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Title Nitrogenous Constituents in the Blood of Four Lines of Calves

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Certain nitrogenous blood components and production traits were studied on 57 Hereford calves and 37 Angus calves from birth to 800 pounds body weight. To determine sex, line and age differences, an analysis of variance was performed on the characteristics at each weight period.

Male calves had higher nursing and feed-test gains than female calves and required less feed to make a unit gain. The greater efficiency of male calves is probably due to a difference in enzymatic activity and production of growth hormone.

Female calves consistently had higher blood urea nitrogen concentration than male calves. Female calves also consistently had higher serum protein concentration than male calves.

Blood urea nitrogen, serum protein concentration, specific gravity, and serum gamma globulin increased with increases in age and weight of the calves.

Rapidly gaining calves had a blood composition that was similar to that of younger calves while slowly gaining calves had a blood composition that was similar to that of older animals.

Blood urea nitrogen was negatively correlated with feed-test gains and positively correlated with feed per unit gain at 500 and 700 pounds body weight.

Female calves were an average of 32.6 days older than male calves at 500 pounds body weight. At 800 pounds body weight, the female calves were an average age of 64.1 days older than the male calves. Therefore, it appears from this study that differential growth rate and relative amounts of certain blood components between male and female calves can be in part attributable to a differential age at a particular weight period and in part to a differential hormone balance between male and female calves.

NITROGENOUS CONSTITUENTS IN THE BLOOD OF FOUR LINES OF CALVES

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INTRODUCTION

Blood is a complex mixture of protein components of wide and varying size, shape and function; and non-protein components that serve a variety of functions. By separating blood into a series of relatively pure components, one can study the properties of each by methods now at our disposal. Thus, these methods make a study of the interactions and interrelationships between these components possible.

One of the principal contributions of isotope methodology to biochemical thinking has been the experimental verification of the concept of the dynamic state of body constituents. These studies demonstrate that there is a constant interchange of dietary feed constituents with the body constituents and that the body constituents are in a state of flux, of continuous synthesis and degradation. This ceaseless flow of interconversion and synthetic and degradation reactions is exemplified by the utilization of the feed amino acids for plasma and serum protein formation.

A major function and characteristic feature of metabolism in animals is the maintenance of approximate qualitative and quantitive constancy of the chemical constituents of the tissues and body fluids at rest. The restitution of stationary

composition of the blood following alterations due to functional activity of adaptive response also occur. Stability of the chemical pattern of the living organism is based upon coordination of the metabolic processes by the complex interplay of neural and humoral regulations and the automatic control of intercellular reactions. Like other metabolic processes, the metabolism of nitrogen, i.e., the sum of biochemical transformations of proteins, is more or less rigidly controlled.

Growth, reproduction, repair, maintenance, resistance to diseases, and all of the faculties of the living system are correlated with the intake and utilization of feed proteins. Through digestion in the gastrointestinal tract, amino acids and possibly polypeptides both of which are the raw materials needed to build the body proteins of animals are furnished. The body proteins form the matrix of the living system; they are the catalysts, the centers around which the dynamic equilibrium of life develops; they form the tissues of the body, the protein stores. These stores are the proteins of the gut, the plasma or serum, and the other tissues of the body.

The present study is concerned with one of these protein stores, blood serum. This study has as its objectives the determination of the association of one non-protein nitrogen component (urea nitrogen) with production traits to ascertain if the

relationships are of such a nature that they might be used to predict future performance. The protein nitrogenous components studied also have been correlated with production or growth and development, with the intention of determining if relative amounts of the various protein and non-protein components in the blood may be used to characterize relative rates and efficiencies of growth.

As animals grow older certain changes occur in their metabolism, since there is a gradual shift from protein synthesis for growth to the deposition of fat as the animal reaches a plateau in growth. What effect, if any, does this metabolic change with increase in age have on the level of nitrogenous components found in the blood? If there is an association of the level of nitrogenous constituents found in the blood with a difference in growth rate, efficiency of feed utilization and age - perhaps concepts can be developed regarding protein metabolism which will aid in developing an index to predict future performance. This study was designed with the idea of finding answers to some of the above questions.

LITERATURE REVIEW

Descartes once said, "How do you know that that idea would have come before your mind if you had not been nurtured among men of culture, but had passed all your life in some desert spot? Have you not derived it from reflections previously entertained, from books, from interchange with your friends, etc., not from your own mind alone or from some supreme being who exist?" On the other hand, Francis Bacon once wrote, "It is idle to expect any great advancement in science from the superinducing and engrafting of new things upon old. We must begin a new from the very foundation, unless we would revolve forever in a circle with mean and contemptible progress." Perhaps Bacon's point bears some merit today, and probably a stronger merit during the time in which he wrote, because there is a certain tendency for researchers to become too engrossed in some great man's theories on how a particular thing should be done, stifling their own originality which may well be a contribution to science. Thereby one becomes a mimic which could be desirable or undesirable depending upon the man being emulated. Yet I cannot help from being partial toward Descartes's philosophy, due to conditioning no doubt, since by incorporating or correlating the findings of

others with one's own, greater progress should occur in a shorter period of time. Therefore the literature review serves a two-fold function of providing a source of information from which one can build new concepts, and a guide to prevent one from the unnecessary duplication of work that has already been performed.

The standard method for the determination of protein concentration is by the Kjeldahl procedures. This method involves digestion and exidation, converting the nitrogen present to the form of ammonia, and determining the amount of nitrogen from which protein can be calculated. For blood analysis with its inherent limitations in amount of material available, this macro-kjeldshl method may be replaced by various micro-kjeldahl methods. To make satisfactory determinations more rapidly and simply than is possible by the micro-kjeldahl methods, several direct colorimetric, turbidimetric and specific gravity procedures have been developed.

The method used in the present study is based upon the fact that proteins are by far the most abundant constituent in the blood, hence the specific gravity should be determined largely by the protein content. The copper-sulphate method of determining specific gravity, as outlined by Phillips et al. (26, p.607-610) was used to obtain total protein concen-

trations. Moore and Van Slyke (38) showed that the specific gravity of serum was essentially a straight line function of its protein content. This information led to extremely rapid methods for the determination of total serum protein.

Barbour and Hamilton (26, p.607-610) and Kagan (28) developed a series of copper sulphate solutions to be used in the determination of serum or plasma specific gravities. The chief disadvantage of the falling drop method of Barbour and Hamilton was the dependance on the size of the drop and the temperature. Lowry and Hunter (36) developed the gradient tube method which removed the disadvantages inherent in the falling drop method of Barbour and Hamilton. The gradient tube seemed to be the answer to most problems that are connected with specific gravity determination but it requires special instruments. In 1944 Phillips and Van Slyke et al. (21) revised the old formula for the determination of protein concentration in blood from specific gravity procedures, making it applicable to the falling drop method of Barbour and Hamilton.

Bernstein (9) found that the correlation of protein concentration with specific gravity was high (0.86) in normal sera and altered albumin-globulin ratios did not influence the specific gravity to any extent.

The effect of varying salt, glucose, and non-protein nitrogen contents presumably prevent accurate protein determination by the specific gravity method, but are not sufficient to interfere with obtaining valuable practical results. The question arises as to how nearly the albumin and globulin fractions exert equivalent influences upon the specific gravity of the serum? Since, if these were not almost the same in effects, the total serum protein content will depend upon the albumin-globulin ratio. Nugent and Towle (39) performed a study on synthetic solutions of serum albumin, serum globulin, and mixtures to ascertain if the effects of the albumin and globulin fractions were almost the same.

Nugent (39) observed that when the specific gravity is plotted against the total protein concentration, the points for all albumin-globulin ratios are found to be distributed uniformly about a single straight line leading the workers to conclude that beef serum albumin and globulins exert effects upon the specific gravities of their synthetic solutions which were identical to methods usually employed for the accurate determination of specific gravity values.

Phillips (26, p.206-210) found that deviation in accuracy of plasma protein concentration could partly be due to the influence of non-protein constituents on specific gravity of the

plasma. Lowry and Hunter (36) found that in order to influence the apparent serum protein concentration by as much as 0.1 gm. percent it would be necessary to double the normal concentration of either the serum lipids, the blood glucose, or the non-protein nitrogen.

Peters and Van Slyke (40) have reviewed the many physical methods for the determination of total serum protein and have concluded that the specific gravity method is the most accurate. These workers not only concluded that this method was easy, time-saving and can be done with extremely small amounts of blood, but, it provided a measure of protein content with an accuracy which exceeded clinical requirements, and was twice as accurate as the refractometric method.

Proteins are synthesized in the living system from twenty or more amino acids. Protein anabolism results when amino acids are joined one to the other through peptide linkages. These anabolic processes allow for the production of the albumin, the constituent of serum responsible for most of its specific gravity, the blobulins, the immunity carriers and transporters, and numerous other important building blocks. The complex process of synthesis of proteins from amino acids cannot be set apart from the reverse process which is an expression of integrated anabolic and catabolic processes; one

process being dependent on the other. The dynamic state of body proteins does not represent a shift of amino acids from one protein to the other, or from one tissue to the other without loss. The process of tissue breakdown and regeneration result in the irreversible destruction of some of the amino acids, an essential destruction which yields energy to the living system. Urea nitrogen is the end waste produce of this catabolism of amino acids.

Practically all of the methods in use at the present time for the determination of blood urea are based upon incubation with a preparation of the enzyme, urease. The urea present is converted into ammonium carbonate. The ammonium carbonate formed may be determined directly by colorimetric methods, or separated either by aeration or distillation and then determined either colorimetrically or titrimetrically. The carbon dioxide produced by decomposition of ammonium carbonate may be determined gasometrically. The choice of procedures among many available appears to be largely a question of facilities of the individual laboratory. Therefore, the method of Karr (26) was chosen for this study because it was adaptable to the laboratory facilities present. By the action of urease, the urea in a protein-free filtrate is converted to ammonium carbonate which is nesslerized in the presence of gum

ghatti as a protective colloid. The interference of peptones and amino acids is regarded as so slight and so uniform as not to influence the value of the results.

