PATTERN OF GROWTH
IN
DOMESTIC FOWL

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DECLARATION

I, hereby declare that this thesis entitled "PATTERN OF GROWTH IN DOMESTIC FOWL" is a bonafide record of research work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Jacob Thomas

MANNUTHY, (JACOB THOMAS,M.)

31st July, 1981.

CERTIFICATE

Certified that this thesis entitled "PATTERN OF GROWTH IN DOMESTIC FOWL" is a record of research work done independantly by Sri.Jacob Thomas, M., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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(JACOB THOMAS, M)

INTRODUCTION

INTRODUCTION

It is well known to any right thinking person that the world food situation is one of continuing importance and continuing difficulty. Don Paarlberg (1975), Director of Agricultural Economics, US Department of Agriculture said: "It is extremely important that we devote continuing attention to this important and difficult subject".

According to William Jasper(1975), President, World poultry science Association, about one-fifth of the people in the world are well fed, while about four-fifth are poorly fed. Experts on population studies have predicted that the World population may shoot up to 6.2 billions by 2000 A.D., (Indian Poultry Industry year book, 1976) and this may be due mainly to population explosion in South East Asia, Africa and Latin American countries. It is common knowledge that these areas are limping far behind the goal of self reliance in food production. Expert opinion is that long term shortage of food may lead to energy crisis.

Eminent agriculturists and planners have conceded that a partial solution for this crisis is to improve present technology in agricultural and animal production. (Indian Poultry Industry year book, 1976) The developing countries have about 62 percent of domestic livestock and fowl. But they produce only about 26 percent of world supply of meat, milk and eggs. Animal food can help to solve the problem of food shortage. These foods supply quality nutrients needed for human diets. The faster the animals and birds grow the more will be the output of food from them for the human population. Interest was, therefore, evinced in the growth of fowls and animals even from olden times.

The development of poultry farming in India as a large scale commercial enterprise took place only during the past two decades. But the poultry were known to Indians 5000 years ago. Egyptians and Chinese had developed their own breed. The original red jungle fowl and silver jungle fowl from which many contemperary breeds have been developed in Western Countries, originated in India(Reddy,1981). Development of poultry in the country as a whole received a new life after independence.

In India poultry have shown increase in their numbers in the past. Their number was 115 million in

1940. This was 440 millions in 1961 and it rose to 549 millions in 1971. A much more significant increase in their numbers was found in the next decade. In 1980, the number of poultry in India was estimated at 600 millions. Many factors contributed to their increase in numbers during the successive decades. Control of diseases, introduction of profitable breeds, development of scientific management etc., were some of them. One remarkable feature of the poultry population during the last four decades was that the layer population increased considerably. It rose to 90 millions in 1980 against 54 millions in 1971 and 35 millions in 1961. This increase had its impact on egg production. The estimated annual production of eggs in 1980 was 13000 millions. It was only 2340 millions in 1961, and 5340 millions in 1971.

There was marked improvement in the value of poultry production also. In 1980, it was estimated at Rs.6,400 millions. This was Rs.76 millions in 1940, Rs.650 millions in 1961 and Rs.1,755 millions in 1971. During the same period there was improvement in the ratio of Desi to improved varieties. It rose to 33:57 in 1980 from 35:18 in 1971 and 33:2 in 1961. The per capita consumption of eggs per year increased from 5.3 in 1961, and 9.8 in 1971 to 19 in 1980. It is to be remembered that this rise in the percapita consumption was achieved inspite of the increase of the human population from 400 millions in 1940 to an estimated population of 680 millions in 1980. It is evident that the increase in poultry numbers was proportionately more than the increase in human population. This along with the qualitative improvement helped the present situation to prevail.

Poultry are extremely important to Kerala. In a survey in the Trichur Taluk (Surendran and Pushkaran, 1977) it was found that 63.18% households had poultry. A large percentage of the rural population had stake in poultry keeping. Their objectives are to derive supplimentary income and also to get quality products. According to 1966 census, Kerala had a poultry population of 9.9 million which was 8.62 percent of total poultry population in the country. Since then the population increased; it was 12.2 millions in 1972 and 12.96 millions in 1977 (Bulletin of Animal Husbandary Statistics, 1977).

A recent survey (Nambiar,1981) indicated that about 55 percent of the poultry population of the state are improved varieties and almost 50 percent of households in Kerala have taken poultry farming as a sideline.

According to another study conducted by ICAR, the egg production in the state in 1975 went up by 100 percent in comparison with the production during 1961. i.e. from 464 millions to 880 millions. It is expected that during 1980, it has touched the 1200 million mark. The egg production at the national level went up only by 43 percent during the last 7 years.

The National commission on Agriculture(N.C.A.) projected estimates for eggs showed that in the urban areas the egg production was considerable (Reddy,1981). The projection in 1971 for urban production was 1,932 million and it was estimated that it will reach 15900 millions by 2000 A.D. The corresponding projection for rural areas was 4,108 millions and 12,600 millions respectively. In the case of poultry meat the annual production in 1971 was 89000 million tonnes and it was estimated that by 2000 A.D., it will surpass 3,00,000 millions tonnes. In Kerala the bulk of egg production is from rural areas and 12 crores of eggs are exported from Kerala to neighbouring states. The turn over in this respect is estimated at 2 crores of rupees per year.

Poultry meat is becoming increasingly popular as beef and pork being taboo for a particular segment of Indian population. Annually about 39.4 millions animals including poultry are slaughtered to meet the demand for meat protein in India. These animals provide around 0.66 million tonnes of meat; of this poultry meat contributes to approximately 0.08 million tonnes, i.e. about 13 percent of total meat produced (Lachhiramani, 1979). Inspite of the production of such a huge quantity of meat and meat products, per-capita consumption of animal protein, including fish according to 1969-70 census was 71.5g. in USA, 68.2g. in Australia, 53.4g in UK(1970-71 census), 64g in France, 34.6g. in spain and 30.8g. in Japan (Lister *et al*.,1976).

The increased interest in the poultry meat production has resulted in a interest in the broiler breeds. The broilers have unique fleshing qualities. Those which grow faster are preferred to others. That is, the choice of breeds depends on growth rate. In birds for egg production too the growth rate is important. It can be used for selection of birds for breeding. Faster growing birds would give more number of eggs than others (Gilbreath and Upp, 1950).

The usual measure of growth that we employ to study the pattern of growth is the body weight. The collection and analysis of basic growth information on the fowls has followed various pattern in recent years. An elementary study or normal growth progression for the domestic fowl was reported by Kempster(1941). He found that body weight is the sole satisfactory measure for studying growth. In another study Baker (1944) reported that the body weight is used as a single measure, because it is convenient to obtain. It permits further use of bird. It shows normally a steady increase from hatching until maturity. Although body size and growth rate inheritance have been extensively studied, very little information is available on the growth, adult body size and their statistical analysis (Godfrey,1950).

The study of pattern of growth offers an opportunity to examine growth rate at the micro level. The Encyclopedia Britanica defines growth as a sequence of body changes which an animal or plant undergoes during the life time. The term may be used to encompass both anatomical and physiological development. A fowl's physical growth refers only to anatomical as well as physiological modification that an organism undergoes from the beginning of prenatal life (from the time of fertilization). There are changes due to age, size, shape, position and composition of body parts.

Growth probably is analysed most in its biological connotation i.e. growth is a characteristic of living things, the results of numerous metabolic processes at work, continuously during life. Growth of population involves replication of individual, which involves replication of cells. Growth of cells involves replication of molecules and replication of molecules involves mobilization of precursors. What grows and how it grows is different at each level and yet all are involved in the over all phenomenon.

Organism grows differently at different time points under different feeds, climatic conditions environment etc. When size is plotted against time a curve of growth(growth curve) is obtained. Growth curve is a graphical representation of the growth of an organism or population during a sequence of similar length periods. Thus the rate and duration of growth is a part of heriditary endowment of the organism. But the regularity and relative simplicity of overall growth curves give way to an astonishing complexity when growth patterns are examined. Each bird has its own growth curve and no two seem to behave in exactly the same way, though there may not be significant difference between them. In certain cases certain birds may even be decreasing in size "de growing" while overall growth continues. Clearly regularity of overall growth is the resultant of the growth of individual parts probably at different rates.

Frequently growth of a bird can be expressed as a relatively simple mathematical function. Such mathematical relations have attracted the interests of many students of growth. Interest is fed by some spectacular correspondence between results of purely mathematical transformation of growth rates, and actual changes undergone by organism during development. The mathematical approach to growth, however can yield an encompassing function that captures the full subtlety and variety of organismal growth.

Growth curves vary in detail from bird to bird but they resemble each other in their approach to a sigmoid. This kind of curve indicates that growth of individuals begins slowly and reach a sustained maximum and then retard. The level of sustained growth rate, and the period over which it is sustained are the chief variables correlating with differences in size among living organism. But the changes in rate at the beginning and end of the curve seem to indicate that size attained is itself a regulator of growth, that is, growth is in some measure self regulating. The organisms behave as though it were at first too small for maximum growth, it slowly achieves optimum size, but then very consequences of rapid growth act to limit it.

A study of pattern of growth relates the growth parameter to an appropriate mathematical function such as, Exponential, Modified exponential, Pareto, Gompertz, Logistic or even a straight line. A mathematical function is always determined in terms of certain constants which we conveniently call the parameters. When the organism grows identically these parameters will be equal. The functional approach therefore offers a very stark logical procedure for comparing the growth rates of different groups of birds, the difference being either due to genetical factors or due to induced treatments. The functional form further offers the golden opportunity of examining the rate of growth at a particular point of time in the life of the organism. Evidently such an approach is very much called for in relation to domestic fowls.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature abounds with the study of growth mainly in cattle, sheep, pigs, goats and poultry. Comparitively less work was done on this aspect in domestic fowls, such as White Leghorns, Australorps, White Leghorns x Australorps etc. In general growth is measured in terms of body weight. Reasons for the examination of growth in terms of body weight are many.

The body weight, which is the first measurable character of an animal has an economic importance, since it provides a basic background for future performance. It can be measured with reasonable accuracy and it indicates the fowl's ability to survive and grow. Wide variations in it may provide opportunity for early selection of chicks for better performance at latter stages.

Wright(1934) reported that birth weight is of great practical importance as the new born of less than average weight for its breed is, as a rule physiologically younger or premature. Philips and Dawson(1940) stated that birth weight is an earlier expression of growth that influences the survival of lambs. Brody

(1945) reported that animals younger than normal are often lacking in the normal development of heat regulating system and so have less power for survival after birth in a new environment.

Gawecki *et al.*(1953) stated that live weight of White Leghorn cockerels ranged from 800g to 1000g at 15 weeks of age. Mondonedo(1953), after rearing White Leghorn chicks for 12 weeks of age, found that they weighed 571.4g. Chueng-Shyang(1954) reported that cockerels showed a greater and rapid growth than females even though both were fed equal amount of same feed. Initial weight, weights at third and nineth weeks of age were respectively 36g, 143g, 930.4g for males and 36g, 130.4g and 790g for the females.

Morales(1955) reported that the best economic return would be from sale of eleven week old White Leghorns. Podhradsky(1957) opined that the feed utilization was efficient in Leghorn cockereles only upto a body weight of 1,200g. Sacki *et al.*(1963) reported that at 10 weeks of age White Leghorns(Sexes Combined) weighed 948g and its feed conversion ratio was 3.58.

Reddy *et al.*(1965 b) made a comparitive study of growth of White Leghorn chicks at four, six, eight, ten and twelve weeks on two different litters. With ground nut husk as the litter material the weight at 4, 6, 8, 10 and 12 weeks of age was 216g, 326g, 478g, 754g, and 977g respectively. With chopped straw the same was 198g, 337g, 412g, 630g and 825g.

Briones and Tomillo(1965) in a study of Leghorns and Cornish x White Rock crossbreds, reported that White Leghorn male chicks required 66 days to reach 900g live wieght and 84 days to reach 1,300g. The cross bred required 52 and 66 days respectively to attain the corresponding weights. They also opined that if White Leghorn male chicks could be obtained at a reasonable price it would be an economical proposition to fatten them to 900g.

Tanabe _et al._(1965) stated that White Leghorns (sexes combined) at 100 weeks of age attained 999g with feed conversion figure of 3.60. Perez(1970) stated that at 10 weeks of age White Leghorn male chicks averaged 693g. Feed conversion averaged 5.07. Sapronova(1971) reported that the average body weight was 862g. and 842g at 90 days, 1098g and 1,173g at 120 days and 1,449g and 1,462g at 150 days for penned and caged White Leghorn males.

Chhabra and Sapra(1973) stated that the White Leghorns averaged 31.26g, 136.75g and 649.64g at first day, fourth week and twelth week respectively. Pathak and Barsaul(1973) reared White Leghorn chicks for eight weeks on deep litter. There after only male chicks were retained upto 14 weeks of age. The chick weighed 483g at eight weeks for sexes combined, and 1,304g at fourteen weeks for the males only. The feed conversion index averaged 4.21.

Taylor et al.(1975) opined that it would be economical to raise male hybrid chicks of egg producing strains upto 75 days of age. Average body weight obtained at 75 days of age was 804.67g. In an experiment conducted to assess the effect of two housing systems on body weight gain, Chand et al(1976) found that the birds housed in floor pens made a slightly higher weight then those in individual cages at 140 days of age.

Jain and Sharma(1977) reported that the mean live weight of White Leghorn Cockerels at day old, two months and five months were 39.1g, 612g and 1,846g respectively. Singh and Barsaul(1977) reported that White Leghorn male chick attained a slaughter weight of 1,300g at 15 weeks of age.

It is an accepted fact that growth rate is of great practical importance in livestock industry,especially in poultry farming. It is an important factor in determining the optimum period, at which the maximum gain can be effectively achieved.

Brody(1945) defined growth as a relatively irreversable time change in the measured dimension. Growth is pliable, it can be accelerated or delayed with little influence on final body size(Crichton <u>et al</u>. 1959). Both WebSters and Oxford dictionaries define growth as increase or what is grown or is growing. Gould defines growth as the augmentation of body between infancy and adult age. Hammond(1955) explained that rate at which an animal grows is of greater importance for the livestock as only few animals live a long enough to reach the mature weight.

