A Study on

The Effect of Slow Feathering and Rapid Feathering on Some of the Economic and Physical Characters

&

The Correlations between Some of the Physical and Physiological Characters Associated with Egg Production

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A THESIS

Submitted to the

Magadh University,

In Partial Fulfilment Of The Requirements For The Degree Of

M. Sc. (A. H.)

SUMAN KUMAR VERMA

B. V. Sc. & A. H. N. D. P. H. (I. V. R. I.)

Post Graduate Department of Genetics and Animal Breeding.

BIHAR VETERINARY COLLEGE, PATNA.

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I ceify that this Thesis has been prepared under my survision by Shri S.K.Verma, a candidate for the degree M.Sc.(Animal Husbandry), with Animal Genetics and Breedi as Major subject and that it incorporates the results ofis independent study .

R. B. Prasad 28/12/67

(R. B. Prasad)

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December, 1967 , 20.12.67

Patna. (S.K.Verma).

Abbreviations and Symbols frequently used.

S. E. = Standard Error.

C. V. = Coefficient of variation .

r = Correlation coefficient.

** = Significant at 1% level .

* = Significant at 5% level .

S. S. = Sum of squares.

M. S. = Mean squares.

D. F. = Degree of Freedom .

Rapid male = Rapid feathering male.

Rapid female = Rapid feathering female .

Slow male = Slow feathering male .

Slow female = Slow feathering female .

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CHAPTER-I

INTRODUCTION

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INTRODUCTION

With the population explosion the production of increased quantity and improved quality of human food has assumed one of the burning problems of the age. Therefore, for the conversion of unedible and less nutritive substances into the edible products of high biological value, the scientific development of Live-stock industry, in which poultry industry occupies an important position, is essential .

Poultry meat and eggs were accepted as an edible substance from the days of yore, when the people were groping in darkness and despair and struggling against nature to discover things for their existence. They traced out many edible things which were easily available, palatable and efficient in maintaining their body temperature during the chilling nights; out of many such things poultry meat and egg was one.

In the recent past and even to some extent now, there has been mixed feeling regarding the consumption of poultry products on account of religious sentiments. But with the increase in literacy percentage the consensus of the opinion is changing fast, and the people are getting more inclined towards the consumption of eggs and other poultry products. Moreover, if the keeping

quality of the egg is improved this is one of the purest form of animal products in which adulteration is not possible.

According to the Live-stock census of 1961 the total population of poultry in India and Bihar is about 117 millions and 12.3 millions respectively. India ranks among the top ten poultry producing countries of the world. Although, poultry meat and eggs are efficient to meet the nutritional requirements of the people, an average Indian diet is not properly balanced to meet the nutritional requirements of the body, as the average annual per capita consumption of eggs is only seven in India, while it is over 400 in U.S.A. The reason is the poor productivity of the indigenous stocks which may be increased by improving the breeding quality of the flocks.

If the food spectrum is represented by poultry meat and eggs, mutton, beef, pork, rice, wheat, maize, tapioca and sweet potato, it will be found that the poorer nations shift their food habits in the range, rice to sweet potato which contain very little protein. Therefore, the important constituent in which our food is sharply deficient is the proteins of good quality, i.e., of animal origin.

Egg as a protective food equals cow's milk to a great extent in having good quality and sufficient quantity of protein, fat, vitamins and minerals and excels it in having vit. D and certain minerals in appreciable quantity (Refer the table below).

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In addition, its easy handling, storage and purity in form tempt one to advocate for the production and consumption of large quantity of eggs and hence the proper development of poultry industry .

Table No.(1)

An egg weighing 50 gms. contains the following nutrients.

Solids (grams)	12.5
Calories	48.0
Fat (grams)	5.2
Proteins (grams)	6.7
Calcium (grams)	0.03
Phosphorus (grams)	0.11
Vit. A (units)	200 - 800
Vit. D (units)	10 - 50
Thiamin (units)	20 - 40
Riboflavin (micrograms)	100 - 200
Pantothenic acid(micrograms)	660 - 1200

The economics of the poultry industry depends upon checking the losses, how-so-ever minute and insignificant they may be from all possible sources. In order to achieve it this industry is to be handled very intelligently, scientifically and at the same time economically in every respect. Therefore, the birds which are able to balance the economics over them effectively are to be selected for maintaining in the farm and

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also to be used as breeding stocks. To economise the expenditure further, the breeders should be able to sex the birds preferably on the day of hatch itself. But unfortunately the method of day-old sexing (By vent examination) requires a high degree of skill which is not expected from the general breeders.

Not only this, sometimes the frequency of a particular gene or a mutant strain increases in the farm, if regular selections are not made to cull out such birds. The effect of such genes may disturb the economy of a farm considerably. But before recommending culling for a particular character, it must be proved uneconomic to act as a guide line for future days. If we are able to spot out promising birds in early life the margin of profit not only increases in proportion to quantity but also because of the premium prices paid for the quality of poultry meat and eggs, obtained from the young and laying stocks .

These general concepts when scientifically interpreted lead to the conclusion that the birds which are to be maintained in the farm should have faster rate of growth, less age at maturity, lower percentage of mortality and higher rate of egg laying. Birds having faster rate of growth reach the marketable age earlier for broiler industry and also acquires more weight at the age of first laying to produce bigger size of eggs and to withstand depletion during active laying

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With these views in mind the present study was undertaken to find out the effects of Slow-feathering and Rapid-feathering on some of the economic as well as physical characters, as these characters being determined by a single pair of sex-linked genes(Screbrovsky 1922, Warren 1925) are likely to increase very rapidly in the farm. A point of considerable interest, both theoretical and practical, is that the differences in rate of feathering caused by these sex-linked genes provide one of the few cases known in animals in which a distinct modification of a physiological process depends upon a single pair of alleles. By some geneticists inherited traits are separated into " morphological characters", affecting form, structure, colour, or other more or less superficial variations, and "physiological characters ", or variation in function. In the fowl most of the latter, such as rate of growth, body size, fecundity, and viability, depend upon multiple factors, the exact number of genes being impossible to determine by existing techniques. This makes breeding for improvement in these physiological characters a very slow process, whereas traits dependent on a single pair of genes are easy to eliminate or acquire as may be desired.

The stock selected for the study was the cross-bred chickens of R.I.R. and W.L. breeds, as the present policy of the State Government is to supply day-old cross-bred chicks of these breeds to private poultry keepers, because it is slightly bettern than the pure ones (Dudley, 1944).

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The physical characters studied were the length of the shank, width of the breast, length of the thigh(Drumstick) and head. Shank is highly correlated with body weight (+ 0.659, Lerner 1937) specially during the period of growth. There are some indications that it is a more sensitive indicator of body size than other bones are likely to be. Generally the size and weight of the birds when considered togdher is a fair measure of vitality assuming that birds of the same variety and age are compared. Broad and prominent breast is one of the desirable characteristics. Drumstick (Thigh) being the longest bone in the limbs, yields more meat and is one of the important parts examined to adjudge the amount of meat in a bird.

Besides, these characters are easily measurable and the attempt was also made to study how far these apparently unrelated characters are affected by the action of a single pair of genes, which in its ultimate analysis demonstrates the pleiotropic action of gene .

Lastly, the objective of the study was also to decide as to how far it would be judicious to recommend the use of this sex-linked gene(Slow-feathering) for the day-old sexing as the effect of this gene is descernible on the day of hatch itself.

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II.

Following the evolution of a score-card at I.V.R.I. for judging the bird for production, the second part of the study was undertaken to see whether the same score-card held good for evaluating the production potentiality of the cross-bred layers or not, as the author, on personal communication from Dr.S.Bose, Head,Poultry Research Division, I.V.R.I., came to know that the scores varied with breed and strain. The reason for making a choice of this score-card is the fact that it is much more intelligible to general breeders than the other methods so far tried for this purpose by various workers viz. Wyekoff, and Babcock(1891), Gleichauf(1957) and Bogoljubskii(1963).

The necessity for such a study was acutely felt, because it has been observed that a sizeable proportion of the birds in a laying flock is not productive up to the mark, which tells heavily on the economy of the industry. Such birds can easily be culled in early life and used for table purposes before propogating their inferior germ-plasm to the future generations.

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CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A. Genetic Study of Slow-feathering and Rapid-feathering.

The first case of the sex-linkage of rate of feathering was that reported by Serebrovsky(1922) in a cross of Russian Orloffs X Barred Plymouth Rocks.

Warren(1925) crossed white Leghorn males and Jersey Black Giant females and observed that the sons were all of the Slow-feathering type, whereas the daughters were of the Rapid-feathering type. In this mating, the Jersey Black Giant females transmitted Slow-feathering to their sons but not to their daughters. The reciprocal crosses, Jersey Black Giant males X White Leghorn females, produced sons and daughters that were all Slow-feathering . The two matings, he said, demonstrated that slow rate of feathering is sex-linked and dominant to rapid rate of feathering .

Warren(1925) found that when Leghorn males were mated to the first generation hybrid females obtained from a mating of Jersey Black male X White Leghorn females, all the female progeny were Rapid-feathering and the male progeny were Slow-feathering. The results proved that slow rate of feathering is

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a sex-linked character.

Saharova(1926) crossed a Cochin male with Indian Pavloff females and observed that all the progeny were Slow-feathering, whereas an Indian Pavloff male to Cochin females produced Slow-feathering cockrels and Rapid-feathering pullets.

Kinugawa(1927) found that the male progeny were invariably slow-feathering and female progeny Rapid-feathering when White Leghorn males were mated to females of following varieties: Black Orpington, Barred Plymouth Rock, White Wyandotte, Rhode Island Red, Light Brahma, and Nagoya. He also found that the same results were obtained when Mottled Ancona males were mated to Rhode Island Red females and when Silver-Spangled Hamburg males were mated to Black Orpington females.

The fact that rate of feathering is inherited as a sex-linked character has also been demonstrated by Horn(1927).

B. Differentiation of the two Strains.

Warren(1930 a) found from crosses involving the use of males possessing the gene for Rapid-feathering and females possessing the gene for Slow-feathering, that the sexes may be identified accurately by the extent of the growth of the primary and secondary wing feathers at hatching time and by the presence or absence of tail feathers at 10 days of age .

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Radi and Warren(1938) found that in Rhode Island Reds it was possible to develop strains of Rapid-feathering birds by taking advantage of the variability in the rate of feathering that existed in this breed. Selection carried on for four years was effective in establishing a Rapid-feathering strain that differed genetically from the normally Slow-feathering strain.

Cooper(1941) stated that Slow-feathering of chicks was found to be a dominant sex-linked character, so that by isolating slow and fast feathering strains and crossing fast male x slow female, the sexes could be separated at hatch with 91% accuracy and at 2 weeks with 100% accuracy.

Warren(1944) demonstrated that the character could be most accurately identified about 24 hours after hatching, when it is recognised by the well developed primaries and the presence of not more than 3 visible secondaries in the wing. Confusion with a late feathering (Slow-feathering) type with exceptionally long primaries may be avoided by noting that the primary coverts here nearly equal the primaries in length, whereas in the early feathering birds they are only 2/3 to 3/4 as long .

Glazener and Jull(1946) stated that 8-wk. feathering was better in birds that had better 10-day tail feathering. In general, in all strains 8-wk. feathering was more closely related to the number of secondaries on hatching than to 10-days

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tail feathering.

Williams and Wiegers(1947) found that approximately 10% of 2000 White Plymouth Rocks Judged as fast feathering at the time of hatching were later observed to develop feathers at slow rate. Ten days of age appears to be the earliest satisfactory for selecting birds of this breed for wing and tail characters. Birds with tail feathers ½ in long at 10 days are certain to transmit the recessive, sex-linked gene for wing and tail feather development.

Hale(1954) observations on the White Wyandotte flock showed that Chicks feathering in the first few weeks was largely controlled by the sex-linked allelic series in which a a recessive gene leads to Rapid-feathering of the type characteristic of Leghorns. It was found that the Rapid-feathering prevented the action of other genes leading to poor-feathering at around 2 months of age.

Pilla(1958) found out the criteria used in determining whether feathering was late(Slow) or early(Rapid) at 1,10,30 and 60 days. He also confirmed the conclusion of other authors that the early feathering is inherited as simple, sex-linked recessive.

While the difference between Slow-feathering and Rapid-feathering chicks depends on a pair of sex-linked genes,

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there are also autosomal genes that may prevent full expression of Rapid-feathering. These account for somewhat bare chicks with ragged plumage that are not infrequently seen in White Leghorns. These are caused by either of two recessive autosomal mutations, tardy(t) and retarded(t^s), which, together with their normal allele(T), comprise a series of multiple alleles. Retarded was first recognized by Warren(1933 a), While tardy was identified as a separate mutation and proved to be a third allele by Jones and Hutt(1946).

Jones and Hutt(1946) showed that :

(1) Retarded and Tardy are both unifactorial mutations, recessive to the normal condition T;

(2) Retarded(t^s) and tardy(t) are alleles, with the latter recessive to former; and .

(3) all types can be obtained from the mating Tt x t^st.

C. Effect on growth rate and physical measurements.

Warren and Payne(1945) found that the birds with Rapid-feathering was consistently heavier at 12 weeks of age than the ones with Slow-feathering.

Glazener, and Jull(1946) found in short and long shanked B.P.R. and New Hampshires that within one strain 10-wk. live weight was higher in chicks with 6 or more than, 5, or less

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secondaries on hatching; in all strains live weight was higher in birds that had better 8-wk. feathering, and higher in male than in female. As some poorly feathered birds had good live weight, there are probably separate genes for feathering and growth.

Kondra and Cavers(1947) showed that size of keel bursae were greater in late than in early feathering sex-linked B.P.R.

Hurry and Nordskog (1953) found in B.P.R. and New Hampshires that Rapid-feathering B.P.R. cockrels were 25 gms. heavier than Slow-feathering male; Rapid-feathering B.P.R. pullets weighed 27 g.more than Slow-feathering pullets, at 8th weeks. In New Hampshires 8 weeks body weight was slightly lower in Rapid-feathering than in Slow-feathering in both sexes. Analysis of variance showed that the sex-linked gene had no influence in the variability in 8-wks. feathering score in either sex or breed, nor on 8-wks. body weight, in pullets; the Slow-feathering cockrels, however, were significantly more variable in body weight at 8-wks. than Rapid-feathering cockreles in both breeds.

Hale (1954) found that the chickens weights at 8-weeks of age, in the Hillsborough flock at least, Rapid-feathering was not connected, to any significant degree, with more rapid growth. Such a conclusion was in agreement with other results published since the work on that flock was begun.

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Pilla(1958) found that live-weight at 60 days and rate of feathering were determined in the offspring of 10 N.H. hens mated with 2 cocks of the same breed. No significant correlation could be found between the two variables.

Saeki and Katssurgi(1961) reported that the weight at hatching time of the k group was highly significantly heavier than of K group and this difference continued till 10-wks. Highly significantly differences were also found in body weight between the two feathering types among the progenies produced by crossing heterozyous N.H. male (Kk) with hemizygous W.L. female(k-). The sex-linked alleles K and k controlling feathering in N.H.S. seemed to have a pleiotropic action on chick growth.

Seridan and McDonald(1963) in broiler chicken found no significant relationship between body weight and feathering rate at 10 wks. of age. Sire and sex-effect were significant for both traits and there was a significant hatch effect on 10-wk. body weight. Slow-feathering birds tended to be heavier than Rapid-feathering birds at 5 wks. whereas at 10 wks. the converse was applied.

Siegel(1963) found that the heritability estimates for the unselected traits of feathering, egg production, semen Vol. and sperm concentration were low(0.25), body weight, age at sexual maturity in female and egg weight were high. Pleiotropy was considered to be the primary cause of correlated responses

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in body weight, egg weight, egg sp.gr. and sperm motility as the responses were present through all 4 generations of selection.

Knize, RyDlova, Drobna and KniZetova(1963) found in reciprocal crosses between White Plymouth Rock and White Cornish fowls, correlations at 2 wks. of age for male and female between body weight and feathering which ranged from 0.41 and 0.53 and body weight at 12 wks. and (a) feathering at 2 weeks ranged between 0.13 and + 0.21 .

D. Effect on economic characters.

Niesel(1941) concluded that there was strong evidence of sex-linked inheritance of laying capacity as opposed to autosomal influences.

Godfrey and Farnsworth(1952) reported that body weights and mortality rates to 10 weeks of age were related to rate of feathering on the basis of all sire families containing Slow and Rapid feathering birds, matings within sire families, and matings of the type Kk x k- within the silver Oklabar breed. In the birds studied, the gene, k, for sex-linked Rapid-feathering, was found to have no relation to body weight or mortality rate to 10 weeks of age.

Hale(1954) reported that there was no effect of rate of feathering on adult performance.

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Kawahara(1965) reported that a gene located on the sex-chromosome, possibly the k(rapid-feathering) allele, could be responsible for early sexual maturity in the domestic fowl.

Auther did not come across with any work on the effect of these two alleles on the physical measurements. Although indirectly it is apparent that the birds having faster rate of growth should have greater physical measurements, as most of the bones are correlated with body weight specially during growth period under normal condition.

E. Sexual dimorphism in growth rate and physical measurements.

Jull(1923); Ackerson and Mussehl,(1930) reported that male chickens grow more rapidly than do females. The similar report has been given by Card, and Kirkpatric(1918), Warren(1930) Waters(1931) , Lerner and Asmundson(1932), Kempster and Parker(1936) .

Schneider and Dunn(1924) found that in the combined length of the humerus, ulna, femur and tibio-tarsus males exceeded females by 16% in the W.L.Latimer found this difference 15.6% whereas Hutt(1929) found 13.4% in the study conducted on miscellaneous Leghorns. In the Hutt's materials, sex dimorphism in the appendicular skeleton was greatest in the tarso-metatarsus (16.5%) and least in the phalanges of the toes (7 to 10%).