The proteins of the serum can be sub-divided into components by many different procedures but the method that has obtained wide use was developed by Tiselius (53). The determination of the albumin and globulin fractions for sera of normal adults (13; 20; 27) and with the changes in the serum components of young calves before and after suckling (45;48) have been the object of many studies using the "classical" Tiselius apparatus.

Investigations of serum protein fractions have been further enhanced by such optical devices as the cylindrical-lens system of Philpot(42) and Svensson (52) and Longsworth's scanning technique (34) enabling photographic recording of refractive index gradients. The efforts in recent years have led to numerous refinements in procedure, notably improved resolutions of the peaks in electrophoretic patterns by Longsworth's introduction of 0.1 N sodium diethylbarbiturate buffer at pH 8.6.

Colloidal particles carry electrical charges which are considered to be distributed over the surface of the entire particle. Because of the presence of electrical charges, the

particles in a colloidal solution migrate toward one of the poles in an electric field. The advantages of this method is manifested in the differences in mobility of the different ions present.

The electrophoretic patterns consist of a series of peaks in a definite sequence of sizes and shapes. It should be pointed out that although electrophoretic separation provides greater detailed information than ordinary chemical fractionation, the areas under the separate peaks do not represent quantities of "pure" proteins, but indicate closely related proteins with similar mobilities. The peaks obtained include those of simple proteins, lipoproteins, glycoproteins, and traces of numerous proteins that function as immune bodies, enzymes and hormones.

Gutman (23) found that the principal limitation of the electrophoretic analysis lies in the fact that the separation of protein components depend upon a single property, their mobility in an electrical field. Some serum though of very different molecular size and shape, chemical composition, and biological significance, happen to have the same or similar mobilities and appear together in apparent homogenous peaks. Despite this limitation, the electrophoretic method has proved an invaluable aid in the analysis and purification of serum proteins.

Serum Protein Nitrogen

The amount of protein required per day is a nutritional factor of practical significance to the animal breeder. The efficiency with which a given protein (40, 934) supplies the nitrogen requirement of an animal may be defined as the biological value of the protein. Broadly speaking, a protein of high biological value is one which has a high digestibility and absorptivity and which supplies the organism with an adequate amount of the amino acids it needs. The relationship between the amount of nitrogen excreted from the body in the form of metabolic end-products (chiefly urea) and the amount of nitrogen entering the body from the diet in the form of amino acids or proteins is known as the nitrogen balance (40, 935).

The young animal must be in positive nitrogen balance since a certain portion of the ingested nitrogen is retained as newly formed body protein and non-protein nitrogenous compounds. The normal adult is ordinarily in a state of nitrogen equilibrium.

Larson and Touchberry (32) observed a tendency for older animals to have a higher "normal" level of proteins in the serum than younger animals. Since information could not be found in the literature indicating that such a relationship existed in bovine or for that matter any other species, studies

were undertaken involving a significant number of dairy cattle of all ages to elaborate further on the preliminary observations. From that study, they found a highly significant correlation (positive) between age and blood serum proteins in the bovine. The increase in total protein concentration with age was attributed to the increase in several blood protein fractions associated with immunity.

Smith and Holm (50) and other workers have shown that the protein level in the serum of the new-born bovine is low (4-5%) but increases when the new-born consumes colostrum. Proteins, including globulin antibodies, present in the colostrum are transferred across the gut wall into the blood stream of the new-born during the first 24 hours. The passage of proteins apparently does not raise the blood serum protein level to a "normal" level; the work of Larson and Touchberry (32) indicated that the serum protein level continues to increase for several years.

The fact that bulls sampled in this study also showed increased globulin values with an increase in age indicates that the increased globulin values reported for the cows with an increase in age were valid. In cows there is a normal fluctuation in the serum protein level, increasing prior to parturition and decreasing immediately following parturition.

Cornalius et al. (18) made a study on 38 Hereford and Angus dwarf cattle ranging in age from 6 days to 14 months. From this study it was concluded that the blood serum protein values were within the normal range for the bovine. An average total serum protein value of 6.03 ± 0.9 percent was reported.

Bradish et al. (13) studying serum protein concentrations in 51 Devon steers ranging in age from 18 to 30 months of age, found an average serum protein value of 6.97 ± 0.53. Kunkel et al. (30) made a study of serum bound iodine in 54 head of beef calves, 8-11 months of age, in three feeding trials. The results indicated that Hereford and Angus calves that showed wide variation in protein bound iodine exhibited a wide variation in rate of gain. Under some conditions, a negative correlation between the level of protein bound iodine and feed lot gains was observed. A study on a group of Hereford and Angus bulls indicated that this negative correlation existed only in animals which had an optimal or high level of protein bound iodine. A low level of protein bound iodine may be accompanied by lowered rates of gain.

Belhova (8) found that as cattle grow older, the ability of their serum proteins to form complexes with cholesterol and the phosphatases increased for alpha globulin, decreased for

gamma globulin and did not change for beta globulin. Complex-formation intensity of albumin varied in narrow limits with age of the bovine, as compared with the globulins, and differed from the globulins basically in the complexes formed (10).

Kunkel and Green (31) found evidence from a study that indicated that a part of the globulin fraction as well as part of the albumin fraction is related to gaining ability. Preliminary evidence suggests a positive relationship between the glutha-thlone concentration in the erythrocytes and the albumin frac-tion, because of the interrelations between albumin and glutha-thione, the interpretation of serum protein-gain relationships are quite difficult to make.

In the electrophoretic study of the blood plasma from twenty species of animals, including domestic animals and birds, Deutsch and Goodloe (20) concluded that distinct spe-cies differences in mobility, amount, and number of protein components occur. There was greater constancy within spe-cies than between species.

Wayman and Asdell (55) made investigations on the phys-iology of bovine nymphomania. Observations of six nympho-maniac cows showed a total blood protein concentration of 9.23 gms. per 100 ml. while six normal cows had values of 7.61 gms. per 100 ml. The protein fractions for the normal cows

were 3.05, 4.56, 0.65, 1.57, and 2.34 gms. per 100 ml. for albumin, total globulin, and alpha, beta,and gamma globulins, respectively. The nymphomaniac cows had 2.31, 6.41, 0.73, 1.95 and 3.73 gms. per 100 ml. for albumin, total globulins, and alpha, beta, and gamma globulins, respectively.

Svensson (52) studying electrophoretic distributions of serum protein expressed as a percentage of the total protein concentration, gave means of 41.0, 14.4, 7.4, and 24.9 for albumin, and alpha, beta, and gamma globulins, respectively. Bradish et al. (14; 15) found an increase in gamma globulin from 3-10 percent above normal values between the third and sixth week following innoculation with the virus, vesicular stomatitis. The beta globulin fraction increased about 4 percent but was back to normal after the first week. Likewise, other studies indicated that changes in the electrophoretic distribution of normal sera of a single animal are such that differences exceeding 3 percent in concentration of any component may be regarded as abnormal.

Allison (4) agreed with other workers that the increase in the concentration of alpha and beta globulin, so often associated with disease, may be primarily the result of malnutrition. In many metabolic disorders, there is a pronounced elevation

in the amount of alpha globulin estimated electrophoretically.

Hogness (27) made an electrophoretic analysis of bovine plasma and serum and gave the following values for the protein fractions expressed as a percentage of the total: albumin - 38.0, alpha - 20.4, beta - 16.9, and gamma - 24.7 globulins.

Pierce (43) found that the electrophoretic pattern of pre-colostral calf serum frequently showed two alpha globulin components on the descending side which were not apparent or were indicated by an assymmetry in the alpha component on the ascending side. Therefore, the presence of two alpha components is not always clear because of poor preparation. In the same study, neonatal protein concentrations were studied electrophoretically in four calves. The results indicated that one day after suckling, the protein component of the adult electrophoretic pattern associated with the gamma globulin fraction increased from a pre-colostral level of less than 2.2 percent to 25-33 percent after feeding colostrum. This acquired globulin showed considerable electrochemical spreading and only one peak could be distinguished. The alpha globulin fraction declined shortly after birth in the colostral-fed group; the alpha globulin fraction first rose then fell in the non-colostral fed group. The beta globulin frequently showed transient though marked increases when the alpha globulin fraction was at its

lowest value. No changes in the electrophoretic mobilities of the major serum proteins were detected as the calves matured; and no significant difference was found between the mobilities of the electrophoretic components of calf and adult sera.

Smith and Holm (30) observed marked increases in the mobility and concentration of serum albumin and alph globulin with increases in age of growing cattle. Perhaps the small number of animals used in the study by Pierce had something to do with his not obtaining any difference in mobility and concentration with maturity.

Reference to serum proteins related to rate of gain per day and efficiency of feed utilization of feed test was given by Price (47), who found a significant correlation between rate of gain per day and albumin. Ampy (5) studying a group of Hereford and Angus calves from 500 to 800 pounds body weight found indications of a possible relationship between the amount of gamma globulin, estimated electrophoretically, and growth rate. The males had higher gamma globulin fraction than the females. The constancy of the pattern of the serum proteins observed, even in many of the abnormal conditions reported, points to the greater capacity of the serum proteins for maintaining a relatively constant internal environment in the living animal.