Yacowitz and Wind(1957) when comparing the nutrient requirements of male and female chicks, found that male chicks grew more rapidly and therefore had higher requirement than females. Unidentified growth factor responsees were also found to be greater in males. Moskalenko (1960) reported that the average daily weight gain to 100 days was 8.61g for the straigh run White Leghorns. Wilson <u>et al</u> (1963) observed that feeding of low protein diets resulted in very low weight gain in White Leghorn cockerels. Bhatnagar <u>et al</u>.(1964) stated that White Leghorn males were heavier than females at all ages and their growth rate also significantly heavier, particularly between 4 to 8 week of age. Males with low hatch wieght showed higher gain between 8 weeks and 3 months of age than those with a higher hatch weight.

Reddy *et al*(1965a) in a study with single comb White Leghorn hybrid chicks observed that males were significantly heavier than females at eight, nine and ten weeks of age.

Menawat, *et al*(1977) observed that live weight at ten weeks of age varied from 657.5g for desi to 866.5g for White Leghorn x Rhode Island red birds. Mean weight of the two-way crossbreds was higher(811g) than that of purebred(759g) and of the three-way crossbred(795g). The food conversion efficiency index was better in two way crossbreds(2.50 to 2.69) than that of purebreds(2.64 to 2.81) or of three-way crossbreds (2.69 to 2.74).

El-Maghraby *et al*.(1969) while studying the effect of crosses of light sussex and Australorps with Fayoumi on body weight found that average weights at hatching of three groups, sussex Males x Fayoumi females, Australorps males x Cross bred Fayoumi females and Fayomi purebred were 30.93g, 27.41g and 27.50g. Their body weights at 4 weeks of age were 121.19g, 140.55g and 117.90g. At eight weeks, their average body weight was 272.8g, 293.09g and 213.09g. The corresponding figures for the twelfth week were 479.92g, 438.37g and 354.88g. All the above differences in body weight between purebreds and cross breds and between crossbreds were highly significant. Overall absolute gain in body weight for twelve weeks was 488.99g for sussex X Fayoumi 410.96g for Australorps X Fayoumi and 327.38g for Fayoumi purebred. During the same period their relative growth rates were respectively 218.6g, 176.5g and 171.5g.

In an experiment to study the effect of season on hatching of Australorps and White Leghorn chicks, it was reported (Gupta et al., 1974) that there was significant difference between breeds on daily weight gain. The average body weight of Australorps hatched in December at 160 days was 1757.4g and that of White Leghorns hatched in April was 1354.6g.

Growth models that relate animal's weight as a function of age are of value not only to engineers, but also to nutritionists, geneticists, physiologists, economists, statisticians and managers. Typically, growth models relate the average weight of animals of one breed of a species as a function of age. From such a model, one could determine, the expected average weight of a group of animals of the same breed at any given age, within the limits of the model.

A functional relation between body weight and age, if it could be established with the desired closeness, is useful for planning and future analysis. (Surendran and Rajagopalan, 1975). The growth in body weight of domestic fowl has two phases, viz., self accelerating phase and self limiting phase and the rate of growth in these phases need not be similar.

Some authors(Le gros Clark and Medawar,1945) interpreted growth in mass curves. The mass curve is simply "One of which each point represents the mean size of a number of individuals of same age". There is no doubt that the mass-curve or average curve of growth is a favourite, though poor tool, of investigators in the field. Since, it is entirely hypothetical it is very difficult to interpret (Brant,1950 a).

Baker(1944) raised the question "should the growth curve be based on averages of individuals or should the curve be based on typical individual growth curve". Baker concluded that "the answer depends upon the purpose of investigator". Professional students of growth like

D'arcy Went Worth Thomson (Le Gros Clark and Medawar, 1945) and Biometrician like Brant (1950 a), preferred to work with the curve of growth and its straight forward derivatives. A curve of growth is that of an individual organism and as such it gives information readily.

Medawar(1945) explained curves of growth as "sketched in from finite number of points each defined by a pair of values for size and age and then smoothed out." There are a number of investigators who break up the time schedule into shorter periods or cycles. Commenting on the practice, Zucker _et al._(1941) cautioned: The cycle theory applied to fullest extend without rational substitution should be able to make any equation, of whatever quality, fit almost any set of data, whether suitable or not, for it offers an almost limitless reservoir of adjustable features.

Medawar(Le Gros Clark and Medawar,1945) has cautioned against splitting the growth curve injudiciously into many parts as this would not be in consonance with the growth pattern of the chick. If the curve is smooth, there is no need for breaking up the time schedule into shorter periods indicated by a series of straight line segments.

The term rate of growth has been profusely used by the researchers of all time. Websters dictionary defines rate as a quantity or degree of a thing measured per unit of something else.

If weight is the criterion used (Kempster,1937; Baker,1944), then rate of growth is defined as the change in weight per unit of time(Snedecor,1946). Early rate of growth is the progressive augmentation of the body as measured by the change in weight, per unit of time. Thus growth rate is a relation between change in weight and unit of time.

The relation can best be expressed as regression coefficient, which Mather(1946) defines as coefficient representing the rate of change of the dependent variate in the independent variate". Similarly a growth curve can be referred as a regression(Snedecor,1946) a descriptive connotation of the mathematical term function. In brief the regression coefficient 'b' is a constant that expresses rate of growth (Tuttle and Saterly,1925).

The growth constant, 'b' is a part of the straight line formula

$$y = a + bx$$

where 'a' is the intercept;

'b' is the slope.

'y' the dependent and
'x' the independent variable.

Curves other than straight line are easily transformed or reduced into linear form through the substitution of variables (Crumpler and Yoe, 1940).

Brant,(1950) b) held the opinion that the curve of growth accurately expresses the graphical relation between variables X and Y. It is the experiment that leads to the relation. Based on experimental results, the relation is expressed mathematically as an emperical equation so as to distinguish it from a natural law.

There are innumerable equations used in the study of rates of growth (Zucker et al.,1941a, 1941b, 1942, Gray and Addis, 1948, Dunn et al. 1947 1948, Mayer 1948, Roberts,1964). These according to Brandt(1950 a) have not been used to their best advantage.

Yoshida and Mori Moto(1961) reported that an equation was necessary to describe growth curve. In an experiment on normal growth curve of White Leghorn chicks, they found that on the average, White Leghorn chicks reached half their maximum body weight at 8 weeks of age.

Zelenka(1970), while studying growth of Chicken during the early period of post embryonal life used, exponential function

$$W = a e^{Kt}$$

and the power function

$$W = a t^{b}$$

to calculate growth from 2 to 22 days of age in 40 cockerels and 90 chicks of both sexes. Growth was divided into 2 periods. The first period ended at 14 days of age. It was markedly different from period two, regardless of the function used. In the first period both experiments and in the second period of the second experiment no significant difference was found in the accuracy of calculations between two functions. In the second period of the first experiment the power function was more accurate. Roberts(1964) also used power function in the study of growth.

Again, Zelenka(1979) in a study of growth of 64 males and an equal number of females of Ross-1 birds using Brody's growth equation

$$W = A e^{Kt}$$

where W is body weight
A is a constant,
K is allelometric growth coefficient
t is time

found that K for males and females were 0.1647 and 0.1645 at 7 days of age, 0.1555 and 0.1521 at 10 days of age and 0.0929 and 0.0894 at 35 days of age. From tenth day onwards the difference between sexes were significant. Simillar results were obtained by using the power function.

In an experiment on three selected lines and a control line of Japanese quail, Marks (1978) reported that the growth of body weight of four lines of birds was best approximately by logistic growth curves models. When a twenty eight percent protein diet was fed, the age at maximum growth (point of inflexion) of the three selected lines was four to six days earlier than corresponding age of the control birds. Similar rates of gain after four weeks of age between the selected and the control lines suggested that the mechanism influenced by selection for four-week body weight in quails operated only during the period prior to age at selection, with little or no residual effect. Simillar opinions were expressed by Solomon(1968), and Wilson(1977).

Pillai et al.(1969), while studying growth rate of chickens from six different crosses found that weekly growth rate was 106.9g for white cornish X Haringhatta black x Rhode Island Red, 93.4g for white cornish x Haringhatta, black x white Leghorn, 123.7g for Asselx

Asseel, 100g for white plymouth Rock x Brown Desi, 98.5g for Asseel x Haringhatta black-Rode Island Red and 120.8g for white cornish x asseel. The rates of growth of Asseel x Asseel, white cornish x Asseel crossbred, white plymouth Rock x Brown Desi-Rhode Island Red and Asseel x Haringhatta black-Rhode Island Red crossbred were homogeneous. It was found that simple exponential function

$$W = A e^{Kt}$$

yielded a very good fit.

Tanabe and Sacki(1964) constructed growth curves for chicks of white cornish, white Rock, New Hampshire, Barred plymouth Rock and white Leghorn breeds. From two to fifteen weeks of age growth rate was defined by the equation of the type

$$\log y = \log a + b \log x$$

where y is body weight

x is age and a

and b are constants.

Log x and Log y were highly correlated. The constant a' differed among breeds but not between sexes, 'b' was higher in males than in females.

Susaki(1966) constructed growth curves from data on body weight of three broiler breeds and three crosses upto ten weeks of age. Curves of the type

$$y = ax^b,$$

$$y = a + bx + cx^2$$

$$y = a + bx + c\,(\log x)$$

gave a satisfactory fit to data. Earlier Wishart(1938) constructed the parabolic growth cruve.

$$y = a_0 + a_1x + a_2x^2.$$

In this relation the growth rate was affected only by thechanges in the coefficient of linear and quadratic terms and hence comparison of different groups were based on a_1 and a_2 values of the groups.

Gompertz curve was also used to fit the data on growth. The Gompertz equation is based on observed growth phenomena and the parameters have a clear and unambiguous biological interpretation(Kidwell and Howard, 1970). Laird(1966) had found that Gompertz equation adequately described the postnatal growth of many mammuls and birds. Other investigators (Kidwell, et al. 1969, Lumer 1937, Von Bertalaffy,1957) have described the growth by Gompertz equation.

A more thorough review of gompertz equation and other growth models was presented by Zucker and Zucker(1942) and Buffington(1971). The Gompertz growth model was fitted to data of mean weight as well as the data for the curve forming 95 percent confidence limits of the mean weight. The Gompertz equation provided an excellent fit in Buffington's experiment. The form considered was

$$W = A e^{-Be^{-Ct}}$$

where W = weight in kg at time t

t = age in days

Parameters A, B, and C were interpreted as

A = asymptotic weight approached i.e. weight in kg at time $t = \infty$

$A e^{-B}$ = weight in kg at time $t = 0$

C = Rate of exponential decay of specific growth rate per days.

The values A, B, and C in the Gompertz equation, which gave the best fit, were found out by the author for mean weights of entire flock, weights of all males and for the weights of females.. The Gompertz equation was also fitted to the two curves forming confidence limits to the mean weights.

The mathematical model that has most closely approximated the observed growth was the asymmetrical sigmoid curve. The asymetrical sigmoid curve was found to give good fit to growth response in poultry as also in most vertebrate species. Brody(1945) pointed out the difficulties in assuming the linearity of body increments, when the biological data clearly shows the dependence upon a non-linear function. His solution to the problems of this non-linearity in the gain of bodyweight, during the accelerating growth phase was based on logarithmic function.

Historically the Sigmoid curve was given in the Gompertz form(Brody,1945, Gompertz, 1825, Thompson, 1948, Weymouth and Mc Millian, 1930). The estimation of parameters of such a curve so far has defied traditional statistical approaches (maximum likelihood). To simplyfy the estimation, simpler models are often used e.g. a half parabola or asymmetric Sigmoid curve(Brody, 1945, Rao,1958). Such a simplification is useful for comparing differential growth under varying circumstances, but is inappropriate when the purpose is to describe the complete growth pattern.

Walford(1946) suggested a clever transformation which permitted estimation under usual assumption(violated only in case of pathological pattern) of asymptotic maximum of an organism's(or population's growth) coupled with a mathematical means of drawing the upper part of growth curve. Walford's technique, however, provides no information on the infection point location, the lower and central part of curve or on the age at any time.

Liljedhl,(1970) used a mathematical function of the logistic type

$$y = \frac{(A + B e^{kx})}{(1 + C e^{kx})}$$

to give information about the growth of broiler chickens where 'y' is body weight and 'x' is age. All the four parameters A, B, C and k were significantly different from zero. For one of the forms in which the time difference between the early and late hatch of chicken tested was so large that they represented two different stages of genetic improvement. Statistically significant difference between two hatches were found in all four parameters. By making second derivative of the body weight function equal to zero, some important growth characteristics such as Co-ordinates of growth rate maximum, the corresponding inflexion weight and proportion of body weight at slaughter (56 days) attained at the point of inflexion(growth rate maximum) were derived. Among other things it was found that growth rate increased upto a maximum of 29g to 45g per day-more in males than in female-and it decreased subsequently. The maximum occured between 36 and 48 days; later in males than in females. Sang,(1962) inferred that the logistic formula was moresignificant, in growth of selected lines of brown leghorns.

In general, crossbred fowls of Indian breeds with exotic breeds were found to weigh higher at birth than the local breeds. Effect of breeds was reported to be a significant factor causing variation in birth weight. Growth rate was reported to be higher in crossbreds than in locals. Most of the workers reported that sex, hatch and season of birth significantly influenced birth weight. Breed, sex and hatch were observed to be important factors causing variation in growth rate. Most of the workers depended on some equation to, adequately, describe growth curve.

MATERIALS AND METHODS

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This study was initiated using day-old straight run chicks of White Leghorn eighty in number and that of Australorp (Australorp x White Leghorn) ninty in number from Kerala Agricultural University Poultry farm, Mannuthy. The chicks were hatched on October 23, 1980. They were sereially numbered and wingbanded for identification.