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which have only one sex chromosome.

Lerner and Asmundson(1932) in the matings of Ancona x Light Sussex, Observed that up to 12 weeks of age there was a significant difference in the length of tarsometatarsi between the two types of backcross progeny in favour of the Light sussex x F mating.

Jaap and Penquite(1938) found that in females the growth of the length of the shanks ceases at 5 months and in males at 6 months.

Kempster(1941) found that the greatest gain made by W.L., White Rock, White Wyandotte, Rhode Island Red and New Hampshire were during 9 to 12 weeks. Sex differences in growth became apparent at 8 weeks and increased thereafter.

Jull and Glazener(1946) found that in all cases male shank length was greater than female.

Gilbreath and Upp(1952) reported that the males were significantly heavier than the females at 1 week age, and sex differences became highly significant from 3 weeks of age. Shank length difference was highly significant in two sexes from day old, whereas keel length at 8 weeks age.

Bhatnagar,Shrivastava and Kulsherestha(1963) reported that males were heavier than females at all ages from 1st day to 3 months. Growth rate was also significantly higher in males

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than females particularly between 4 to 8 weeks of age. In female, body weight at hatching did not affect growth up to 8-wks. of age, whereas males with a low hatching weight showed higher gains between 8th week and 3 months of age than those with a higher hatching weights. Growth up to 4 wks. of age amounted to approximately 46% of that between 8 week and 3 months of age. There was significant differences between the offspring of different pullets.

Roberts(1964) carried out an analysis of variance of weekly growth rates, 7-weeks growth rate, and body weights from hatching to 7 weeks in 4 lines of chickens. Line and sex effect were significant for 7-wks. growth rate and body weight, and the line sex interaction was significant for body weight.

F. Growth rate .

Birds having faster rate of growth is economical not only because it reaches the marketable age earlier but is also the economic measure of general vigor and vitality. Therefore, various workers have studied growth rate with different view points.

Hogan and Hunter(1926) calculated growth rate by 3 methods.

(1) Calculating the average weight of all the pullets and cockrels on each weigh day during the experiment.

(2) Calculating the average weight of all the pullets and cockrels alive on each weigh day, excluding from the average

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the preceeding weighings of those that died or removed from the analysis.

(3) Calculating average biweekly weights of only those pullets and cockrels that survived the experiment. They concluded that the differences between means for any two lots were slight.

Davis, Insko and Martin(1932) have reported that the growth rate was studied as early as 1918 in White Leghorn by Buckner, Wilkins and Kastle under artificial and natural conditions up to 28 weeks of age. Card and Kirkpatrick(1918) also studied the growth rate in White Leghorhorns. Hogan and Hunter (1926) studied the growth in fowl and Mitchell, Card and Hamilton(1931) were the workers to take up these studies.

Asmundson and Lerner(1933), on the basis of an analysis of the rates of growth from 2 to 8 weeks among six families of White Leghorns, concluded that the six families could be divided into three classes from the standpoint of rate of growth: three families exhibited a relatively rapid rate of growth, two families exhibited an intermediate rate of growth, and one family exhibited a relatively slow rate of growth. It was concluded that these differences in rate of growth are determined by multiple genes.

Asmundson and Lerner(1934) were led to conclude that the period from 2 to 8 weeks was the most suitable for a genetic study of differences in growth rates.

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Inspection of any flock of growing chickens shows that some birds grow more rapidly than others. According to the experiments by Dove (1935) those growing most rapidly are able to select a diet conducive to such growth when given an opportunity to do so. There are also differences in growth rate to 8 weeks among the families of different dams(Asmundson and Lerner, 1933) and in progenies from different sires(Jaap and Morris, 1937) within one breed. Presumably these indicate hereditary differences. Evidence to that effect is found in the demonstration by Schnetzler(1936) that in two generations of mass selection he could differentiate two strains of B.P.R., one of which grew rapidly to 8 and 12 weeks of age, while the other grew much more rapidly.

Japp and Morris(1936) studied the various causes of genetic variation in eight week weight and feathering and reported the following causes under the similar conditions of managements:

Varieties	13%
Sires	19%
Dams when mated to one male	27%
Sex	23%
Residual(Non heritable)	18%

Convariance between 8 week weight and feathering tendency showed that these were correlated but to a low degree. They in 1937 concluded the rate of growth up to 8 weeks to be

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independant of the weight at maturity.

Schnetzler(1936) found that correlations between weight at 8 and 12 weeks and weight at maturity to be + 0.29 and + 0.39 respectively. He reported that :

(1) It was possible to select fowls at 8 or 9 weeks of age which had inherent differences in body weight.

(2) Rate of growth appears to be associated to some extent with mature body weight following sexual maturity.

(3) Increase in weight ceases when chicks were 52 weeks of age.

(4) Chicks hatched from fast growing parents, were heavier at all weighings and were heaviest when mature and laid the heaviest egg.

(5) Egg production was independent of body weight.

Yadao(1936) reported that the chicks hatched in December had the highest hatching percentage and the highest percentage of pullets laying at 6 months and the lowest mortality. There growth rate was second to those hatched in February. The April hatches were poor in every respect.

Asmundson(1938) concluded that the decreased early growth rate usually exhibited by chicks that were hatched late as compared with those hatched early leads to compensatory growth among the later-hatched chicks during the later growth stages.

Kempster(1941) found that early hatched chicks grew faster in the 1st. part of the period, and the later hatched

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chicks faster in the later part, but the time of hatching had a effect on weight at 40 weeks. The variation in monthly gains of early and late hatched chicks were associated with climatic conditions, especially t°.

Peeler, Glazener and Blow(1955) estimated a high genetic correlation(0.79 and 0.68 in 1952 and 1953 respectively) between boiler weight and weight at sexual maturity. This may be utilized if a large type of layer is preferred .

Moskatenko(1957) found that average daily weight gain to 100 days was 8.61 g. for the Leghorn and 11.36 g. for the cross breds.

Thomas(1957) found that the correlations between weights at different ages were high and positive, hence weight at any age may be used as a critarion for evaluating growth to 10 weeks.

Kwiatkowaska, Kotlinski and Sawicka(1962) found no correlation between growth rate and number of eggs laid or number of eggs and weight of the hen at any age.

Bhatnagar,Shrivastava and Kulsherestha(1963) found that growth up to 4 weeks of age amounted to approximately 46% of that between 8 weeks and 3 months of age.

Knize, Knizetova, Rydlova and Drobna(1963) calculated the correlations between the body weight of the progeny at 3 months

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and at 2,4,6,8 and 10 weeks; correlations between 6 weeks and 3 months(0.67 - 0.87) indicated that selection could be made at 6 weeks.

Roberts(1964) using a log x log scale, the graph indicated that an approach to linearity in growth rate was obtained up to 7 or 8 weeks of age. The C.V. of growth rate was fairly uniform up to 8 weeks of age, after which it increased. Based on the evidence of graphs and C.V.s., it was suggested that the average of weekly growth rates up to 7 weeks would provide a valid estimate of an individual's growth over the period.

G. Size.

The problem of the inheritance of adult body size has been the subject of numerous investigations, the results of which appear to demonstrate that there are many genes involved in determining the size of the body as a whole and other genes that have a particular effect on certain parts. Among the foremost exponents of this view has been Wright(1918, 1932), whose statistical analysis of the bones of inbred White Leghorn developed by Dunn(1928) led to the conclusion that inheritance of bone length was due primarily to genes having a general effect on size.

Latimer(1927) found that of the 6 longest bones of the appendiculars skeleton, the tibia and the tarso-metatarus were the latest to complete growth in length.

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That some genes exercise specific effects on certain parts of the body has been reported by various workers. For example, the length of leg in the creeper fowl as well as in the Dark Cornish have been found to be due to specific genes, Landauer(1939) . It has been stated that the weight of a mature healthy fowl depends upon (1) size of its skelton (2) the amount of organs, muscles, skin, and feathers supported by that skeleton, and (3) the amount of the stored fat. The second and third of these variables, particularly the latter, may change considerably with differing environmental conditions, but the skeleton is little affected after maturity. Schneider and Dunn(1924) and Kope'c(1926) found the variability of body weight in White Leghorns, as measured by the co-efficient of variation, to range from 12 to 18 percent, whereas the co-efficients of variation for bone measurements were only 3 to 45% . Weight of the plumage is even more variable than that of the body (Kope'c). Genetic studies of size could be made more accurately by measuring skeletal dimensions, as Maw(1935) did, than by considering body weights, but the latter are more easily obtained.

Sinnott and Dunn(1935) in their extensive review of the effect of genes on the development of size and form, came to the conclusion that a relatively large number of genes are involved in size inheritance. Schkljar(1935) arrived at a similar conclusion.

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Fortunately it is possible to make measurements in living bird of a bone that gives a good indication of body size. This is the tarso-metatarsus in the Skeleton, or shank in the live bird. Lerner(1937) found the correlation between the shank length and body weight to be + 0.659

Lerner(1946) increased shank length by 8.1 mm., with corresponding increase of 210 gm. in body weight in W.L. in December.

Svoboda(1959) compared body weight and 7 body measurements in White leghorn and R.I.R. crossbreds with those in pure-bred R.I.R.s at various ages.

H. Rocording of Egg Production .

In pioneer studies of egg production made by Ramond Pearl and his associates at Maine Experiment Station in the decade begining in 1908' the number of eggs laid by a hen in November, December, January and February was taken as the measure of her capacity to lay. This led to the belief that the "Winter Cycle" of egg laying constitute some sort of a specific biological unit, and even to suggestion that there were specific genes for high productivity in these four months.

Ball and Alder(1917), Goodale(1918 a), and Herris and Lewis(1922) showed that there is no basis for considering the winter production as any special biological entity.

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Harris et al.(1918) Harris and Lewis(1921), and Harris and Goodale(1922) found that the predictive value of a records for single months was higher for the 4 winter months and for August,September and October at the end of the laying year than for the 5 months of Spring and early summer .

Gericke(1940) showed on analysis of 1st year egg records in White Leghorn the following sexual maturity is negatively correlated with winter production, winter clutch size and annual production but not with persistency. Annual egg production is positively correlated with winter rate and persistency. Persistency is correlated with winter rate but not with winter long pause.

Hays(1946) suggested by his studied on Rhode Island Reds that selection by egg record is unsatisfactory, winter intensity and winter pause might be better criteria for the selection of dams for breeding purpose as correlation co-efficients between dam's and daughter's annual egg production was 0.1590 $\pm$ 0.0159 which is of little biological significance.

Maddison(1954) estimate of the heritabilities of egg production based on partial records were in November 0.240, in December 0.252 and on the full record in July 0.203. The genetic gain in egg production per generation was greater with the full than with the partial record, but the gain per year was greatest with the use of partial records, giving the latter an

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advantage in efficiency over full records of about 1.5:1 in a system of individual selection, and also in a system based on individual plus sister records.

Bartsch(1957) in 5 strains of White Leghorn used rate of laying as a measure of comparison rather than absolute egg yield. The experimental laying year began on 1st. October and partial annual yield were calculated from the date of 1st egg to 31st December(Part winter production) and to 1st. March and 31st. May of following year. Results from both laying seasons showed that even on short term-test such as the part winter production (31st December) good predictability of the laying capacity of families can be obtained.

V(AN), Albada(1958) found in White Leghorn the following characters correlated with annual egg yield :

Age at first egg	r = - 0.432
Age at last egg	r = + 0.596
Length of laying year	r = + 0.664
Lay to 1st. Feb.	r = + 0.718
Average length of laying-cycle of 9 months.	r = + 0.489
Average cycle length over the whole year.	r = + 0.606
Average egg weight	r = + 0.108

He concluded that the best critaria for high egg yield are the average length of the laying cycle and age at 1st.egg.

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Schaaf and Wendt(1959) found that the co-efficients of correlation between winter laying and annual production increased from 0.571 when winter production was based on production to the end of Dec., to 0.657 and 0.726 when it was extended to the end of Jan. and Feb. respectively.

Erasmus(1962) showed that selection on part records lead to improvement in the production index 1.1 - 1.8 times as rapid as selection on full records.

Kraszewska - Domariska(1963) calculated in R.I.R., Leghorn and Polish Greenleg pullets, co-efficient of correlation between a number of production characters. Co-efficient of correlation between annual egg. yield and yield to 1st. Jan. (Initial yield) were low(average, 0.38), although higher in the Leghorn(0.56) than in the Green Leg(0.35) or R.I.R.(0.28)

Sigaeva(1963) showed from the Nov. Feb. production data of Russian White pullets hatched in April that pullets in which production averaged 63 eggs had more and longer clutches and shorter laying pauses than the pullets in which production averaged 27 eggs.

I. Relation of physical & physiological characters associated with egg production.

Selection of birds for high productivity on the basis of physical and physiological characters is economical in comparison to trapnesting.

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Walter Hogan(1873) extended the view that the following characters revealed the prepotency of good hen:(1) the thickness of pubic bones(2) the width of pelvic arch,(3) the span of the abdomen indicated by the distance between the end of the pubic bones and rear end of the Keel bone and (4) shape of the skull. This was known as Hogan system.

Asmundson(1920-21) found the following correlations between the physical measurements and egg production.

Distance between pubic bones	0.35 ± 0.04
Capacity of abdomen	0.23 ± 0.04

Sherwood(1922) working on White Leghorn reported the correlations between the annual egg production and the various measurements as :

Distance between pubic bones	0.21 ± 0.06
Capacity of abdomen	0.09 ± 0.06

Hall(1923) with White Leghorns reported the following correlations with annual egg production .

Distance between pubic bones	0.15 ± 0.07
Capacity of abdomen	0.14 ± 0.07

Hervey and Lewis(1923) working with B.P.R. reported correlations with annual egg production of various measurements.

Quality of pelvic bones	0.0384 ± 0.0753
Spread of the pelvic bones	0.3961 ± 0.0645

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He concluded from his results that July was too early to cull the birds on this basis.

Knox(1924) reported the following correlations between physical measurements and egg production .

Capacity of lay bones	0.358 ± 0.061
Thickness of pubic bones	0.026 ± 0.069
Span of pubic bones	0.147 ± 0.068
Capacity of abdomen	0.108 ± 0.069
Body capacity	0.019 ± 0.071

Weinmiller (1924) working on light breeds measured 10 characters and concluded that :

(1) Birds with broad and deep breast and long body in proportion to their body size, were the best layers.

(2) Birds with comparatively long breast bones and greater distance between pubic bones and breast bones were good layers.

(3) Distance between pubic bones and breast bone considered alone was no proof of good egg production.

(4) Distance between the pubic bones equal to ⅓rd of the breadth the body for optimum egg production.

(5) The length of the shank and thigh did not have any bearing on egg production.

In heavy breeds there was no correlation between production and the respective body measurement.

Studies of the body changes are shown to be due to the

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great increase in the size of the reproductive organs when in active production, sometimes as high as 900 percent in the reproductive system alone (Hall, 1926) .

Knox and Ritten-bender(1927) working on White Plymouth Rocks studied the various physical measurements in first two weeks of July and the last two weeks in August and found them to be correlated with egg production. Correlation of the measurements taken at different times varied with the same bird, especially the correlations of the span of the pubic bones and the size of the abdomen with total egg production.

Waynemiller and Carver(1933) found a correlation between egg production and capacity to be + 0.2285 ± 0.036

Quinn(1934) discussed the importance of Wattles, Comb, Vent, Pubic bones, abdomen and of lateral processes for selecting for early maturity, good laying and persistency.

Knox and Quinn(1936) independently studied eighteen measurements and found that the quality of shank and pubic bones showed no significant correlation with egg production. Other characters as body feathering, body type, comb size, comb quality, head shape, head quality, eye shape, eye quality, shank shape, abdomen size, back width and abdomen quality etc. all showed significant correlation with egg production.

Bogoljubskii(1963) calculated the correlations in

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Russian Whites between each of 7 body measurements and both body weight and early maturity. Egg production was closely correlated with conformation, comb size, the number of moulting flight feathers and eye pigmentation at 3 months; at 5 months it was more closely correlated with abdomen volume, Comb size and conformation with moulting flight feathers and eye pigmentation. Estimated production based on selection by visual appraisal was correlated with actual production, the correlations being 0.82 for hens and 0.46 for pullets.

Shrivastava and Bose (Under publication) observed the following physiological and physical conditions for the study of intensity.

(a) Condition of comb.

(b) Condition of vent.

(c) Distance between pubic bones.

(d) Quality of abdomen(Pliability) .

(e) Quality of pubic bones.

(f) Capacity - distance between keel and pubic bones .

(g) Quality of shank (Round or flat) .

The study was conducted on the flocks of 50 W.L. and 50 R.I.R. pullets of the same hatch and 60 W.L. pullets of bulkley strain, hatched between January to April. Scores were awarded to the individual bird on the condition of the above

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characters and the birds were also trapnested throughout the laying year. All the individual character scores and their totals were correlated with annual egg production. A positive significant co-efficient of correlation was found between all the characters(except shank quality) and their total annual egg production. It was revealed that the shank quality is not correlated with the annual egg production. It was also found that the scores varied with breed and strain.

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CHAPTER-III

MATERIAL & METHOD

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MATERIAL & METHODS.

A. MATERIAL.

(i) Source of Material.

The day-old chicks for the study were sorted out from the routine hatched chicks of the Central Poultry Farm, Patna of R.I.R. and W.L. crosses during the year 1967. The chicks were hatched within the period of a fortnight in the month of May. On the day of hatch itself the individual chick was wing-banded. The analysis has been made only on the records of those individuals which survived whole of the experimental period and with the wing bands intact. Table(2) presents a full account of the individuals in different groups.