Serum Urea Nitrogen

The protein pool may be considered as the summation of protein metabolism in many centers, which are integrated into a dynamic state of the whole body. It is assumed from the calculation of protein turnover that a dietary amino acid entering into the dynamic system will either be used for synthesizing protein tissue or deaminized to contribute to the excretion of urea.

Allison (3) stated that the excretion of urea is the result of a continuous metabolism of tissue and dietary proteins. From this catabolism a urea pool develops in the body, a pool which Pietro and Rittenberg (44) using N^{14} labeled urea, have determined to be merely identical in space to body water. The magnitude of excretion of urea is usually high when the tissue proteins of the animals are maximum, and low when the proteins are in a depleted state. The greater the labile protein component, the greater the supply of tissue amino acids is utilized for energy and for maintaining essential structures. Thus, catabolism of tissue amino acids to form the waste product, urea, is continuous, the amount being low when the stores and activity are low. Allison (3) states that evidence is beginning to be accummulated that indicates that high protein stores with the high catabolic activity give energy and reserves to

meet the stress and strains of living. The formation of urea is limited almost entirely to the liver (12). The modern concept of urea formation states that carbon dioxide, ammonia, from oxidative deamination of amino acids, and ornithine combine to give citrulline. Then citrulline reacts with more ammonia to give arginine, which by the action of the liver arginase is broken down to urea and ornithine for repetition of the cycle. Once formed the urea does not exchange amino groups with proteins or amino acids.

Greatorex (22) made monthly examination on each of four adult animals in four breeds and weekly examinations on 80 calves under one year of age to study blood urea nitrogen. The urea values were higher in the calves during the first three months than during the second period, followed by a gradual increase. The range of blood urea nitrogen was between 2.8 and 13.4 mgs. per 100 ml. with the mean varying between 4.3 and 9.1 mgs. per 100 ml. of blood. Values were much lower in January, February, and March than the rest of the year, with the highest values being obtained in August.

Austin et al. (6) found that the rate of urea excretion per unit of body weight in the normal dog or man increases in a simple direct proportion to the blood urea concentration and

in proportion to the square root of the rate of volume output of urine per unit body weight, as long as the volume rate remains within normal limits.

Colby et al. (17) studying relationships of various blood constituents to rate of gains in beef cattle, found that the mean level and correlation coefficient of urea with rate of gain were 11.98 mgs. percent and r = -.55 respectively. This was not a significant correlation coefficient.

Bloch (11) stated that while the major nitrogenous end-product of protein metabolism in mammals is urea, it appears to serve no nutritive purpose.

Williams (57) conducted a study on changes in certain nitrogenous blood constituents which might be associated with growth and development in Hereford calves and found that blood urea nitrogen showed a sex difference. The heifer calves showed higher urea nitrogen values than the bull calves.

Prince (47) in a study of Hereford and Angus calves found that feed intake had a significant affect on urea nitrogen levels in the blood. The blood urea nitrogen increased as feed consumed per 100 pounds increased.

MacDonald (37) observed in a group of 45 Angus and Hereford calves at the Oregon Agriculture Experiment Station that as rate and efficiency of gains decreased, blood urea

nitrogen concentrations per 100 cc. of blood increased in a somewhat linear manner at both 500 and 800 pounds body weight.

Since urea nitrogen represents one of the intermediary products of protein metabolism enroute to excretion, it is not very difficult to understand that a knowledge of its concentration in the blood could possibly serve as a criterion of the state of protein metabolism and perhaps as a measure of the rate of protein catabolism.

METHOD

Data for the present study were obtained from calves born in the spring of 1959 and 1960, and maintained at Oregon Agricultural Experiment Station, Corvallis, Oregon. Data were taken from 59 Hereford and 37 Angus calves.

The Hereford calves represented three genetically different lines of cattle. The Lionheart line has been closed since 1950 to outside breeding. The Prince and David lines originated from the same stock. No outside breeding has been introduced into the Prince or David lines since 1948.

The calves born in the spring of 1959 were studied during the feed test period, that is, from 500 to 800 pounds body weight. The calves born in the spring of 1960 were studied at each 100 pound increment starting at 100 and continuing through to 800 pounds body weight.

Calves during the suckling period were kept on pasture with their dams until weaning either at 400 pounds or the first Wednesday in November. During the feed test period the calves were grouped by sexes into pens of six animals. From the beginning of the feed test period the calves were tied by neck chains while being fed. The calves were fed twice daily a completely pelleted ration of two-parts chopped alfalfa and one

part concentrate. For a more detailed review of the management procedures, a paper by Dahmen and Bogart (19) is recommended.

Blood Collection

Two separate blood samples were taken on each calf at each 100 pound increase in weight. One sample was collected in an oxalated tube to prevent coagulation from which a protein-free filtrate was obtained for urea nitrogen studies. The other was collected in a 10 ml. centrifuge tube without any oxalate to obtain serum after coagulation and centrifugation for the other studies on protein nitrogen.

The samples were taken from 5:30 to 6:30 a.m. on calves being feed tested prior to feeding in order to minimize the effects of ingested materials on the chemical composition of the blood. Of course, it was not possible to collect blood at a time removed from eating with the suckling calves, therefore, collections of samples were always done between 9:00 a.m. and 10:00 a.m. Immediately after collecting the sample, chemical analyses were initiated.

Chemical Analysis

Total Serum Protein Nitrogen and Specific Gravity

The specific gravity and total serum proteins were determined by a modification of Barbour and Hamilton's falling drop method (26, 553-556). This method involved the preparation of a series of standard copper sulphate solutions of known and varying specific gravities, differing by 0.001 in specific gravity. With a syringe a sample of the serum to be tested was dropped from a height of about 1 cm. above the solution into the copper sulphate having approximately the specific gravity expected. The behavior of the drop was observed for about 10 seconds after the serum drop had lost the momentum of the fall. If the drop rises at all during the time, it is lighter than the tested solution; if the drop continues to fall, it is heavier than the tested solution; if the drop remains stationary, it has the same specific gravity of the solution. Since the specific gravity is a straight line function of the serum protein concentration, a formula has been introduced from which it is possible to calculate serum protein concentrations from the specific gravity. The formula is as follows:

$$P = 360(G - 1.007)$$

where P represents the protein concentration, 360 represents a

constant base upon specific gravity measurements by pycnometer and upon protein concentrations calculated by Kjeldahl determination; G represents the specific gravity of serum sample being tested; and 1.007 represents a constant which approximates the specific gravity of solutions of serum crystalloids free of proteins.

Serum Protein Fractionation by Paper Electrophoresis

Serum protein fractionations were performed on a Spinco model R Electrophoresis apparatus as outlined in the operations manual (51). The strips were analyzed by a commercial integrating scanner (51) to determine the relative concentrations of the different protein fractions. A detailed description of the procedures has been given by Ampy (5).

Serum Urea Nitrogen

Serum urea nitrogen was determined by Karr's method (26, 505-506). By the action of urease, the urea in a protein free filtrate is converted to ammonium carbonate which is nesslerized in the presence of gum ghatti as a protective colloid. This method is a standard method for the determination of urea nitrogen by spectrophotometric methods.

Statistical analysis

The data for this study were analyzed for sex, line, breed, year and age effects by the method of least squares as outlined by Petersen (41). Studies made earlier indicated that although age and weight were confounded in a model, some information was obtained by doing an analysis with age held constant along with other variables sex, line, breed and year. Therefore, the model used was as follows:

$$Y_{ijk} = \mu + B_j + C_k + (DC) + A_m + e_{ijk}$$

Where Y_i = an individual measurement of either

1. Specific gravity
2. Total serum proteins
3. Serum albumin
4. Serum alpha globulin
5. Serum beta globulin
6. Serum gamma globulin
7. Serum urea nitrogen
8. Rate of gain for a particular weight period
9. Feed efficiency for a particular weight period
10. Total rate of gain
11. Total feed efficiency
12. Suckling gains

Where

μ = the added effect due to the mean
B_j = the added effect due to the j^{th} sex
j = male or female
C_k = the added effect due to the k^{th} line
k = Lionheart, Prince or David
D_l = the added effect due to the l^{th} year
l = 1959 or 1960
DC = the added effect due to the interaction of year with lines

A_m = a continuous variable
m = age
e_{ijk} = random error, normally independently distributed with mean equal to zero and variance equal to

Data obtained during the nursing period were analyzed by a model using the method of least squares. The model was the same as that used for the data in the studies made during the feed test period, with the exception that the data were taken from only one calf crop. Therefore, there was no year effect, consequently, the independent variable of year was omitted.

RESULTS

Data for this study were taken from 57 purebred Hereford calves and 37 purebred Angus calves maintained at the Oregon Agricultural Experiment Station. The study was divided into two parts consisting of a nursing period from birth to weaning or 400 pounds body weight and a feed-test period from 500 to 800 pounds body weight. Data for the nursing period were obtained from calves born in the spring of 1960 while data for the feed-test period were obtained from calves born in 1959 and 1960.

The data on each animal included traits indicative of production (rate of gain, feed per unit gain, feed per unit gain and suckling gains) and certain nitrogenous blood components (serum protein concentration, serum protein fractions, blood urea nitrogen and specific gravity). The data were obtained at each 100 pound increment in weight from birth to 800 pounds body weight.

Average values of the blood components and production traits are reported in tabular form in tables 1-5 and 10-14. Correlation coefficient are also reported in tables 6-9 and 15-18.

Terminology

Age - The actual age of the animal in days at a particular weight period.

Gains per period - Gain per day from one weight to the other, for example from 100 to 200 pounds body weight.

Feed per period - Feed per unit gain calculated from one weight to the other, for example from 500 to 600 pounds boey weight.

Total rate of gain - Gain per day calculated over the entire feed-test period from 500 to 800 pounds body weight.