On the day of hatching the chicks were placed in electrically operated, thermostatically controlled battery type brooders. They were allocated to different compartments of the brooder at random. About one-fourth of chicks were alloted to each section of the battery brooder. A commercial all - mash starter ration was fed <u>ad libitum</u> while the chicks were brooded in the batteries. Fresh water was made available at all times.

After a few weeks, the chicks were moved to deep litter houses/pens. They were housed in two adjacent sections of a brooder house, divided into sections. Adequate floor space and water space were made available. Necessary warmth was provided by infra-red bulbs for 4 weeks. At this stage the birds were fairly well feathered and due to temperate weather, only moderate brooder heat was required. All the chicks were fed on the same feed formula and all the management practices were identical.

The weight of each chick was recorded on all days during the first seven days. Thereafter it was taken at weekly intervals. The weighing was continued until the chicks attained an age of 24 weeks. At the end of the experiment weights were available on 30 males and 26 females of Austerlarp group and 25 males and 31 females of white Leghorn group. The remaining birds either died during the course of the experiment or the data on them were not available for recording body weights.

The data so gathered were used for the comparsion of the rates of growth of:-

i) between genetic groups
ii) between males and females within each genetic group
iii) between males of the genetic groups
iv) between females of the genetic groups.

Further they were used to fit appropriate functions of growth.

The data corresponding to each bird was plotted on a graph paper to ascertain the pattern of growth at different time points.

Measuring body weights along the Y-axis and age along the X-axis, the graph of growth of each bird was drawn separately. The graph indicated a Sigmoid curve in general. The choice of an approxpriate curve to depict the growth pattern in any situation is not easy. As the pattern of growth approximated a sigmoid curve the following functions were considered:

i) Exponential
ii) Modified exponential
iii) Gompertz, and
iv) Logistic.

For fitting the exponential the method of least squares was employed. The form of the exponential considered was

(3.1) $$y = a e^{bx}$$

where y = body weight at age x and
a and b are constants.

The exponential, Gompertz and logistic curves were fitted to the data for 24 weeks while the modified exponential was fitted only to the first 12 weeks of the data.

The modified exponential considered was of the form

(3.2) $$y = a e^{bx} - C$$

where a, b and C are constants.

In order to determine 'C' the observed series was divided into three parts at equal intervals. If M_1, M_2 and M_3 are the means of the three groups,

$$(M_1 + C)(M_3 + C) = (M_2 + C)^2$$

(3.3) $$\text{and} \quad C = \frac{(M_2^2 - M_1 M_3)}{(M_1 + M_3 - 2M_2)}$$

The value of 'C' computed was then subtracted from each observed value. The resulting data were then treated as from an exponential population. The rest of the work was same as fitting an exponential curve.

Gompertz curve was fitted in the form

(3.4) $$Y = a b^{c^x}$$

which takes the logarithmic form

(3.5) $$\log y = \log a + (\log b) c^x = A + BC^x$$

The method employed in fitting this curve is an approximate one, since the least squares procedure in the customary form is not applicable. The series was first broken into three equal parts. The logarthms of the observations in these were first computed.

Let 'n' be the number of observations in each of the three segments and S_1, S_2, S_3 the sum of the logarithms of the observations in them.

(3.6) Then, $$c = \left(\frac{S_3 - S_2}{S_2 - S_1} \right)^{1/n}$$

As

(3.7) $$\frac{S_1 - 3A}{B} = \frac{S_2 - 3A}{B\,c^n}$$

after simplification,

(3.8) $$A = \frac{1}{n} \left(S_1 - \frac{(S_2 - S_1)}{(c^n - 1)} \right.$$

That is,

(3.9) $$\log a = \frac{1}{n} \left(S_1 - \frac{S_2 - S_1}{(c^n - 1)^2} \right)$$

When growth curves are fitted the rate of growth at the particular period can be verified as the ratio of the weight during that period to the weight during the previous period minus one. In the case of exponential, this approach gives the rate of growth as

$$\left(a\,e^{b(x+1)} \div a\,e^{bx} \right) - 1$$

$$= (e^b - 1)$$

and therefore growth rate will be equal if 'b's are equal.

When modified exponential is fitted the rate of growth is

$$(ab^{(x+1)} - a\,b^{x}) \div (ab^{x} - c)$$

$$ab^{x}(b - 1) \div (ab^{x} - c)$$

and the growth rates are not significantly different provided the b's do not differ significantly.

If Gompertz curve is fitted the rate of growth is (3·10) $b^{c} - 1 = (ab^{c(x+1)} \div ab^{cx}) - 1$

and growth rates are equal if the values of b^{C} are not significantly different, i.e. if the values of 'C' log 'b' are not significantly different.

We may therefore make use of analysis of variance for testing the difference in growth rates.

Rao (1958) suggested a procedure for the comparison of rates of growth between different groups.

Let Y_i denote the increase in body weight at time i and g_i the mean of all y_i's in the experiment. Then g_i

is the time metameter. The difference in the values of Y_i are due to the time factor (g_i). Hence we may write

(3-11) $$Y_i = b\, g_i.$$

and the method of least squares leads to

(3-12) $$b = \sum Y_i\, g_i / \sum g_i^2$$

Thus obviously, comparison of difference in rates of growth between groups will be a comparison of 'b's. The 'b' values may be affected by initial body weight. Hence, a covariance anlysis of the b' values taking initial values as concomitant variable can be adopted for comparing the growth rates of the groups.

RESULTS

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The average body weights of the Australorp males (ALP males) during the first seven days were 35g., 36.8667g., 38.1333g., 40.0667g., 42.3333g., 44.3330g., and 45.9333g., respectively (Table 1). The corresponding figures for the Australorp females(ALP females)were 34.4615g., 36.6154g., 36.6154g., 38.8461g., 41.0769g., 42.9231g., and 45.2038g. While there was consistant increase in mean body weight during the first seven days for the males, that feature was lacking in the females. In the latter case, though there was increase from first to second day, the mean value was stagnant during the second and third days. Males in each genetic group had a higher mean weight on all the seven days.

The average body weight of the White Leghorn males (WL males) increased from 33.04g., on the first day to 42g. on the seventh day (Table 1). There was a drop in the average body weight to 30.48g. on the fourth day. It was nearly stagnant at 34g. on second and third days.

The White Leghorn females(WL females)had an average body weight of 32.0645g. on the first day(Table 1). It recorded a slight increase on the second and third days, but decreased to 29.2903g. on the fourth day.

There was stady increase thereafter and it reached 41.92g. on the seventh day.

On the seventh day, the males in each group had a higher average body weight than females. The average body weight of the Australorp group was higher than the same for White Leghorns. These features were found to be true even on the first day.

The average weekly body weights of four groups, viz. Australorp males, Australorp females, White Leghorn males, White Leghorn females for the first twenty-four weeks are presented in Table 2.

In 24 weeks the ALP males reached a mean live body weight of 1858g., with a standard error of 33.6766g. Steady increase was noted during the first twenty-two weeks. During the two weeks that followed, the average body weight was stagnant at 1858g. (Table 2) thereby indicating that a plateau was reached in the body weight of birds at least by the end of twenty-three weeks. This feature was noted individually in all the birds.

The ALP females had an average body weight of 1488.4615g. by the end of 24 weeks (Table 2). This was less by roughly 370g. than the corresponding average body weight of ALP males. As in the case of male birds the average body wieght was constant during twenty-third and twentyfourth weeks. The indication was that the constant body weights were reached between twenty-second and twenty-third weeks. The overall increase in the average body weight during the twentyfour weeks was about 1454g.

As in the case of ALP group, the WL males were, on an average, heavier than WL females. The average body weight attained at the end of twentyfour weeks by the former was 1556.8g. with a standard error of 35.7665g. During this period, the latter could attain a mean body Weight of 1306.1290g. with a standard error of 17.6993g. (Table 2). Thus a WL male weighed 250g. more than WL females at the end of twenty four weeks. In the case of both the categories of birds the plateau in average body weight was reached at least by the end of twentythird week. This is also the case with the most of the birds of WL groups.

In general, the constant body weight was attained at least by the twentythird week by almost all birds of the two genetic groups irrespective of their sex.

The analysis of variance of initial weights of the four categories of the birds are given in Table 3. It was found that each of the three pairs viz. ALP males and WL males, ALP females and WL females, ALP males and WL females were not homogeneous. Each of the remaining were significantly different (Table 3).

The initial difference between the groups was not maintained at all later stages. During 4th week the average body weight of the ALP males was 100.133g. The mean body weight was 96.7692g. for ALP females, 92.48g. for WL males and 94.252g. for WL females. The analysis of variance of body weight at fourth week (Table 4) showed no significant difference between the four groups. That is, on an average, the body weights of ALP males, ALP females, WL males, WL females were homogeneous.

The difference between the groups emerged again during the eighth week. During this week, the ALP male had an average body weight of 341.2667g. The mean body weight of ALP females, WL males, WL females were 287.76g., 297.7692g., 273.4839g. respectively. The analysis of variance (Table 5) showed that the groups were not homogeneous. This was due to higher average body weight of ALP males compared with those of the other three.

No significant difference was noted in the average body weights of the latter 3 groups.

The difference between the groups was more pronounced during twelfth week. There was significant difference between them (Table 6). The ALP males had the highest mean body weight of 789.6667g. This was followed by the WL males which had a mean body weight of 720g. This was significantly lower than the same for ALP males. There was no significant difference between the mean body weight 637.6293g. of ALP females and average body weight 630.9677g. of WL males. However each of these significantly differed from ALP males and WL females.

At the end of 16th week the comparison of average body weights of birds showed significant difference between the groups (Table 7). The average body weight of ALP males during this period was 1266g. and this was significantly different from the average body weights of each of the other three groups. The mean body weight was 988.4615g. for ALP females, 1083.2g for WL males and 882.5806g for WL females. On pairwise comparison significant differences were found between any pair.

The analysis of the body weight of the birds at the end of 20 weeks indicated difference in mean weights (Table 8). The mean body weight was 1656g for ALP males 1249.2307g., 1314.4g. for WL males and 10.65.4939g for WL females. Each mean was significantly different from any other. Thus in each of the genetic groups, the males outweighed the females on the average. The same trend was observed as at the end of 20 weeks was reflected in the average body weight at the end of twentyfourth week(Table 9). The males had a significantly higher weight than the females in each genetic group. The females of the two genetic groups had significantly different mean body weights. Further males of WL group had a dignificantly higher mean weight than the females of Australorp group and ALP males were significantly heavier than WL Males. In short each group differed significantly in its mean weight from any other.

To depict, the pattern of growth, exponential, modified exponential, gompertz and logistic curves are attempted. The exponential curve was fitted for each of the 112 birds using their body weights for 24 weeks at weekly intervals. The exponential curve fitted was of the form

$$\log y = \log a + (b \log e) x$$

The values of b, when exponential was fitted to Australorp males were in the range 0.1555 to 0.1861 (Table 10). The compound rate of growth during the twenty four weeks was in the range 16.82 percent to 20.40 percent(Table 14). The implication here is that the bird would attain the final body weight observed if they had maintained the observed rate of growth from the initial stages onwards. The correlation between observed and expected weights (Table 15) indicated that it was pretty high for each bird. It was close to 0.9 in all cases.

In the case of Australorp females the 'b' value of the exponential fitted were generally smaller than the same for Australorp males(Table 11). The range of 'b' was from 0.1470 to 0.1715. The compound rate of growth was atmost 18.71 percent and atleast as 15.84 percent (Table 14). The correlation between the observed and expected weights was high and in most cases it was above 0.9. In no case it was less than 0.8898 (Table 15).

The body weights of WL males also gave a good fit to the exponential curve. The values of 'b' were sufficiently homogeneous. They were observed in the range

0.1505 and 0.1750 (Table 12). Correspondingly, from the rate of growth ranged from 16.42 percent to 19.12 percent (Table 14). Correlation between the observed and expected body weights was again high. Majority of them were very close to 0.9. The least value it assumed was 0.8272 and highest 0.9217 (Table 15).

The body weights of WL females were found to obey the exponential law. The 'b' values of fitted curves were generally lower than those for the males of the same genetic group (Table 13). They were in the range 0.1349 to 0.1646 and the percentage rates of growth observed were in the range 14.42 to 17.89 (Table 14). The correlation between the observed and expected weights of the birds by the exponential law was also high. Its value was around 0.9 in most of the cases. The range was 0.853 to 0.9263 (Table 15).

The analysis of variance of 'b' values for the four groups obtained by fitting the exponential law for the twentyfour week body weights is given in Table 16. There was significant difference between the four groups. The average value of 'b' was highest for ALP males followed by the WL males. A similar relation was observed in the case of females of the two genetic groups.

The rate of growth was therefore highest for ALP males, next higher for the WL malex, third higher for the ALP females and least for WL females.

Gompertz curve was also fitted using twenty-four week body weights of each bird in the experiment. The curve was of the form;

$$\log y = \log a + c^{x} (\log b)$$

The values of a, b, c and b^c for four groups are given in Tables 17, 18, 19, 20. The analysis of variance of b^c associated with four groups is given in Table 21. It was found that rates of growth of the four groups were all distinct.

Logistic curve was fitted to the body weights of each bird for 24 weeks. The parameters of the curve are presented in Tables 22, 23, 24, 25. The form of the curve was

$$\frac{10^5}{y} = a + bc^{x}$$

In general the smaller values of a, b, c were found for the males of the genetic groups thereby indicating that the growth rates in males were more than those for the females. Attempt was made to fit modified exponential for the twenty four week data on the birds. In many cases it could not even be obtained. However the modified exponential could be fitted to twelve week body weights of each of the 112 birds. The constants of the curve are given in the Tables 26, 27, 28, 29.

The analysis of variance of 'b' (modified exponential) values for the four groups are given in Table 30. The groups were not homogeneous. It was found that there was no significant difference between rates of growth as measured by 'b' values of ALP males and WL males. Same was the case with ALP males and WL females. Further no significant difference was observed between the females of two genetic groups. Correlation between observed and expected weights was nearly unity in all cases (Table 31).

For the sake of comparison the exponential curve was fitted to the body weights for twelve weeks. The fit was exteremely good. The correlation between observed and expected weights was nearly units (Table 33) Thus showing that the exponential represents exquisitely the growth during the period.