Table No.(2)

Table showing the detail account of individuals in different groups that survived the experimental period

	Rapid male	Rapid female	Slow male	Slow female
With wing bands	208	230	50	30
Bandless	13	7	x	x
Total	221	237	50	30

diseases which were controlled by the regular use of T.M.-5 in drinking water. Besides, very little space was available in the farm. Therefore, the birds had to be kept in much overcrowded condition, although efforts were made to minimise the environmental component of variation between the groups as far as practicable.

(iii) Collection of data.

(a) Physical measurements.

These were taken on the day of hatch and afterwards at each biweekly intervals up to 12 weeks of age. The measurements of the following characters were taken.

I. Length of the shank(Tarso-metatarsal bone) in cms.

II. Width of the breast in cms.

III. Length of the thigh(Drumstick) in cms.

IV. Length of the head in cms.

All these measurements were taken by means of slide-calliper with an assistant to hold the bird in position.

(b) Economic Characters.

(i) Growth rate.

For the study of growth rate the individual bird was weighed on the day of hatch and at each biweekly interval thereafter up to 12 weeks of age. Different amount of data was available in different biweeks on account of the birds

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(few in number) that escaped without being weighed. At second week the measurement of the body parts of one batch could not be taken.

The body weights were taken in grams of both male and female chicks, in both the groups, kept together on the same feed and in the same brooder or house up to 12 weeks of age. After which the males were separated and kept in different pens.

Comparisons of the biweekly growth rate and total growth have been made between the following groups.

1. Rapid-feathering male versus Slow-feathering male.
2. Rapid-feathering female versus Slow-feathering female.
3. Rapid-feathering male versus Rapid-feathering female.
4. Slow-feathering male versus Slow-feathering female.

The similar comparisons have been made for other measurements also at each bi-weekly interval to study the trend of difference in development of each character at different periods of growth.

Sexing of the chicks was done at 8-weeks of age in both the groups to study the sex differences in the growth rates.

(ii) Age at first lay .

The appearance of the first egg in a group was taken as the age at first lay for the whole group. For this study the

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birds of only two hatches were available.

(iii) Sex-ratio.

Tertiary sex-ratio was calculated in each group.

(v) Egg production .

The egg production record was taken on hen-house basis. Twelve and five Slow-feathering pullets hens of two hatches and the equal number of Rapid-feathering birds of the same hatches (randomly selected) were separately kept in four rooms in deep-litter system. No artificial light during might was provided in the pens. Egg production of 30 days during the month of November-December was taken as a critarion for the interpretation of the results.

For the individual recording of the egg production 94 birds of the same hatch were transferred to the laying cages after they attained maturity

Egg record of the first forty days was taken, for the correlations study.

B. METHODS .

Differentiation of Slow-feathering and Rapid-feathering.

The two types of the birds were differentiated by the method given by Warren(1930 b). Soon after hatching as the

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chicks were thoroughly dried the primary and secondary feathers were examined. In Rapid-feathering chicks primary and secondary feathers project well beyond the down, but in the showly feathering chicks they do not. In Rapid-feathering chick, the coverts which are usually more slender, is only about two-thirds or three-fourths the length of the primaries. If the coverts are equal to, or longer than the primaries, regardless of the fact that both coverts and primaries are relatively long, the chicks will not be Rapid-feathering. Slow-feathering chicks possess not more than 3 secondaries on the day of hatch(Warren 1944).

To attain 100% accuracy in differentiation of the two types all the chicks of the Slow-feathering group were re-examined on the 10th day. Chicks with at least ½" long tail-feathers (Williams and Wiegers 1947) were transferred to the Rapid-feathering group.

The attempt was also made for the selection of multiple alleles tardy(t) Jones and Hutt(1946) and retarded(t^s) Warren (1933 b) from the Rapid-feathering group. But no bird could be located having these alleles.

Growth rate.

Growth rate was calculated according to the definition given by Schloss(1911). The formula used was $\frac{W_2 - W_1}{t_2 - t_1}$ where $W_2 - W_1$ is the gain in weight during the time interval $t_2 - t_1$.

To find out the total growth of a character up to 12 weeks of age, the weight or measurements on the day of hatch was subtracted from the corresponding weight or measurements at 12 weeks of age.

Method of scoring.

For the correlations study the scoring system developed at I.V.R.I. was followed, which is given below :

Character	Max.Marks allotted	Conditions observed.	Symbol	Marks scored on conditions
1.Condition of comb.	10	1.Normal turgid and red	NR	10
		2.Normal turgid and dull	ND	5
		3.Shrunken & dull	SD	0
2.Condition of vent	10	1.Moist & oval	MO	10
		2.Moist & Round	MR	5
		3.Dry & Round	DR	0
3.Spread of pubic bones	10	1.Distance above 2 fingures or 3.3 cms.		10
		2.Distance between 2 - 1½ fingures or 2.4 cms to 3.3 cms.		5
		3.Distance less than 1½ fingures or 2.4 cms.		0
4.Measure of capacity	40	1.Above 4 fingures or 6.6 cms.		40
		2.Between 3½ to 4 fingures or 5.7 cms. to 6.6 cms.		30

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Character	Max.Marks allotted	Conditions observed.	Symbol	Marks scored on conditions.
		3.Between 3 to 3½ fingures or 4.9 to 5.7 cms.		20
		4.Below 3 fingures or 4.9 cms.		0
5.Quality of pubic bones	10	1.Soft	S	10
		2.Hard	H	0
6.Quality of abdomen	10	1.Pliable	P	10
		2.Non-pliable	NP	0
7.Quality of shank	10	1.Flat	F	10
		2.Round	R	0

The individual bird was examined on the 41st. day of laying. Different scores were alloted on the condition of each character which were finally summed up to give a single score for one bird. Correlation co-efficients were calculated between the total score and the single character's scores, with no. of eggs laid within the period.

To make this method easily applicable by the general breeders for the classification of the layers in each of the four categories: very good, good, medium and poor layers; ranges of scores were determined. This classification of the layers was based on the I.V.R.I. standard with slight modifications, because it was observed that with the help of this score-card the layers could be classified only in four categories and not in five as has been laid down in the I.V.R.I. standard.

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On the basis of the report of Veiga and Raimo(1942) that to ensure an annual egg production of 200 eggs, a hen must lay a minimum of 12 eggs during the first 30 days, the following numbers of eggs within the first 40 days of production, were determined for the categorisation of the layers after giving a presumptive allowance for the delay in the start of laying as this score-card is based on the characters associated with intensity of laying . Therefore, a bird may have delayed maturity but good intensity of laying .

Table No.3

Categories of layers.	Annual Egg production	No.of eggs laid within first 40 days of laying.
1. Very good	Above 250 eggs.	Above 25 eggs.
2. Good	200 to 250 eggs.	16 to 25 eggs.
3. Medium	100 to below 200 eggs.	6 to 15 eggs .
4. Poor	Below 100 eggs.	Less than 6 eggs.

Statistical Analysis.

Analysis of variance was done to find out the significance of difference among all the four groups at each bi-weekly interval. Where the F.value was significant, they were further tested by calculating critical differences according to the formula given below for knowing the roles

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of specific variables.

Critical difference =

$$\text{Mean Squar of error d.f.} \left(\frac{1}{n_1} + \frac{1}{n_2} \right) \times \text{t-value at 5\% or 1\% level of significance.}$$

Where ;

n_1 = No.of replicates in one group.

n_2 = No.of replicates in another group.

A value thus obtained should be greater than the difference between the means of the two groups considered, to make it significant.

Means, standard errors and co-efficients of variation wer calculated by using the methods suggested by Snedecor(1957).

Z- Statistics was applied to find out the significance of difference between sex-ratio and total egg production between the two groups. The formula is as follows:-

$$p = \frac{n_1 \; p_1 + n_2 \; p_2}{n_1 + n_2}$$

Where ;

n_1 = No.of observations in one group.

n_2 = No.of observations in other group.

p_1 = Percentage of observations within one group.

p_2 = Percentage of observations within other group.

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p = Proportion of one variable .

q = Proportion of other variable .

$$q = 100 - p$$

S.E. of the difference of their percentages=

$$\sqrt{p \times q \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

If the difference between two percentages is greater than twice S.E., it is significant.

Phenotypic correlation was calculated by the formula :-

$$r_{xy} = \frac{\sum xy - \frac{(\sum x) \cdot (\sum y)}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right) \left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

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CHAPTER IV

RESULTS

RESULTS

A. The average growth rate and different body measurements along with standard error and co-efficient of variation were calculated on the day of hatch and at each biweekly interval thereafter up to 12 weeks of age.These estimates are presented in the tables below :

Table No. 4

Hatch weight.

	Mean gms.	No.of obs.	S.E.	C.V.
Rapid male	40.04	208	0.19	7.2
Rapid female	39.28	230	0.06	24
Slow male	39.84	50	0.15	2.5
Slow female	39.36	30	1.5	20.8

Table No. 5

Rapid-feathering male.

Growth Rate.	Mean gms.	No.of obs.	S.E.	C.V.
Day old to 2nd. wk.	27.19	207	0.64	41.3
2nd. wek. to 4th wk.	49.84	207	1.6	47.59
4th. wk. to 6th. wk.	89.45	207	2.61	42.05
6th.wk.to 8th. wk.	98.17	207	3.4	50.66
8th. wk. to 10th. wk.	98.31	207	4.2	61.54
10th.wk.to 12th. wk.	131.88	207	5.0	55.53

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Head Length	Mean cms.	No.of obs.	S.E.	C.V.
Hatch	2.54	208	0.014	7.8
2nd. wk.	2.84	139	0.008	3.5
4th. wk.	3.15	207	0.010	4.4
6th. wk.	3.54	207	0.016	6.2
8th. wk.	3.99	207	0.014	5.2
10th. wk.	4.30	207	0.015	6.3
12th. wk.	4.60	207	0.029	9.1
Breast width.				
Hatch.	1.30	208	0.007	7.6
2nd. wk.	1.56	139	0.012	8.9
4th. wk.	2.06	207	0.026	12.1
6th. wk.	2.44	207	0.013	8.1
8th. wk.	2.80	207	0.022	11.7
10th. wk.	3.18	207	0.026	11.9
12th. wk.	3.54	207	0.037	14.7
Shank Length				
Hatch	2.30	208	0.019	12.7
2nd. wk.	2.78	139	0.033	14.38
4th. wk.	3.29	207	0.022	3.2
6th. wk.	4.14	207	0.028	9.97
8th. wk.	4.96	207	0.040	11.69
10th. wk.	5.70	207	0.035	8.77
12th. wk.	6.27	207	0.057	13.07

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Thigh Length	Mean cms.	No.of obs.	S.E.	C.V.
Hatch	3.08	208	0.065	6.4
2nd. wk.	3.74	139	0.020	6.4
4th. wk.	4.63	207	0.028	8.6
6th. wk.	5.72	207	0.042	12.4
8th. wk.	7.00	207	0.046	9.4
10th. wk.	7.96	207	0.063	11.4
12th. wk.	8.67	207	0.079	12.6

Table No. 6

Rapid -feathering female.

Growth rate	Mean gms.	No.of obs.	S.E.	C.V.
Day old to 2nd. wk.	24.00	231	0.61	39.16
2nd.wk.to 4th.wk.	40.40	226	1.7	28.46
4th.wk.to 6th.wk.	70.07	225	2.2	44.93
6th.wk.to 8th. wk.	77.55	225	3.0	58.32
8th.wk.to 10th. wk.	80.88	223	2.7	50.99
10th.wk.to 12th.wk.	112.31	223	4.1	54.76

Head Length	cms.			
Hatch	2.52	230	0.011	6.7
2nd. wk.	2.56	151	0.092	42.9
4th. wk.	3.08	224	0.010	4.8
6th. wk.	3.45	223	0.015	6.6
8th. wk.	3.83	223	0.015	5.7
10th. wk.	4.05	221	0.25	8.1
12th. wk.	4.32	221	0.25	7.6

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Breast Width	Mean cms.	No.of obs.	S.E.	C.V.
Hatch	1.28	230	0.007	7.8
2nd. wk.	1.51	151	0.011	8.5
4th. wk.	1.88	224	0.049	38.8
6th. wk.	2.32	223	0.014	8.1
8th. wk.	2.66	223	0.021	11.6
10th. wk.	2.99	221	0.024	12.0
12th. wk.	3.36	221	0.038	16.9
Shank Length				
Hatch	2.28	230	0.010	7.01
2nd. wk.	2.56	151	0.012	5.85
4th. wk.	3.12	224	0.016	8.01
6th. wk.	3.90	223	0.099	35.89
8th. wk.	4.60	223	0.027	8.6
10th. wk.	5.19	221	0.067	19.2
12th. wk.	5.78	221	0.061	15.7
Thigh Length.				
Hatch	3.10	230	0.064	8.3
2nd. wk.	3.74	151	0.011	3.7
4th. wk.	4.43	224	0.030	10.1
6th. wk.	5.49	223	0.036	9.8
8th. wk.	6.56	223	0.040	9.1
10th. wk.	7.38	221	0.058	11.8
12th. wk.	8.16	221	0.074	13.4

MAGADH UNIVERSITY M. Sc. (A.H.) THESIS, 1967

Table No.7

Slow -feathering male.

Growth Rate	Mean gms.	No. of obs.	S.E.	C.V.
Day old to 2nd. wk.	29.14	50	1.37	32.98
2nd. wk.to 4th. wk	55.62	50	3.4	44.24
4th. wk.to 6th. wk.	99.46	50	5.6	40.44
6th. wk.to 8th. wk.	119.74	50	9.9	58.56
8th. wk. to 10th. wk.	134.14	50	4.5	34.89
10th. wk. to 12th.wk.	176.16	50	11.3	45.71
Head Length	cms.			
Hatch	2.52	50	0.011	3.1
2nd. wk.	2.90	36	0.012	2.7
4th. wk.	3.22	50	0.017	3.7
6th. wk.	3.61	50	0.028	5.2
8th. wk.	4.08	50	0.032	5.6
10th. wk.	4.36	50	0.098	15.8
12th. wk.	4.85	49	0.052	7.4
Breast Width				
Hatch	1.34	50	0.017	8.8
2nd. wk.	1.62	36	0.027	9.8
4th. wk.	2.04	50	0.033	11.2
6th. wk.	2.53	50	0.042	11.4
8th. wk.	3.03	50	0.053	11.4
10th. wk.	3.37	50	0.092	19.2
12th. wk.	3.98	49	0.106	18.5

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Shank Length	Mean cms.	No.of obs.	S.E.	C.V.
Hatch	2.34	50	0.037	11.1
2nd. wk.	2.68	36	0.023	4.8
4th. wk.	3.33	50	0.040	8.7
6th. wk.	4.20	50	0.056	9.2
8th. wk.	5.12	50	0.70	9.5
10th. wk.	5.90	50	0.14	16.9
12th. wk.	6.83	49	0.094	9.3
Thigh Length.				
Hatch	3.17	50	0.041	9.1
2nd. wk.	3.86	36	0.043	9.3
4th. wk.	4.78	50	0.056	8.3
6th. wk.	5.89	50	0.77	9.1
8th. wk.	7.20	50	0.097	9.4
10th. wk.	8.21	50	0.201	17.0
12th. wk.	9.44	49	0.142	10.4

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Table No.8

Slow-feathering female.

Growth Rate	Mean gms.	No.of obs.	S.E.	C.V.
Day old to 2nd. wk.	25.03	30	1.8	40.80
2nd. wk. to 4th. wk.	41.50	30	3.8	52.04
4th. wk. to 6th. wk.	78.06	30	7.2	50.64
6th. wk. to 8th. wk.	76.83	30	9.5	68.09
8th. wk. to 10th. wk.	92.33	30	7.9	43.66
10th. wk. to 12th. wk.	111.16	30	10.8	53.19
Head Length	cms.			
Hatch.	2.54	30	0.010	1.9
2nd. wk.	2.86	20	0.030	3.4
4th. wk.	3.12	30	0.024	4.1
6th. wk.	3.62	30	0.170	25.7
8th. wk.	3.78	29	0.074	10.5
10th. wk.	4.13	29	0.449	5.8
12th. wk.	4.41	29	0.450	8.6
Breast Width.				
Hatch.	1.30	30	0.027	11.5
2nd. wk.	1.57	20	0.032	8.9
4th. wk.	1.89	30	0.049	14.2
6th. wk.	2.29	30	0.065	15.7
8th. wk.	2.65	29	0.105	21.5
10th. wk.	3.08	29	0.35	61.6
12th. wk.	3.47	29	0.131	20.1

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Shank Length	Mean Cms.	No.of obs.	S.E.	C.V.
Hatch.	2.30	30	0.043	10.0
2nd. wk.	2.61	20	0.027	4.6
4th. wk.	3.17	30	0.044	7.5
6th. wk.	3.93	30	0.080	11.2
8th. wk.	4.62	29	0.11	13.2
10th. wk.	5.32	29	0.14	14.4
12th. wk.	5.92	29	0.17	15.5

Thigh Length.				
Hatch.	3.15	30	0.050	8.5
2nd. wk.	3.79	20	0.72	84.4
4th. wk.	4.54	30	0.065	7.7
6th. wk.	5.54	30	0.113	11.0
8th. wk.	6.55	29	0.16	13.2
10th. wk.	7.48	29	0.28	20.0
12th. wk.	8.35	29	0.23	14.3

Table showing total growth in each character from the time of hatching to 12 weeks of age.

Table No.9

Rapid-feathering male.

Characters.	Mean	No.of obs.	S.E.	C.V.
Growth	493.71 g.	207	9.9	28.9
Head length	2.08 Cms.	206	0.034	21.6
Breast width	2.27 "	206	0.024	16.8
Shank length.	3.99 "	206	0.051	10.7
Thigh length	5.62 "	206	0.071	17.7

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Table No.9(a)

Rapid-feathering female.

Characters.	Mean gms.	No.of obs.	S.E.	C.V.
Growth	411.84	221	8.0	29.6
Head length	1.82	221	0.030	22.8
Breast width	2.10	221	0.017	14.2
Shank length	3.55	221	0.042	17.4
Thigh length	5.08	221	0.054	15.9

Table No.10

Slow-feathering male.