Total Feed Efficiency - Feed per unit gain calculated over the entire feed-test period from 500 to 800 pounds body weight.

Nursing Period

Comparison between sexes

The male calves had significantly higher protein concentrations in their serum than female calves at 100 pounds body weight. The male calves had an average serum protein concentration of 5.79 gms./100 ml. of blood as compared to 5.40 gms./100 ml. of blood for the female calves.

At a body weight of 100 pounds, the female calves had a significantly higher concentration of blood urea than male calves with an average value of 15.39 mgs./100 ml. as compared with 11.77 mgs./100 ml. for the male calves. No significant difference among the production traits were found at this early age. However, there was found a significant age effect on gamma globulin which indicates that the older calves have higher gamma globulin concentrations than younger ones (Table 5).

At body weight periods of 200 and 300 pounds no significant sex differences were found among any of the blood components or production traits.

At a body weight of 400 pounds, there was a sex difference on serum protein concentration. There was a reversal of the condition found at 400 pounds from that at 100 pounds body weight. The female calves had a significantly higher

serum protein concentration than the male calves. The average serum protein concentration for the female calves was 5.71 gms./100 ml.of blood as compared with 5.54 gms./100 ml. of blood for the male calves (Table 5).

Comparison between lines

The Prince calves had significantly higher alpha globulin concentration in their serum than calves of the other three lines at 100 pounds body weight. The Prince calves had an average alpha globulin concentration of 29.34% as compared with 23.94% for the Lionheart calves, 22.68% for the David calves and 23.09% for the Angus calves. During this same weight period the David calves had a significantly higher gamma globulin concentration than calves of the other three lines.

At 100 pounds body weight the Lionheart calves with an average rate of gain of 1.89 pounds per day (Table 1) had a significantly higher growth rate than the Prince (0.96 lbs./ day), David (1.69 lbs./day) and Angus (1.67 lbs./day) calves.

At a body weight of 200 pounds, the Prince calves (26.22%) had a significantly lower albumin concentration in their serum than calves of the other three lines. At this

weight there was a significant age effect on albumin. The calves of the Angus line at this weight period had a significantly greater growth rate than the calves of the Hereford lines. The average growth rate of the Angus calves was 1.60 lbs./day while that for the calves of the Lionheart, Prince and David lines was 1.45, 1.25 and 1.56 lbs./day respectively (Table 2).

At a body weight of 300 pounds, the serum protein concentration was significantly higher in calves of the David line than the calves of the other lines. The calves of the David line had an average serum concentration of 5.48 gms./100 ml. of blood as compared with an average of about 5.36 gms./100 ml. of blood for calves of the other lines (Table 3). The Prince calves had significantly higher beta globulin fraction than the other calves. A value of 22.08% was recorded for the Prince calves while considerably lower values were recorded for the Lionheart (18.04%), David (17.43%) and Angus (17.53%) calves.

Table 1. Average Values of Blood Components and Production Traits by Lines at 100 Pounds Body Weight

	Lionheart(12)	Prince(4)	David(13)	Angus(20)
Specific Gravity	1.0222	1.0210	1.0224	1.0226
Protein[1] Concentration	5.55	5.27	5.48	5.71
Serum[2] Albumin	37.12	30.51	32.94	31.78
Alpha Globulin	23.94	29.34	22.68	23.09
Beta Globulin	16.31	15.09	17.05	19.50
Gamma Globulin	23.01	25.21	27.34	25.63
Blood[3] Urea	15.50	11.90	10.21	15.41
Gain, Period	1.89	0.96	1.69	1.67

[1] Serum protein concentration average reported as grams per 100 ml. of blood.

[2] Serum protein fraction average reported as percentages of total.

[3] Blood urea nitrogen concentration average reported as milligrams per 100 ml. of blood.

Table 2. Average Values of Blood Components and Production Traits by Lines at 200 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0216	1.0215	1.0215	1.0220
Protein Concentration	5.38	5.22	5.29	5.42
Serum Albumin	32.27	26.22	32.61	34.63
Alpha Globulin	24.97	23.04	23.29	22.31
Beta Globulin	17.22	20.30	18.04	17.07
Gamma Globulin	26.86	30.45	26.21	25.40
Blood Urea	11.93	11.84	10.33	12.50
Gain, Period	1.45	1.25	1.56	1.60

Table 3. Average Values of Blood Components and Production Traits by Lines at 300 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0219	1.0220	1.0222	1.0219
Protein Concentration	5.37	5.37	5.48	5.36
Serum Albumin	29.56	26.34	31.31	30.36
Alpha Globulin	23.83	23.13	22.78	25.75
Beta Globulin	18.04	22.08	17.43	17.53
Gamma Globulin	28.58	28.44	28.23	26.28
Blood Urea	14.14	11.24	13.04	11.79
Gain, Period	1.85	1.25	1.62	1.82

Table 4. Average Values of Blood Components and Production Traits by Lines at 400 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0223	1.0233	1.0233	1.0223
Protein Concentration	5.54	5.85	5.84	5.51
Serum Albumin	29.49	29.06	27.62	31.44
Alpha Globulin	24.11	24.31	23.65	22.98
Beta Globulin	17.33	14.20	16.95	17.51
Gamma Globulin	29.57	32.43	30.29	28.08
Blood Urea	13.57	15.52	13.02	11.98
Gain, Period	2.01	1.54	1.82	2.19

Table 5. Average Values for Blood Constituents and Production Traits for Calves by Sexes at Each of Four Weights

	100		200		300		400	
	♂	♀	♂	♀	♂	♀	♂	♀
No. Animals	22	27	22	27	22	27	22	27
Specific Gravity	1.0230	1.0217	1.0219	1.0216	1.0219	1.0220	1.0224	1.0230
Serum Proteins	5.79	5.40	5.41	5.31	5.35	5.43	5.54	5.71
Serum Albumin	33.42	33.19	32.81	32.84	28.97	30.63	30.60	29.07
Alpha Globulin	23.71	23.55	22.19	24.17	25.09	23.62	24.59	22.68
Beta Globulin	16.86	18.39	18.33	17.05	18.27	17.78	16.97	17.11
Gamma Globulin	26.03	24.90	26.21	26.52	27.59	27.50	28.06	30.47
Blood Urea	11.77	15.39	15.49	12.37	11.81	13.34	12.20	13.54
Gain, Period	1.68	1.68	1.58	1.48	1.81	1.67	2.16	1.86

Correlations among blood components and production traits during the nursing period

At 100 pounds body weight (Table 6)

1. The correlation coefficients between specific gravity and:

   a. Serum protein concentration was 0.91

   b. Suckling gain was 0.31.

2. The correlation coefficients between serum protein concentration and suckling gain was 0.31.

3. The correlation coefficient between serum albumin and:

   a. Alpha globulin was -.45

   b. Beta globulin was -.65

   c. Gamma globulin was -.38.

4. The correlation coefficient between alpha globulin and:

   a. Gamma globulin was -.38

   b. Rate of gain for this weight period was -.28.

5. The correlation coefficient between age and rate of gain for this weight period was -.46.

6. The correlation coefficient between rate of gain for this weight period and suckling gain was 0.57.

At 200 pounds body weight (Table 7)

1. The correlation coefficient between specific gravity and serum protein concentration was 0.92.

2. The correlation coefficient between albumin and:

   a. Alpha globulin was -.34

   b. Beta globulin was -.49

   c. Gamma globulin was -.41

   d. Rate of gain for this period was 0.36

   e. Suckling gain was 0.29.

3. The correlation coefficient between alpha globulin and beta globulin was -.41.

4. The correlation coefficient between gamma globulin and suckling gain was -.32.

5. The correlation coefficient between age and:

   a. Rate of gain for this period was -.62

   b. Suckling gain was -.55.

6. The correlation coefficient between rate of gain for this period and suckling gain was 0.76.

At 300 pounds body weight (Table 8)

1. The correlation coefficient between serum protein concentration and specific gravity was 0.92.

2. The correlation coefficient between albumin and:

a. Alpha globulin was -.48

b. Gamma globulin was -.62.

3. The correlation coefficient between blood urea and rate of gain for this period was -.28.

4. The correlation coefficient between age and:

a. Rate of gain for the period was -.69

b. Suckling gain -.82.

5. The correlation coefficient between rate of gain for this period and suckling gain was 0.62.

At 400 pounds body weight (Table 9)

1. The correlation coefficient between specific gravity and:

a. Serum protein concentration was 0.92

b. Gamma globulin was 0.36

c. Age was 0.29

d. Rate of gain for this period was -.42

e. Suckling gain was -.57.

2. The correlation coefficient between serum protein concentration and:

a. Gamma globulin was 0.41

b. Age was 0.30

c. Rate of gain for this period was -.41

d. Suckling gains was -.59.

3. The correlation coefficient between albumin and:

a. Alpha globulin was -.47

b. Beta globulin was -.38

c. Gamma globulin was -.67.

4. The correlation coefficient between gamma globulin and suckling gain was -.39.

5. The correlation coefficient between age and:

a. Rate of gain for this period was -.63

b. Suckling gain was -.68.

