the three, high temperatures caused the greatest depressions of growth rate. An average maximum temperature of over 90°F. rising to 106°F. led to a decline in growth of nearly 40%, heavier chicks being affected more than smaller ones. However, if growth is retarded in this way compensatory growth usually occurs at some later stage, so that eventually the bird reaches normal size. (Kempster, 1941. Wilson, 1952).

Humidity averaged 80% throughout the Missouri experiment and had no pronounced influence on the pullet growth. This is confirmed by Hammond (1954).

Periods of high percentage of sunshine coincided with slow growth, but Kempster attributed this to the high temperatures during these periods rather than to the sunshine itself.

Weavind (1953) concluded from his work on Rhode Island Red stock at I.C.T.A. New Farm that the tropical environment of Trinidad, with a mean annual temperature of 86°F., is not as favourable as a temperate environment for the growth of chicks up to twelve weeks old. Growth in the wet season was found to be superior to that in the dry season with respect to liveweight gain, food utilisation and earliness of physiological maturity.
It is generally agreed that there is no correlation between body weight and egg production (Sherwood, 1922) (Platt, 1927) (Bryant & Stephenson, 1945). It is the environment, and in particular the length of daylight, that will alter production figures (Hammond, 1940).

Jull reported as far back as 1924 that an increase in egg weight is analogous to an increase in body weight, but egg size is to a certain extent inherited. Birds beginning to lay at an early age lay smaller eggs than pullets older at first egg, (Funk & Kempster, 1934) but there is little evidence of ultimate body weight being related to egg weight. Residence in a hot climate reduces egg size but acclimatisation to heat by the birds may be expected to improve it.

Naturally the genetic influence is the strongest with regard to fertility and hatchability of eggs, although once again environment is a most important factor. High temperatures, weather, wet and abnormal feeding can all reduce fertility percentages, whilst good hatchability results will only be obtained with precise conditions for egg storage and incubation. Mahadevan (1954) reported Rhode Island Red eggs in Ceylon as giving an average fertility of 84.2%, and hatchability of fertile eggs averaged 81.1%. Body weight seems to have little or no effect upon either fertility or hatchability.

Mention was made earlier in this section of the division of the growth process into two segments, and the particular demands of the consumer played a large part in causing attention to be turned towards the aspect of development of poultry in the sense of growth in size and a change in body proportions. What characters are likely to be the best criteria of mass development, and are external body characters in any way an indication of subsequent production? These were but two questions that had to be answered.

/- Obviously........
Obviously it is possible to take measurements of many external body parts. For instance Mitchell et al., (1931), in an attempt to formulate poultry feeding standards, took nine external measurements. However, as an index of size there seem to be perhaps four or five important criteria, including both linear or skeletal and depth measurements. Lerner (1939) obtained a correlation coefficient of $0.659 \pm 0.032$ between body weight and shank length in mature White Leghorns, and he concluded that shank length at an early age may be used to determine body weight at a later age. This was confirmed by Bird (1943) who stated that length of long bones determines body size more consistently than any other skeletal measurement.

Gilbreath and Upp (1952) measured shank length, anterior body depth, keel length and breast width, as well as body weight, in their study of the growth pattern of Dark Cornish fowls. Correlation coefficients were determined at stages from hatching to twelve weeks old and all but the breast width score were found to be significantly correlated one with another. The conclusion was that weight and shank length are probably the best measurements to use for skeletal and mass development. Jaap (1941) also found significant correlations between these same measurements, and as far back as 1922 Sherwood obtained a strong positive correlation between body depth and liveweight in eighteen-month old birds.

In 1952 Wilson began an extensive analysis of the growth of four groups of chickens, each group being on a different nutritional plane. He expressed his measurements as percentage increases from hatching, and bone length increases were shown to be made earlier than increases in body width or depth. 'Centripetal' growth, as first put forward by Hammond (1932) using sheep, was illustrated by growth gradients from head to trunk and up to the two hind limbs.
With regard to fleshing, it appears that measurement of breast width, by the method described by Gilbreath and Upp (1952), is the best single indication. (Hathaway et al., 1953). Breast measurements and grade have a higher correlation ratio than shank length and grade. (Frischknecht and Jull, 1946. Collins et al., 1950).

The lack of correlation between body weight and type and egg production which most early workers found (Sherwood, 1922. Platt, 1927. Jull et al., 1933) was confirmed by Bryant and his co-workers in 1945. They reported no relationship at all between egg production and either keel length, shank length, anterior body depth or body weight.

It has therefore been possible in the present work to continue study of the type of growth induced by four different feeds as well as by hatching and rearing chicks in two different seasons.