Characters.	Mean	No.of obs.	S.E.	C.V.
Growth	611.94	50	24.9	28.8
Head length	2.28	50	0.077	21.0
Breast width	2.57	50	0.064	19.7
Shank length	4.39	50	0.121	19.5
Thigh length	6.07	50	0.19	21.4

Table No.10(a)

Slow-feathering female.

Characters.	Mean	No.of obs.	S.E.	C.V.
Growth rate	424.63	30	29.0	37.4
Head length	1.80	30	0.15	41.9
Breast width.	2.05	30	0.089	26.6
Shank length	3.49	30	0.198	28.6
Thigh length	5.02	30	0.281	29.8

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B. Study on the significance of difference in the average growth rate, length of the different body parts at biweekly intervals, and total growth in body weight and length of the different parts from the time of hatching to 12 weeks of age.

Analysis of variance were conducted to estimate the differences in all the characters between Rapid-feathering and Slow-feathering groups at biweekly intervals. These are presented in the tables below :

Table No.11

Analysis of variance to estimate the difference in the average hatch weights of all the groups.

Source of variation	D. F.	Sum of squares	M.S.	F.
Between group	3	67.3	22.4	1.80 N.S.
Within group	514	6422.5	12.4	
Total:-	517	6489.8		

N.S. → Non-Sig.

Differences in the average body weights between all the groups were non-significant at hatch.

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Growth rate.

Table No.12

Analysis of variance to estimate the difference in the average growth rate during hatch to 2nd week of age.

Source of variation	D. F.	Sum of squares	M.S.	F.
Between group	3	1720.4	573.48	6.42 **
Within group	514	45894.0	89.28	
Total:-	517	47614.4		

Critical difference.

	1%	5%	Difference between averages
Rapid Male vs. Slow male.	3.8	2.9	1.95
Rapid Female vs. Slow female	4.69	3.57	1.03
Rapid male vs. Rapid female	2.32	1.77	3.19 **
Slow Male vs. Slow female	5.61	4.31	4.11 *

Average growth rate of males of both Rapid-feathering and Slow-feathering groups were more than female of the corresponding groups at 1% and 5% level of significance respectively. These differences were non-significant between Rapid-feathering male and Slow-feathering male, and Rapid-feathering female and Slow-feathering female.

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Table No. 13

Analysis of variance to estimate the difference in the growth rate during 2nd. wk. to 4th. wk.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	15336.0	5112.0	10.9**
Within group	509	238589.0	468.7	
Total:	512	253925.0		

Critical difference.

	1%	5%	Difference between averages
Rapid Male vs. Slow male.	2.77	2.11	5.78 **
Rapid Female vs. Slow female	3.18	2.42	1.10
Rapid male vs. Rapid female	1.69	1.08	9.44**
Slow Male vs. Slow female	4.04	3.07	14.12**

The average growth rate of Slow-feathering male was highly significantly more than the Rapid-feathering male.

The differences in the average growth rate of males of both groups were also significantly more than females of the corresponding groups.

Between the females of both groups this difference was non-significant.

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Table No.14

Analysis of variance to estimate the difference in the average growth rate during 4th to 6th week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	29898.6	9966.2	7.3 **
Within group	508	685196.6	1348.8	
Total :	511	715095.2		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	14.88	11.32	10.01
Rapid female vs. Slow female.	18.36	13.97	0.99
Rapid male vs. Rapid female	9.09	6.91	12.38**
Slow male vs. Slow female.	21.84	16.62	21.40 *

The average growth rate of males in the Rapid-feathering group was more than females of the same group at 1% level of significance, whereas sex difference in the Slow-feathering group was significant at only 5% level.

The differences in the average growth rate were non-significant between Rapid-feathering male and Slow-feathering male, and Rapid-feathering female and Slow - female.

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Table No. 15

Analysis of variance to estimate the difference in the average growth rate during 6th.wk. to 8th.wk.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	122860.6	40953.5	16.00**
Within group	506	1294397.8	2558.0	
Total:	509	1417258.4		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	20.37	15.50	21.57**
Rapid female vs. Slow female	25.19	19.16	0.72
Rapid male vs. Rapid female	12.49	9.50	20.62**
Slow male vs. Slow female.	29.95	22.79	42.91 **

Difference in the average growth rate was highly significant in the favour of Slow-feathering male than Rapid-feathering male.

Sex differences were also highly significant in both the groups being more in the male than female.

The differences between the females of the two groups were non-significant.

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Table No.16

Analysis of variance to estimate the difference in the average growth rate during 8th.to 10th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	122860.6	40953.5	16.00**
Within group	506	1294397.8	2558.0	
Total :	509	1417258.4		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	20.50	15.60	35.83 **
Rapid female vs. Slow female	25.32	19.26	11.45
Rapid male vs. Rapid female	12.57	9.56	17.43 **
Slow male vs. Slow female.	30.06	22.87	41.81 **

Average growth rate was highly significantly more in Slow-feathering male than Rapid-feathering male.

Differences between the two sexes within the group were also highly significant being more in the male than female.

Within the females between the groups the difference was non-significant.

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Table No.17

Analysis of variance to estimate the difference between average growth rate during 10th. wk. to 12th. wk.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	181246.7	60415.5	12.93**
Within group	506	2363613.6	4671.1	
Total:	509	2544860.3		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	27.71	21.08	44.28 **
Rapid female vs. Slow female.	34.20	26.02	1.15
Rapid male vs. Rapid female.	16.97	12.91	19.57 ***
Slow male vs. Slow female.	40.62	30.90	65.00 **

Average growth rate of male of Slow-feathering group was more than the male of Rapid-feathering group at 1% level.

The difference between the two sexes within a group was also highly significant being more in the male than female.

Females of both the groups did not differ significantly.

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Table No. 18

Analysis of variance to estimate the difference in the average total growth from day old to 12th. weeks of age.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	1919876.51	639958.83	33.48 **
Within group	504	9633741.52	19114.56	
Total:-	507	11553618.03		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	54.22	41.25	118.23 **
Rapid female vs. Slow female .	69.24	52.68	12.79
Rapid male vs. Rapid female.	34.44	26.20	81.87 **
Slow male vs. Slow female.	82.20	62.54	187.31 **

The average total growth of Slow-feathering male was significantly more than Rapid-feathering male.

Males of both the groups had highly significantly more average total growth than the females of the corresponding groups.

This difference was non-significant within females between the groups.

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Table No. 19

Average head length.

Analysis of variance to estimate the difference in the average head length at the time of hatch.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.03	0.01	1.25 N.S.
Within group	514	4.57	0.008	
Total:	517	4.60		

N.S. → Non-significant

Differnces in the average head length between all the groups were non-significant.

Table No. 20

Analysis of variance to estimate the difference at 2nd. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	7.50	2.50	4.38**
Within group	342	196.21	0.57	
Total:	345	203.71		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.36	0.27	0.06
Rapid female vs. Slow female.	0.46	0.35	0.30
Rapid male vs. Rapid female.	0.22	0.17	0.28 **
Slow male vs. Slow female.	0.54	0.41	0.04

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The average length of the head was highly significantly more in male than female in the Rapid-feathering group.

This difference was non-significant between Rapid male vs. Slow male, Rapid female vs. Slow female and Slow males vs. Slow-female.

Table No. 21

Analysis of variance to estimate the difference at 4th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.97	0.32	16.00**
Within group	507	11.34	0.02	
Total:	510	12.31		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.11	0.08	0.07
Rapid female vs. Slow female.	0.14	0.10	0.04
Rapid male vs. Rapid female.	0.06	0.05	0.07 **
Slow male vs. Slow female.	0.16	0.12	0.10

The average head length of males of Rapid-feathering group was highly significantly more than females of the same group.

While this difference was non-significant between Rapid male vs. Slow male, Rapid female vs. Slow female and Slow male vs. Slow female .

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Table No. 22

Analysis of variance to estimate the difference at 6th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	1.87	0.623	6.29 **
Within group	506	50.24	0.099	
Total:	509	52.11		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.12	0.09	0.07
Rapid female vs. Slow female.	0.15	0.11	0.17 **
Rapid male vs. Rapid female.	0.07	0.05	0.09 **
Slow male vs. Slow female.	0.18	0.14	0.01

Slow-feathering females had highly significantly greater average head length than Rapid-feathering females.

Average length of head in the males of Rapid-feathering group was greater than the females of the same group.

This difference was non-significant between Rapid male vs. Slow male and Slow male vs. Slow female.

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Table No. 23

Analysis of variance to estimate the difference at 8th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	4.70	1.566	55.7**
Within group	505	14.27	0.028	
Total:	508	18.97		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.06	0.05	0.09**
Rapid female vs. Slow female.	0.08	0.06	0.05
Rapid male vs. Rapid female.	0.04	0.03	0.16**
Slow male vs. Slow female.	0.10	0.07	0.30 **

The average head length in the males of Slow-feathering group was greater at 1% level of significance than the Rapid-feathering males.

Sex differences were also highly significant within the groups being more in the male than female.

The differences within the females between the groups were non-significant.

Table No. 24

Analysis of variance to estimate the difference at 10th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	8.67	2.89	9.3**
Within group	503	160.75	0.31	
Total:	506	169.42		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.23	0.18	0.06
Rapid female vs. Slow female	0.28	0.21	0.08
Rapid male vs. Rapid female.	0.14	0.11	0.25 **
Slow male vs. Slow female.	0.35	0.27	0.23

Average head length of the males of Rapid-feathering group was highly significantly more than females within the same group.

These differences were non-significant between Rapid-feathering males vs. Slow-feathering males, Rapid females vs. Slow females, and Slow males vs. Slow females.

Table No.25

Analysis of variance to estimate the difference at 12th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	14.90	4.966	25.2**
Within group	502	99.13	0.197	
Total:	505	114.03		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.18	0.13	0.25 **
Rapid female vs. Slow female.	0.20	0.15	0.09
Rapid male vs. Rapid female	0.10	0.08	0.28 **
Slow male vs. Slow female.	0.26	0.20	0.44 **

Slow-feathering males had greater average head length than Rapid-feathering males. This difference was significant at 1% level of significance.

Differences between the two sexes within the same group were also highly significant.

Difference between the famales of the two groups was non-significant.

Table No. 26

Analysis of variance to estimate the difference in the average total growth in length from the day of hatch to 12 wks. of age.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	13.10	4.36	39.63**
Within group	503	58.12	0.11	
Total:	506	71.22		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.13	0.10	0.20 **
Rapid female vs. Slow female	0.16	0.12	0.02
Rapid male vs. Rapid female	0.08	0.06	0.26 **
Slow male vs. Slow female	0.19	0.14	0.48 **

The average total growth in length of the head of Slow-feathering male was more than Rapid-feathering male. This difference was significant at 1% level of probability.

Differences between the two sexes within a group were also highly significant in both the groups.

The females of the two groups did not differ significantly in the average head length.

Table No.27

Average breast width

Analysis of variance to estimate the difference on the day of hatch.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.17	0.056	4.6**
Within group	514	6.49	0.012	
Total:	517	6.66		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.04	0.03	0.04 **
Rapid Female vs. Slow female.	0.05	0.04	0.02
Rapid male vs. Rapid female.	0.02	0.01	0.02**
Slow male vs. Slow female	0.06	0.04	0.04 *

Average width of the breast in the males of Slow-feathering group was highly significantly more than Rapid-feathering males.

The two sexes within both the groups also differed significantly being more in the male than female. This difference was significant at 1% level within Rapid-feathering group while at 5% level within Slow-feathering group.

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Table No.28

Analysis of variance to estimate the difference at 2nd. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.44	0.146	7.30**
Within group	342	7.13	0.020	
Total:	345	7.57		

Critical difference.

	1%	5%	Difference between average
Rapid male vs. Slow male.	0.06	0.05	0.06 **
Rapid female vs. Slow female.	0.08	0.06	0.06 *
Rapid male vs. Rapid female.	0.04	0.03	0.05 **
Slow male vs. Slow female.	0.10	0.07	0.05

The differences in the average breast width between Rapid male vs.Slow male, Rapid female vs.Slow female and Rapid male vs.Rapid female were significant respectively at 1%,5% and 1% level of significance being greater in Slow male, Slow female and Rapid male.

The difference between the two sexes was non-significant.

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Table No.29

Analysis of variance to estimate the difference at 4th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	3.77	1.25	4.6**
Within group	507	140.77	0.27	
Total:	510	144.54		

Critical difference.

	1%	5%	Difference between average
Rapid male vs. Slow male.	0.20	0.15	0.02
Rapid female vs. Slow female.	0.25	0.19	0.01
Rapid male vs. Rapid female.	0.12	0.09	0.18 **
Slow male vs. Slow female	0.30	0.23	0.15

Sex difference within the Rapid-feathering group was highly significant in the favour of male.

The differences in the average breast width were non-significant between Rapid male vs. Slow male, Rapid-female vs. Slow female and Slow male vs. Slow female.

Table No.30

Analysis of variance to estimate the difference at 6th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	2.85	0.95	17.92**
Within group	506	27.10	0.053	
Total	509	29.95		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male	0.09	0.07	0.09 **
Rapid female vs. Slow female.	0.11	0.08	0.03
Rapid male vs. Rapid female.	0.05	0.04	0.12 **
Slow male vs. Slow female	0.13	0.10	0.24 **

Average breast width of males of Slow-feathering group was highly significantly more than males of Rapid-feathering group.

Male of both the groups had highly significantly greater average breast width than females of the corresponding groups.

Between the females of the two groups there was Statististically no difference in the average breast width.

Table No.31

Analysis of variance to estimate the difference at 8th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	6.80	2.26	20.5 **
Within group	505	59.28	0.11	
Total.	508	66.08		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.13	0.10	0.23 **
Rapid female vs. Slow female.	0.16	0.12	0.01
Rapid male vs. Rapid female.	0.08	0.06	0.14 **
Slow male vs. Slow female	0.19	0.15	0.38 **

Average breast width of Slow-feathering male was significantly greater at 1% level of significance than Rapid-feathering male.

Difference between the two sexes within a group was also highly significant being more in the males than females.

Females of the two groups did not differ significantly.

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Table No. 32

Analysis of variance to estimate the difference at 10th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	7.32	2.44	6.8 **
Within group	503	184.73	0.36	
Total:	506	192.05		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.24	0.18	0.19*
Rapid female vs. Slow female.	0.28	0.21	0.09
Rapid male vs. Rapid female.	0.12	0.09	0.19 **
Slow male vs. Slow female	0.36	0.27	0.29 *

The average width of breast was significantly more in the males of Slow-feathering group than Rapid-feathering group.

Males had more average breast width than females within the group. This difference was significant at 1% level in Rapid-feathering group and at 5% level in Slow-feathering group.

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Table No.33

Analysis of variance to estimate the difference at 12th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	16.00	5.33	15.91 **
Within group	502	172.31	0.34	
Total:	505	188.31		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.23	0.18	0.44 **
Rapid female vs. Slow female.	0.28	0.21	0.11
Rapid male vs. Rapid female.	0.14	0.10	0.18 **
Slow male vs. Slow female	0.35	0.26	0.51 **

Average breast width of Slow-feathering male was highly significantly more than Rapid-feathering male.

Sex differences were also highly significant within both the groups in the favour of male.

Differences between females of the two groups were non-significant.

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Table No.34

Analysis of variance to estimate the difference in the average total growth in width from day old to 12 weeks of age.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	10.48	3.49	13.42 **
Within group	503	132.92	0.26	
Total:	506	143.40		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male	0.20	0.15	0.30 **
Rapid female vs. Slow female.	0.23	0.17	0.05
Rapid male vs. Rapid female.	0.12	0.096	0.17 **
Slow male vs. Slow female	0.30	0.22	0.52 **

Average total growth in width was highly significantly more in the Slow-feathering male than Rapid-feathering male.

Males of both groups had more average total growth in width than females within the same group.

This difference between females of the two groups was non-significant.

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Table No.35

Av. Shank length.

Analysis of variance to estimate the difference in the average hatch length.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.20	0.06	1.2 N.S.
Within group	514	27.36	0.05	
Total:	517	27.56		

N.S. → Non-significant

The differences between all the groups were non-significant.

Table No.36

Analysis of variance to estimate the difference at 2nd. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	3.60	1.20	15.00**
Within group	342	26.59	0.078	
Total:	345	30.19		

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Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.13	0.10	0.10 *
Rapid female vs. Slow female.	0.17	0.12	0.05
Rapid male vs. Rapid female.	0.08	0.06	0.22 **
Slow male vs. Slow female	0.19	0.15	0.07

Average shank length was more in the Rapid-feathering male than Slow-feathering male . This difference was significant at 5% level of significance.

Rapid-feathering males had greater average shank length than the females. The differences between the averages of males and females were significant at 5% level of significance.

This difference was non-significant between the females of the two groups.

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Table No.37

Analysis of variance to estimate the difference at 4th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	3.86	1.28	14.2 **
Within group	507	41.99	0.090	

Critical differences

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.12	0.09	0.04
Rapid female vs. Slow female.	0.14	0.11	0.05
Rapid male vs. Rapid female.	0.07	0.05	0.17 **
Slow male vs. Slow female	0.17	0.13	0.16 *

Average shank length of Rapid-feathering males and Slow-feathering males were more than females of the same group at 1% and 5% level respectively.

Differences between Rapid-feathering male and Slow-feathering male, and between Rapid-feathering female and Slow-feathering female, were non- significant

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Table No.38

Analysis of variance to estimate the difference at 6th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	7.58	2.52	2.37 **
Within group	506	536.90	1.06	
Total:	509	544.48		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.41	0.31	0.06
Rapid female vs. Slow female.	0.51	0.39	0.03
Rapid male vs. Rapid female	0.25	0.19	0.24 *
Slow male vs. Slow female	0.59	0.45	0.27

Rapid-feathering males had significantly more average shank length than females of the same group.