6. The correlation coefficient between rate of gain for this period and suckling gain was 0.48.

Table 6. Correlation Coefficients Among Certain Blood Components and Production Traits at 100 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Rate of Gain	Suckling Gains
Specific Gravity	.01**	-.13	.03	.03	.12	-.02	.12	.03	.31*
Serum Protein		.18	.08	.04	.14	.05	.15	.05	.35*
Serum Albumin			-.45**	-.65**	-.38**	-.13	-.04	.11	.05
Alpha Globulin				.20	-.38**	.16	.26	-.28*	-.19
Beta Globulin					-.19	.07	.01	.01	-.01
Gamma Globulin						.00	-.17	.07	.10
Blood Urea							.11	.26	.18
Age (days)								-.46**	-.26
Rate of Gain									.57**

* Significant at the 5% level
** Significant at the 1% level

Table 7. Correlation Coefficients Among Certain Blood Components and Production Traits at 200 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Rate of Gain	Suckling Gains
Specific Gravity	.92**	-.20	-.09	.24	.17	-.07	-.02	.02	.12
Serum Protein		-.21	-.05	.26	.17	-.12	-.12	.12	.24
Serum Albumin			-.34*	-.49**	-.41**	-.21	-.09	.36**	.29*
Alpha Globulin				-.41**	-.21	.40	-.06	.13	-.13
Beta Globulin					.06	-.24	.04	-.24	-.07
Gamma Globulin						.02	.17	-.21	-.32*
Blood Urea							.16	-.21	-.03
Age (days)								-.62**	-.55**
Rate of Gain									.76**

* Significant at the 5% level
** Significant at the 1% level

Table 8. Correlation Coefficients Among Certain Blood Components and Production Traits at 300 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Rate of Gain	Suckling Gains
Specific Gravity	.92**	-.09	.01	.05	.06	.06	.18	-.25	-.18
Serum Protein		-.05	-.05	.03	.02	.07	.17	-.24	.19
Serum Albumin			-.48**	-.24	-.62**	-.13	-.26	.09	.19
Alpha Globulin				-.04	-.18	.10	.11	.01	.01
Beta Globulin					-.27	.02	.01	.03	.06
Gamma Globulin						.05	.21	-.13	-.26
Blood Urea							.13	-.28*	.05
Age (days)								-.69**	-.82**
Rate of Gain									.62**

* Significant at the 5% level
** Significant at the 1% level

Table 9. Correlation Coefficients Among Certain Blood Components and Production Traits at 400 pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Rate of Gain	Suckling Gains
Specific Gravity	.92**	-.10	-.17	-.11	.36**	.15	.29*	-.42**	-.57**
Serum Protein		-.13	-.18	-.11	.41**	.14	.30*	-.41**	-.59**
Serum Albumin			-.47**	-.38**	-.67**	-.19	.02	.01	.22
Alpha Globulin				.05	.07	.11	-.09	.24	.01
Beta Globulin					.06	-.00	-.09	.06	.01
Gamma Globulin						.19	.15	-.20	-.39**
Blood Urea							.26	-.23	-.17
Age (days)								-.63**	-.68**
Rate of Gains									.48**

* Significant at the 5% level
** Significant at the 1% level

Feed-Test Period

The results during the feed-test period will be reported by sexes and by lines within weight groupings. The data during the feed-test period were analyzed by least squares in order to make group comparisons. Probabilities of 0.05 or less have been taken to indicate statistically significant differences.

Comparison between sexes

500 pounds body weight

Male calves grew at a significantly faster rate than female calves having an average growth rate of 2.49 pounds per day as compared with 1.92 pounds per day for the females (Table 14). Likewise to make this gain, the male calves required an average of 2.3 pounds less feed per unit gain than the female calves.

In spite of the very small differences found in the relative amounts of blood components between male and female calves, the suckling gains were on the average higher in male calves. The male calves had an average suckling gain of 1.70 pounds per day while the female calves had an average of 1.53 pounds per day.

Their results were substantiated by the fact that there

was a significant age effect. The older animals had lower suckling gains, rate of gains on feed and a higher feed requirement per unit gain. The female calves had an average age of 277.1 days while male calves had an average age of 244.5 days.

Blood urea nitrogen was the only blood component that showed a significant sex difference at this weight period. The female calves with a 14.57 mgs./100 ml. of blood had a significantly higher concentration of urea nitrogen in their blood than male calves with 11.80 mgs./100 ml. of blood (Table 14.) Serum protein concentration, serum albumin and serum gamma globulin showed a significant year effect.

600 pounds body weight

At this weight period there were little changes in growth rate, male calves had an average growth rate of 2.49 lbs./day while female calves had an average rate of gain of 1.89 lbs./day (Table 14).

The male animals during this period required 7.0 lbs. of feed to make a unit gain as compared with 5.9 lbs. of feed per pound gain at 500 pounds body weight. The female animal required 9.2 lbs. of feed to make a unit gain as compared with 7.6 lbs. per pound gain at 500 pounds body weight.

The female calves (Table 14) had significantly higher concentrations of blood urea nitrogen than male calves had at this weight period. The female calves had an average blood urea level of 15.58 mgs./100 ml. of blood as compared with 14.04 mgs./100 ml. of blood for the male calves. Also at this weight period, serum protein concentrations had a significant year effect along with albumin and serum gamma globulin concentration.

700 pound body weight

Male calves had an average rate of gain of 2.53 compared with 2.09 for the females (Table 12). The trend in past years in studies made on these same lines of cattle has been either no change in growth from 500 to 800 pounds body weight or a slight decrease in growth rate. However, there was a significant year effect on growth rate. Male calves required an average of 8.0 pounds of feed per unit gain as compared with 9.4 pounds of feed per unit gain for the females.

Blood urea (Table 14) concentration was significantly higher in females (18.11 mgs./100 ml. of blood) than in males (13.95 mgs./100 ml. of blood). The blood urea concentration in the blood is increasing with size in both sexes. There was a significant age effect on beta globulin, indicating that

older animals had a higher concentration of this blood component.

800 pounds body weight

The male calves had an average growth rate of 2.46 pounds per day and required 8.5 pounds of feed per unit gain while the female calves had an average growth rate of 1.93 pounds per day and required 10.9 pounds of feed per unit gain (Table 13). There was also a significant age difference indicating that older calves in general had lower growth rates than younger animals. Specific gravity and alpha globulin also showed significant age effects indicating that older animals had higher concentrations of serum proteins and alpha globulins. The blood urea nitrogen concentration of females was significantly higher than that of males. The blood urea concentration in females was 19.18 mgs./100 ml. of blood while that of the males was only 15.46 mgs./100 ml. of blood (Table 14).

Total rate of gain and total feed per unit (figured from 500-800) was significantly higher in male calves than female calves. The trend in rate of gain and feed per unit gain for the various periods followed that for the entire period in that the total rate of gain was higher for the male calves than the

female calves. The male calves had a lower average total feed requirement per unit gain than females.

Comparison among lines

500 pounds body weight

The Angus line had a significantly higher rate of growth than the Hereford lines. The Angus line had an average rate of gain for this period of 2.39 lbs./day as compared with 2.07 lbs./day for the Lionheart, 2.13 lbs./day for the Prince and 1.80 lbs./day for the David line (Table 10). At this weight period the Angus line was considerably more efficient in utilization of feed than the Hereford lines. The average feed per unit gain for the Angus line was 3.9 lbs. as compared with 7.0 lbs. for the Lionheart, 7.1 lbs. for the Prince and 7.4 lbs. for the David (Table 10).

The Angus line had significantly higher suckling gains than the Hereford lines with an average of 1.69 pounds per day as compared with an average of about 1.53 lbs./day for the Hereford lines (Table 10).

There were no significant line differences among the blood components studied possibly indicating a large amount of within-line variation. There was a significant line-by-year interaction in feed per unit gain for this weight period.

600 pounds body weight

The line differences which were quite pronounced at 500 pounds body weight did not exist at this weight. The only line difference was found in gamma globulin where the Prince line had a significantly lower blood concentration of gamma globulin than the other three lines (Table 11). There was a significant line-by-year interaction in feed per unit gain for this period.

700 pounds body weight

The Angus line of cattle had significantly higher concentrations of proteins in their serum than the Hereford lines. An average serum protein value of 6.36 mgs./100 ml. of blood was recorded for the Angus while lower averages of 5.96, 5.84 and 5.90 was recorded for the Lionheart, Prince and David lines respectively. The Angus line (33.63%) had significantly higher concentrations of serum albumin than the average for the Hereford lines (24.37%). The David line had a considerably lower gamma globulin fraction than the other three lines. There was a significant line-by-year interaction for gamma globulin. No significant line differences were found among the production traits.

800 pounds body weight

There was a significant difference in the amount of protein found in the blood of Lionheart calves as compared with calves of the other three lines. The Lionheart line had an average serum protein concentration of 6.25 gms./100 ml. of blood as compared with 5.91 gms./100 ml. of blood for the Prince line, 5.90 gms./100 ml. of blood for the David line and 6.11 gms./100 ml. for the Angus line. There was also found a significant line-by-year interaction for protein concentration. The David line had a significantly lower concentration of serum gamma globulin than the other three lines (Table 13).

At this weight period, the David line grew at a significantly faster rate than either the Lionheart, Prince or David. The average rate of gain for the David calves was 2.26 lbs./day as compared with 2.03 lbs./day for the Lionheart and Prince calves and 2.17 lbs./day for the Angus calves (Table 13). The David calves required significantly less feed to make a unit gain at this weight period than the other lines of calves. The David calves required 9.3 lbs. of feed per pound of gain while the Lionheart calves required 10.0 lbs. per pound gain, the Prince required 10.4 lbs. per pound gain and the Angus required 10.2 lbs. of feed per pound gain.

Correlations Among Production Traits and Blood Components During the Feed-Test Period

The correlation coefficients are presented in tabular form in Tables 15-18. Only the significant correlations will be reported here. The significance level was set at 0.05. All possible correlations among production traits and blood components were computed.