Further to this additional records have been kept of aspects equally important in any work which involves long-term studies of poultry, and these aspects are listed in order below.
IV. EXPERIMENTAL PROCEDURE.

PART 1.

Two batches of 250 - odd Rhode Island Red chicks each were hatched out by Weavind (1953), hatch I on 23rd. October and hatch II on 28th December, 1953. Weekly body weights were taken from hatching date to twelve weeks old and a comparison was thus made of the early growth rate of birds hatched in the wet and the so - called dry seasons of Trinidad.

Although Weavind (1953) finished his study when the birds were twelve weeks old, continuous records were kept subsequently and, in the case of body weight, weighings were made at four - week intervals up to 32 weeks old and thereafter every twelve weeks up to the age of 56 weeks. Hatch I reached this age on 22nd. November, 1954, and the younger batch on 24th January, 1955.

At twelve weeks old hatch I was moved from carry - on brooders which were housed in an open - sided shed to open range pens. Hatch II was moved at the same age into deep litter pens affording shelter from rain and radiation of the sun.

By dividing each hatch into four pens Weavind (1953) introduced into his experiment four commercial rations, namely :-

1. Trinidad Stock Feed (T.S.F.) - local origin.
2. Marbord Feed (M.B.) - local origin.
4. Full-O-Pep (F.O.P.) - imported.

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/- Egg Production...
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Trapnests are used in the four open range pens to record the individual production of all wet-season hatched birds. In the case of hatch II on deep litter, open nests are used and only daily production figures per pen can be kept.

Egg Size:

Once a week from 17th November, 1954, to 2nd March, 1955, the eggs from each pen were weighed and the size recorded in ounces per dozen.

Hatchability Percentages:

Eggs from the four pens of each hatch are graded daily into four groups:

- **Incubation** - Above 22 ozs. per dozen.
- **'A'** - 20 - 22 ozs. per dozen.
- **'B'** - Below 20 ozs. per dozen.
- **'C'** - Cracked eggs.

At intervals from 24th November to 8th February inclusive, eleven settings of eggs of the first two grades were made in a Jamesway incubator. Candling took place on the fifth and eighteenth days after setting, the number of infertile eggs and dead germs being recorded on each occasion. Thus the percentage hatchability of fertile eggs from each feed-pen of both hatches was calculated. Of the 2,059 eggs set altogether, 1,073 were from hatch I and 986 from hatch II. F.O.P.-fed hens contributed 540 eggs, Purina hens 583 eggs, M.B. hens 485 eggs, and 451 eggs from T.S.F.-fed birds were set.

PART 2.

To gain more detailed information on the growth of poultry in the humid tropics and at the same time to enable...
comparisons to be made with the data that Weavind (1953) obtained, three lots of Rhode Island Red chicks were hatched out this season.

Hatch I - 40 chicks - Hatched on 15/12/54.
Hatch II - 52 chicks - Hatched on 27/12/54.
Hatch III - 71 chicks - Hatched on 6/1/55.

Every chick of all three lots was weighed as day-old, wing-banded, and inoculated against Newcastle disease by the method of nasal inhalation. Their first four weeks of life were spent in indoor brooders, from which they were moved at about four weeks to wire-floored carry-on brooders in an open-sided shed. At five weeks old 28 males were taken from hatch III and 13 males from hatch I. Hatches II and III were put out on to open range at eight weeks of age, that is, on 21st February and 3rd March respectively, whilst hatch I was put out on 16th February at 9 weeks old.

All the birds were weighed weekly from hatching day to twelve weeks. Besides liveweight, certain external body measurements were made of each chick in hatch I. These were:

1. Shank length :-

This was measured with a pair of dividers from the sole of the foot to the top of the hock joint flexed at right angles. The measurements were made in centimetres and taken weekly from hatching to six weeks, then again at nine weeks and twelve weeks old.

2. Keel length :-

The same method was used for keel length as for shank length, but measuring was begun at two weeks of age instead of on the first day.

/ 3. Anterior body depth
3. Anterior body depth

This measurement was taken with dividers from the anterior end of the sternum to the mid-dorsal surface, at right angles to the dorsal surface. Measuring intervals similar to those for shank length were used.

It should be pointed out that sharp-pointed dividers were by no means the ideal instrument for this work, and although the same operator made the measurements throughout the experiment, strict accuracy was impossible. Calipers would probably be the best to use, or a large pair of dividers with the points filed flat to prevent injury.
V. RESULTS AND DISCUSSION.