While the differences between Rapid males and Slow males, Rapid females and Slow females, and Slow male and Slow females were non-significant.

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Table No.39

Analysis of variance to estimate the difference at 8th. week

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	20.61	6.87	27.48 **
Within group	505	129.32	0.25	
Total	508	149.93		

	Critical difference. 1%	5%	Difference between averages
Rapid male vs Slow male.	0.19	0.15	0.16 *
Rapid female vs. Slow female	0.25	0.19	0.02
Rapid male vs. Rapid female.	0.12	0.09	0.36 **
Slow male vs. Slow female.	0.30	0.22	0.50

Average shank length of Slow-feathering male was significantly more than female.

Rapid-feathering males had significantly greater average shank length than females of the same group.

While differences between Rapid female and Slow-female, and Slow male and Slow female were non-significant.

Table No.40

Analysis of variance to estimate the difference at 10th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	37.42	12.47	18.3 **
Within group	503	343.30	0.68	
Total	506	380.72		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male .	0.41	0.31	0.20
Rapid female vs. Slow female.	0.51	0.39	0.13
Rapid male vs. Rapid female.	0.25	0.19	0.51 **
Slow male vs. Slow female.	0.59	0.45	0.58 *

Average shank length in Rapid males were more than females of the same group. The difference between the two averages was significant at 1% level of significance. While this difference was significant at only 5% level in Slow-feathering group.

Differences between Rapid males and Slow males, Rapid females and Slow females were non-significant.

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Table No.41

Analysis of variance to estimate the difference at 12th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	55.37	18.45	25.2 **
Within group	502	369.65	0.73	
Total:	505	425.02		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.33	0.25	0.56 **
Rapid female vs. Slow female.	0.43	0.33	0.14
Rapid-male vs. Rapid female.	0.20	0.15	0.49 **
Slow male vs. Slow female	0.51	0.39	0.91 **

Average shank length of Slow-feathering males was highly significantly more than Rapid-feathering males.

Male of both the groups had highly significantly greater average shank length than the females of the same group.

While the differences between the females of the two groups were non- significant.

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Table No.42

Analysis of variance to estimate the difference in the average total growth in length from the time of hatching up to 12 weeks of age.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	41.98	13.99	27.43 **
Within group	503	259.71	0.51	
Total:	506	301.69		

Critical difference.

	1%	5%	Difference between averages
Rapid male vs. Slow male.	0.28	0.21	0.40 **
Rapid female vs. Slow female.	0.36	0.27	0.06
Rapid male vs. Rapif female.	0.17	0.13	0.44 **
Slow male vs. Slow female.	0.42	0.32	0.90 **

Average total growth in length of the shank in the Slow males was highly significantly more than Rapid males.

This growth was more in the males of the two groups than the females of the corresponding groups.

Difference between Rapid female and Slow female was non-significant.

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Table No.43

Average Thigh Length.

Analysis of variance to estimate the difference in the hatch length.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.41	0.136	5.90 **
Within group	514	11.72	0.023	
Total:	517	12.13		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.05	0.04	0.09 **
Rapid female vs. Slow female.	0.23	0.18	0.05
Rapid male vs. Rapif female.	0.025	0.01	0.02 *
Slow male vs. Slow female	0.09	0.06	0.02

Average thigh length of Slow-feathering male was highly significantly more than the Rapid-feathering male.

Rapid-feathering males had significantly more average thigh length than females of the same group.

Differences in the averages between Rapid female and Slow female, Slow male and Slow female were non-significant.

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Table No.44

Analysis of variance to estimate the different at 2nd. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	0.50	0.166	6.15 **
Within group	342	9.32	0.027	
Total:	345	9.82		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male	0.07	0.05	0.12 **
Rapid female vs. Slow female.	0.10	0.07	0.05
Rapid male vs. Rapid female.	0.04	0.03	0
Slow male vs. Slow female.	0.11	0.08	0.07

Average length of thigh of Slow-feathering males was significantly more than Rapid-feathering males.

Differences between Rapid females and Slow females, Rapid males and Rapid females, and Slow males and Slow females were non-significant.

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Table No. 45

Analysis of variance to estimate the difference at 4th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	7.16	2.38	13.07 **
Within group	507	92.28	0.182	13.07
Total	510	99.44		

Critical difference.

	1%	5%	Differance between averages.
Rapid male vs. Slow male.	0.17	0.13	0.15 *
Rapid female vs. Slow female	0.21	0.16	0.11
Rapid male vs. Rapid female.	0.12	0.096	0.20 **
Slow male vs. Slow female.	0.25	0.19	0.24 *

Slow feathering male had significantly greater average thigh length than Rapid-feathering males.

Rapid males and Slow males had significantly greater average thigh length than females of the same group. The difference between the averages significant respectively at 1% and 5% level.

Difference between Rapid famel and Slow female non-significant.

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Table No. 46

Analysis of variance to estimate the difference at 6th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	9.55	3.18	9.63 **
Within group	506	169.23	0.33	
Total:	509	178.78		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.25	0.19	0.17
Rapid female vs. Slow female.	0.28	0.21	0.05
Rapid male vs. Rapid female.	0.14	0.10	0.23 **
Slow male vs. Slow female	0.34	0.25	0.35 **

Rapid-feathering males and Slow-feathering males had greater average thigh length than females of the same group. The differences between their averages were significant in both the cases at 1% level of significance.

Differences between Rapid male & Slow male, and Rapid female & Slow female were non-significant.

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Table No.47

Analysis of variance to estimate the different at 8th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	30.66	10.22	23.76**
Within group	505	217.98	0.43	
Total:	508	248.64		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male	0.26	0.20	0.20 *
Rapid female vs. Slow female.	0.32	0.25	0.01
Rapid male vs. Rapid female.	0.16	0.12	0.44 **
Slow male vs. Slow female.	0.39	0.29	0.65 **

Average length of thigh was significantly more in Slow-feathering male than Rapid-feathering male.

Males of both groups had greater average thigh length than the females of the same group. This difference was significant at 1% level of significance.

Difference between Rapid females and Slow females was non-significant.

Table No.48

Analysis of variance to estimate the difference at 10th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	58.61	19.536	19.4 **
Within group	503	505.99	1.005	
Total	506	564.60		

Critical difference.

	1%	5%	Difference between average.
Rapid male vs. Slow male.	0.40	0.30	0.25
Rapid female vs. Slow female.	0.51	0.39	0.10
Rapid male vs. Rapid female.	0.24	0.18	0.58 **
Slow male vs. Slow female.	0.60	0.45	0.73 **

Males of both the groups had greater average thigh length than the females of the same group. This difference was significant at 1% level of probability.

Differences between Rapid-feathering males & Slow-feathering males, and Rapid-feathering females & Slow-feathering females were non-significant.

Table No.49

Analysis of variance to estimate the difference at 12th. week.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	76.25	25.41	20.3**
Within group	502	628.32	1.25	
Total:	505	704.57		

Critical difference.

	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.45	0.34	0.77 **
Rapid female vs. Slow female	0.56	0.43	0.19
Rapid male vs. Rapid female.	0.27	0.21	0.51**
Slow male vs. Slow female.	0.66	0.50	1.09 **

Average thigh length of males of Rapid-feathering group was highly significant more than the males of the Slow-feathering group. Similary males of both groups had more average thigh length than the females of the same group

Difference between Rapid- feathering female and Slow-feathering female was non-significant.

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Table No.50

Analysis of variance to estimate the difference in the total growth in length from the time of hatching till 12 weeks of age.

Source of variation	D.F.	Sum of squares	M.S.	F.
Between group	3	59.71	19.90	19.32 **
Within group	503	521.04	1.03	
Total:	506	580.75		

	Critical difference.		
	1%	5%	Difference between averages.
Rapid male vs. Slow male.	0.40	0.31	0.45 **
Rapid female vs. Slow female.	0.50	0.38	0.06
Rapid male vs. Rapid female.	0.25	0.19	0.54 **
Slow male vs. Slow female.	0.60	0.45	1.05**

Average total growth in length of thigh was more in Slow-feathering males than Rapid-feathering males. The difference between the averages of the two groups was highly significant.

This growth in length was more in the males than the females of the same group. The differences between the averages in both the groups were significant at 1% level .

Differences between the females of the two groups were non-significant.

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C. Sex-ratio.

The sex-ratio in both the groups was estimated at 8 weeks of age.

Rapid-feathering group.		Slow-feathering group.	
Male.	Female .	Male.	Female.
48.2 %	51.8%	63.2%	36.8%

The S.Es. of their percentages were estimated to be 4.6 and 11.5 in Rapid-feathering and Slow-feathering groups respectively. In Slow-feathering group the percentage of male birds was significantly more than female. While in the Rapid-feathering group this difference was statistically non-significant.

D. Age at first lay.

(One batch)

(i) Rapid-feathering group 165 days.

(ii) Slow-feathering group 190 days.

(2nd. batch)

(i) Rapid_feathering group 170 days .

(ii)Slow-feathering group 192 days.

The age at first lay was more in the Slow-feathering group than Rapid-feathering group.

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E. Egg production.

In the Rapid-feathering group, on an average 30.2% of the pullets were in production daily, as compared to 36.6% in the Slow-feathering group.

The Standard Error of their percentages was estimated to be 2.8 . This difference in the level of production was statistically significant.

F. Study on correlations between pysical and physiological characters associated with egg production .

Co-efficients of correlation wer calculated between the following :

(1) Individual character's score and number of eggs laid within first forty days of production.

(2) Total score alloted to each bird and number of eggs laid within the period.

These estimates are presented below :

(i) Condition of comb.	r	=	0.54 ±	0.0734 **
(ii) Condition of vent.	r	=	0.44 ±	0.0836 **
(iii) Spread of pubic bones	r	=	0.61 ±	0.0651 **
(iv) Capacity	r	=	0.55 ±	0.0723 **
(v) Quality of pubic bones	r	=	0.24 ±	0.0977 *
(vi) Quality of abdomen	r	=	0.48 ±	0.0798 **
(vii) Quality of shank	r	=	0.66 ±	0.0585 **
(viii) Total score	r	=	0.81 ±	0.0356 **

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To determine the significance of correlation these values were compared with the values of correlation co-efficients for 5% and 1% level of significance furnished in the statistical table for Biological, Agricultural and Medical Research by Fisher and Yates(1957) at table No.7

Total scores were found to be highly correlated with egg production. Similarly, scores of all the characters except the quality of pubic bones were separately highly correlated with egg production. Scores alloted on the quality of pubic-bones were correlated at 5% level of significance.

On the basis of the classification of layers done in the table No.3, the following ranges of scores were determined for each class of layers. The percentage of birds lying within each range was as follows:

Categories of birds.	Ranges of scores	No.of eggs fixed for the class	Total no. of birds lying with the range.	No. of birds laying eggs within the range fixed for the class	Percentage.
1.Very good	Above 95	Above 25	x	x	x
2.Good	95 - 71	25 - 16	21	15	71.4%
3.Medium	70 - 41	15 - 6	46	32	69.5%
4.Poor	40 - 0	Less than 6	27	19	70.3%

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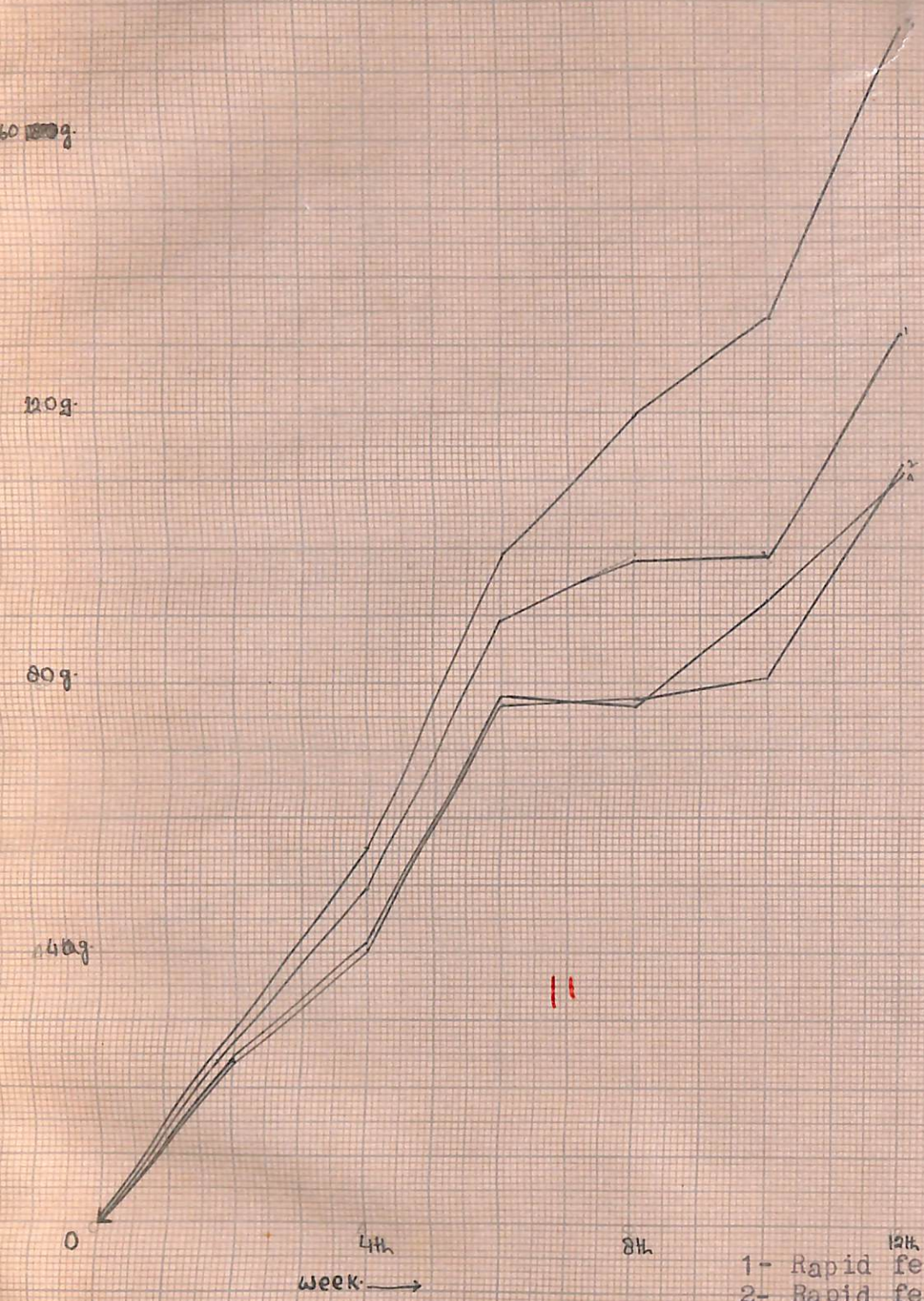
Graph showing the comparative growth rate.

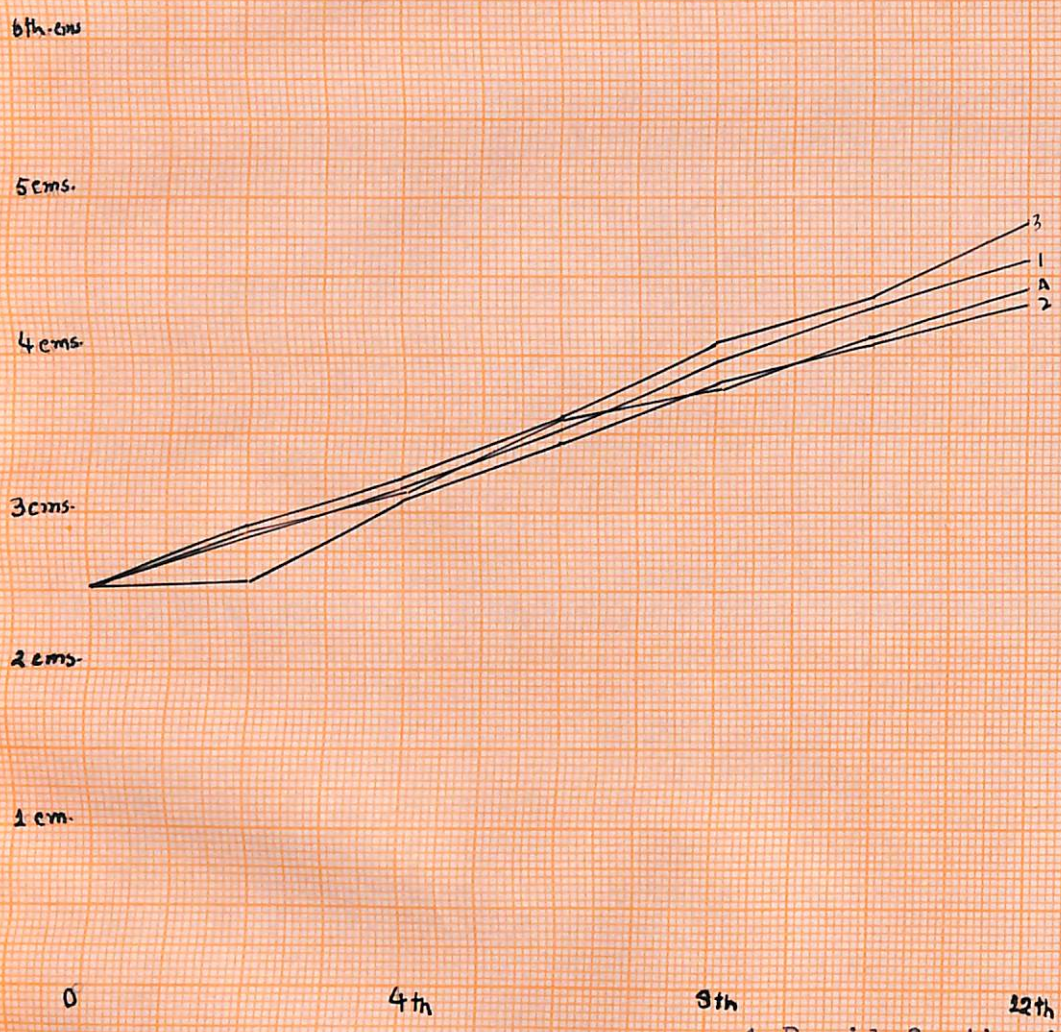


1- Rapid feathering male.
2- Rapid feathering female.
3- Slow feathering male.
4- Slow feathering female.