Table 10. Average Values of Blood Components and Production Traits by Lines at 500 Pounds Body Weight

	Lionheart(23)	Prince(11)	David(21)	Angus(37)
Specific Gravity	1.0231	1.0220	1.0239	1.0234
Protein Concentration	5.87	5.56	6.15	5.99
Serum Albumin	36.74	37.41	32.10	34.09
Alpha Globulin	21.23	19.32	21.82	22.54
Beta Globulin	13.58	13.65	16.75	15.36
Gamma Globulin	28.44	29.56	28.57	27.11
Blood Urea	13.95	14.49	12.03	13.72
Gain, Period	2.07	2.13	1.80	2.39
Feed, Period	705.6	710.7	743.1	391.4
Total Gain	2.07	2.16	2.23	2.11
Total Feed	935.6	876.7	855.1	926.03
Suckling Gain	1.53	1.54	1.53	1.69

Table 11. Average Values of Blood Components and Production Traits by Lines at 600 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0241	1.0233	1.0237	1.0236
Protein Concentration	6.22	6.08	6.09	6.07
Serum Albumin	32.46	36.10	32.12	34.95
Alpha Globulin	20.85	21.95	21.93	19.07
Beta Globulin	15.71	14.35	17.11	14.48
Gamma Globulin	30.45	27.60	28.85	29.07
Blood Urea	13.95	11.95	14.52	16.76
Gain, Period	2.00	2.02	2.21	2.20
Feed, Period	897.7	890.4	768.7	822.00

Table 12. Average Values of Blood Components and Production Traits by Lines at 700 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0232	1.0228	1.0234	1.0247
Protein Concentration	5.96	5.84	5.94	6.36
Serum Albumin	31.50	30.64	25.96	33.63
Alpha Globulin	22.60	20.45	18.76	21.09
Beta Globulin	16.63	17.01	14.15	16.31
Gamma Globulin	28.83	31.75	22.18	29.19
Blood Urea	17.29	15.89	14.95	17.02
Gain, Period	2.29	2.53	2.32	2.27
Feed, Period	887.6	779.3	860.8	935.8

Table 13. Average Values of Blood Components and Production Traits by Lines at 800 Pounds Body Weight

	Lionheart	Prince	David	Angus
Specific Gravity	1.0243	1.0233	1.0230	1.0237
Protein Concentration	6.25	5.91	5.92	6.11
Serum Albumin	31.53	30.44	35.53	35.28
Alpha Globulin	22.20	21.34	21.06	20.24
Beta Globulin	15.69	16.25	15.95	15.92
Gamma Globulin	30.32	31.42	27.20	28.85
Blood Urea	16.72	17.02	19.25	17.69
Gain, Period	2.03	2.03	2.26	2.17
Feed, Period	1009 .8	1035.8	933.9	1016.26

Table 14. Average Values of Blood Components and Production Traits by Sexes at Four Weight Gauges

	500		600		700		800	
	♂	♀	♂	♀	♂	♀	♂	♀
No. Animals	36	56	36	56	36	56	36	56
Specific Gravity	1.0230	1.0234	1.0237	1.0237	1.0238	1.0238	1.0236	1.0237
Protein Concentration	5.86	6.02	6.11	6.11	6.10	6.11	6.06	6.09
Serum Albumin	33.78	35.41	34.84	33.16	30.56	31.27	32.57	34.62
Alpha Globulin	22.52	21.11	21.23	21.98	20.89	20.84	20.83	21.19
Beta Globulin	15.17	14.93	15.48	15.31	12.48	16.14	17.34	14.99
Gamma Globulin	27.81	28.02	28.46	29.66	27.18	28.21	29.09	29.18
Blood Urea	11.80	14.57	14.04	15.58	13.95	18.11	15.46	19.18

Table 14, continued

	500		600		700		800	
	♂	♀	♂	♀	♂	♀	♂	♀
No. Animals	36	56	36	56	36	56	36	56
Gain, Period	2.49	1.92	2.49	1.89	2.53	2.09	2.46	1.93
Feed, Period	593.9	763.4	704.5	922.1	800.5	944.2	851.6	1092.5
Total, Gain	2.45	1.93	2.45	1.93	2.45	1.93	2.45	1.93
Total Feed	776.1	988.3	776.1	988.3	776.1	988.3	776.1	988.3
Suckling Gain	1.70	1.53	1.70	1.53	1.70	1.53	1.70	1.53
Age (days)	244.5	277.1					369.6	433.7

500 pound body weight

1. The correlation coefficient between albumin and:
   a. Alpha globulin was -.41
   b. Beta globulin was -.43
   c. Gamma globulin was -.64
   d. Total feed per unit gain was 0.21.
2. The correlation coefficient between alpha globulin and:
   a. Beta globulin was -.22
   b. Feed per unit gain for this period was -.23.
3. The correlation coefficient between beta globulin and total feed per unit gain was -.22.
4. The correlation coefficient between blood urea nitrogen and:
   a. Age was 0.21
   b. Feed per unit gain at this weight period was 0.27
   c. Total rate of gain was -.36
   d. Total feed per unit gain was 0.24.
5. The correlation coefficient between age (days) and:
   a. Rate of gain for this weight period was -.50
   b. Feed per unit gain for this weight period was 0.67
   c. Total rate of gains was -.20

d. Total feed per unit gain was 0.26

e. Suckling gains was -.89.

6. The correlation coefficient between rate of gain for this weight period and:

a. Feed per unit gain for this weight period was -.67

b. Total rate of gain was 0.23

c. Suckling gain was 0.34.

7. The correlation coefficient between feed per unit gain and:

a. Total rate of gain was -.26

b. Total feed per unit gain was 0.36

c. Suckling gains was -.53.

8. The correlation coefficient between total rate of gain and total feed per unit gain was -.79.

9. The correlation coefficient between specific gravity and serum protein concentration was 0.96.

600 pounds of body weight (Table 16)

1. The correlation coefficient between specific gravity and:

a. Albumin expresses as a % of the total was -.31

b. Gamma globulin expressed as a % of the total was 0.27

c. Feed per unit gain for this weight period was -.26

d. Total feed per unit gain was -.21.

2. The correlation coefficient between serum protein concentration and:

a. Albumin expressed as a % of the total was -.23

b. Gamma globulin expressed as a % of the total was 0.22

c. Feed per unit gain for this weight period was -.24.

3. The correlation coefficient between albumin and:

a. Alpha globulin was -.51

b. Beta globulin was -.47

c. Gamma globulin was -.72.

4. The correlation coefficient between gamma globulin and blood urea was .25.

5. The correlation coefficient between age (days) and:

a. Rate of gain for this weight period was -.35

b. Feed per unit gain for this weight period was 0.28

c. Total rate of gain was -.35

d. Total feed per unit gain was 0.36

e. Suckling gains was -.82.

6. The correlation coefficient between rate of gain for this weight period and:

a. Feed per unit gain for this weight period was -.81

b. Total rate of gain was 0.67

c. Total feed per unit gain was -.61

7. The correlation coefficient between rate of gain for this period and:

a. Total rate of gain was -.60

b. Total feed per unit gain was 0.73.

700 pounds body weight (Table 17)

1. The correlation coefficient between specific gravity and serum protein concentration was 0.95.

2. The correlation coefficient between albumin and:

a. Alpha globulin was 0.38

b. Beta globulin was 0.22

c. Gamma globulin was 0.31

d. Feed per unit gain for this period was 0.24

e. Total feed per unit gain was 0.21.

3. The correlation coefficient between alpha globulin and:

a. Beta globulin was 0.53

b. Gamma globulin was 0.43

c. Total feed per unit was 0.22.

4. The correlation coefficient between beta globulin and gamma globulin was 0.42.

5. The correlation coefficient between blood urea and:

a. Age was 0.29

b. Rate of gain for this weight period was -.33

c. Total rate of gain was -.41

d. Total feed per unit gain 0.26.

6. The correlation coefficient between age (days) and:

a. Rate of gain for this period was -.40

b. Feed per unit gain for this period 0.37

c. Total rate of gain was -.46

d. Total feed per unit gain was 0.45

e. Suckling gains was 0.64.

7. The correlation coefficient between rate of gain for this weight period and:

a. Feed per unit gain for this weight period was -.81

b. Total rate of gain was 0.67

c. Total feed per unit gain was -.55.

8. The correlation coefficient between feed per unit gain for this weight period and:

a. Total rate of gain was -.54

b. Total feed per unit gain was 0.64.

800 pounds body weight (Table 18)

1. The correlation coefficient between specific gravity and:

a. Serum protein concentration was 0.87

b. Albumin was -.27.

2. The correlation coefficient between albumin and:

a. Alpha globulin was -.42

b. Beta globulin was -.32

c. Gamma globulin was -.70

3. The correlation coefficient between beta globulins and:

a. Total rate of gain was 0.31

b. Total feed per unit gain was -.27.

4. The correlation coefficient between blood urea and age was 0.26.

5. The correlation coefficient between age (days) and:

a. Rate of gain for this weight period was -.43

b. Feed per unit gain for this weight period was 0.39

c. Total rate of gain was -.61

d. Total feed per unit gain was 0.58

e. Suckling gains was -.68.

6. The correlation coefficient between rate of gain for this weight period and:

a. Feed per unit gain for this period was -.79

b. Total rate of gain was 0.58

c. Total feed per unit gain was -.59.

7. The correlation coefficient between feed per unit gain for this period and:

a. Total rate of gain was -.49

b. Total feed per unit gain was 0.70.