It has already been mentioned that Weavind began his work in 1953 with about 450 head of poultry. Figure I is a parametric curve of the growth rate data of the 190-odd birds now remaining, and the figures plotted in this graph are expressed as 'single-bird means' at four-week intervals from 0 to 56 weeks of age. It is not intended to show more than the general trend of growth up to maturity and beyond, and the scale is too small to show the usual minor inflection that Weavind (1953) found at 5 weeks old.

He did not study results taken after twelve weeks and therefore rightly concluded that the pubertal inflection does not occur within twelve weeks of growth. Yet Figure I shows well that this inflection does in fact occur at twelve weeks, after which the rate of growth is in the self-inhibiting phase and at the mercy of environment conditions. This latter point is clearly indicated by the distinct drop in growth rate around the twenty-eighth week, caused no doubt by the onset of the wet season plus a fault in management during this period. Even without these factors it is obvious from subsequent growth that a major inflection occurred at the twenty-fourth week, and this is explained by the attainment of sexual maturity.

Figure II continues up to 32 weeks the comparison that Weavind made of the so-called dry-season and wet-season hatches.

Now it must be pointed out here that Weavind was at fault in referring to the chicks hatched on 28th December, 1953, as having been hatched in the dry season. It will be shown later that this time of year in Trinidad should be more correctly termed the mid-season, and in the rest of this paper hatch II is called a mid-season hatch.
Figure I. - Parametric growth curve of the pullets in the 1953 trial.
Comparison of the growth of the two hatches started in 1953.

Figure II. - Comparison of the growth of the two hatches started in 1953.
Weavind found that liveweight gains up to twelve weeks are greater in wet-season birds, and the inflection of the curve at five weeks is delayed until eight weeks of age in the mid-season hatch. In other words chicks reared in the wet season make better progress than mid-season chicks, whose maturation is set back by three weeks.

The twelve-week inflection is more evident in wet-season birds and up to 24 weeks their growth rate dropped below mid-season birds. This was probably due to their removal into open range conditions where they would be more prone to climatic vagarities during their growth toward maturity. Nevertheless, sexual maturity having been reached at 24 weeks, the mid-season birds, unlike the others at this age, experienced a considerable drop which can only be explained by the managemental fault mentioned earlier.

To indicate the importance of climatic conditions in any study of growth rate, the four-weekly body weight gains of the wet and mid-season hatches are set out in Figure III as histograms comparable with curves of all the climatic data for the period. It can be seen that the wet-season birds made greater gains up to 12 weeks than the mid-season birds in the 1953/54 season. The former grew faster, yet both lots reached maturity more or less at the same time with peak gains at 9 - 12 weeks of age. Again it must be stressed that from the age of puberty to sexual maturity the earlier hatched birds weighed less than those hatched in late December, due to their removal at twelve weeks from rearing pens onto open range. This is in fact shown clearly in Figure III by the considerable drop in liveweight gain in February at the height of the dry season. The mid-season hatch showed practically no reaction when put onto deep litter at the same age in April as they were
Figure III. - Monthly bodyweight gains of the 1955 hatches in relation to climatic data.

Figure III. - Monthly bodyweight gains of the 1955 hatches in relation to climatic data.
afforded shelter from the direct rays of the sun. Weavind (1953) pointed out that in the dry season variations in temperature are greater and the strong radiation of the sun must be withstood for an hour longer each day on open range.

It is interesting to note the appreciable drops in liveweight gain by both lots in June and July, 1954. The average loss of 102 grams by mid-season birds over July is attributed to the aforementioned mistake of bedding down the deep litter pens with wet straw, whilst the lesser drop that the open-range birds experienced can only have been caused by the onset of the wet season. Reference to Appendix I will show that the monthly rainfall rose from 1.64 inches in May to 7.41 inches in June. This again emphasises the considerable effect of environmental factors upon animal growth rate. Humidity, closely associated with rainfall, appears the greatest factor, and in both hatches after their removal to the field the occurrence of higher humidity percentages leading to less liveweight gain is closely followed. Temperature in Trinidad, like daylight length, varies very little throughout the year (Appendix I) and appears to have little or no effect on growth rate, although it has been shown elsewhere that extremes of temperature may have serious consequences.

After the age of sexual maturity the gain in weight of wet-season hens is low and varies comparatively little. In the second batch, however, the bad setback in July subsequently led to large gains in weight over a long period. This fully bears out the 'compensatory growth' that Kempster (1941) experienced, enabling the birds to revert to the 'norm' of weight, size and shape that they have at the adult stage.