Graph showing the comparative growth rate.

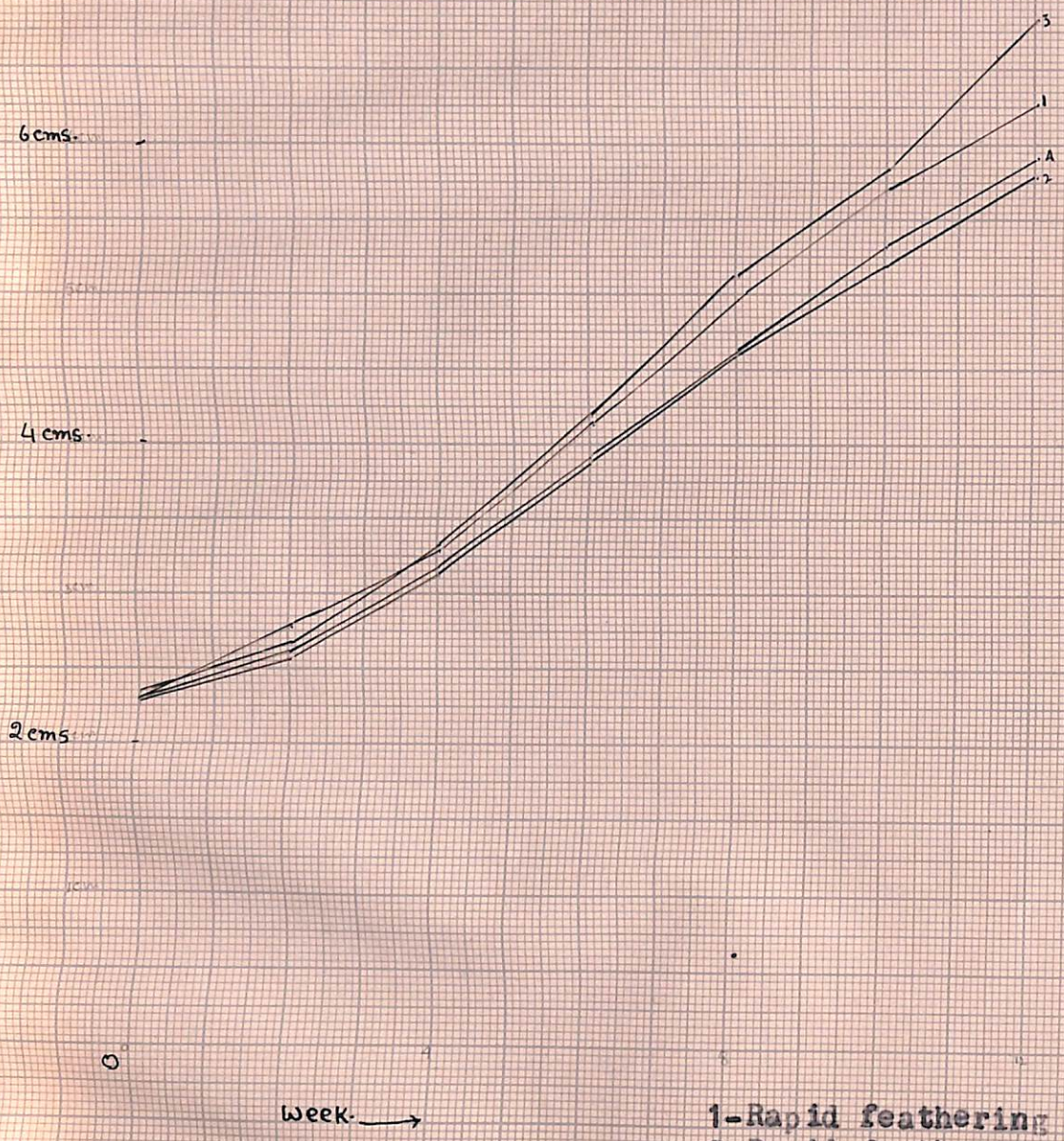
1- Rapid feathering male.
2- Rapid feathering female.
3- Slow feathering male.
4- Slow feathering female.

Graph showing the comparative growth in Head length.



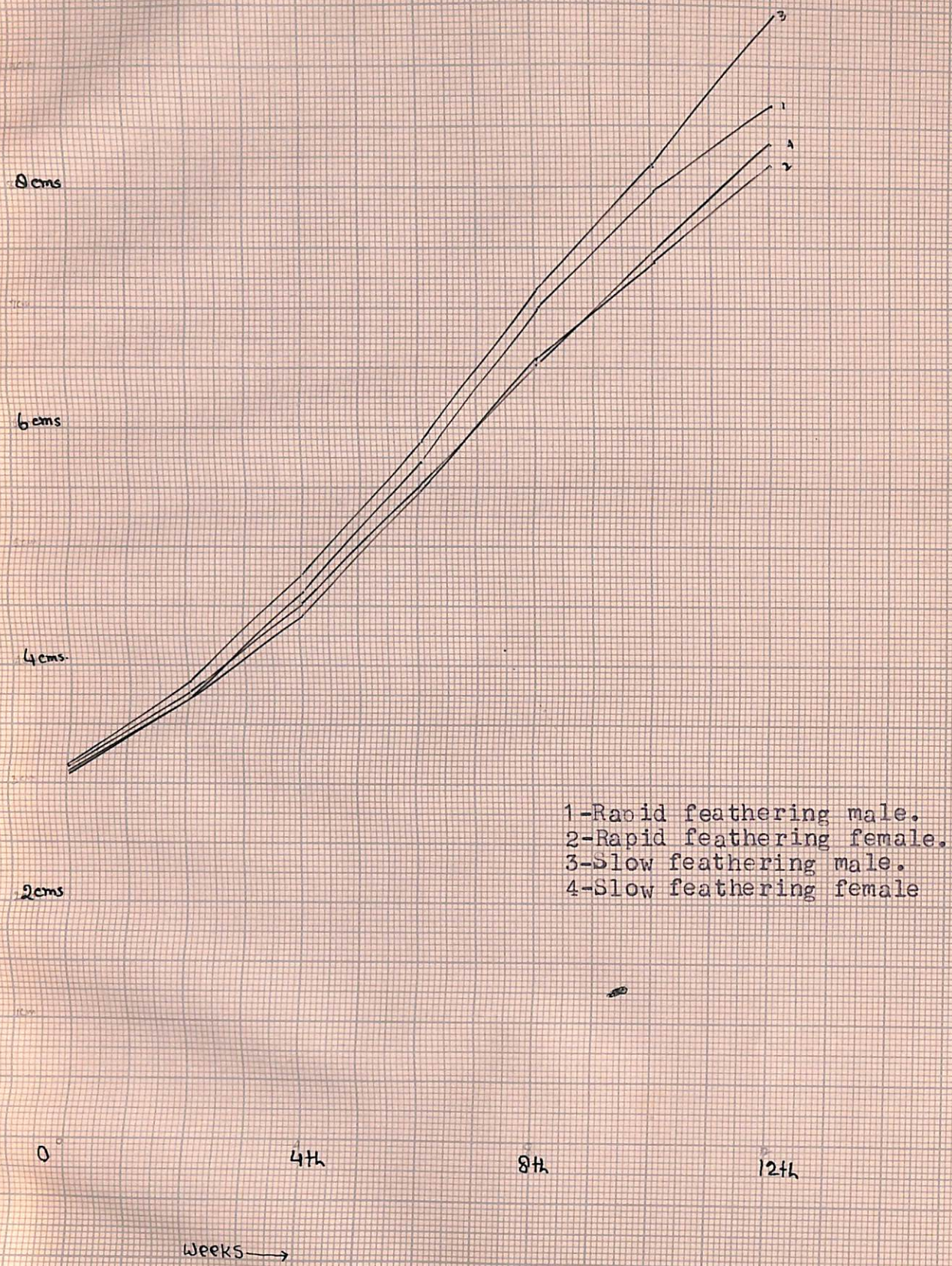
1-Rapid feathering male.
2-Rapid feathering female.
3-Slow feathering male.
4-Slow feathering female.

Graph showing the comparative growth in Shank length.

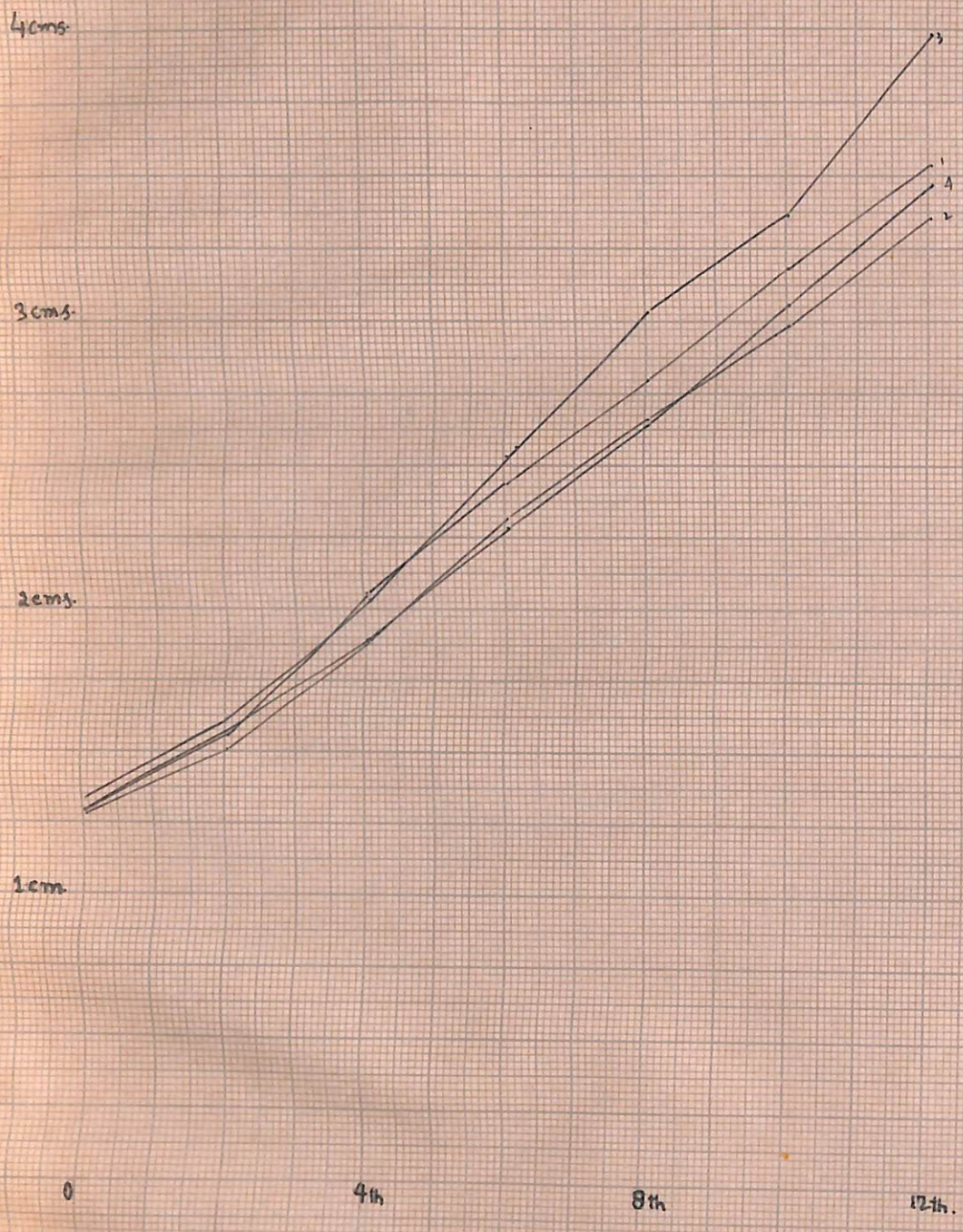


1-Rapid feathering male.
2-Rapid feathering female.
3-Slow feathering male.
4-Slow feathering female.

Graph showing the companative growth in Thigh length

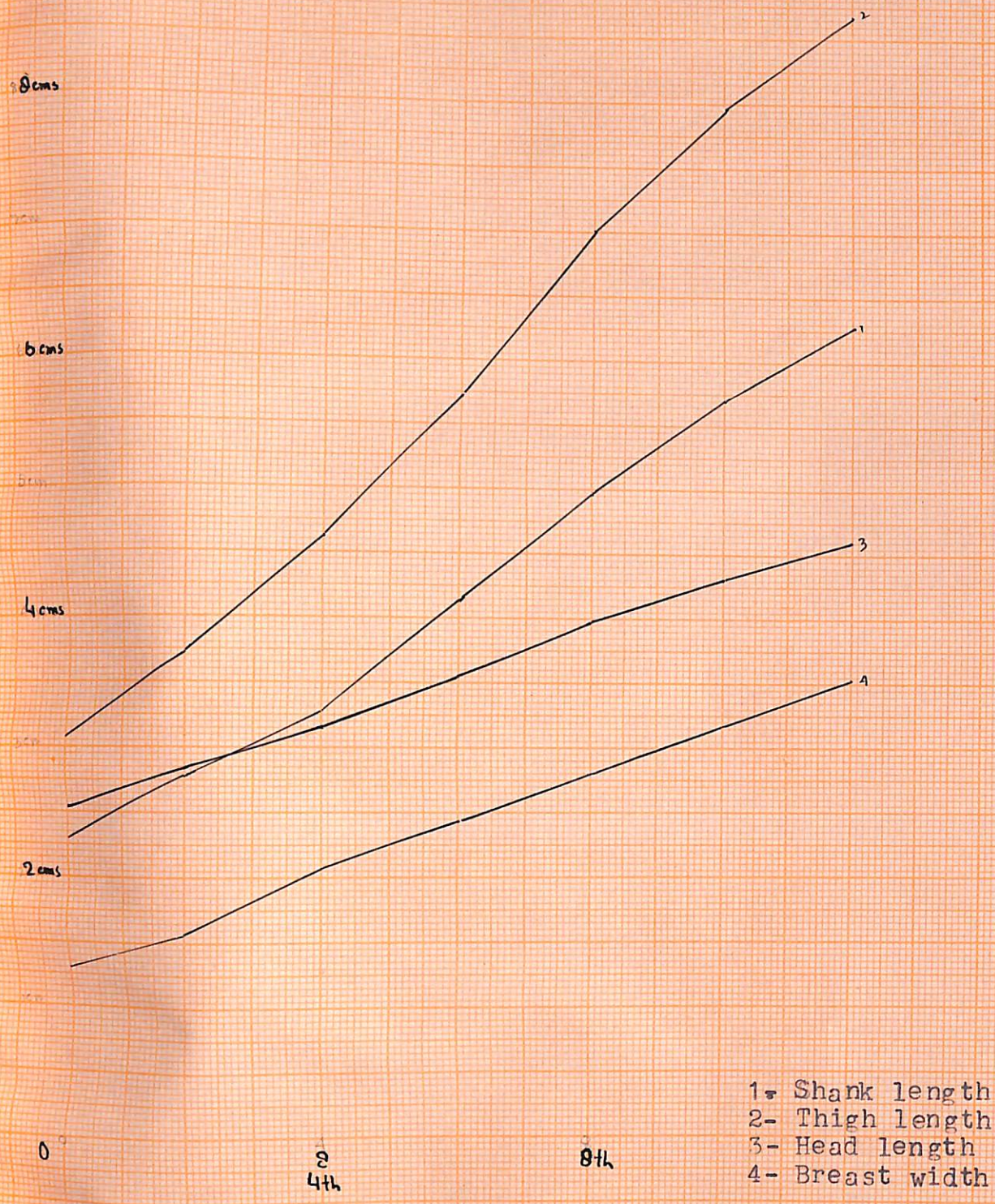


Graph showing the comparative growth in Breast width.