Table 15. Correlation Coefficients Among Certain Blood Components and Production Traits at 500 Pounds Body Weight

Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Specific Gravity											
0.96**	-.19	0.07	0.11	0.11	0.04	0.02	-.14	-.03	-.04	-.03	-.04
Serum Protein											
	-.09	0.03	0.07	0.04	0.09	0.04	-.13	0.01	-.08	0.02	-.05
Serum Albumin		-.41**	-.43**	.64**	0.06	0.10	0.11	0.18	-.02	0.21*	-.10
Alpha Globulin			-.22*	-.13	0.02	-.14	0.15	-.23*	-.03	0.01	0.17
Beta Globulin				0.09	-.16	0.06	-.15	0.01	0.11	-.22*	0.07
Gamma Globulin					0.07	-.03	-.15	-.05	-.05	0.11	-.05
Blood Urea						0.21*	-.16	0.27**	-.36**	0.24*	-.17
Age (days)							-.50**	0.67**	-.20*	0.26**	-.89**
Gains/Period								-.67**	0.23*	-.13	0.34**
Feed/Period									-.26*	0.36**	-.53**

Table 15, continued

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Total Gains											-.79**	0.01
Total Feed												-.09

* Significant at the 5% level
** Significant at the 1% level

Table 16. Correlation Coefficients Among Certain Blood Components and Production Traits at 600 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Specific Gravity	0.97**	-.31**	0.04	0.19	0.27**	0.16	0.11	0.06	-.26*	-.03	-.21*	0.04
Serum Protein		-.23*	0.03	0.13	0.22*	0.16	0.06	0.06	-.24*	-.05	-.18	0.00
Serum Albumin			-.51**	-.47**	-.72**	-.19	-.07	0.19	0.01	0.02	0.13	0.11
Alpha Globulin				-.03	0.03	0.06	0.00	-.19	0.11	-.14	0.12	0.02
Beta Globulin					0.01	-.02	0.01	0.05	-.03	0.08	-.15	-.10
Gamma Globulin						0.25*	0.11	-.17	-.06	0.01	-.15	-.12
Blood Urea							-.09	0.01	-.05	0.00	0.09	0.05
Age (days)								-.35**	0.28**	-.35**	0.36**	-.82**
Gains/Period									-.81**	0.69**	-.61**	0.00
Feed/Period										-.60**	0.73**	-.01

Table 16, continued

Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Total Gains										-.79**	0.01
Total Feed											0.09

* Significant at the 5% level
** Significant at the 1% level

Table 17. Correlation Coefficients Among Certain Blood Components and Production Traits at 700 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Specific Gravity	0.95**	-.01	-.01	-.01	0.09	-.07	-.13	-.03	-.15	0.00	-.06	0.16
Serum Protein		0.02	-.03	0.03	0.10	0.08	0.13	-.02	-.17	-.01	-.07	0.16
Serum Albumin			0.38**	0.22*	0.31**	-.01	0.01	0.11	0.24*	0.04	0.21*	-.04
Alpha Globulin				0.52**	0.43**	0.07	0.08	0.06	0.08	-.06	0.22*	-.19
Beta Globulin					0.42**	0.19	0.16	-.13	0.09	-.19	0.14	-.14
Gamma Globulin						0.11	0.00	-.05	0.01	0.09	0.13	0.00
Blood Urea							0.29**	-.33**	0.20	-.41**	0.26*	-.16
Age (days)								-.40**	0.37**	-.46**	0.45**	0.74**
Gains/Period									-.81**	0.69**	-.55**	-.04
Feed/Period										-.54**	0.64**	0.02

Table 17, continued

Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Total Gains										-.79**	0.02
Total Feed											0.09

* Significant at the 5% level
** Significant at the 1% level

Table 18. Correlation Coefficients Among Certain Blood Components and Production Traits at 800 Pounds Body Weight

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Specific Gravity	0.97**	-.27**	0.16	0.04	0.18	-.14	0.00	-.11	0.04	-.03	0.05	-.02
Serum Protein		-.24*	0.17	0.01	0.18	0.11	0.02	-.09	0.03	-.07	0.06	-.03
Serum Albumin			-.42**	-.32**	-.70**	0.02	0.08	0.01	-.01	-.19	0.15	0.05
Alpha Globulin				-.20	-.06	0.11	-.04	0.06	0.00	0.06	0.02	0.07
Beta Globulin					-.07	-.11	-.24*	0.06	-.06	0.31**	-.27**	0.01
Gamma Globulin						-.03	0.12	-.13	0.09	-.06	0.02	-.14
Blood Urea							0.26*	-.09	0.00	-.17	0.06	-.09
Age (days)								-.43**	0.39**	-.61**	0.58**	-.68**
Gains/Period									-.79**	0.58**	-.59**	0.12
Feed/Period										-.49**	0.70**	-.13

Table 18, continued

	Serum Protein	Serum Albumin	Alpha Globulin	Beta Globulin	Gamma Globulin	Blood Urea	Age (days)	Gain/ Period	Feed/ Period	Total Gains	Total Feed	Suckling Gains
Total Gains											-.79**	0.01
Total Feed												0.09

* Significant at the 5% level
** Significant at the 1% level

TRENDS AMONG THE BLOOD COMPONENTS AND PRODUCTION TRAITS FROM BIRTH TO 800 POUNDS BODY WEIGHT

Trends by sexes

In many instances because of correlations among the independent variables differences that may have occurred in the absence of these correlations were masked. In a number of cases there were certain trends that were consistent throughout both study periods. Therefore, the purpose of this section is to report consistent trends that may or may not have been significant.

With the exception of the 100 and 200 pound weight periods female calves consistently had serum protein concentrations that were higher than those of the male calves. On the other hand, the male calves in all instances except at 100 pounds body weight had significantly higher growth rates than female calves.

Blood urea concentrations were consistently higher in the female calves than in the male calves. The differences were significant at all weight groups. At 200 pounds body weight, the blood urea concentration was higher in the males than in the females. These trends were also supported by significant

positive correlation coefficients between the two variables. A positive correlation was found between blood urea and feed per unit gain while a negative correlation coefficient was found between blood urea and growth rate.

From 400 to 800 pounds body weight, when blood urea was higher in females than in male calves, gamma globulin concentration was also higher in females than in males. This was supported in a number of instances by significant positive correlation coefficients between gamma globulin and blood urea nitrogen.

Trends by Lines

During the nursing period there were a few trends that probably should be reported. With the exception of the 300 pound weight period, the line that had the highest rate of gain had the highest concentration of serum albumin and lowest concentration of serum gamma globulin.

During the feed-test period, the line with the highest feed requirement per unit gain also had the highest concentration of serum protein with the exception of calves at 800 pounds body weight. The Angus calves at 800 pounds body weight had the highest feed requirement per unit gain, but the Lionheart line had the highest concentration of serum

proteins.

During the nursing period, the David calves grew at a more rapid rate than the Prince calves, but at a significantly slower rate than the Lionheart or Angus calves. During the feed-test period this superiority in gaining ability of the Lionheart and Angus calves seemed to shift and the David calves were the most rapidly gaining calves and required significantly less feed to make a unit of gain.

During the nursing period there was a period that seemed to be inconsistent with the other periods. One example from birth to weaning, all of the lines of calves seemed to grow at an increasing rate, that is the average growth rate was higher at subsequent periods. This was true at weight periods 100, 300 and 400 pounds, but at 200 pounds body weight the calves grew at a slower rate than they did at 100 pounds body weight.

There was a consistent trend among the calves that indicates that the older calves grew at a slower rate than younger animals in a given weight period. There was also the trend for older animals to require more feed per unit gain than younger animals. The blood urea nitrogen and serum protein nitrogen consistently increased with age. Of the protein fractions, gamma globulin increased consistently with age from birth to 200 pounds body weight.

During the feed-test period the rate of growth, unlike during the nursing period, seemed to remain practically constant but there was a tremendous increase in the amount of feed required to make a unit gain as calves increased in size.

SUMMARY OF BLOOD COMPONENTS AND PRODUCTION TRAITS

Specific gravity and serum protein concentration increased as calves grew from birth to 800 pounds body weight. At the majority of the weight periods, the specific gravity and serum protein concentration were higher in female calves than in male calves.

Serum albumin concentration did not differ greatly between animals during the nursing period but during the feed-test period younger animals had lower albumin concentrations. Alpha globulin concentrations were higher in the nursing period than in the feed-test period (Tables 5 and 14). Beta globulin concentration remained similar throughout the two study periods. Gamma globulin concentrations increased as animals grew older and gained in weight.

Blood urea nitrogen levels increased in the blood of calves as they increased in weight. Slower gaining animals had higher blood urea levels than faster gaining animals. Female calves had significantly higher levels of blood urea than male calves.

Rate of gain for the various periods increased from birth to weaning but during the feed-test period the growth rate

remained fairly constant. Males grew at a faster rate than females. Over the entire nursing period the Angus line had significantly higher suckling gains than the other lines.

Feed per unit gain increased as calves grew from 500 to 800 pounds body weight. Male calves consistently required less feed per unit than female calves. The David line of calves required significantly less feed per unit gain than the other lines of calves.

Female calves were an average age of 277.1 days as compared to 244.5 for the male calves at 500 pounds body weight. At 800 pounds body weight, the female calves were an average age of 433.7 while the average age of the male calves was 369.6. Female calves were an average of 32.6 days older than male calves at 500 pounds body weight and an average of 64.1 days older at 800 pounds body weight.

DISCUSSION

The fundamental laws of genetics were discovered in studies on plants and lower animals. Their validity is universal. A great many books and pamphlets have been filled with the partisan view of those who have wished to make either nature or nurture all-responsible for the fate of man, beast and plant. For the proper understanding of the phenotype, one must recognize that in the majority of cases tissues of developmental processes of mature organisms are controlled by complex interaction of forces from within and without.