The 'b' values of the exponential when it was fitted to twelve weeks of body weights of the ALP males were in the range 0.2650 to 0.3198 (Table 32). Consequently the compound rate of growth had a range 30.36 percent to 37.68 percent (Table 36). These two rates were higher when compared with the corresponding range for the ALP females. In the case of latter the least value of 'b' was 0.2242 and highest 0.2894 (Table 33) and the compound growth rate ranged from 25.13 percent to 33.56 percent (Table 36).

Almost the same trend of 'b' values as in the case of ALP males and females was noted in the case of males and females of WL breed. While the highest value of 'b' for the males was 0.3121, it was 0.3019 for the females. The lowest values of 'b' for the two groups were respectively 0.2474 and 0.2488 (Tables 34, 35). The compound rate of growth was in the range 28.07 to 36.63 percent for the males and 28.25 percent to 35.24 percent (Table 36).

Analysis of variance of the 'b' values (Table 37) showed lack of homogenity between the rates of growth. However no significant difference in the rates of growth of the males as also those between the females of the two genetic groups was found. All other comparsions between rates of growth showed significant difference.

The results of the analysis of growth by fitting modified exponential and exponential were found to be identical. The constants a, b, c of the Logistic curve fitted to the data for 12 weeks are presented in Tables 39, 40, 41 and 42.

By the method of Rao(1958) the growth parameter 'b' was estimated for each bird. Each of these values was enormously large running into crores. To reduce them to manageable size, each was divided by 10^6. The resulting values of 'b' are presented in Tables 43, 44, 45 & 46.

The growth parameter had a mean value of 17.0793 for ALP males 13.6363 for ALP females 15.4217 for WL males and 12.3247 for WL females. These actually indicated the difference in growth rates of the four groups.

The analysis of covariance of 'b' values taking initial body weights of the birds as concomitant variable is presented in Table 47. The initial body weight had no significant correlation with 'b' values. It was also found that the rates of growth of all the four groups were distinct. The order of magnitude of the rates of growth were in agreement with the order found in the analysis based on the parameters of exponential and Gompertz curves.

Table-1

Means and standard errors of bodyweights (in g.) of four groups of chicks in the first seven days.

	ALP males	ALP females	WL males	WL females
1	35 ± 0.4959	34.4615 ± 0.5469	33.04±0.4915	32.0645±0.4682
2	36.8667 ± 0.4667	36.6154 ± 0.3964	34 ± 0.6	32.9032±0.5705
3	38.1333 ± 0.5668	36.6154 ± 0.6727	34.08±0.6681	32.9677±0.5153
4	40.0667 ± 0.6101	38.8461 ± 0.7289	30.48±0.6364	29.2903±0.5041
5	42.3333 ± 0.6920	41.0769 ± 0.8960	39.92± 0.7255	39.5484±0.5385
6	44.3333 ± 0.7181	42.9231 ± 1.1106	40.1935±0.6631	40.1935±0.5965
7	45.9333 ± 0.7993	45.2038 ± 0.9484	42 ±0.7063	41.92 ±0.7069

Table 2

Means and Standard Errors of body weights of four groups of chicks in the first Twenty-four weeks.

ALP (Males)	ALP(Females)	WL(Males)	WL(Females)
1 35 ± 0.4960	34.4615 ± 0.5469	33.04 ± 0.4915	32.0645 ± 0.4682
2. 45.93 ± 0.7993	45.2308 ± 0.9484	41.92 ± 0.7069	42 ± 0.7063
3. 78.53 ± 2.0699	79.3077 ± 1.8126	71.12 ± 2.5951	71.3548 ± 2.1995
4.100.133± 2.9879	96.7692 ± 2.7289	92.48 ± 3.6374	94.2581 ± 3.1775
5.132.7667±4.4956	128.6923 ± 3.8812	120.64 ± 5.8238	124.3871 ± 4.5545
6.185.4667±6.1153	171.5 ± 4.9474	163.92 ± 7.2097	164.1935 ± 6.1391
7.244.4667±7.6808	214.7692 ± 5.7111	216.8 ± 7.4142	209.9355 ± 6.4827
8.341.2667±9.6345	297.76 ±11.0032	287.76 ± 11.0032	273.4839 ± 9.5332

Table 2(Contd.)

	1	2	3	4
9.	451.5333 ± 15.5723	361.3846 ± 11.3125	363.68 ± 12.2091	340.8337 ± 11.212
10.	589 ± 21.4647	480.8462 ± 19.0401	519.2 ± 19.0091	482.7419 ± 13.6911
11.	679.3333 ± 18.1559	571.1538 ± 16.3267	597.6 ± 20.9863	528.7097 ± 16.557
12.	789.6667 ± 21.3050	637.6923 ± 14.4361	720 ± 21.4787	630.9677 ± 13.5944
13.	928 ± 24.0038	738.4615 ± 16.8221	815.2 ± 22.7824	703.7097 ± 15.0322
14.	1021.3333 ± 27.7249	825.3846 ± 18.9755	980.4 ± 27.7277	815.4830 ± 14.0494
15.	1110.6667 ± 30.4711	874.6154 ± 17.5957	1086.0 ± 27.6646	868.3871 ± 13.3045
16.	1266 ± 28.626	988.4615 ± 18.6687	1083.2 ± 30.6524	882.5806 ± 14.0274

Table 2 (Contd.)

	1	2	3	4
17.	1374.6667 ± 30.1709	1073.8461 ± 18.3896	1184.8 ± 29.4002	951.6129 ± 11.9416
18.	1502.6667 ± 30.2895	1170 ± 21.8315	1220 ± 29.3712	974.8387 ± 13.2784
19.	1584.6667 ± 32.3157	1222.3077 ± 21.4928	1264.8 ± 30.2717	1025.1613 ± 13.3430
20.	1656 ± 32.1691	1249.2307 ± 23.4352	1314.4 ± 32.1148	1062.9032 ± 13.1427
21.	1791 ± 34.4358	1363.8461 ± 29.1208	1480 ± 38.3667	1173.5483 ± 15.1093
22.	1831.3333 ± 32.5154	1432.3077 ± 29.6871	1512.8 ± 38.1205	1246.4516 ± 17.8738
23.	1858 ± 33.6766	1488.4615 ± 28.3966	1556.8 ± 35.7665	1302.1290 ± 17.6993
24.	1858 ± 33.6766	1488.4615 ± 28.3966	1556.8 ± 35.7665	1302.1290 ± 17.6993

Table 3

Analysis of Variance of Initial body weights of four groups of chicks

Source	df	Mss	F
Between Groups	3	52.9858	7.56**
With in Groups	108	7.012	

** indicates significant at 0.010 level.

CD for comparison between

Groups	ALP (males)	ALP (females)	ML (males)	ML (females)
ALP(Males)		1.3939	1.4083	1.3323
ALP(Females)			1.4574	1.3841
ML (Males)				1.3987
ML(Females)				

MEAN TABLE

Groups	Mean Weights
ALP(Females)	34.4615
ALP(Males)	35
ML (Males)	33.04
ML (Females)	32.0645

Table 4

Analysis of Variance of the fourth week body weights of four groups of chicks.

Source	df	Mss	F
Between Groups	3	422.82	1.4903 N.S.
Within groups	103	283.7176	

Mean table

Groups	Mean in gm
ALP (Males)	100.133
ALP (Females)	96.7692
WL (Males)	92.48
WL (Females)	94.2581

Table 5

Analysis of Variance of the eighth week body weights of four groups of chicks.

Source	df	Mss	F
Between groups	3	23063.8735	8.33**
Within groups	108	2768.5009	

CD for Comparison Between					Mean Table
	ALP(males)	ALP(Females)	WL(Males)	WL (Females	Body Weight in gms.
ALP(Males)		27.6328	27.9273	26.4120	341.2667
ALP(Females)			28.8873	27.4251	237.76
WL (Males)				27.7218	297.7692
WL(Females)					273.4839

Table 6

Analysis of Variance of the twelfth week body weights of four groups of chicks.

Source	df	Mss	F
Between groups	3	166342.2605	18.29**
Within group	108	9094.1220	

	CD for comparison between				Mean Table
	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Body Weight in gms.
ALP(Males)		50.0322	50.6159	47.8696	789.6667
ALP(Females)			52.3558	49.8457	637.6293
WL (Males)				50.2435	720
WL (Females)					630.9677

Table 7

Analysis of variance of the sixteenth week body weights of four groups of chicks.

Source	df	Mss	F
Between Groups	3	797398.2	51.07**
Within groups	108	15612.926	

CD for Comparisin between	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Mean Table Body Weight in gms
ALP(Males)		65.3535	66.05	62.4662	1266
ALP(Females)			68.8204	64.8622	988.4615
WL (Males)				65.5639	1083.2
WL (Females)					832.5806

Table 8

Analysis of variance of the twentyth week body weights of four groups of chicks

Source	df	Mss	F
Between Groups	3	1864288.9929	97.39**
Within Groups	108	19242.5094	

CD for Comparison between

Mean Table

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Body Weight in gms.
ALP (Males)		72.6605	73.4349	69.4505	1656
ALP (Females)			75.9592	72.1143	1249.2307
WL (Males)				72.8945	1314.4
WL (Females)					1062.9032

Table 9

Analysis of Variance of the twenty-fourth week body weights of four groups of chicks.

Source	df	Mss	F
Between Groups	3	1616680.5459	68.42**
Within Groups	108	23627.4501	

CD for Comparison Between | Mean Table

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Body Weight in gms.
ALP (Males)		80.7256	81.5859	77.1592	1858
ALP (Females)			84.3904	80.1188	1488.4615
WL (Males)				80.9856	1556.8
WL (Females)					1302.129

Table 10

Parameters of the Growth Curves of ALP(Males) for twenty-four weeks in the exponential form $y = ae^{bx}$

	a	b
1.	81.4236	0.1658
2.	65.2681	0.1616
3.	62.4762	0.1713
4.	68.1093	0.1699
5.	72.4954	0.1667
6.	74.8036	0.1555
7.	58.4404	0.1718
8.	68.9535	0.1675
9.	69.1211	0.1715
10.	63.8083	0.1716
11.	70.2844	0.1672
12.	66.4959	0.1713
13.	61.8443	0.1702
14.	67.5217	0.1699
15.	78.7164	0.1628
16.	68.4912	0.1688
17.	54.5263	0.1558
18.	53.2727	0.1749
19.	59.6990	0.1724
20.	52.1407	0.1730

Table 10 (Contd.)

	a	b
21	62.3414	0.1698
22.	74.9455	0.1688
23.	54.9823	0.1641
24.	60.6467	0.1736
25.	61.1464	0.1796
26.	57.0063	0.1708
27.	90.7401	0.1564
28.	42.9575	0.1861
29.	59.9701	0.1723
30.	61.3950	0.1674

Table 11

Parameters of the Growth Curves of ALP(Females) for twenty-four weeks in the exponential form $y = ae^{bx}$

	a	b
1	67.86	0.1547
2	66.33	0.1577
3.	72.22	0.1549
4.	60.01	0.1572
5.	52.01	0.1623
6.	58.87	0.1610
7.	56.35	0.1646
8.	67.48	0.1598
9.	77.67	0.1474
10.	65.01	0.1544
11.	52.29	0.1470
12.	59.24	0.1609
13.	72.68	0.1522
14.	65.04	0.1548

Table 11(Contd.)

	a	b
15	47.64	0.1715
16	60.47	0.1620
17.	65.92	0.1558
18	61.10	0.1509
19	58.25	0.1714
20	67.02	0.1556
21	52.26	0.1568
22	60.39	0.1568
23	60.22	0.1610
24	70.55	0.1523
25	76.72	0.1484
26	62.59	0.1563

Table 12

Parameters of the Growth curves of WL(Males) for twenty-four weeks in the exponential form $y = ae^{bx}$

	a	b
1	57.35	0.1750
2	66.27	0.1600
3	56.67	0.1703
4	64.17	0.1602
5	56.07	0.1639
6	47.33	0.1714
7	68.63	0.1600
8	46.81	0.1778
9	72.54	0.1617
10	65.37	0.1505
11	65.46	0.1623
12	73.18	0.1545
13	44.51	0.1738

Table 12 (Contd.)

	a	b
14	64.27	0.1682
15	56.22	0.1549
16	69.23	0.1585
17	44.17	0.1591
18	52.67	0.1723
19	74.49	0.1601
20	56.76	0.1661
21	56.04	0.1667
22.	65.01	0.1639
23	68.31	0.1519
24	54.69	0.1652
25	47.64	0.1704

Table 13

Parameters of the Growth Curves of WL(Females) for twenty-four weeks in the exponential form $y = ae^{bx}$

	a	b
1	73.52	0.1487
2	50.12	0.1636
3	51.52	0.1595
4	51.88	0.1582
5	64.86	0.1502
6	61.02	0.1520
7	44.69	0.1606
8	51.85	0.1583
9	52.29	0.1556
10	64.51	0.1496
11	73.58	0.1513
12	80.32	0.1349
13	60.94	0.1537
14	49.46	0.1617
15	49.82	0.1608
16	61.58	0.1609

Table 13 (Contd.)

	a	b
17	72.36	0.1423
18	46.62	0.1646
19	67.48	0.1433
20	67.76	0.1511
21	66.74	0.1459
22	78.56	0.1412
23	48.71	0.1607
24	57.69	0.1545
25	65.12	0.1483
26	66.10	0.1478
27	55.33	0.1563
28	62.04	0.1547
29	78.23	0.1475
30	70.60	0.1531
31	73.69	0.1429

Table 14

Relative growth rates of four groups of chicks for twenty-four weeks based on exponential.

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)
1	18.03	16.73	19.12	16.03
2	17.54	17.03	17.35	17.77
3	18.68	16.75	18.57	17.32
4	18.52	17.02	17.37	17.14
5	18.14	17.62	18.40	16.23
6	16.82	17.47	18.70	16.42
7	18.74	17.89	17.53	17.42
8	18.23	17.33	19.46	17.15
9	18.71	15.88	17.55	16.84
10	18.72	16.70	16.24	16.14

Table 14 (Contd.)