Figure IV compares the growth rate from 16 - 56 weeks of bird on the four feeds. Weavind (1953) found the order of liveweight of both males and females at twelve weeks old to be Purina, M.B., T.S.F., and F.O.P., the first three giving
very similar weights and the last being far inferior. The position up to 20 weeks is more or less similar with females only except that the liveweight differences between those first three feeds have widened somewhat. However, from the twentieth week growth rate begins to fall away and by the twenty-eighth week all the hens drop considerably whatever the feed. It was previously pointed out that maturity was reached by the twenty-fourth week and this, together with the onset of full egg production in April for the first hatch and in May for the second, must be the reason for the drop in growth rate. This is also the time when the wet season began. It is not until the birds are 44 weeks old towards the end of the season that their former liveweights are attained, and the rate of growth is increased once more.

Taking feeds individually it would seem that the Purina - fed birds were in the best position with regard to energy supply to withstand the additional requirements of egg production. Their growth check was shortlived and furthermore by the fortieth week hens on this feed showed the best liveweights. Those fed on M.B. dropped 115 grams mean liveweight but this again was of short duration and within 16 weeks they regained their former weight. T.S.F. - fed hens weight with an average of 2000 grams were the heaviest over the period when egg production began, and Figure VI shows their egg production also to be the highest at this time. However the slight check in weight that is caused continues for over five months, and it appears that T.S.F. is unable to supply energy enough to overcome the setback brought on by production. The same applies to F.O.P. to an even greater degree. It is interesting to note that this graph is similar to the production histograms of Figure VI in that by and large greater egg production coincides with greater liveweight, and vice versa.
Summarising the growth potential of the feeds, local rations outstrip the imported ones from hatching to about 32 weeks old. The most likely reason for this is the freshness of T.S.F. and M.B. when fed. The imported feeds are shipped from the United States and Canada and may be several months in transit and storage before use. Consequently some ingredients, vitamins especially, are bound to deteriorate and thus lower the value of the feed. The possibility of shortening the time between manufacture and use, and of introducing such substances as anti-oxidants is well worth investigating.

Figure V indicates that egg production began at the average age of 20 weeks for both hatches. Daylight length varies no more than 70 minutes either way throughout the year, with a maximum in June and a minimum in December (Appendix I), so, unlike the temperate areas, this factor causes little variation in production at different seasons. (Whetham, 1933).

Comparing the production of wet and mid-season hatches, that of the former on open range gains rapidly, reaching a peak in June four months after the date of first lay. Thereafter a fairly constant figure of 8.5 eggs per bird per month is maintained up to the end of the wet season of 1954. When production of this hatch is set against monthly rainfall it is noticeable that the failure of the figures to rise after June coincides with the onset of the wet season in that month, thus confirming the observation of Hammond (1940) that wet season will depress egg production. It is well to remember that body weight is also down in June. The same fact is clearly seen in the histograms combining production of both hatches in that the rise in production per month from first egg is checked by the onset of wet weather and only starts to rise again at the end of the season in November and December.
Figure V. - Egg production of the two hatches compared with the rainfall curve for that period.
Although their average age at first egg was the same, the younger mid-season birds naturally came into lay after the wet-season hatch, only a month or so before the beginning of the 1954 wet season. Their early production is therefore less than the earlier hatched pullets but on the other hand onset of wet season in June has much less effect on their general rise in egg production from month to month, and by the time the dry weather begins at the end of the year their production figures are greater than those of the first hatch, with a peak of 14.8 eggs per bird per month at twelve months old. This is obviously due to the fact that these mid-season hatched birds are housed on deep litter all year round and wet climatic conditions do not affect them to any great extent.

The average production per bird over the 48-week period was 104 eggs. The mid-season birds averaged 110 eggs on deep litter whereas wet-season birds on open range gave a total of only 98 eggs per 48-week period.

Thus one concludes that birds hatched early have time to reach a peak of production, in this case 11.3 eggs per bird per month, as well as an optimum liveweight before the following wet season sets in, but that younger birds hatched in mid-season can reach maximum production in the shorter time with much higher annual production figures in their first year.

The ideal management in this climate for maximum egg production would therefore seem to be to hatch chicks early, say in October or November, in order to allow maximum body weight gain up to maturity to occur during dry months; put them out from rearing pens onto deep litter to prevent any setback in the first months of production, and finally use open range pens once the following dry season has set in.
The egg production figures of the four feeds have been separated out in the form of four-weekly histograms in Figure VI. Over the whole 48-week period covering March, 1954, to February, 1955, total production of a single bird on each feed was as follows:

- M.B. .......... 112.5 eggs per bird.
- T.S.F. .......... 106.0 eggs per bird.
- Pur. .......... 89.1 eggs per bird.
- F.O.P. .......... 86.3 eggs per bird.