Little is known about the chemical means by which genes produce their effects. There is considerable reason to believe, however, that the developmental function of the genes occurs at definite rates and at specific times and that the intersection of the gene-determined rates of biochemical processes at given stages results in a pattern of increasing complexity. Therefore, we are faced with the problem of either developing methods by which we can obtain answers to this complex genetic-physiological maze or we will continue along the lines of past investigators and study superficial traits of aesthetic value only which give little insight into the basic problem of why and how characteristics develop. The fruits of basic

research are not always evident at the time that it is being pursued. Yet without answering some of the questions that appear to have no immediate application, progress toward answering the questions of greater utility would not be possible. Therefore, advocates of basic research are not seeking knowledge for the sake of knowledge, but are searching for bits of truth to serve as a template for information of greater applicability. To completely discard the arguments against basic research in applied fields would be an error because there are some inherent disadvantages in working with larger species of domestic animals. In order to follow metabolic effects in beef cattle, for example, through a well defined growth period it is necessary that at least several months must pass before the results are known which is not only time consuming but costly. To study smaller laboratory animals would require much less time to cover the same physiological period and at a much lower cost. On the other hand, experimental work with the larger farm animals is desirable since results obtained may be applied directly to the breeds and species studied.

Nursing Period

The environmental variations are extremely large during

this period. The four lines are not equally as good in female productivity as measured by the amount of milk available for the calves. The calves are with the dams during the breeding season where pasture conditions are not uniform. Yet there exist certain differences between lines and sexes. Although male calves did not have significantly higher growth rates than females during this period, the values for the males were higher than those for the female calves. With the exception of one weight period female calves had higher concentrations of serum proteins and blood urea. As the calves grew older, regardless of sex, there was an increase in gamma globulin concentration within the serum.

Certain significant line differences were found at certain weight periods but the differences found were not consistent. Perhaps in some of the cases the lack of significance could be attributed to a correlation among the independent variable since the total regression was significant and corresponding individual degrees of freedom were not. However, this is not the entire picture because the same independent variables were used during the feed-test periods without correlation among the independent variables interfering with the significance. Thus, it would appear at first that we either have different polygenic systems operating during the nursing period or a smaller

number of genes resulting in a smaller expression between lines and sexes. If one considers the amount of environmental variation that exists certain possibilities become evident. Perhaps there is not a polygenic system operating during the nursing period that is different from that of the later life but rather the environment may be the limiting factor. This is not to be interpreted as meaning that the environment is depressing anything for this presupposes that compensation will occur at some later period. The different environmental conditions provided by dams cause extreme variation within lines and within sexes which may automatically destroy any significant variation between lines or between sexes.

At body weight periods of 200 and 300 pounds certain blood and production trends were interrupted, i.e. any changes in trends usually occurred at one or the other of these weight periods. The drastic changes in trend can be explained by noting the time at which the calves reached the weight period which coincides with a reduction in amount of forage present in pastures. The calves reached 200 pounds body weight about the time pastures were declining due to lack of rain. Since the cows had limited amounts of pasture, milk production decreased and the calves probably had to supplement this reduction in milk with grass. Therefore, this is a period of change from

an all milk diet to a combination of milk and grass which causes an alteration in growth rate and in the concentration of blood constituents.

Feed-Test Period

During this period, the environmental variations were minimized in that all calves were managed in the same way.

Difference between sexes

Consistent differences have been found between males and females with respect to their productive level and physiological characteristics. Male calves had significantly higher growth rates than corresponding female calves. Feed required per unit of gain followed the same pattern in an inverse relationship. Male calves required considerably less feed to make a unit gain than the female calves. This was supported by a correlation coefficient between rate of gain and feed per unit gain of -.79.

There were no significant differences between sexes in suckling gain. There was no correlation between suckling gain and subsequent growth rate except at 500 pounds body weight where a correlation coefficient between rate of gain for that period and suckling gain was 0.34.

The difference in growth rate exhibited by male and female

calves was perhaps partly conditioned by hormonal differences. It is generally accepted that injection of testosterone into both steers and heifers results in increased growth rate and decreased feed requirement per unit gain. The testosterone appears to increase nitrogen retention in the steers and heifers. Another possible reason for the difference in growth rate and efficiency of feed utilization is in the type tissue being laid down. If we accept the hypothesis that female calves mature at an earlier age than male calves, it becomes clear that the female calves begin to deposit fat at an earlier age. Since fat deposition requires more energy than protein synthesis, female animals would require more feed per unit gain than male calves. The fact that female calves are laying down fatty tissue while the male calves are actively synthesizing protein is substantiated by the fact that at a given weight period female calves are older than male calves.

Few sex differences were found among the blood components studied but where there was a difference they were consistent. Female calves had higher blood urea nitrogen concentration than male calves. Although the serum protein concentration of male calves and female calves was not significantly different, female calves had consistently higher serum protein concentration than male calves.

The significantly higher urea concentration in the blood of females seems to indicate an increased destruction of protein or amino acids over that of male calves. Since the female calves are growing at a slower rate than the male calves this could possibly mean that the deamination of the amino acid is occurring in order to supply carbon chain fragments which can be used in the synthesis of fat tissue. There is always the possibility that urea clearance mechanisms within females is not efficient as those of male calves and therefore there is a pile up of urea in the blood. This is not supported by higher urine urea excretion of females compared with males. It appears that females are less efficient in protein utilization than males.

Line differences

No consistent differences were found between the lines in the blood components and production traits studied. The analysis of variance indicated that there were in numerous instances significant year effects and line-by-year effects. Price (47) found a significant line difference in blood urea nitrogen levels in his study in which one calf crop was used. Although the tendency in the present study was for the more rapidly gaining animals to have lower levels of blood urea nitrogen,

the difference in growth rate between lines was not always a significant one. At body weights of 500 and 700 pounds, significant negative correlations of -.36, and -.41 were found between blood urea nitrogen and total rate of gain.

Trends in blood components correlated with growth

The term growth is very difficult to define and perhaps biologists have, on the whole, been more willing to study the phenomenon of growth than to attempt to define it in exact terms. Philosophically, it might be wiser to define growth as an increase in the amount of protoplasm, but in actual experimental studies such a definition would be impossible to apply, for there has not been established a good criterion which enables one to distinguish the protoplasmic from the non-protoplasmic constituents of the organism. Therefore, a definition of growth will not be given here, but instead some trends in the blood composition of beef calves as they increase in weight will be discussed.

Certain consistent trends were noted. As calves grew older and became larger blood urea nitrogen concentration, serum protein concentration and gamma globulin concentration increased. Bulls had lower levels of these constituents than heifers. From birth to weaning there was a consistent

increase in rate of growth. From 500 to 800 pounds body weight, the rate of growth was more or less constant or a very small decrease in growth rate occurred.

Previous work performed at this experiment station (36; 37) has shown that on the average blood amino acid nitrogen increases from 500 to 800 pounds body weight. Male calves had lower levels of blood amino acid nitrogen than females at all weights studied. In all studies the more rapidly gaining animals had the lower levels of blood amino acid nitrogen.

Thus, blood protein and non-protein nitrogen (amino acid and urea nitrogen) increase as the animals grow older and gain weight. The blood composition of older animals indicates that the protein and amino acid of the blood are not drawn out of the blood stream for protein synthesis of growth but the proteins are probably by enzymatic action broken down into amino acids which are deaminated to urea. The carbonacous fraction of the amino acid is used for energy or used in the synthesis of fats.

The blood composition of the younger animals indicates that large quantities of amino acids are drawn from the blood for protein synthesis for growth. Since there is a great demand for protein for the formation of new tissue, the amount of circulating protein is at a minimum for maintaining the proper

osmotic relationship in the body fluids.

The blood composition of rapidly gaining animals is similar to that of younger animals. There is perhaps a greater demand for the blood constituents in rapidly gaining animals for growth. Thus, the rapidly gaining animals by virtue of the fact that they are gaining at a faster rate are actually physiologically younger at a given weight period.

One would expect a differential amount of growth hormone between rapidly gaining and slowly gaining animals or between younger and older animals. The directional amount of growth hormone has not been determined yet but one would expect that calves having larger quantities of circulating growth hormone would grow at a more rapid rate. This generalization does not follow with plants, because a very low concentration of Auxins, plant growth hormones, cause root elongation while a high concentration may inhibit elongation of the root. This information on plants was obtained under laboratory or artificial conditions which might be different from what would happen in the intact plant.

SUMMARY AND CONCLUSIONS

1. Data for this study were obtained from 97 purebred Angus and Hereford calves maintained at the Oregon Agricultural Experiment Station during 1959 and 1960. The study was composed of a nursing period from birth to 400 pounds body weight and a feed-test period from 500 to 800 pounds body weight.

2. Male calves consistently grew at a more rapid rate than female calves and required considerably less feed to make each unit of gain during the feed-test period. Male calves during the nursing period consistently had higher growth rates than females although the difference was not always significant.

3. No significant difference was found between the suckling gains of male and female calves. The Angus calves had a significantly higher suckling gain than the Hereford calves.

4. With the exception of the 100 pound weight period, female calves consistently had significantly higher blood urea nitrogen concentrations than male calves. Blood urea nitrogen concentration increased with increases in age and weight.

5. Rapidly gaining calves had significantly lower blood urea nitrogen concentration than slowly gaining calves.

6. Serum protein concentration, specific gravity, and

serum gamma globulin concentration increased steadily from birth to 800 pounds body weight.

7. Age was consistently significantly negatively correlated with growth rate and positively correlated with feed required per unit gain.

8. The nitrogenous composition of the blood of rapidly gaining calves is similar to the nitrogenous composition of the blood of younger calves while that of slowly gaining calves resembles the blood composition of older calves.

9. The significant correlations among the independent variables allowed for a condition where the total regression was significant while none of the individual degrees of freedom were significant.

10. The blood components were not consistently correlated with the production traits. However, at 500 and at 700 pounds body weight periods, urea nitrogen was significantly negatively correlated with rate of gain and positively correlated with feed per unit gain.

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