	1	2	3	4
11	18.20	15.84	17.62	16.33
12	18.68	17.46	16.71	14.42
13	18.55	16.44	18.98	16.61
14	18.52	16.74	18.32	17.55
15	17.68	18.71	16.75	17.44
16	18.39	17.59	17.18	17.46
17	16.86	16.86	17.25	15.29
18	19.11	16.29	18.80	17.89
19	18.82	18.70	17.36	15.41
20	18.87	16.84	18.07	16.31

Table 14 (Contd.)

	1	2	3	4
21	18.51	16.98	18.14	15.71
22	18.39	16.98	17.81	15.17
23	17.83	17.47	16.40	17.43
24	18.96	16.45	19.96	16.71
25	19.67	16.00	18.58	15.29
26	18.63	16.92		15.93
27	16.93			16.92
28	20.45			16.73
29	18.80			15.89
30	18.22			16.54
31				15.36

Table 15

Correlation between observed and expected body weights of four groups of chicks for twenty-four weeks of age when exponential was fitted.

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)
1	0.8977	0.9051	0.8781	0.8959
2	0.9048	0.9137	0.9017	0.8815
3	0.9049	0.9022	0.8851	0.8997
4	0.8896	0.9251	0.8892	0.9204
5	0.8671	0.9144	0.8831	0.9032
6	0.9319	0.9048	0.8717	0.9139
7	0.9296	0.8898	0.8868	0.9158
8	0.8975	0.9071	0.8822	0.8969
9	0.8659	0.9041	0.8527	0.9082
10	0.8718	0.8936	0.8776	0.9104

Table 15 (Contd.)

	1	2	3	4
11	0.8909	0.9164	0.8722	0.8716
12	0.8738	0.9068	0.9053	0.8802
13	0.8866	0.9089	0.9077	0.9035
14	0.8978	0.9281	0.8830	0.8577
15	0.8682	0.9058	0.8465	0.8890
16	0.8870	0.9216	0.8959	0.9014
17	0.9009	0.9082	0.9204	0.9102
18	0.9074	0.9212	0.8770	0.9119
19	0.8786	0.9174	0.8648	0.9183
20	0.9221	0.8967	0.9044	0.9066

Table 15 (Contd.)

	1	2	3	4
21	0.8918	0.9178	0.8834	0.9119
22	0.8924	0.9396	0.8924	0.9251
23	0.9199	0.9097	0.9237	0.9154
24	0.9116	0.9071	0.8272	0.9263
25	0.8752	0.9217	0.9256	0.9144
26	0.9171	0.8963		0.8430
27	0.8737			0.9006
28	0.8874			0.8745
29	0.8837			0.8959
30	0.8997			0.8919
31				0.8967

Table 16

Analysis of Variance of 'b' values (exponential) for twenty-four weeks.

Source	df	Mss	F
Between Groups	3	15.4276	32.82**
Within groups	108	0.4701	

CD for Comparison between | Mean Table

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	b
ALP(Males)		0.00358	0.00362	0.003422	0.1689
ALP(Females)			0.003743	0.003553	0.1572
WL (Males)				0.003592	0.1641
WL (Females)					0.1527

Table 17

Parameters of Gompertz curve $y = ab^{c^x}$ for twenty-four weeks(ALP Males)

	a	b	c	b^c
1	2563.4772	0.0101	0.8653	0.0188
2	2406.2849	0.0119	0.8909	0.0193
3	3140.7206	0.0091	0.8981	0.0147
4	2745.7593	0.0094	0.8824	0.0163
5	2318.0392	0.0100	0.8654	0.0186
6	2797.1388	0.0139	0.9028	0.0211
7	3490.1822	0.0085	0.9076	0.0132
8	2786.1362	0.0101	0.8876	0.0169
9	2434.2345	0.0086	0.8644	0.0164
10	5517.2710	0.0049	0.9108	0.0079
11	2448.2773	0.0101	0.7840	0.0180
12	2651.7999	0.0087	0.8774	0.0156
13	2434.5192	0.0089	0.8783	0.0158
14	2586.4030	0.0095	0.8783	0.0167
15	2332.4197	0.0106	0.8645	0.0196
16	2527.3186	0.0096	0.8764	0.0170
17	1516.8947	0.0136	0.8755	0.0232
18	2852.9228	0.0083	0.8993	0.0134
19	2521.5035	0.0084	0.8805	0.0149
20	2937.8753	0.0083	0.9022	0.0133

Table 18

Parameters of Gompertz Curve $y = ab^{c^x}$ for twenty-four Weeks(ALP Females)

	a	b	c	b^c
1	1988.8911	0.0143	0.8838	0.0234
2	1838.4823	0.0130	0.8708	0.0228
3	1975.2363	0.0143	0.8766	0.0241
4	2245.1023	0.0134	0.9002	0.0206
5	2061.7163	0.0113	0.8947	0.0181
6	1960.5080	0.0122	0.8817	0.0205
7	1996.2303	0.0110	0.8815	0.0182
8	2243.7640	0.0126	0.8857	0.0208
9	1740.9329	0.0171	0.8710	0.0289
10	1702.2545	0.0138	0.8711	0.0240
11	1695.9386	0.0167	0.9750	0.0245
12	1859.2134	0.0119	0.8767	0.0205
13	1696.9500	0.0152	0.8644	0.0268

Table 18(contd)

	1	2	3	4
14	2310.8636	0.0143	0.9007	0.0218
15	2292.4320	0.0154	0.8948	0.0239
16	2622.3602	0.0114	0.8022	0.0177
17	1943.6103	0.0141	0.8826	0.0232
18	2236.3084	0.0155	0.9089	0.0267
19	2681.5967	0.0089	0.8907	0.0149
20	1921.0958	0.0140	0.8797	0.0234
21	2268.9023	0.0124	0.9094	0.0185
22	2093.5955	0.0134	0.8948	0.0212
23	1675.9394	0.0146	0.8645	0.0256
24	1982.6433	0.0177	0.8863	0.0280
25	1930.3540	0.0145	0.8871	0.0234
26	2185.1296	0.0119	0.8903	0.0193

Table 19

Parameters of Gompertz curve $Y = ab^{c^x}$ for twenty-four weeks (WL males).

	a	b	c	b^c
1	2278.9717	0.0078	0.8694	0.0147
2	1909.6334	0.0125	0.8707	0.0220
3	2135.5985	0.0090	0.8743	0.0163
4	1923.7394	0.0120	0.8683	0.0215
5	1918.2453	0.0091	0.8668	0.0170
6	1558.4075	0.0073	0.8515	0.0152
7	1960.9037	0.0127	0.8703	0.0224
8	2101.2497	0.0074	0.8761	0.0136
9	1979.8539	0.0108	0.8569	0.0206
10	1295.3760	0.0127	0.8377	0.0258
11	2154.8197	0.0116	0.8790	0.0199
12	1737.9650	0.0138	0.8592	0.0352
13	2328.9511	0.0080	0.8965	0.0132

Table 19(Contd.)

	1.	2.	3.	4.
14.	2117.7335	0.0090	0.8633	0.0171
15.	1328.9211	0.0125	0.8545	0.0236
16.	2060.9719	0.0131	0.8775	0.0223
17.	1639.2622	0.0128	0.8963	0.0201
18.	1910.7284	0.0079	0.8640	0.0153
19.	1917.5185	0.0114	0.8539	0.0219
20.	1985.2935	0.0104	0.8766	0.0183
21.	2283.5850	0.0102	0.8909	0.0168
22.	2252.5213	0.0116	0.8820	0.0196
23.	1874.4953	0.0156	0.8835	0.0253
24.	1474.1835	0.0073	0.8375	0.0162
25.	2954.3647	0.0088	0.9120	0.0133

Table 20

Parameters of Gompertz Curve $Y = ab^{c^x}$ for twenty-four weeks (WL females).

	a	b	c	b^c
1	1517.0713	0.0155	0.8547	0.0234
2	1376.7117	0.0092	0.8490	0.0187
3	1714.7923	0.0127	0.8860	0.0209
4	1585.3657	0.0123	0.8784	0.0210
5	1489.9278	0.0158	0.8715	0.0269
6	1430.8984	0.0157	0.8612	0.0279
7	1594.1940	0.0123	0.8903	0.0199
8	1411.3107	0.0120	0.8652	0.0219
9	1468.5710	0.0137	0.8769	0.0232
10	1522.0482	0.0168	0.8732	0.0282
11	1357.0178	0.0137	0.8423	0.0269
12	1242.8251	0.0239	0.8557	0.0449
13	1438.1989	0.0138	0.8599	0.0251
14	1388.4636	0.0109	0.8605	0.0204
15	1343.6424	0.0110	0.8574	0.0209
16	1757.9392	0.0112	0.8647	0.0206

Table 20 (Contd.)

	1	2	3	4
17	1363.2017	0.0198	0.8629	0.0339
18	1059.4779	0.0112	0.8925	0.0182
19	1458.5978	0.0200	0.8786	0.0322
20	1525.3539	0.0153	0.8619	0.0273
21	1559.2932	0.0189	0.8814	0.0303
22	1522.4560	0.0213	0.8714	0.0349
23	1783.1016	0.0122	0.8922	0.0196
24	1639.0031	0.0161	0.8828	0.0247
25	1501.3635	0.0177	0.8744	0.0294
26	1263.1019	0.0139	0.8414	0.0274
27	1498.8505	0.0134	0.8713	0.0233
28	1378.9485	0.0117	0.8440	0.0234
29	1438.0997	0.0149	0.8394	0.0294
30	1769.0208	0.0154	0.8719	0.0263
31	1276.8598	0.0176	0.8449	0.0329

Table 21

Analysis of Variance of rates of growth based on Gompertz equation for twenty-four weeks.

Source	df	Mss	F
Between Groups	3	53327.2833	30.83**
Within Groups	108	1729.5116	

CD for Comparison Between — Mean Table

	ALP (Male)	ALP (Female)	WL (Male)	WL (Female)	b^c
ALP(Males)		0.2164	0.2187	0.2069	0.0162
ALP(Females)			0.2262	0.2148	0.0223
WL (Males)				0.2171	0.0191
WL (Females)					0.0260

Table 22

Parameters of Logestic Curve $\frac{10^5}{y} = a+bc^x$ for twenty-four weeks(ALP Males)

	a	b	c
1	49.7118	2491.2766	0.6939
2	60.4874	2500.6998	0.7319
3	50.9373	2594.1361	0.7300
4	50.7477	2501.7092	0.7191
5	54.3371	2745.3522	0.6990
6	57.8677	2212.9449	0.7395
7	51.6333	2618.9535	0.7389
8	5108532	2473.1122	0.7223
9	52.4391	3112.7644	0.6857
10	47.9638	2853.9684	0.7098
11	54.1146	2651.6928	0.7066
12	51.3139	2721.0876	0.7086
13	55.8527	2734.2802	0.7158
14	53.1082	2794.7863	0.7058
15	53.6848	2515.7242	0.6991

Table 22 (Contd.)

	1	2	3
16	53.4124	2694.6199	0.0775
17	85.9016	3211.5890	0.7197
18	55.4600	2949.3496	0.7299
19	54.8351	2808.2130	0.7464
20	57.1770	2841.9148	0.9385
21	56.4656	2857.0295	0.7103
22	49.1811	2531.4785	0.7020
23	70.4262	3137.2341	0.7169
24	52.5611	2882.7420	0.7132
25	48.8397	3074.0900	0.6969
26	52.4123	2622.0139	0.7456
27	53.3574	2273.5139	0.6988
28	52.6473	3470.6846	0.7277
29	57.1675	3045.8122	0.7018
30	57.1700	2667.9087	0.7262

Table 23

Parameters of Logestic curve $\frac{10^5}{y} = a + bc^x$ for twenty-four weeks (ALP Females)

	a	b	c
1	68.3788	2512.0682	0.7289
2	69.8895	2848.9474	0.7093
3	66.0866	2511.0371	0.7203
4	69.2807	2573.0611	0.7448
5	72.4906	2940.3594	0.7394
6	69.5243	2908.8976	0.7221
7	67.8531	2945.8035	0.7263
8	61.5675	2443.2736	0.7319
9	72.3917	2431.2624	0.7158
10	74.1639	2677.8703	0.7207
11	91.3631	2709.3345	0.7653
12	70.8950	2813.8060	0.7231
13	72.6286	2705.3030	0.7081
14	67.6231	2450.5356	0.7429
15	67.4376	3447.7291	0.7279

Table 23
(Contd.)

	1	2	3
16	61.9442	2543.8479	0.7417
17	69.4568	2592.6757	0.7282
18	72.7311	2366.4964	0.7633
19	56.9904	2941.6545	0.7172
20	68.9381	2576.5299	0.7254
21	71.8540	2546.5373	0.7688
22	72.0445	2686.7337	0.7345
23	65.8889	2647.2126	0.7347
24	73.6735	2637.4807	0.7107
25	69.3762	2381.9190	0.7274
26	71.7225	2725.5660	0.7320

Table 24

Parameters of Logestic Curve $\frac{10^5}{y} = a + bc^x$ for twenty-four weeks (WL Males)

	a	b	c
1	56.7969	3033.4030	0.7092
2	67.0946	2765.7767	0.7127
3	61.2587	2918.4352	0.7198
4	65.6181	2761.9842	0.7103
5	66.1555	3152.6197	0.7079
6	77.0191	3866.5808	0.6927
7	65.0900	2882.6599	0.7075
8	63.9335	3495.9200	0.7161
9	60.5656	2723.8981	0.7001
10	87.0155	3101.3219	0.6912
11	61.4207	2637.9199	0.7243
12	70.0912	2833.2242	0.6971
13	67.1895	3359.8890	0.7370

Table 24(contd.)