This again demonstrates the superiority of local feeding stuffs over imported ones. Naturally the figures are low according to temperate standards but they compare very favourably with results obtained elsewhere in the tropics. Rhode Island Red pullets in Ceylon for instance gave 104.2 eggs per laying year (Mahadevan, 1954).

The superiority of M.B. - fed birds is shown by the high maximum that they attain towards the end of their laying year, whereas it is the rapid gain in production from month to month for the first six months that is outstanding in T.S.F.-fed hens. The maximum figures for the latter batch are no better than those of hens on the two imported feeds.

All hens began laying at about 20 weeks old, with the exception of those on Purina which started about four weeks later. By nine months of age a peak was reached in all but the T.S.F. hens and thereafter there was a slight drop which lasted about four months. Those fed T.S.F. however gave a steady monthly rise right up to the forty-fourth week, when they laid on the average two eggs per bird fewer for three months. M.B. showed a similar drop of 1.9 eggs per bird per month whereas the imported feeds F.O.P. and Pur. dropped only 1.3 eggs and 0.7 eggs respectively at this time. In other words, the greater the annual
Figure VI. - Comparison of the four feeds by means of the egg production per bird per month.
production the greater is the fall around ten months old when the wet season is normally in full swing. All birds regardless of their feed gave fewer eggs in the last two months of their first laying year when the dry season was starting.

Table I summarises the hatchability percentages of fertile eggs from each pen of the two hatches.

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<th>F.O.P</th>
<th>Pur.</th>
<th>M.B.</th>
<th>T.S.F.</th>
<th>( \bar{x} )</th>
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<tr>
<td><strong>WET - SEASON</strong></td>
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<tr>
<td>HATCH</td>
<td>74.2</td>
<td>63.2</td>
<td>65.3</td>
<td>72.5</td>
<td>68.8</td>
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<td><strong>MID - SEASON</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HATCH</td>
<td>69.1</td>
<td>65.7</td>
<td>64.0</td>
<td>73.9</td>
<td>68.2</td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>71.6</td>
<td>64.5</td>
<td>64.7</td>
<td>73.2</td>
<td>68.5</td>
</tr>
</tbody>
</table>

The average figure of 68.5% for all fertile eggs set is rather low. 81.1% hatchability was obtained in Ceylon in 1952/53 although Funk (1934) found that, above an optimum level, summer temperature and hatchability are inversely proportional. In temperate countries hatchability varies with season, being low in autumn and at the beginning of winter, and this is due to the effect of daylight length more than anything else. (Hammond, 1954). The eleven settings involved in the present work covered only two months, January and February, and results over a much longer period would be necessary to bring out any seasonal differences that there may be.

The average percentages for each hatch are almost identical, but those for the feed pens differ quite markedly, F.O.P. and T.S.F. - fed birds averaging higher figures than those on Pur. and M.B. Actually these differences are not statistically significant, nor are the differences between setting dates and hatching dates of the females, but further work...
Figure VII. - Comparison of the average weekly egg weights of each hatch.
on the subject may reveal a persistent difference large enough to influence the decision of a poultryman interested in hatching eggs.

The sample egg weights taken weekly over a 15-week period have been separated into the two hatches in Figure VII. The eggs laid by mid-season pullets maintained a more or less constant average of 22.7 ounces per dozen, with the exception of the first two weeks in December when the egg size rose to 24 ounces per dozen. On the other hand the eggs of wet-season birds steadily dropped in weight from a maximum of 24.6 ounces to 20.9 ounces per dozen on 19th and 26th January, with a gradual rise subsequently.

It will be remembered that at that time there were two important differences between the hatches as a whole. Firstly, hatch I birds were kept on open range whilst hatch II was on deep litter, and secondly hatch I was two months older than hatch II, the former being 13 months old when egg size was first recorded. With regard to the first point the reason for the gradual decline in weight of eggs from hatch I could be put down as climatological, but that is definitely not so. Climatic data for the period has been carefully studied but there is no connection at all between figures for either temperature, humidity, rainfall or sunshine and egg size of either hatch. Long experience in temperate zones shows that, after hens have reached mature body weight at about a year old, egg size tends to decrease somewhat during intensive laying periods (Mann, 1953), and Appendix II indicates the general rise in production that the older birds show from the beginning of the period, together with the corresponding decline in egg weight. The birds of hatch II did not reach the age of twelve months until the end of December and this may account for the constant size of their eggs...
Figure VIII. - Growth rate curve of all the chicks hatched in the 1954-1955 trial.
eggs in relation to their production.

Yet this explanation is merely surmise and it remains to be seen whether this actually accounts for a decline in size of eggs laid by mature birds which have been reared in the humid tropics.