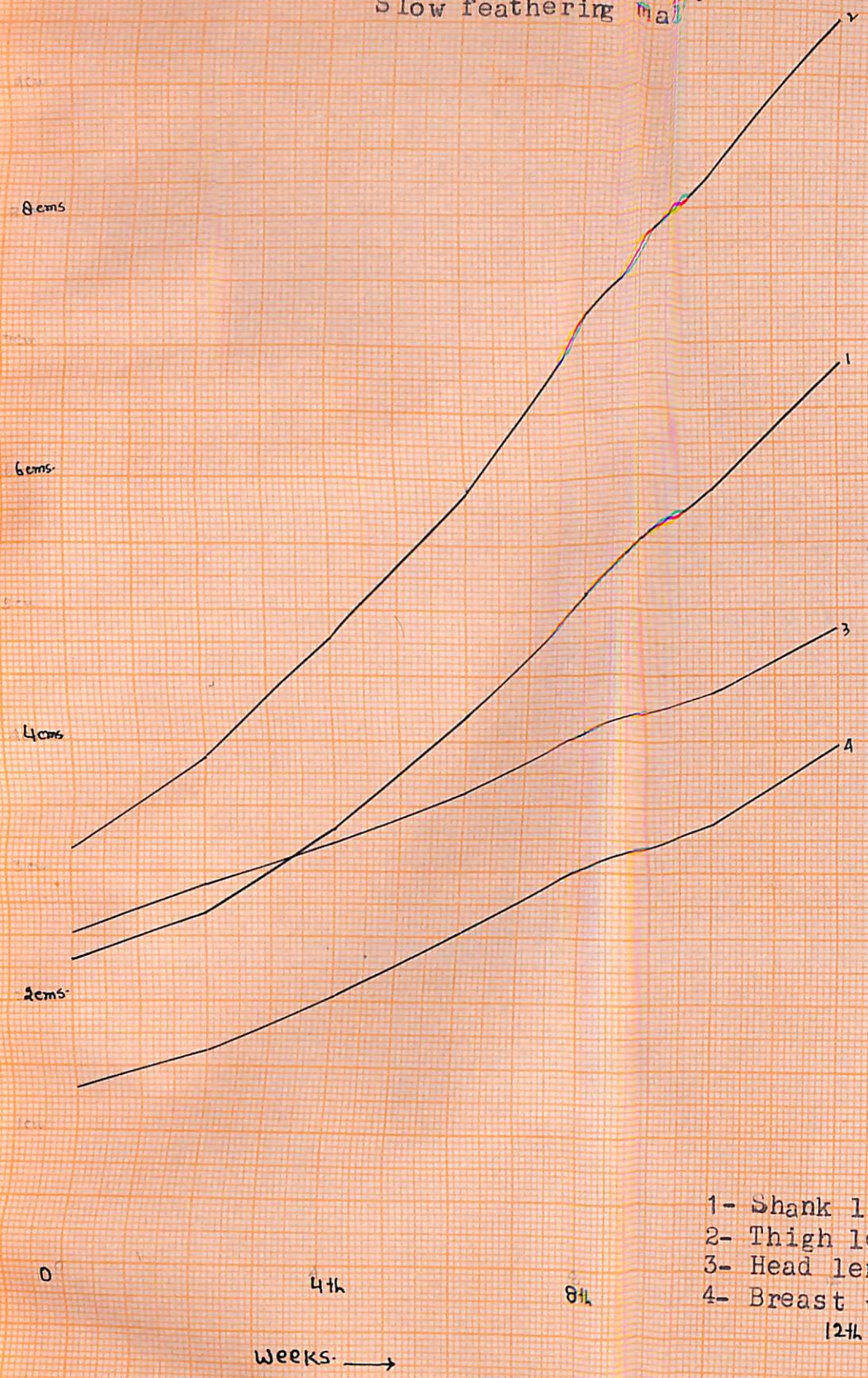
1-Rapid feathering male.
2-Rapid feathering female.
3-Slow feathering male.
4-Slow feathering female.

Graph showing the growth of different body parts of Rapid feathering male.



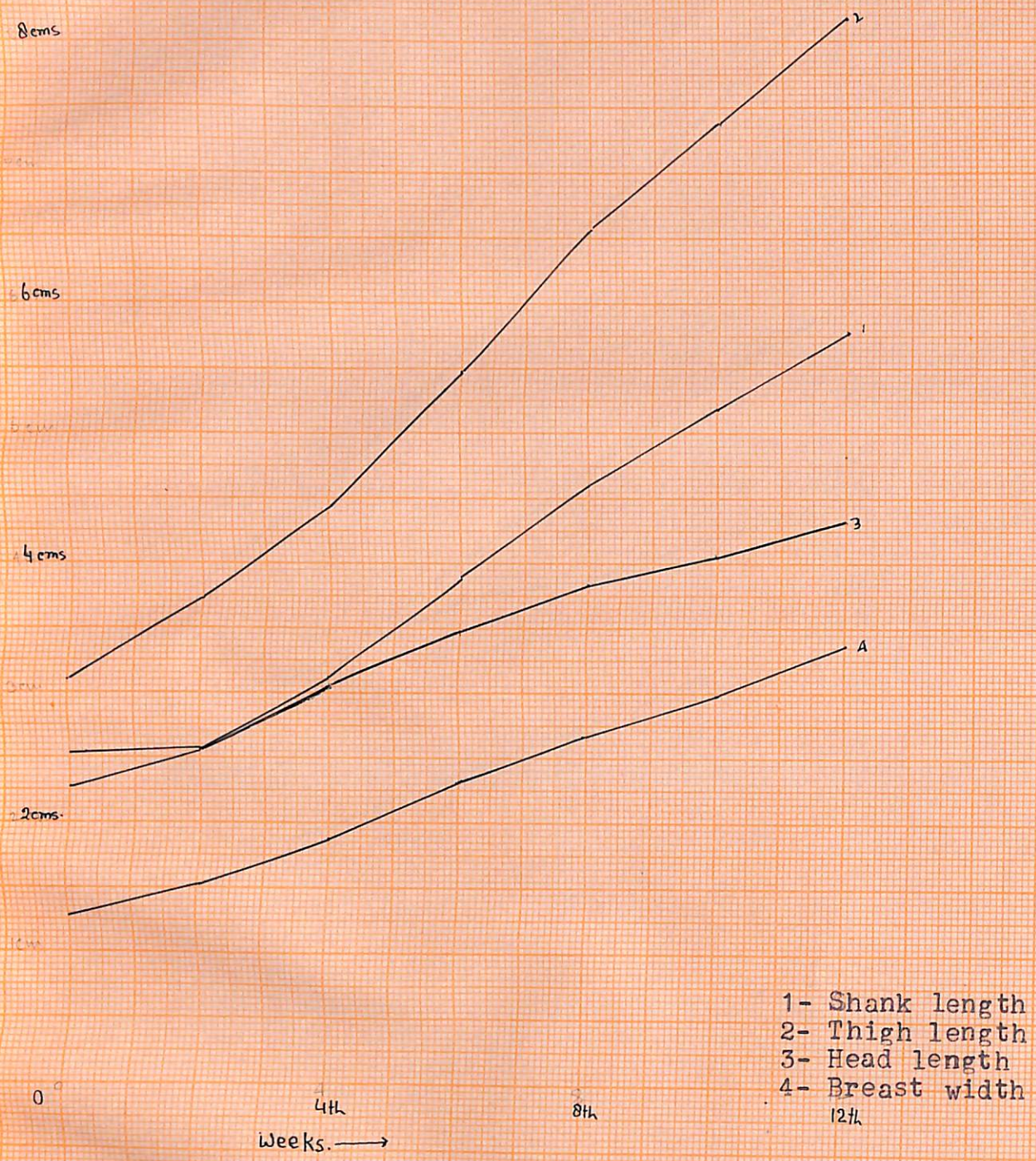
1- Shank length
2- Thigh length
3- Head length
4- Breast width

Graph showing the growth of different body parts of Slow feathering male.



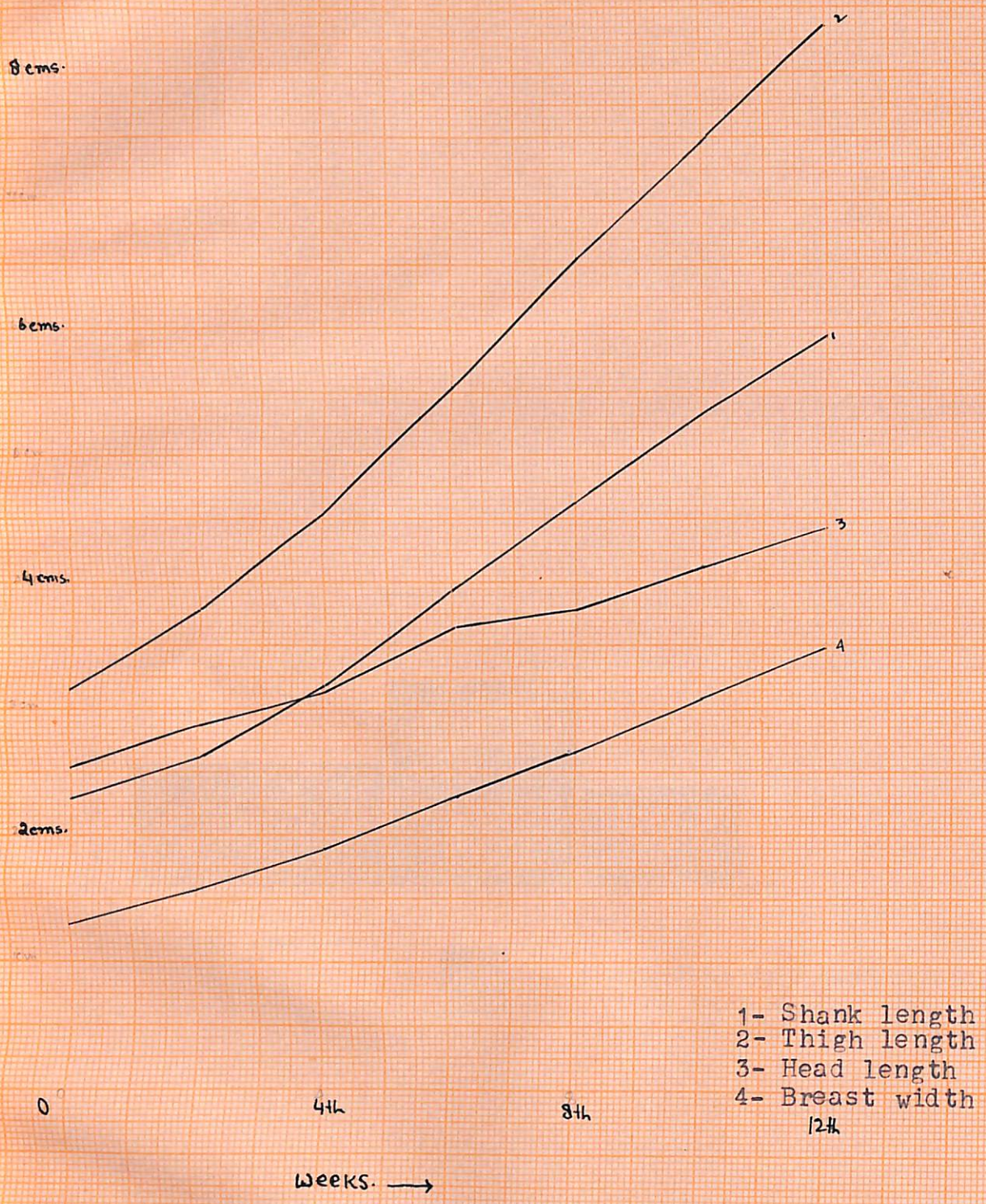
1- Shank length
2- Thigh length
3- Head length
4- Breast width

Graph showing the growth of different body parts of Rapid feathering female.



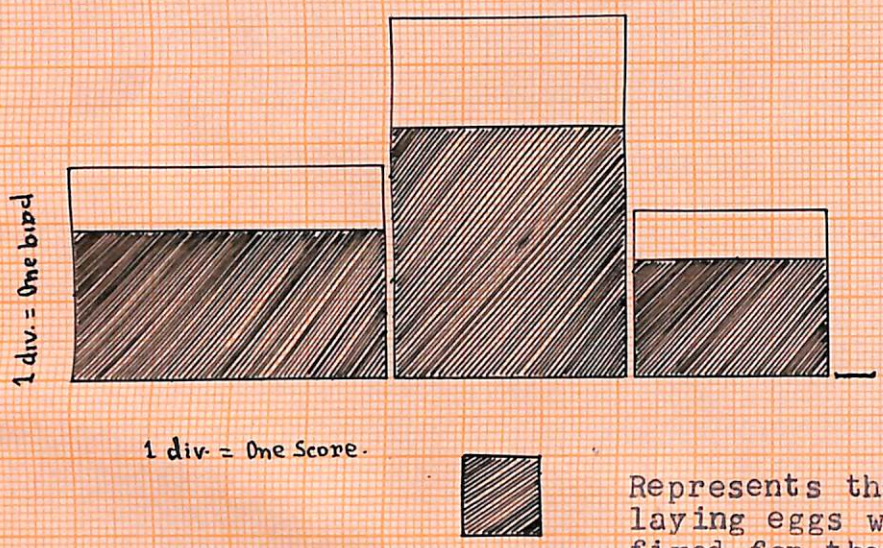
1- Shank length
2- Thigh length
3- Head length
4- Breast width

Graph showing the growth of different body parts of Slow feathering female.



1- Shank length
2- Thigh length
3- Head length
4- Breast width

Histogram showing the number of birds lying within each range fixed for the different classes of layers .



Represents the number of birds laying eggs within the range fixed for the different classes.

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CHAPTER V

DISCUSSION

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DISCUSSION.

Growth Rate

The average growth rate at biweekly intervals, and total growth from hatching to 12 weeks of age were significantly more in Slow-feathering than Rapid-feathering males (Table No.13,15, 16,17 and 18) except during (0-2) and (4-6) weeks periods (Table No.12,14), whereas the differences in the average growth rates between the females of the two groups were non-significant at all intervals. The average hatch weights of the males of Slow-feathering and Rapid-feathering groups were 39.84 ± 0.15 gms. and 40.04 ± 0.19 gms. respectively. But as the differences in their hatch weights were found statistically non-significant (Table No.11), it clearly reveals that the increased average growth rate of the Slow-feathering males is attributable to either the genetic differences between the groups or any other factors conducive to better growth in the males of Slow-feathering group operating after the hatching of the chicks. From the present results it may be inferred that the inherent difference for growth rate between the males of the two groups becomes apparent only after the 2nd week of age.

The non-significant difference in the growth rates during(4-6) week might be due to the physiological derrangement consequent upon the out break of respiratory diseases during that week.

The present finding is in partial agreement with the results obtained by Seridan and McDonald(1963) in the broiler chickens. They reported a significant relationship between body weight and feathering rate up to 10 weeks of age. They found that Slow-feathering birds tended to be heavier than Rapid-feathering at five weeks whereas at 10 weeks converse was applied. In the present study reason of more average body weight of Slow-feathering males even after 10th week (Table 17) might be due to their late hatch.

The result obtained in the present study also agrees to some extent with the finding of Hurry and Nordskog(1953) who reported that in New Hampshires the body weight in Rapid-feathering was slightly lower than in Slow-feathering in both sexes at 8 weeks.

Knize et al.(1963) found in the reciprocal crosses between white Plymouth Rock and White Cornish fowls that the correlations between 12 weeks body weight and feathering at 2 weeks ranged from -0.13 and +0.21 in both sexes. This shows the variability in the correlation between body weight and rate of feathering. The negative correlation is in the agreement with the result of present finding .

The result of the present study did not agree with those of Saeki and Katsuragi(1961), Warren and Payne(1945),

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Hurry and Nordskog(1953) in Barred Plymouth Rock, Glazener and Jull (1946) and Bernardini Battaglini(1956). These workers reported that the body weights of Rapid-feathering group were more than Slow-feathering group. This conversibility with the present finding may be explained by the fact that their results were based on the early hatched chickens of the pure breeds unlike the present one which was conducted on the cross-bred chikens of May hatch(Late hatch).

The following reasons may be put forth to explain the present results :-

(i) Slow-feathering gene may have stimulating effect on the growth rate. The highly significant difference between the males and non-significant difference between the females of the two groups lead to presume that gene K(Slow-feathering) has got stimulating effect only when in homozygous(KK) or heterozygous (Kk) conditions and not in the hemizygous(K-) conditions.

(ii) It seems more probable that the beneficial effect of Slow-feathering gene is accomplished by its action on the rate of feather development only and not on the genetic growth promoting factors. Slow-feathering birds are poorly feathered in comparison to Rapid-feathering birds at least up to 8 weeks of age at which there is no variation in feathering between the two types Hurry and Nordskog(1953). All the chicks of the

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present study were hatched during the summer season(May) during which the environmental temperature of this place rises considerably above 90°F. It has been reported by Heywang(1938), Lee et al(1945) that at an air temperature of 90° F there is a rise of 0.5 to 1.5°F in rectal temperature. Well developed feathers interfere with the dissipation of heat from the body. Therefore, it may be reasonably presumed that the heat taxation in the body of Rapid-feathering birds should be more than Slow-feathering birds with the consequent derrangement in the physiological functions. Moreover, it has been reported by Okamato et al(1961) that there is a highly significant negative correlation between environmental temperature and food consumption. This effect should be less pronounced in the less feathered Slow-feathering than Rapid-feathering birds. Therefore, increased growth rate may be due to comparatively more consumption of food by the Slow-feathering than Rapid-feathering birds.

Non-significant difference between the females of the two groups may be due to the variation in the degree of feathering between males and females of the two groups. Siegel et al.(1957) reported that in R.I.R. birds homozygous late(Slow) feathering male (KK) differed significantly in degree of feathering from the heterozygous(Kk) and hemizygous (k-) late(Slow) feathering chicks. Generally no significant

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differences were found between heterozygous late(Slow) feathering males and hemizygous late(Slow) feathering females. From this report it appears that the effect of Slow-feathering gene is more pronounced in males than females. This may be the reason why Slow-feathering males had highly significantly more average growth rate than the Rapid-feathering males, while the differences between the females of the two groups were statistically non-significant, although the average body weights of Slow-feathering females, 25.03 ± 1.8 g., 41.50 ± 3.8 g., 78.06 ± 7.2 g., 76.83 ± 9.5g. 92.33 ± 7.9 g. and 111.16 ± 10.8g. as compared to 24.00 ± 0.61, 40.40 ± 1.7, 70.07 ± 2.2 gms, 90.88 ± 2.7 g., 112. 31 ± 4.01 g. respectively of Rapid-feathering females at different intervals, suggested the tendency of Slow-feathering female to have more rate of growth than the Rapid-feathering females.

The relationship between the rate of feathering and growth rate is further evidenced by the fact that the Standard errors of means in the males of the Slow-feathering group were more than the Rapid-feathering males(Table5,7). This variability in the growth rate within the males of Slow-feathering group may be attributed to the differences in rate of feathering between homozygous(KK) and heterozygous(Kk) males and their consequent differences in the interaction with environmental temperature and food intake. This is in

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agreement with the report furnished by Hurry and Nordskog(1953) that in New Hampshires and B.P.R. the sex-linked genes had no influence on 8- wk. body weight in pullets while Slow-feathering Cockrels were significantly more variable in body weights at 8 wk. than Rapid-feathering cockrels . Good man and Muir(1965) also reported that in broiler chickens the Rapid-feathering birds were more uniform in body weight than Slow-feathering ones.