	1	2	3
14	59.2192	2972.6023	0.6994
15	88.7286	3390.8542	0.7041
16	63.5891	2482.3542	0.7240
17	90.5214	3359.0382	0.7474
18	65.7099	3300.9711	0.8063
19	62.1816	2393.7686	0.7905
20	67.0994	2968.0299	0.7188
21	62.8646	2781.7386	0.7381
22	60.3764	2667.9741	0.7236
23	72.0210	2434.6342	0.8331
24	77.0680	3637.2680	0.6839
25	63.3454	3050.8992	0.7481

Table 25

Parameters of Logestic Curve $\frac{10^5}{y} = a + bc^x$ for twenty-four weeks (WL Females)

	a	b	c
1	77.9842	2752.2559	0.7011
2	85.8749	3815.8389	0.6918
3	79.2036	2947.9783	0.7418
4	84.5881	3192.7213	0.7227
5	84.8365	3019.3043	0.7056
6	85.1554	2975.5026	0.7187
7	88.1694	3287.0501	0.8763
8	87.6151	3302.9058	0.7167
9	83.2156	3107.2533	0.7310
10	82.9298	2671.4876	0.7274
11	83.8537	3105.6140	0.6930
12	93.2024	2564.7170	0.7107
13	84.1109	2929.4894	0.7128
14	86.9617	3656.7191	0.7108
15	89.6991	3702.8924	0.7054

Table 25 (Contd.)

	1	2	3
16	70.8355	2840.6889	0.7129
17	88.0084	2565.3139	0.7191
18	78.4270	3303.9264	0.7395
19	88.0615	2562.3233	0.7338
20	79.9127	2878.6265	0.7068
21	83.7529	2534.2789	0.7356
22	81.4186	2269.3808	0.7268
23	80.0778	3000.3783	0.7469
24	82.5517	2948.9522	0.7293
25	84.4568	2698.0294	0.7274
26	86.1295	3056.3196	0.6966
27	83.7358	2917.7152	0.7293
28	83.1893	3145.6316	0.6962
29	78.5443	2283.8131	0.6872
30	70.8558	2493.8191	0.7261
31	89.3909	2812.6036	0.6988

Table 26

Parameters of Modified exponential Curve

$y = ab^x - c$ for twenty-four week

(ALP Males.)

	a	b	c
1	26.4543	1.3382	-1.0976
2	84.8611	1.2104	74.6149
3	23.3292	1.3469	-6.0950
4	70.1651	1.2340	56.9811
5	41.9562	1.2813	26.5169
6	13.8900	1.4011	-11.8567
7	127.4311	1.1765	127.782
8	34.1905	1.2878	19.2972
9	70.7540	1.2471	58.8084
10	27.7544	1.3345	0.6552
11	55.5301	1.2489	33.2857
12	112.3237	1.1988	113.0817
13	15.1259	1.3642	-13.1306
14	25.3595	1.3597	-4.5683
15	65.7000	1.2171	58.4129
16	61.4827	1.2411	38.4404

Table 26 (Contd.)

	1	2	3
17	43.3508	1.2191	25.4028
18	18.5475	1.3780	-8.3700
19	97.5914	1.2161	92.5876
20	51.3782	1.2513	36.1179
21	28.4849	1.3057	-0.2922
22	120.7038	1.2620	118.6873
23	46.6945	1.2620	16.9514
24	23.3310	1.3559	3.1293
25	132.1520	1.1377	133.2135
26	103.1168	1.1716	101.4845
27	86.6649	1.2430	68.5548
28	19.4950	1.3465	-4.8238
29	33.1613	1.3263	12.1372
30	37.4748	1.2936	10.2419

Table 27

Parameters of Modified exponential curve $y = ab^x - c$ for twenty-four weeks (ALP Females)

	a	b	c
1	65.4653	1.2296	44.6721
2	72.3995	1.2299	60.6401
3	75.0975	1.2249	56.1625
4	89.2925	1.1823	75.2391
5	43.3152	1.2470	22.8400
6	66.9946	1.2224	54.2948
7	51.9085	1.2434	35.0056
8	40.9462	1.2814	9.0083
9	91.4599	1.2120	77.7346
10	47.0796	1.2656	24.6256
11	33.9697	1.2426	3.3411
12	45.9935	1.2605	25.3513
13	84.3035	1.2160	70.4401

Table 27 (Contd.)

	a	b	c
14	134.2158	1.1553	128.9280
15	53.1155	1.2327	42.6646
16	85.5014	1.1951	73.375
17	77.4668	1.2114	62.3498
18	86.2705	1.1730	64.0714
19	48.2569	1.2683	29.8419
20	48.2569	1.2683	29.8419
21	17.0426	1.3370	-20.6468
22	84.8017	1.1956	74.2855
23	45.8096	1.2595	21.9078
24	56.2414	1.2566	35.3967
25	142.0609	1.1640	134.2795
26	208.6734	1.1218	221.8810

Table 28

Parameters of Modified exponential curve $y = ab^x - c$ for twenty-four weeks(ML Males)

	a	b	c
1	96.4578	1.2350	90.3166
2	67.5406	1.2263	47.8693
3	76.5228	1.2191	62.5013
4	48.0254	1.2803	22.0600
5	114.6309	1.2041	118.9013
6	122.4249	1.1783	109.9675
7	47.3097	1.2597	22.1491
8	64.9909	1.2486	46.2166
9	105.6912	1.2156	110.4792
10	42.1817	1.3008	21.6865
11	94.0902	1.2183	90.2355
12	41.7936	1.3037	18.3438
13	30.3812	1.3275	1.7229

Table 28 (Contd.)

	1	2	3
14	83.1742	1.2275	74.8225
15	73.2790	1.2526	57.3048
16	54.1938	1.2764	35.7577
17	60.3547	1.2228	49.9403
18	95.7200	1.1865	94.0017
19	13.5271	1.2958	15.6654
20	32.6248	1.2918	7.2960
21	42.5496	1.2943	22.6094
22	101. 9070	1.2215	100.7603
23	37.1874	1.2899	18.1952
24	39.1363	1.3030	16.7344
25	46.1400	1.2969	31.7934

Table 29

Parameters of Modified exponential Curve $y = ab^{x} - c$ for twenty-four weeks(WL Females)

	a	b	c
1	80.3131	1.2243	68.5256
2	31.8545	1.3009	17.6087
3	45.2596	1.2335	24.5018
4	28.5179	1.2960	3.7552
5	151.4465	1.1545	161.1989
6	103.6326	1.1703	104.2846
7	29.2761	1.2658	6.7852
8	20.9487	1.3372	-5.6727
9	21.5391	1.3238	-7.4319
10	80.8458	1.1963	65.2975
11	96.5454	1.1978	93.8159
12	217.6431	1.1249	220.3704
13	36.6180	1.2857	12-2015
14	36.8762	1.2705	22.1129
15	20.3766	1.3440	-3.0743

Table 29(Contd.)

	1	2	3
16	32.8235	1.3049	5.2391
17	87.2271	1.1965	69.3203
18	55.4303	1.2142	44.3793
19	85.1598	1.1909	68.0164
20	105.7982	1.1887	103.0237
21	94.6137	1.1793	77.6852
22	144.0696	1.1548	131.8923
23	40.9983	1.2369	18.5113
24	77.7554	1.1986	67.6311
25	100.2967	1.1753	87.8466
26	41.9946	1.2769	19.7692
27	88.9362	1.2943	1.1837
28	29.8142	1.3202	4.8812
29	118.2294	1.1923	116.5821
30	101.3305	1.1899	91.5015
31	67.1400	1.2345	48.7843

Table 30

Analysis of Variance of the 'b' values (modified exponential) for twelve-weeks.

Source	df	Mss	F
Between Groups	3	0.0126	3.96*
Within groups	108	0.0032	

CD for Comparsion Between	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Mean Table b
ALP(Males)		0.0295	0.0298	0.0282	1.2746
ALP(Females)			0.0303	0.0293	1.2272
WL (Males)				0.0296	1.2596
WL (Females)					1.2246

Table 31

Correlation between observed and expected body weights based on modified exponential curve for twelve-weeks of age

	ALP (Males)	ALP (Females)	NL (Males)	NL (Females)
1.	0.9859	0.9948	0.9952	0.9883
2	0.9912	0.9887	0.9856	0.9815
3	0.9953	0.9915	0.9911	0.9760
4	0.9924	0.9967	0.9878	0.9459
5	0.9974	0.9963	0.9988	0.9860
6	0.9920	0.9910	0.9812	0.9959
7	0.9975	0.9969	0.9973	0.9914
8	0.9968	0.9959	0.9904	0.9863
9	0.9854	0.9831	0.9942	0.9841
10	0.9830	0.9834	0.9765	0-9939
11	0.9940	0.9893	0.9943	0.9913

Table 31(Contd.)

	1	2	3	4
12	0.9938	0.9848	0.9929	0.9939
13	0.9867	0.9916	0.9852	0.9969
14	0.9911	0.9880	0.9840	0.9972
15	0.9855	0.9978	0.9824	0.9856
16	0.9942	0.9907	0.9976	0.9927
17	0.9943	0.9934	0.9933	0.9878
18	0.9965	0.9948	0.9948	0.9931
19	0.9816	0.9769	0.9940	0.9926
20	0.9914	0.9855	0.9964	0.9890
21	0.9765	0.9954	0.9960	0.9974
22	0.9878	0.9868	0.9955	0.9924
23	0.9700	0.9850	0.9912	0.9826
24	0.9832	0.9814	0.9862	0.9915
25	0.9904	0.9906	0.9867	0.9961
26	0.9957	0.9853		0.9764

Table 31(Contd.)

	1	2	3	4
27	0.9878			0.9915
28	0.9934			0.9892
29	0.9930			0.9897
30	0.9900			0.9919
31				0.9975

Table 32

Parameters of exponential curve $y = ae^{bx}$ for twelve-weeks(ALP Males)

	a	b
1	33.4686	0.3087
2	32.9951	0.2682
3	31.5739	0.2778
4	32.9168	0.2823
5	29.9263	0.3063
6	31.9181	0.2666
7	31.4594	0.2684
8	32.7958	0.2847
9	27.1909	0.3198
10	28.0232	0.3016
11	30.6988	0.2985
12	29.7085	0.2976
13	29.2735	0.2868
14	29.9751	0.2984
15	33.4813	0.2980

Table 32(Contd.)

	1	2
16	30.1263	0.2991
17	25.1579	0.2792
18	27.1379	0.2802
19	28.3877	0.2875
20	27.7746	0.2709
21	27.8175	0.2978
22	31.9316	0.3049
23	25.2649	0.2905
24	28.0081	0.2965
25	25.8030	0.3149
26	30.9495	0.2651
27	37.8036	0.2944
28	22.4556	0.2843
29	25.6438	0.3068
30	30.5336	0.2766

31

Table 33

Parameters of exponential Curve $y = ae^{bx}$ for twelve-weeks(ALP Females)

	a	b
1	33.0920	0.2681
2	29.2753	0.2894
3	33.8055	0.2752
4	32.0977	0.2552
5	27.4550	0.2615
6	28.5659	0.2775
7	27.5380	0.2751
8	34.4519	0.2641
9	34.4243	0.2799
10	30.2663	0.2760
11	31.4076	0.2242
12	28.7544	0.2742
13	32.0769	0.2833

Table 33 (Contd.)

	a	b
14	33.4955	0.2608
15	23.2267	0.2839
16	31.6767	0.2641
17	31.8169	0.2709
18	35.5214	0.2445
19	27.8750	0.2885
20	32.2918	0.2705
21	32.5604	0.2329
22	30.2007	0.2684
23	30.5629	0.2676
24	31.5549	0.2816
25	36.2820	0.2697
26	30.2076	0.2705

Table 34

Parameters of exponential curve $y = ae^{bx}$ for twelve-weeks(WL Males)

	a	b
1	27.1767	0.2837
2	30.4826	0.2826
3	27.2267	0.2831
4	30.0041	0.2876
5	24.9530	0.2967
6	20.8847	0.2979
7	30.1673	0.2895
8	22.0885	0.2929
9	30.2972	0.2990
10	27.3389	0.2900
11	31.7310	0.2736
12	29.8009	0.3005

Table 34(Contd.)

	a	b
13	23.4191	0.2691
14	28.4448	0.2960
15	24.6926	0.2829
16	33.7787	0.2706
17	24.7030	0.2474
18	23.5423	0.2977
19	30.2679	0.3029
20	26.9893	0.2824
21	28.6821	0.2661
22	31.1426	0.2780
23	34.4102	0.2608
24	21.5242	0.3121
25	26.7681	0.2588

Table 35

Parameters of Exponential curve $y = ae^{bx}$
for twelve weeks(WL females)

	a	b
1	30.8885	0.2894
2	20.9359	0.3019
3	27.8145	0.2528
4	25.9893	0.2679
5	27.6422	0.2887
6	28.5912	0.2721
7	24.5727	0.2515
8	24.6456	0.2752
9	26.6990	0.2603
10	31.7852	0.2611
11	27.7573	0.2916
12	35.3336	0.2677
13	28.3117	0.2752
14	22.1010	0.2866
15	22.4334	0.2854
16	29.3136	0.2767

Table 35(Contd.)

	a	b
17	34.1624	0.2622
18	22.9564	0.2675
19	33.0793	0.2578
20	29.2929	0.2862
21	33.9723	0.2523
22	38.5825	0.2552
23	27.2924	0.2488
24	27.7827	0.2718
25	30.9910	0.2600
26	28.2728	0.2813
27	28.7315	0.2605
28	26.6018	0.2886
29	31.5858	0.2936
30	33.2772	0.2709
31	31.3131	0.2811

Table 36

Relative Growth rates of Chicks for Twelve weeks(exponential curve)

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)
1	36.16	30.74	33.48	33.56
2	30.76	33.56	32.66	35.24
3	32.02	31.68	32.72	28.76
4	32.62	29.07	33.32	30.72
5	35.85	29.98	34.40	33.47
6	30.55	31.98	34.74	31.27
7	30.79	31.67	33.58	28.69
8	32.94	30.23	34.03	31.68
9	37.68	32.30	34.85	28.73
10	30.20	31.78	33.64	29.84
11	34.78	24.13	31.47	33.86
12	34.65	31.55	35.05	30.70
13	33.22	32.75	30.88	31.68
14	34.77	29.77	34.45	33.19
15	34.72	32.83	32.70	33.16

Table 36 (Contd.)