PART 2.

The experimental work this season involved three hatches, two in December and one in early January, and totalled 163 Rhode Island Red chicks at hatching. Figure VIII is a curve of the growth rate of all three lots as single-bird means per week up to twelve weeks. Reference to monthly rainfall figures taken at I.C.T.A. New Farm over a number of past years will indicate that between the true wet season covering June to October and the true dry season of January to May there is definitely what may be called a 'mid-season' when rainfall is mid-way between wet and dry season figures. This was not actually the case in 1954/55, (Appendix I), but over a long period it is quite evident. It is therefore reasonable to class these 1954/55 hatchings as collectively representative of this mid-season and so comparable with the mid-season hatch which occurred on 28th December last year.

Figure VIII in itself confirms the results obtained by Weavind (1953) last year, namely, that the inflection of the growth curve, which normally takes place at five weeks and which reflects some unidentified physiological maturation, is delayed three weeks by hatching chicks in the mid-season period. Actually a very slight five-week inflection is noticeable but this is probably due to the removal of thirteen males from hatch I at that time.

It may be argued that the eight-week inflection is abnormally large but hatch III was put on open range at that age and consequently their body weight gains dropped appreciably.

/- Figure IX ............
Figure IX depicts the separate growth rates of the three hatches. Because they all occur within three weeks it would be wrong to compare them one with another with regard to hatching dates and the other environmental factors that each may have experienced. However it does seem feasible to compare hatch II with hatch II of last year, there being a difference of only one day between the hatching date of each, and this has been done in Table II as well as in the graph.

Table II.

Mean liveweights per week of hatch II, 1954, compared with hatch II, 1953, and the differences in favour of the former. (In grams.)

<table>
<thead>
<tr>
<th>AGE</th>
<th>HATCH II 27/12/54</th>
<th>HATCH II 28/12/53</th>
<th>DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 weeks</td>
<td>38.13</td>
<td>35.58</td>
<td>2.55</td>
</tr>
<tr>
<td>1 &quot;</td>
<td>80.08</td>
<td>66.46</td>
<td>13.62</td>
</tr>
<tr>
<td>2 &quot;</td>
<td>115.31</td>
<td>113.82</td>
<td>1.49</td>
</tr>
<tr>
<td>3 &quot;</td>
<td>192.89</td>
<td>172.93</td>
<td>19.96</td>
</tr>
<tr>
<td>4 &quot;</td>
<td>290.18</td>
<td>272.58</td>
<td>17.60</td>
</tr>
<tr>
<td>5 &quot;</td>
<td>411.44</td>
<td>366.33</td>
<td>45.11</td>
</tr>
<tr>
<td>6 &quot;</td>
<td>558.85</td>
<td>458.51</td>
<td>100.34</td>
</tr>
<tr>
<td>7 &quot;</td>
<td>684.88</td>
<td>562.99</td>
<td>121.89</td>
</tr>
<tr>
<td>8 &quot;</td>
<td>798.66</td>
<td>669.03</td>
<td>129.63</td>
</tr>
<tr>
<td>9 &quot;</td>
<td>806.64</td>
<td>742.44</td>
<td>64.20</td>
</tr>
<tr>
<td>10 &quot;</td>
<td>991.77</td>
<td>893.13</td>
<td>98.64</td>
</tr>
<tr>
<td>11 &quot;</td>
<td>1144.97</td>
<td>1006.96</td>
<td>138.01</td>
</tr>
<tr>
<td>12 &quot;</td>
<td>1225.70</td>
<td>1108.32</td>
<td>116.88</td>
</tr>
</tbody>
</table>
The superior growth of this year's hatch is obvious, and the reason is probably one of improved management together with the superior genetic worth of the 1954 stock.

The curves in Figure IX show small differences between the three hatches, the maximum being no more than 60 grams or so up to eight weeks old. The eight-week inflection is obvious in hatches I and II with that of the latter exaggerated by removal of the bird to open range. Hatch I was put into the same pen at nine weeks and again the resulting drop in liveweight gain is obvious. Both drops are subsequently made up in full.

Now with regard to hatch III, its growth curve inflects at five weeks and again at eight weeks. The removal of 28 males during the fifth week would account for the earlier inflection and similarly the switch to open range conditions during the eighth week would lead to the later one. Neither inflection is as great as those experienced by the older hatches and the question therefore arises as to which drop in growth rate includes the minor physiological inflection that Weavind (1953) noticed, if indeed it occurred at all. This is a point to be cleared up in later work, but it should be emphasised that this hatch was on 6th January, and the January rainfall was only 1.25 inches as opposed to 8.29 inches the month before. The general division between seasons may be too fluent to call hatch III a dry-season hatch but its growth rate curve may at least give a clue as to the progress of growth of birds hatched well into the dry season.