The effects of environmental temperature and rate of feathering seem more probable reason as Glazener and Jull(1946), Ram and Hutt(1956) reported the lack of genetic association between the genes for growth and feathering.

Head Length

No definite trend in the differance of average head length between Rapid-feathering males and Slow-feathering males could be drawn as the differences were significant at 8th. and 12th. weeks only(Table 23 and 25). But the total average growth from the time of hatching to 12 weeks of age was highly significantly more in the Slow-feathering than Rapid-feathering males(Table 26); This leads to infer that Slow-feathering gene exercises its influence on the growth of head in the males. At the same time comparatively small number of observations in the Slow-feathering group may also be a reason for this difference.

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Breast Width

Average breast widths of Slow-feathering males were significantly more than Rapid-feathering males at all biweekly intervals(Table No.27,28,30,31,32 and 33) except at 4th. week (Table 29). Here also the period at which the difference has been estimated to be non-significant synchronizes with the onset of respiratory disease.

Differences between the females of the two groups were non-significant in both the total increase (Table 34) and periodical increases (Table 27,29,30,31,32 and 33). However, at 2nd. week the difference was significant at 5% level for which no definite reason can be put forth.

A highly significant difference between the males of the two groups in the average total growth in width, however, suggests the action of this gene on the development of breast.

Shank Length.

There was no difference in the average length of the shank between the males of the two groups at hatch(Table 35). This is also expected, as there was no significant difference between the hatch weights, and this bone has been reported to be highly correlated with body weight (Lerner,1937). The

differences in the shank length were found significant at 2nd. week(Table 36,),8th wk.(Table 39), and 12th week(Table 41) . At 4th. wk.(Table 37), 6th. wk.(Table 38) and 10th wk. (Table 40) the differences between the groups were non-significant. These variable differences in the shank length at different intervals are not accountable with any valid reason. But the average total growth in length of the shank from the time of hatching to 12 weeks of age being more in the males of Slow-feathering group 4.39 ± 0.121 cms. than Rapid-feathering group 3.99 ± 0.051 cms.(Table 42) suggests the action of gene K on the shank development.

Non-significanee of difference between the females of two groups at various intervals (Table 36,37,38,39, 40, 41 and 42) may be accounted by the non-significant difference in their growth rates at these intervals.~~However, the difference was highly significant at 10th weeks (Table 40) which may be due to the reasons which cannot be accounted with valid conclusion.~~

Thigh Length.

No definite conclusion could be drawn regarding the trend of difference in the average thigh length between the males of the two groups. The non-significant differences at the 6th. week(Table 46) and 10th week(Table 48) suggested that the variations in this character were not

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more between the two groups. However, the average total growth in length from the time of hatching to 12 weeks of age, 6.07 ± 0.19 cms and 5.62 ± 0.071 cms.(Table 9,10) respectively in Slow-feathering and Rapid-feathering males (Jaylesu) admits the possibility of the action of Slow-feathering gene on the thigh length.

The difference in the average length of these parts may be due to the consistently more rate of growth in the Slow-feathering than Rapid-feathering males, since these organs are positively correlated with body weight. No condusive inference can be drawn as to the specific action of sex-linked genes on these parts, at the same time the possibility of Slow-feathering gene effecting increased growth cannot also be ruled out. Scientific literatures however, have been found to be silent over this point.

Sexual dimerphism in the physical characters.

(i) Growth Rate :-

The males in both the groups had significantly more average growth rate than females of the corresponding groups at all biweekly interval (Table 12,13,14,15,16,17,18).

The present finding is in close agreement with those of Jull(1923), Gilbreath and Upp(1952), Roberts(1964) and

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Bhatnagar et al.(1963). However, Kempter(1941) found that the sex-difference in the growth rate became apparent at 8 weeks and increased thereafter.

(ii) Average length of different body parts.

Invariably the average length of all the parts were significantly more in the males than the females of the same group at all bi-weekly intervals. The average total growth in length of all the parts characters from the day of hatch to 12 weeks of age were also more in male than female. This was more true for Rapid-feathering than Slow-feathering group. Because non-significant differences were observed in all the parts between the two sexes with in the Slow-feathering group at various intervals viz. between head length; at hatch (Table 19), 2nd week(Table 20), 4th week (Table 21). 6th week(Table 22) and 10th week(Table 24); between breast widths: at 2nd. week(Table 28) and 4th. week (Table 29); between shank lengths : at hatch(Table 35), 2nd. week(Table 36), 6th. week (Table 38), 8th. week(Table 39); and between thigh lengths: at hatch (Table 43) and 2nd week (Table 44). The difference in the sexual dimorphism between the two groups may be due to small number of observations in the Slow-feathering group.

It seems the differences between the two sexes is not caused by the action of male or female hormones, because

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a mature capon does not differ in skeletal dimension from normal male(Landaur,1937) and are usually heavier because they carry more fat. Similarly poulardes remain small in size, as do normal females. Obviously the male hormones do not normally stimulate or protract growth, nor do female hormones inhibit it. But as has been reported by Maw(1925), Warren(1930), and Knox and Olsen(1938) the differences in the size of the males and females are apparently determined by the sex-linked genes, of which the males, with two sex-chromosomes must have more than the females, which have only one sex-chromosome.

Sex - Ratio.

Tertiary sex-ratio in case of Rapid-feathering group was 48.2%, which was estimated to be not different from normal 50:50 . This result is in agreement with that of Godfre et al.(1955) who found in Gold-oklabars, Silver Okalbars and "Smocky" White Rock the tertiary sex-ratio to be 52.07% 51.74 and 52.25 %. respectively

The tertiary sex-ratio in Slow-feathering group was 63.2%. This difference between the percentages of the two sexes was calculated to be significantly different, and not conforming to the normal 50:50. The following reasons may be put forth to account for this difference.

In case thof Poultry the female is heterogametic(ZW)

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and the male is homogametic(ZZ) sex. Therefore, if the mating takes place between Slow-feathering male and Rapid-feathering female , all the males and females progeny will be Slow-feathering when the male is homozygous(ZKZK), and half of the males will be Slow-feathering and half will be Rapid-feathering when the male is heterozygous(ZKZk). Similarly, if the mating takes place between Slow-feathering female(ZK-) and Rapid-feathering male, all the males will be Slow-feathering. It is clear, therefore, that Slow-feathering males are likely to be produced in both types of matings, whereas the Slow-feathering females in only one type of mating. Therefore, in any randomly breeding population the incidence of Slow-feathering males is likely to be more than female.

This is the reason why in the present study the percentage of male was more than female.

Age at first Egg.

In the present study age at first egg in the Rapid-feathering and Slow-feathering group was found to be 165 and 190 days in one batch, and 170 and 192 days in another batch respectively. The early maturity in case of Rapid-feathering group seems to be due to the action of Rapid-feathering gene,on the genes responsible for early sexual maturity, as Hays(1924) and Waters (1934) suggested that at least one gene responsible for this character was located on sex-chromosomes.

This result is in agreement with that of Kawahara

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(1965) who reported that a gene located on the sex-chromosome, possibly the k(Rapid-feathering) allele, could be responsible for early sexual maturity. But Cooper(1941) has denied such effect.

Egg production.

In the egg production study it was estimated that in the Rapid-feathering group, on an average, 30.2% birds were in production daily, whereas in the Slow-feathering group 36.6%. This difference in the level of production was calculated to be satistically significant.

The possible reason to account for this difference may be the action of Slow-feathering gene on egg-producing factors, as Nissel(1941) concluded that there was strong evidence of sex-linked inheritance of laying capacity as opposed to autosomal influences. While Cooper(1941) on the basis of his finding in Black Astralorp furnished the report that Slow-feathering and Rapid-feathering do not have influence on the production ability. Hale(1954) reported that there was no effect of rate of feathering on adult performance. It is also probable that this difference in the level of production may be due to the small sample in the present study, which warrants further research on large number of birds to arrive at conclusive inference .

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From the perusal of over all results, it appears that the sex-linked genes under study, have got pleiotropic action. This is in agreement with the views expressed by Saeki and Katsuragi(1961), and Siegel (1963) .

It may be concluded that although the Slow-feathering birds proved better in some respects under the condition in which the study was conducted, the delayed sexual maturity disqualify it as a type of choice. Therefore, to use it for the day old sexing may be detrimental to the farm economy. However, increased growth rate in Slow-feathering birds tempts one to advocate it for broiler industry if the hatches are to come out in the month of February, March and April. Although it requires further consideration to decide whether the growth was economic or not.

Correlation of Physical and Physiological characters associated with egg production

Various workers have studied the correlations of the characters studied under this heading with egg production. Among such workers names of the following may be quoted: Asmundson (1920), Sherwood(1922), Hewey and Lewis(1923), Scholten(1927), Borgioli(1933), Knox(1924), Waynemiller et al.(1933), Knox et al. (1936), and Grosmane(1951) . Their studies were based on the lenear measurements of these characters unlike the present one which was conducted by scoring method. However, these

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findings reveal the importance of these characters for the evaluation of the laying capacity of a bird.

Knox(1933), Miller et al.(1934) and Jull et al.(1934) could not find correlation between abdominal span and egg production in the weeks following the date of measurements.

In the present study the correlation co-efficients between the number of eggs laid within first forty days and scores alloted on the condition of comb, condition of vent, spread of pubic bones, capacity, quality of pubic bones, quality of abdomen and quality of shank were calculated to be 0.54 ± 0.0734 , 0.44 ± 0.0836, 0.61 ± 0.0651, 0.55 ± 0.0723 , 0.24 ± 0.0977, 0.48 ± 0.0798, 0.66 ± 0.0585, 0.61 ± 0.0356 respectively. But the correlation co-efficient between number of eggs and total score was 0,81 ± 0.0356 . This shows the superiority of the total score over the single characters score. It is clear, therefore, that thes selections made on the basis of total score would be comparatively more reliable and effective .

The result of the present study is in close agreement with that of Shrivastava and Bose(under publication) except that they found shank quality to be non-correlated with egg production. The reason may be that their study was based on the pure breeds viz. Rhode Island Red and White Leghorn unlike the present one which was conducted on cross-

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bred chickens.

Bogoljubskii(1963) also reported that the estimated production based on selection by visual appraisal of abdomen volume, comb size, conformation and number of moulting feathers was correlated with actual production, the correlations being 0.82 for hens and 0.46 for pullets. The present result is also in agreement with this report. The lower correlation co-efficient in the pullets reported by him may be due to small numbers of characters taken into consideration. While in the present study the cumulative effect of seven characters associated with intensity of laying were taken into consideration.

As reported by Shrivastava and Bose that there was a high correlation between actual annual egg production and estimated production among the birds selected by this score-card, the present investigation has revealed that it is possible to select good-layers with the help of this score-card after 40 days of laying only, because the scores have been found to be highly co-rrelated with egg production on this age.

On the basis of the classification of layers done in table No.3 the following ranges of scores were determined for each class of layers: For very good, above 95; good, 95 to 71; medium 70 to 41; and for poor, 40 to 0. It was observed that among the birds laying 16 to 25 eggs(Good layers) 71.4% were lying within this range. Similarly, for the medium and

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poor classes these figures were 69.5% and 70.3% respectively. Unfortunately no bird scored above 95 marks as also no one laid more than 25 eggs. Since the present study was conducted on forty days production only it was thought reasonable to give a high score to layers classed as "very good", because relaxation in any of the characters at this stage may not conform to the estimated annual egg production.

As it is possible by this scoring method to spot out promising birds in early life with single observation, it may be recommended that private breeders as well as the workers in the government farms may use this method on cross-bred birds of R.I.R. and W.L. breeds for the early culling of unproductive birds and for selecting the better ones for profitable industry.

However, similar studies on still larger number of birds will enable to arrive at a more accurate estimate of co-rrelation co-efficient, therefore further studies on the problem would be worthwhile.

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CHAPTER VI

SUMMARY

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SUMMARY.

With a view to study the effect of Slow-feathering and Rapid-feathering on some of the economic and physical characters; and to evolve a score-card for the early evaluation of laying capacity of cross-bred chickens of R.I.R. and W.L. breeds; the present investigation was undertaken.

The data for the present study were collected at the Central Poultry Farm, Patna ~~for~~ from the cross-bred chickens hatched during the month of May. The study was started on altogether 660 chicks of Rapid-feathering type and 114 chicks of Slow-feathering type. Both the groups were maintained under the same environmental conditions including feeding and managements. The analysis was made on the records of those individuals only that survived whole of the experimental period with wing-bands intact. For the comparison between the two groups the physical and economic characters undertaken for study were : Growth rate, breast width, head length, shank length, thigh length, sex-ratio, age at first egg and egg production of first 30 days during the month, November-December.

Body weight(in gms.) and length of each body part (in cms.) were taken on the day of hatch and at each bi-weekly intervals thereafter upto 12 weeks of age. The comparison in the

average growth rate and body measurements were made at each bi-weekly interval. The average total growth in body weight and length of each body part from the day of hatch to 12 weeks of age were also compared between the following groups :

(I) between the males of the two groups.

(II) between the females of the two groups.

(III) between the two sexes within the same group for both Rapid-feathering and Slow-feathering.

For the evaluation of the laying capacity of a bird, 94 pullets of the same hatch on attaining the maturity were transferred from the deep litter pen to laying cages for individual recording of eggs. No artificial light was provided during the night. The egg production of the first forty days was recorded. On 41st. day different physical and physiological conditions of the body were examined and separate marks were alloted on the condition of each character. Finally all were summed up to give a single score for each bird. Correlation co-efficients were calculated between each character score and total score of the bird with the number of eggs laid within the period. Scoring of the bird was done on the basis of the following score-card:

Character	Max. Marks allotted	Conditions observed.	Symbol	Marks scored on conditions
1. Condition of comb.	10	1. Normal turgid and red	NR	10
		2. Normal turgid and dull	ND	5

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Character	Max.Marks allotted	Conditions observed.	Symbol	Marks scored on conditions
		3.Shrunken & dull	SD	0
2. Condition of vent	10	1.Moist & oval	MO	10
		2.Moist & Round	MR	5
		3.Dry & Round	DR	0
3. Spread of pubic bones	10	1.Distance above 2 fingures or 3.3 cms.		10
		2.Distance between 2 - 1½ fingures or 2.4 cms.to 33. 3.3 cms.		5
		3.Distance less than 1½ fingures or 2.4 cms.		0
4.Measure of capacity	40	1.Above 4 fingures or 6.6 cms.		40
		2.Between 3½ to 4 fingures or 5.7 cms. to 6.6 cms.		30
		3.Between 3 to 3½ fingures or 4.9 to 5.7 cms.		20
		4.Below 3 fingures or 4.9 cms.		0
5.Quality of pubic bones	10	1.Soft	S	10
		2.Hard	H	0
6.Quality of abdomen	10	1.Pliable	P	10
		2.Non-pliable	NP	0
7.Quality of shank	10	1.Flat	F	10
		2.Round	R	0

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RESULT

Growth rate and length of different body parts .

It was found in this study that the Slow-feathering males had significantly more average growth rate than Rapid-feathering males, where as the difference between the females of the two groups were non-significant. Similarly, the average length of all the body parts in the Slow-feathering males were more than Rapid-feathering males, while between the females of the two groups these differences were non-significant. Variation in the rate of feathering between the Slow-feathering and Rapid-feathering, and between homozygous(KK), heterozygous (Kk) and hemizygous(K-) birds within Slow-feathering group were considered to be the most probable reason leading to the significant difference between the males and non-significant difference between the females of the two groups.

Males in both the group had significantly more average growth rate and length of all body parts than the females of the same group. Differences in the number of sex-chromosome between male and female ~~was~~ suggested to be the reason for sexual dimorphism.

Sex-Ratio

Tertiary sex-ratios in the Rapid-feathering and Slow-

feathering groups were 48.2% and 63.2% respectively. The difference in the sex ratio was not significant in Rapid-feathering group while in the Slow-feathering there was significant deviation from normal 50:50. This difference in the sex-ratio might be due to the inheritance pattern of sex-linked genes.

Age at first lay.

Age at first lay in the two batches of Rapid-feathering pullets were 165 and 170 days as compared to 170 and 192 days in the Slow-feathering group. The influence of gene k(Rapid-feathering) was considered to be the reason for early maturity.

Egg production

In the egg production study it was observed that in the Rapid-feathering group 30.2% birds were in production daily, whereas in Slow-feathering group it was 36.6%. Small sample was considered to be one of the reasons for this difference.

Correlations of physical and Physiological characters with egg production.

In the correlation study it was found that total score and individual character's scores were highly correlated with 40 days production the co-efficients of correlations being

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0.54 ± 0.0734, 0.44 ± 0.0836, 0.61 ± 0.0651, 0.55 ± 0.0723, 0.24 ± 0.0977, 0.48 ± 0.798, 0.66 ± 0.0585, for condition of comb, condition of vent, spread of pubic bones, capacity, quality of pubic bones, quality of abdomen, quality of shank respectively. The correlation co-efficient between the total score and number of eggs laid within the period was 0.81 ± 0.0356 .

The review of literature suggested that there was a high correlation between the annual egg production and estimated production of birds selected by this score card. The present investigation revealed that since total score had high positive correlation with the number of eggs laid within first forty days, it is possible to select good layers after forty days of production only.

Ranges of scores were also determined to categorise the layers in each of the four classes: Very good, good, medium and poor layers. Ranges of scores alloted for each class were 0-40, 41-70, 71-95, 96-100 respectively for poor, medium, good and very good layers.

It was suggested that general breeders may use this method for the selection of good layers.

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