	1	2	3	4
16	34.86	30.23	31.07	31.83
17	32.21	31.11	28.07	29.98
18	32.34	26.43	34.68	30.67
19	33.31	33.44	35.38	29.41
20	31.11	31.06	32.63	33.14
21	34.69	26.22	30.49	28.70
22	35.65	30.80	32.05	29.07
23	32.71	30.68	29.80	28.25
24	34.51	32.52	36.63	31.23
25	37.01	30.69	29.54	29.69
26	30.36	31.06		32.47
27	34.23			29.75
28	32.88			33.46
29	35.80			34.12
30	31.86			31.11
31				32.46

Table 37

Analysis of variance of 'b' values (exponential curve) for Twelve weeks.

Source	df	Mss	F
Between Groups	3	0.003	13.05^{**}
Within groups	108	0.0002	

CD for Comparison Between	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)	Mean Table b
ALP(Males)		0.007385	0.007464	0.007059	0.2904
ALP(Females)			0.007719	0.007328	0.2680
WL (Males)				0.007408	0.2842
WL (Females)					0.2624

Table 38

Correlation between observed and expected body weights of chicks for twelve weeks (Exponential)

	ALP (Males)	ALP (Females)	WL (Males)	WL (Females)
1	0.9652	0.9875	0.9953	0.9735
2	0.9825	0.9741	0.9687	0.9741
3	0.9881	0.9812	0.9920	0.9763
4	0.9883	0.9863	0.9752	0.9436
5	0.9837	0.9935	0.9956	0.9516
6	0.9749	0.9790	0.9867	0.9775
7	0.9939	0.9942	0.9838	0.9919
8	0.9898	0.9948	0.9891	0.9881
9	0.9571	0.9636	0.9859	0.9859
10	0.9758	0.9774	0.9762	0.9831
11	0.9781	0.9886	0.9911	0.9729
12	0.9904	0.9907	0.9721	0.9624
13	0.9862	0.9783	0.9887	0.9953
14	0.9739	0.9662	0.9862	0.9950

Table 38(Contd.)

	1	2	3	4
15	0.9701	0.9966	0.9674	0.9869
16	0.9842	0.9769	0.9932	0.9920
17	0.9827	0.9839	0.9392	0.9735
18	0.9849	0.9942	0.9962	0.9956
19	0.9766	0.9661	0.9762	0.9848
20	0.9904	0.9790	0.9909	0.9680
21	0.9689	0.9923	0.9960	0.9862
22	0.9654	0.9886	0.9897	0.9731
23	0.9611	0.9799	0.9881	0.9809
24	0.9777	0.9713	0.9852	0.9888
25	0.9835	0.9674	0.9723	0.9830
26	0.9873	0.9736		0.9684
27	0.9733			0.9913
28	0.9943			0.9878
29	0.9902			0.9659
30	0.9873			0.9924
31				0.9909

Table 39

Parameters of Logestic curve $\frac{10^5}{y} = a + bc^x$ for Twelve weeks(ALP Males)

	a	b	c
1	66.1130	2655.9669	0.6621
2	78.6394	2574.5281	0.7149
3	65.4081	2651.4362	0.7171
4	52.5515	2516.4297	0.7163
5	91.7718	2980.2774	0.6528
6	107.3442	2461.3990	0.6800
7	72.7153	2698.8445	0.7211
8	64.0488	2551.8370	0.7062
9	81.9778	3381.8308	0.6224
10	14.8245	2825.5433	0.7240
11	70.4967	2764.8513	0.6847
12	33.9246	2707.3791	0.7164
13	-3.1972	2636.1848	0.9478
14	78.2776	2956.8740	0.6754
15	51.0665	2557.3510	0.6938
16	46.6318	2727.5741	0.7053

Table 39 (Contd.)

	1	2	3
17	70.2209	3255.7474	0.7201
18	84.6837	3048.4975	0.7089
19	-0.5008	2711.7255	0.7463
20	1.5474	2781.9758	0.7616
21	27.8399	2835.8523	0.7221
22	47.6384	2593.4843	0.6933
23	-9.8854	3089.0955	0.7445
24	34.9783	2905.4868	0.7158
25	44.9026	3095.3893	0.6957
26	127.1269	2838.5944	0.6917
27	68.0675	2399.4065	0.6715
28	-63.0419	3314.4973	0.7711
29	-4.5177	2927.3944	0.7350
30	-2.6146	2597.6865	0.7545

Table 40

Parameters of Logestic curve $\frac{10^5}{y} = a + bc^x$ for twelve weeks(ALP Females)

	a	b	c
1	79.8278	2588.7319	0.7138
2	84.3478	2992.4226	0.6851
3	101.2093	2685.0695	0.6819
4	112.3065	2761.9477	0.7129
5	74.8709	2976.5372	0.7343
6	92.2131	3015.4455	0.7015
7	81.3628	2974.0538	0.7189
8	73.0377	2477.1628	0.7228
9	79.2644	2567.3423	0.6926
10	40.2345	2672.0220	0.7693
11	101.4822	2717.4332	0.7615
12	45.5333	2778.8059	0.7354
13	109.7160	2930.4699	0.6637

Table 40(Contd.)

	a	b	c
14	118.5476	2655.1290	0.6954
15	111.6290	3612.5212	0.6990
16	74.5158	2621.0951	0.7267
17	108.9904	2759.6988	0.6910
18	156.5663	3521.6728	0.7119
19	3.3123	2883.9889	0.7403
20	103.5488	2729.8910	0.6916
21	-68.2583	2480.5394	0.8148
22	53.1239	2729.8539	0.7346
23	64.2204	2785.7101	0.7299
24	58.6106	2659.1954	0.7128
25	120.3069	2690.0750	0.6610
26	136.2975	2950.9715	0.6806

Table 41

Parameters of Logestic Curve $\frac{10^5}{y} = a + bc^x$ for Twelve weeks(WL Males)

	a	b	c
1	51.1138	2988.7786	0.7165
2	98.0564	2911.4410	0.6825
3	14.0483	2811.3752	0.7473
4	75.2850	2828.3662	0.6981
5	22.3791	3055.1769	0.7320
6	-160.7895	3461.7828	0.7860
7	123.9018	3213.2358	0.6442
8	-36.3394	3290.6646	0.7623
9	72.6129	2790.0718	0.6866
10	0.4790	2899.7161	0.7422
11	91.1524	2713.9224	0.7035
12	96.6413	3076.5648	0.6552
13	-85.4786	3210.3099	0.7878

Table 41 (Contd.)

	1	2	3
14	46.5593	2955.4678	0.7057
15	-50.0457	3130.1099	0.7686
16	93.2084	2578.1384	0.6998
17	97.3152	3348.1508	0.7470
18	-59.4315	3070.2361	0.7654
19	97.1356	3143.8014	0.6449
20	64.6252	2979.2070	0.7182
21	57.0232	2761.5746	0.7432
22	130.3118	2945.7962	0.6607
23	82.7252	2500.5543	0.7196
24	-81.4454	3277.6782	0.7620
25	97.0433	3112.1617	0.7320

Table 42

Parameters of Logestic Curve $\frac{10^5}{y} = a + bc^x$ for Twelve weeks (WL Females)

	a	b	c
1	95.9604	2933.4640	0.6699
2	-40.1450	3538.7902	0.7500
3	87.1029	2921.8565	0.7428
4	-4.3844	3097.8299	0.7560
5	111.0199	3241.6301	0.6697
6	128.4539	3164.9644	0.6818
7	90.1409	3250.1878	0.7498
8	-48.2304	3104.5835	0.7730
9	34.0950	3021.2014	0.7554
10	121.1543	2796.1447	0.6975
11	112.9184	3269.5116	0.6633
12	142.9129	2916.3295	0.6410
13	58.1719	2881.8192	0.7269
14	88.0502	3646.6902	0.7115
15	19.0588	3534.9238	0.7396

Table 42 (Contd.)

	1	2	3
16	53.4551	2977.8694	0.7240
17	121.5038	2719.0934	0.6843
18	120.0781	3384.0546	0.7201
19	139.1120	2771.7523	0.6366
20	11.5627	3097.3389	0.6677
21	129.0548	2679.6500	0.6994
22	129.8010	2491.4208	0.6716
23	69.6240	2952.0803	0.7554
24	135.8773	3184.2892	0.6840
25	138.8442	2889.8807	0.6829
26	27.2826	2893.6029	0.7356
27	-4.7155	2773.6321	0.7718
28	36.3985	3020.9217	0.7254
29	92.9713	2903.2961	0.6653
30	112.6304	2618.8205	0.6914
31	110.0191	2969.9438	0.6703

Table 43

Initial body weights Y_0 and 'b' values of ALP(Males) by Rao's Method.

	Y_o	b
1	38	19.3325
2	38	14.6624
3	34	16.6862
4	36	19.0216
5	34	17.7459
6	38	15.5046
7	32	17.6362
8	38	16.6925
9	30	18.3814
10	34	17.7210
11	36	18.0691
12	34	18.4480
13	36	17.5005
14	32	18.2311
15	36	16.3643

Table 43(Contd.)

y_o		b
16	34	11.2933
17	30	15.6077
18	34	16.8071
19	38	14.3607
20	36	17.5515
21	34	19.0309
22	40	14.2797
23	32	19.1865
24	32	19.2342
25	32	16.1340
26	36	18.7466
27	40	16.6649
28	38	17.9089
29	34	16.0483
30	34	17.5273

Table 44

Initial body weight and 'b' Values of ALP (females) by Rao's Method.

	y_o	b
1	34	13.0539
2	30	15.0032
3	34	14.3761
4	36	12.9725
5	38	11.7115
6	30	14.6488
7	32	12.9072
8	34	15.3336
9	36	13.0068
10	36	13.1638
11	32	8.7409
12	36	14.6892
13	32	14.5604

Table 44 (Contd.)

	y_o	b
14	36	14.4406
15	30	13.6471
16	42	16.1866
17	36	16.4179
18	34	12.4288
19	32	17.2949
20	38	12.8103
21	36	10.9730
22	34	13.7442
23	36	14.6003
24	36	13.4303
25	32	13.9252
26	34	12.6786

Table 45

Initial body weights and 'b' values of WL (Males) by Rao(s Method.

	y_o	b
1	32	18.7479
2	34	17.2316
3	34	17.7971
4	34	15.7741
5	34	14.2201
6	30	13.9447
7	28	16.7276
8	32	17.2911
9	34	17.7602
10	32	12.6275
11	34	15.4512
12	32	15.1191
13	32	16.7645

Table 45 (Contd.)

	y_o	b
14	32	18.0965
15	32	9.6684
16	36	16.4506
17	28	11.8112
18	34	15.5329
19	30	16.5574
20	38	15.3208
21	34	13.6495
22	36	17.0215
23	36	14.6923
24	36	12.3872
25	32	14.7196

Table 46

Initial body weights and 'b' values of WL (Females) by Rao's Method.

	y_o	b
1	34	13.0865
2	32	12.7971
3	34	12.6505
4	34	13.1681
5	32	11.9246
6	30	12.7117
7	30	11.4008
8	30	12.3422
9	30	11.7952
10	36	22.5690
11	30	22.7782
12	30	10.0058
13	32	13.0634
14	28	11.2367
15	26	11.9423
16	36	16.2714

Table 46 (Contd.)

	y_o	b
17	34	11.6426
18	28	12.3472
19	32	12.7838
20	32	12.8239
21	34	10.7198
22	38	12.4705
23	34	12.0488
24	30	12.4749
25	32	11.8085
26	32	10.5137
27	34	13.2056
28	32	11.9538
29	34	13.4644
30	34	14.1269
31	30	11.9363

Table 47

Analysis of Covariance of initial body weights y_o and b values by Rao's Method.

Source	df	SS(x)	SP(xy)	SS(y)	deviation	df	Mss	F
Between Groups	3	158.9575	179.3635	385.9236				
Within groups	108	757.2925	62.9265	307.8923	302.6635	107	2.8286	
Total (Treatment + Error)	111	916.25	242.29	693.8159	629.7456	110		37.3123**
(Treatment + Error) – Error = Treatment.					316.6245	3	105.5415	

Table 47 (Contd.)

	CD for Comparison between				Means	Adjusted Means
	ALP (Males)	ALP (Females)	ML (Males)	ML (Females)	'b' Values	$\bar{\bar{y}}_{10} - (\bar{\bar{x}}_{10} - \bar{\bar{x}}_{00})$
ALP (Males)		0.8752	0.8846	0.8366	17.0793	16.9650
ALP (Females)			0.9150	0.8687	13.6363	13.5668
ML (Males)				0.8781	15.4217	15.4703
ML (Females)					12.3247	12.4544

To calculate adjusted means

$$= \frac{E(xy)}{E(xx)} = 0.0825$$

To test the significance of 'b'

$$'b' = \frac{E^2(xy)/E(xx)}{E_1} = 0.0294$$

DISCUSSION

DISCUSSION

The average body weight of the day old chicks was 35g for ALP males, 34.4615g for ALP females, 33.04g for WL male and 32.0645g for WL females. In the case of the last two, average weight was greater than the mean weight 31.26g reported by Chabra and Sapra(1973). But less than the 36g reported for males and females by Chueng-Shyang (1954) and the 39.1g reported by Jain and Sharma (1977). The day old male chicks had a higher mean body weight compared with the females of the same genetic group and this was in agreement with the findings of Bhatnagar et al.(1964). The ALP day old chicks had a higher body weight compared with the WL chicks.

Daily increase in mean body weight was observed in the ALP males during the first seven days. This was also true in the case of ALP females except that the body weight was almost stagnant on the second and third days. In WL males and WL females sudden depression in the mean body weight took place in the fourth day though there were increase at a slow rate during the first three days.

The mean body weights of WL males and females observed in the experiment in the third week were 71.12g. and 71.3548g. These were less than the corresponding figures of 143.8g. and 130.4g. reported by Chueng-Shyang (1954). The mean body weights of ALP males and ALP females were 78.53g. and 79.3077g. and these were higher than the corresponding figures for WL males and WL females.