The body measurements as indicated in Figure X were taken at I.C.T.A. New Farm on each bird of hatch I. As they appear to be the first to have been recorded in the humid tropics it is difficult to draw any conclusions from the figures themselves. Several workers in the United States have taken similar measurements as criteria for judging body development but none have used

/- Rhode Island...
Figure IX. - Comparison of the growth rates of the three hatches of this season.
Rhode Island Red stock, and only Gilbreath et al., (1952) used weekly intervals. What was possible however was to determine any correlation that might exist between liveweight and these three external measurements, and Table III sets out the respective correlation coefficients at hatching date, one week, four weeks, nine weeks and twelve weeks old. Gilbreath et al., (1953) made similar calculations using 384 Dark Cornish chicks.

Table III.

Correlation Coefficients between body weight and shank length (S.L.), keel length (K.L.) and anterior body depth (B.D.) at five ages.

<table>
<thead>
<tr>
<th>REF.</th>
<th>0 wks.</th>
<th>1 wk.</th>
<th>4 wks.</th>
<th>9 wks.</th>
<th>12 wks.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICTA New B.W.-S.L.</td>
<td>0.307</td>
<td>0.704</td>
<td>0.704</td>
<td>0.856</td>
<td>0.862</td>
</tr>
<tr>
<td>Farm, 1954 B.W.-K.L.</td>
<td>-</td>
<td>-</td>
<td>0.759</td>
<td>0.444</td>
<td>0.646</td>
</tr>
<tr>
<td>40 R.I.R's. B.W.-B.D.</td>
<td>0.089</td>
<td>0.940</td>
<td>0.628</td>
<td>0.639</td>
<td>0.717</td>
</tr>
<tr>
<td>GILBREATH et al. 1953 B.W.-S.L.</td>
<td>0.255</td>
<td>0.755</td>
<td>-</td>
<td>-</td>
<td>0.755</td>
</tr>
<tr>
<td>Louisiana. B.W.-K.L.</td>
<td>-</td>
<td>-</td>
<td>0.737</td>
<td>-</td>
<td>0.697</td>
</tr>
<tr>
<td>384 Cornish B.W.-B.D.</td>
<td>-</td>
<td>0.617</td>
<td>-</td>
<td>-</td>
<td>0.758</td>
</tr>
</tbody>
</table>

As a whole the results of the present study compare most favourably with those of Gilbreath and his co-workers (1953). After a week's growth, weight increases are significantly associated with growth of the long bones and anterior body depth. The correlations between body weight and shank length are the highest and they increase up to twelve weeks. Body weight - body depth is similar but with slightly lower values, and the body weight - keel length correlations simulate those of Gilbreath by —tending.............
Figure X. - Comparison of the growth of the body parts measured on chicks of hatch I.
tending to decrease with age up to twelve weeks. After one week the figures for body depth and shank length are all significant at 0.1% level, whilst the keel length coefficients at nine weeks and twelve weeks old are significant at 5% and 1% respectively.

Figure X represents the growth rate of the body parts up to twelve weeks of age and the three curves again compare well with similar curves plotted by Gilbreath. The only point which cannot be explained is the lack of growth of the keel bone of hatch I chicks in the fifth week.

As they stand these few results differ very little from those of workers in this field in temperate climates and their conclusions, which are reviewed in an earlier section, seem to apply equally well here. Yet this study is little more than a preliminary to future work to be undertaken. With measurements continued up to the age of maturity more facts would be available concerning the rate of development of the different body parts, and explanations could be put forward in the light of the particular environmental conditions that are experienced here in Trinidad.
ACKNOWLEDGEMENTS.

The author wishes to record his thanks for the assistance and advice given by his supervisor, J. R. Howes.

He also wishes to acknowledge the help given by Mr. Boodoo, stock manager at I.C.T.A. New Farm, and the several other postgraduates concerned with poultry studies.
BIBLIOGRAPHY.


<table>
<thead>
<tr>
<th>Month</th>
<th>Average</th>
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</thead>
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<td>Jan. 1953</td>
<td>85(68)</td>
</tr>
<tr>
<td>Feb.</td>
<td>85(68)</td>
</tr>
<tr>
<td>Mar.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Apr.</td>
<td>87(69)</td>
</tr>
<tr>
<td>May</td>
<td>87(69)</td>
</tr>
<tr>
<td>Jun.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Jul.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Aug.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Sep.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Oct.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Nov.</td>
<td>87(69)</td>
</tr>
<tr>
<td>Dec.</td>
<td>87(69)</td>
</tr>
</tbody>
</table>

The figures in brackets represent data for October 1953 - February 1954.
### APPENDIX I.