The fourth week figures for WL group did not compare favourably with that of Reddy _et_ _al_.(1965 b). The analysis of variance of body weights of four groups at the end of the 4th week did not show any significant difference between groups. However significant results were noted in the initial body weights of the groups. At the initial stage, there was no significant difference between mean body weight of ALP male and ALP female.

Initially ALP male had a higher mean weight than that of WL male, ALP female and WL female. The nonsignificance in body weight at fourth week therefore indicates that the growth rate of WL female and WL male were higher than those of the ALP male and ALP female during the first four weeks. However the fourth week body weights of WL were less than the figures reported by the earlier workers. The fourth week mean weights obtained were less than the mean weight of 136.7g. reported for NL by Chabra and Supra(1973). Those were also less than the mean weights at fourth week of three different Crosses of Sussex and Fayoumi, breeds. These results also do not agree with those of El-Magraby *et al.*(1969) observed in crosses of Sussex and Fayoumi breeds.

The sixth week body weights of NL unfavourably compares with the findings of Reddy *et al.*(1965). The eighth week mean body weights were far less than those reported by Reddy (1965 b). They also do not compare favourably with the observations of Briones and Tonillo (1965) with respect to crosses of Cornish and White Rock.

Significant differences were noted in the body weights of males and females of ALP Breeds at the end of eighth week. The ALP males had a significant higher weight than all the other three groups. This indicated that the ALP males had a higher growth rate than the otherthree categories during the period fourth to eighth week. The finding that nonsignificant difference existed between the male and female in NL groups at fourth and also at eighth week is in contrast with the findings of Bhatnagar et al.(1964) and Reddy et al.(1965 a). The eighth week mean weights of ALP males and females were higher than those of Australorps and Fayoumi observed by El-Magraby et al.(1969).

The tenth week body weights of WL had an extremely unfavourable comparison with the findings of Saeki et al.(1963), Tanabe et al.(1965), Perez(1970) Reddy et al.(1965 b). The Eleventh week body weight observed in the experiment was less than half the weight reported by Morales (1965).

The mean weight of WL at the end of twelveth week was higher than those observed by Chabera and Sapra(1973), Mondonedo(1953), Reddy et al.(1965 b) with chopped straw as litter material, and El-Magraby(1969). But it compared unfavourably with the observations of Reddy et al.(1965 b) with ground nut husk as litter material and Briones and Tomillo(1965) and also with those of Sapranova (1971) for 90 days. The analysis at the end of twelveth week indicated significant difference between body weights of any pair of groups excepting the two female groups. ALP males had a superior growth rate than all others, next to it came the WL males. The growth rates of the two female groups were similar. The males therefore had a significantly higher growth rate than the female during the period eight to twelve weeks and this was in agreement with the findings of Tanabe and Saeki (1964). The body weight of WL males at 14th week was less than the weight reported by Pathak and Barsaul (1973). The corresponding weights for WL cited by Singh and Barsaul (1977) and Gawecki _et al._(1953) were slightly higher.

On the average the fifteenth week body weight of WL observed in the experiment was higher than the findings of Gawecki _et al._(1953) but less than what is reported by Singh and Barsaul (1977).

Under Penned and Caged system Sapranova (1971) has reported the mean body weight of WL male at 120 days. Both were less than the weight observed in the experiment at seventeen weeks. At 150 days, the weight of WL males reported by Sapranova (1971) was less than the findings of the experiment.

Though the average weights of birds in the experiment in the earlier weeks were less than those reported by some research workers, similar to those of some others and higher than those by still others, by the end of 23rd week the birds in experiment had higher mean body weights than those reported by earlier workers.

The analysis at the twentieth week revealed similar difference in body weights as at the end of the sixteenth weeks. Every group was different from every other group, the Males having higher mean body weights. Therefore the growth rates between sixteenth and twentieth weeks were such that they helped to maintain the initial difference between body weights at the end of the period. The analysis at the end of twentyfourth week revealed that there was significant difference between all groups. The order of mean weights were same as at the sixteenth and twentieth weeks, thereby showing that growth rates during the twentieth to twenty-fourth week were similar in character to the growth rates between sixteenth and twentieth weeks.

The analysis of 'b' values associated with modified exponential fitted to body weights of birds for twelve week showed that the rates of growth of the females were not significantly different. They were different for the two male groups. The rate of growth was higher for the ALP males. The same was the picture emerged when the analysis of rates of growth based on exponential curves fitted to the weights for the same period. Thus the two approaches for comparing the rates of growth during the twelve week will yield same result. One cannot be said to be superior to the other.

The initial body weights of ALP (males) were the highest and they have maintained the higher rate of growth both by exponential approach and modified exponential approach. By the end of twelve weeks these birds should have higher mean body weights and it should be higher than the body weights of WL males which had a lower rate of growth compared with ALP males. Since ALP females maintained lower rate of growth than both WL males and ALP males, average body weight at the end of twelve weeks should be less than those for the other two.

THE WL females had a slight edge in growth rate over ALP females and therefore the former is expected to wipe off the initial difference in body weight as was evident from the analysis of the fourth week weight and hence, at the end of twelve weeks, the picture that would emerge on the basis of observed rates of growth should be highest mean weight for the ALP males, second highest for WL males and almost equal weights for the two female groups each different from the two male groups. The analysis of the body weights at the end of twelve weeks confirmed this. There was significant difference between the body weights of male groups each superior to each of the female groups which were not significantly different.

The modified exponential as also exponential gave a very good fit to the twelve weeks body weights of the birds as revealed by the high coefficient of correlation (nearly unity) between the observed and expected weights of each bird and this was in agreement with the observations of Susaki (1966), Pillai *et al.*(1969) and Zelanka (1970, 1979.). Thus it is concluded that analysis of rates of growth based on the 'b' values of modified exponential and exponential curves fitted to the observed body weights for twelve weeks is exquisitely correct.

Analysis of rates of growth of four groups of birds based on exponential curve, showed significant difference between the four groups. The very same conclusion was arrived at, when the estimated rates of growth obtained by fitting Gompertz curve for each bird were analysed. The exponential fit was very close for weekly weights for twenty-four weeks as indicated by high correlation between observed and expected body weights. There was initial difference between body weights of birds. Since subsequent rates of growth were different, the final mean weights attained by the four groups are expected to be different. The analysis of twenty four week's weight showed that the mean values of the four groups were distinct and the mean values of ALP males, WL males, ALP females and WL females were in decending order of magnitude. These results, justify the validity of rates of growth as indicated by exponential curve. Since, the analysis of rates of growth, by the exponential approach and Gompertz curve approach have given identical results, both approaches are valid for comparing the rates of growth of the four groups of birds for twenty four weeks.

It is a well known fact that fitting exponential is easier than fitting Gompertz or modified exponential curve to a given data. Hence for the comparison of rates of growth, fitting exponential curve and comparing the b' values of different groups through a simple analysis of variance can be recommended and it is most effective.

The approach of Rao (1958) revealed that there was significant difference between rates of growth of four groups. Each group had a rate of growth distinct from others. By this method the rates of growth of ALP males, WL males, ALP females, WL females were in descending order of magnitudes. The method suggested by Rao is thus equivalent to other approaches, viz., the exponential approach or modified exponential approach, for the comparison of rates of growth.

The twenty-four weeks actually covered the entire period of growth of the body weight of the birds because weights at twenty third week and twenty fourth week were almost identical.

The exponential and Gompertz curves gave good fit to data for 24 weeks. However a better fit was given to the data for 12 weeks by the exponential and fodified exponential forms.

SUMMARY

SUMMARY

With a view to compare rates of growth of domestic fowls an experiment was initiated on October 23, 1980. It consisted of 112 day old chicks of which 30 were Australorp males, 25 Australorp females, 25 White Leghorn males and 31 white Leghorn females. Body weights of these birds were recorded for twenty-four weeks at weekly intervals along with daily weights for seven days. The chicks were hatched and reared at Kerala Agricultural University Poultry Farm, Mannuthy, under same feed formula and identical management practices. The weights of birds when plotted against time approximated a sigmoid curve.

The initial body weights were 35g. for Australorp males, 34.4615g. for Australorp females, 33.04 g. for WL males and 32.0645g. for WL females. It was 45.9333g., 45.2033g., 42g., 41.92g., respectively on the seventh day. In general, males in each genetic group had a higher mean weight on the first seven days and the Australorp group outwayed the other. The White Leghorn group recorded a degrowth in body weight on the fourth day which eventually improved from next day onwards.

A plateau in body weight was observed during the twenty-third week in almost all the birds and the overall increase in the average body weight during the twenty-four weeks was about 1323g. for ALP males, 1454g. for ALP females, 1524g. for White Leghorn males and 1278g. for White Leghorn females. The analysis of variance of initial body weights of four catagories of birds revealed significant difference between males of the genetic groups, females of the genetic groups, and Australorp males and White Leghorn females. The initial differences between the groups was not maintained at all later stages. At the end of the fourth week there was no significant difference between the groups.

Difference between the groups emerged slightly during the eighth week. The analysis of variances showed that the groups were not homogeneous and this was due to higher body weights of Australorp males compared with those of the other three. The difference between the group was more visible during the twelfth week. Non-significance was observed only between femalesof the two genetic groups. But at the sixteenth week all the four groups were significantly different. This feature was found to exists in the twentieth and twenty-fourth weeks.

As the pattern of growth approximated a Sigmoid curve, the models considered for describing the growth were exponential, modified exponential, Gomperts and logestic. Barring modified exponential all others could be fitted for twenty-four weeks data. Exponential was found to give good fit to the data in individual birds with a correlation between observed and expected body weights around 0.9 The form of the exponential considered was

$$y = ae^{bx}$$

The mean value of b, was 0.1689 for Australorp males, 0.1572 for Australorp females 0.1641 for White Leghorn males and 0.1527 for White Leghorn females. The compound rate of growth during twenty-four weeks was 18.41 percent for Australorp males 17.03 percent for Australorp females, 18.85 percent for White Leghorn males and 16.48 percent for White Leghorn females. The analysis of 'b' values for the four groups showed that groups were not homogeneous. The rate of growth was the highest for Australorp males, second highest for White Leghorn males, next height for Australorp females and the least for White Leghorn females.

The form of Gompertz taken was

$$\log y = \log a + c^{x} (\log b)$$

The relevant analysis also showed that the rates of growth was distinct in each group. The Logistic curve fitted, indicated the same conclusion.

Modified exponential in the form

$$y = ab^{x} - c$$

was fitted to twelve week body weights of each of the 112 birds. The mean values of 'b' was 1.2746 for Australorp males, 1.2272 for Australorp females, 1.2586 for White Leghorn males and 1.2346 for White Leghorn females. The analysis of 'b' values led to the inference that the groups were not homogeneous. There was significant difference between the rates of growth of males and females of each genetic group, and White Leghorn male had a higher growth rate than the Australorp female. The correlation between observed and expected weights was nearly unity in all cases.

For the sake of comparison, the exponential was fitted to body weights of twelve weeks. The fit was extremely good and correlation between observed and expected was nearly unity and this showed that exponential also described exquisitely the growth during the period. The 'b' values were 0.2904 for Australorp males, 0.2680 for Australorp females, 0.2842 for White Leghorn males and 0.2624 for White Leghorn females. The compound rate of growth by exponential was 33.71 percent for Australorp males, 30.75 percent for Australorp females, 32.89 percent for White Leghorn males and 30.64 percent for White Leghorn females.

The analysis of 'b' values led to the same conclusion as in the corresponding analysis for modified exponential. Fitting modified exponential and exponential was therefore identical for twelve weeks of body weights.

If g_i is the time metameter at the i^{th} intensal, increase in weight during the interval 'i' is taken as b g_i by Rao (1958). The relevant analysis of covariance with initial body weight as concomitant variable showed that rates of growth of all the four groups were distinct. By this method the rates of growth of Australorp males, White Leghorn males, Australorp female and White Leghorn females were in decending order of magnitude.

In general, the method suggested by Rao is equivalent to the other approaches viz., fitting the exponential or Gompertz and comparing the values of the parameter or function of the parameter representing relative growth.

Twenty-four weeks were actually found to cover the entire period of growth of body-weights of birds, because the weights at the twenty-third week and twenty-fourth week were almost similar.

The exponential and Gompertz curves gave equally good fit to data. However better fit for 12 weeks of the data was given by exponential and modified exponential.

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PATTERN OF GROWTH
IN
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BY
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ABSTRACT OF A THESIS
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ABSTRACT

Under uniform feed formula and identical management practices, 30 Australorp (ALP) males, 26(ALP) Females, 25 White Leghorn (WL) males and 31 (WL) females, were reared for 24 weeks in Kerala Agricultural University Poultry Farm, Mannuthy to study their growth patterns.

The initial mean body weights of chicks were 35g., for ALP males, 34.4615g.. for ALP females, 33.04g.. for WL males, 32.0645g., for WL females. Throughout the experiment males in each genetic group had a higher mean weight than females. A plateau on the body weight was reached by the end of 23 weeks in almost all birds, indicating that 24weeks completely covered the growth period. By the end of the experiment the mean body weight was 1858g.. for ALP males, 1488.4615g., for ALP females, 1556.8g., for WL males, 1306.1290g. for WL females.

Though there was no significant difference between the groups at the end of the fourth week, significant differences between pairs were observed after 16 weeks.

Exponential ($y = ae^{bx}$), Gompertz ($y = ab^{c^x}$) and Logestic ($\frac{10^5}{y} = a+bc^x$) curves were found to be suitable for fitting body weights for 24 weeks. The first two gave extremely good fit. Modified exponential was good only for data of twelve weeks.

When growth rates for twenty four weeks were compared on the basis of the fitted curves for all birds the conclusion arrived at was the same for exponential and Gompertz curves. The rates of growth for ALP males, WL males, ALP females WL females and were in the descending order of magnitude; they were significantly different. Same was the inference obtained when Rao's method of comparing rates of growth was adopted. The result obtained for comparing the rates of growth by fitting Exponential and Modified exponential for the body weights of birds for 12 weeks were similar. Both the curves gave very satisfactory fit to the data. The coefficient of correlation between the observed and expected body weights was nearly unity in almost all cases.