**CLIMATIC DATA FOR THE PERIOD**

**OCTOBER 1953 - FEBRUARY 1955**

<table>
<thead>
<tr>
<th></th>
<th>Temperature</th>
<th>Humidity</th>
<th>Rainfall</th>
<th>Sunshine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Min. %</td>
<td>Ins./mth.</td>
</tr>
<tr>
<td>Mar. 1954</td>
<td>86°F</td>
<td>77.5°F</td>
<td>69°F</td>
<td>59</td>
</tr>
<tr>
<td>Apr.  &quot;</td>
<td>87</td>
<td>79.0</td>
<td>71</td>
<td>61</td>
</tr>
<tr>
<td>May &quot;</td>
<td>89</td>
<td>80.5</td>
<td>72</td>
<td>56</td>
</tr>
<tr>
<td>June &quot;</td>
<td>87</td>
<td>79.5</td>
<td>72</td>
<td>63</td>
</tr>
<tr>
<td>July &quot;</td>
<td>86</td>
<td>79.0</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>Aug. &quot;</td>
<td>87</td>
<td>79.5</td>
<td>72</td>
<td>70</td>
</tr>
<tr>
<td>Sept. &quot;</td>
<td>88</td>
<td>80.0</td>
<td>72</td>
<td>67</td>
</tr>
<tr>
<td>Oct. &quot;</td>
<td>86(88)</td>
<td>78.5</td>
<td>71(71)</td>
<td>70(66)</td>
</tr>
<tr>
<td>Nov. &quot;</td>
<td>86(87)</td>
<td>78.0</td>
<td>70(72)</td>
<td>70(66)</td>
</tr>
<tr>
<td>Dec. &quot;</td>
<td>84(86)</td>
<td>77.0</td>
<td>70(71)</td>
<td>69(64)</td>
</tr>
<tr>
<td>Jan. 1955</td>
<td>85(85)</td>
<td>76.0</td>
<td>67(69)</td>
<td>62(61)</td>
</tr>
<tr>
<td>Feb. &quot;</td>
<td>85(85)</td>
<td>77.0</td>
<td>69(68)</td>
<td>61(62)</td>
</tr>
</tbody>
</table>

**N.B.** The figures in brackets represent data for October 1953 - February 1954.
APPENDIX II.

COMPARISON OF TOTAL EGG PRODUCTION AND AVERAGE EGG WEIGHT FOR HATCHES I AND II. (PER DAY).

<table>
<thead>
<tr>
<th>Date</th>
<th>Hatch I (75 birds)</th>
<th>Hatch II (70 birds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17/11/54</td>
<td>14 24.6</td>
<td>28 22.2</td>
</tr>
<tr>
<td>24/11/54</td>
<td>14 23.3</td>
<td>39 22.7</td>
</tr>
<tr>
<td>1/12/54</td>
<td>19 23.0</td>
<td>39 23.9</td>
</tr>
<tr>
<td>8/12/54</td>
<td>29 22.9</td>
<td>25 24.0</td>
</tr>
<tr>
<td>15/12/54</td>
<td>25 22.6</td>
<td>30 24.0</td>
</tr>
<tr>
<td>22/12/54</td>
<td>21 22.6</td>
<td>30 22.2</td>
</tr>
<tr>
<td>29/12/54</td>
<td>23 22.5</td>
<td>28 22.6</td>
</tr>
<tr>
<td>5/1/55</td>
<td>25 21.9</td>
<td>27 22.3</td>
</tr>
<tr>
<td>12/1/55</td>
<td>27 21.7</td>
<td>23 22.4</td>
</tr>
<tr>
<td>19/1/55</td>
<td>27 20.9</td>
<td>26 21.9</td>
</tr>
<tr>
<td>26/1/55</td>
<td>24 20.9</td>
<td>21 22.9</td>
</tr>
<tr>
<td>2/2/55</td>
<td>29 22.0</td>
<td>26 22.4</td>
</tr>
<tr>
<td>9/2/55</td>
<td>27 21.4</td>
<td>21 22.9</td>
</tr>
<tr>
<td>16/2/55</td>
<td>30 21.5</td>
<td>23 22.6</td>
</tr>
<tr>
<td>23/2/55</td>
<td>32 21.3</td>
<td>20 23.2</td>
</tr>
<tr>
<td>2/3/55</td>
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<td></td>
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</tbody>
</table>