GROWTH - WITH PARTICULAR REFERENCE TO IT'S ASSESSMENT IN BEEF CATTLE PRODUCTION

by

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ABSTRACT

This thesis is the study of the literature pertinent to the assessment of growth in addition to the analysis of growth data obtained from the Albino Rat, Yorkshire Swine, Black-Tail Deer and a group of ten Hereford Bulls. It has been concluded that animals grow at a constant percentage rate relative to body weight over each distinct portion of their growth curve. A significant error in the expression of rate of gain is introduced if animals growth rate is calculated over any but an instantaneous period. The latter is possible because growth of an animal body is directly proportional to the protoplasmic mass, a first order reaction and as such is exponential and when the expression is integrated, the slope of the regression line, logarithm of body weight on time is provided over the period when relative growth rate is constant. From the results of ration variations with male Wistar rats it was concluded that upon returning to _ad libitum_ feeding they will grow at the same relative rate as their controls despite thirty per cent reduction below _ad libitum_ intake over periods up to two thirds of the birth to sexual maturity phase. The extrapolation is made that beef bull calves proceeding from varying environments normally experienced on pure-breeding establishments will not provide biased data when placed on a test ration and allowed a period for the rumen microflora to become adjusted to the new ration.

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I

Introduction

Growth may be defined as any progressive alteration of a unit or group of units. In the cellular sense it may involve changes in mass, volume, number or quality and the degree of alteration may be defined in descriptive or absolute terms.

As indicated by the title, this thesis will attempt to evaluate the methods used in assessing progressive changes of the beef animal and to expose their implications and applications to practical beef production.

The study may be justified on the grounds that beef production has become an intensive husbandry with narrowing margins of profit and large capital investments. As a result it is imperative that the breeding beef animals be those that will produce progeny yielding a marketable carcass in the shortest time with the highest feed efficiency. To achieve this end an accurate, quantitative method of identifying such animals is required.

Any effort directed at the adjustment of a product destined for the consuming public must first of all comply with popular demands as far as possible. It is true that public opinion may be conditioned to a limited extent, but as is often stated, "The man who pays the piper calls the tune," and such is the case with meat products. A representative of the meat packing industry once categorized the buyers of meat as those that:

(1) Prefer lean meat.

(2) Lack money to buy finished meat.

(3) Compensate with a slightly greater price and a moderate degree of finish.

(4) Prefer to have highly finished meat at any price.

The third category accounts for the major portion of the buying public. (Watkins, 1936)

Associated with the quality of meat is the growing demand for the smaller cuts of meat all of which obliges the producer to provide an 800 - 1000 pound animal, carrying a moderate degree of finish. This must serve as the goal unless sufficient evidence indicates that it is an impractical target.

Present Position:- Beef cattle as they exist to-day are the result of some 200 years of selecting for parents those individuals in the population most nearly meeting a standard visualized by such early breeders as Bakewell or Cruickshank and more recently idealized by livestock exhibitions. The wisdom of this procedure is borm out when it is considered how much more desirable from the stand-point of an edible carcass the beef animal is to-day as compared with the work oxen of the type from which the present breeds arose. Just how much of the improvement can be credited to actual alteration of the genotype and how much has been brought about by improved methods of feeding and management is debatable but undoubtedly both factors have played major roles.

As indicated by Figure 2, the normal growth pattern of the modern beef animal is one greatly confused by the environment which prevails during its production. The growth potential now available to the feeder of cattle is only approximated. As an example the normal growth of Texas range cattle shows an annual depression when feed becomes limiting with the result that they reach a body weight of 800pounds at 2½ years of age. (Lush, 1930). This obviously is not a measure of their growth potential since others of the same breeding can attain a 1000 pound market weight in 16 months.

The literature contains many examples illustrating the growth rate of full fed beef animals which affords an indication of their mean inherent ability to grow. This ability appears to be the attainment of a live weight of 1000 pounds at 16 months of age under favourable conditions. (Moulton, 1923)

The lower curve of Figure 1 is typical of the growth made by range animals. It may be noted that the body weight remains stationary or decreases during the winter periods. The lower side of the shaded section approximates the mean growth potential of beef cattle under favourable conditions. This suggests that the area between the two curves represents the improvement that may be anticipated by improved feeding and management. The upper curve of the shaded section represents the growth potential which exists in certain breeding animals of our present herds when nutrition and management procedures do not limit growth rate. (Gilliam County, 1950-51, 1951-52) (Guilbert 1950) This curve requires an animal to weigh 1000 pounds at an age of 12 months. The shaded area therefore represents the improvement which may be made by selection if the characteristic is not receiving a negative selection pressure due to gene linkage with some characteristic normally culled from the population.

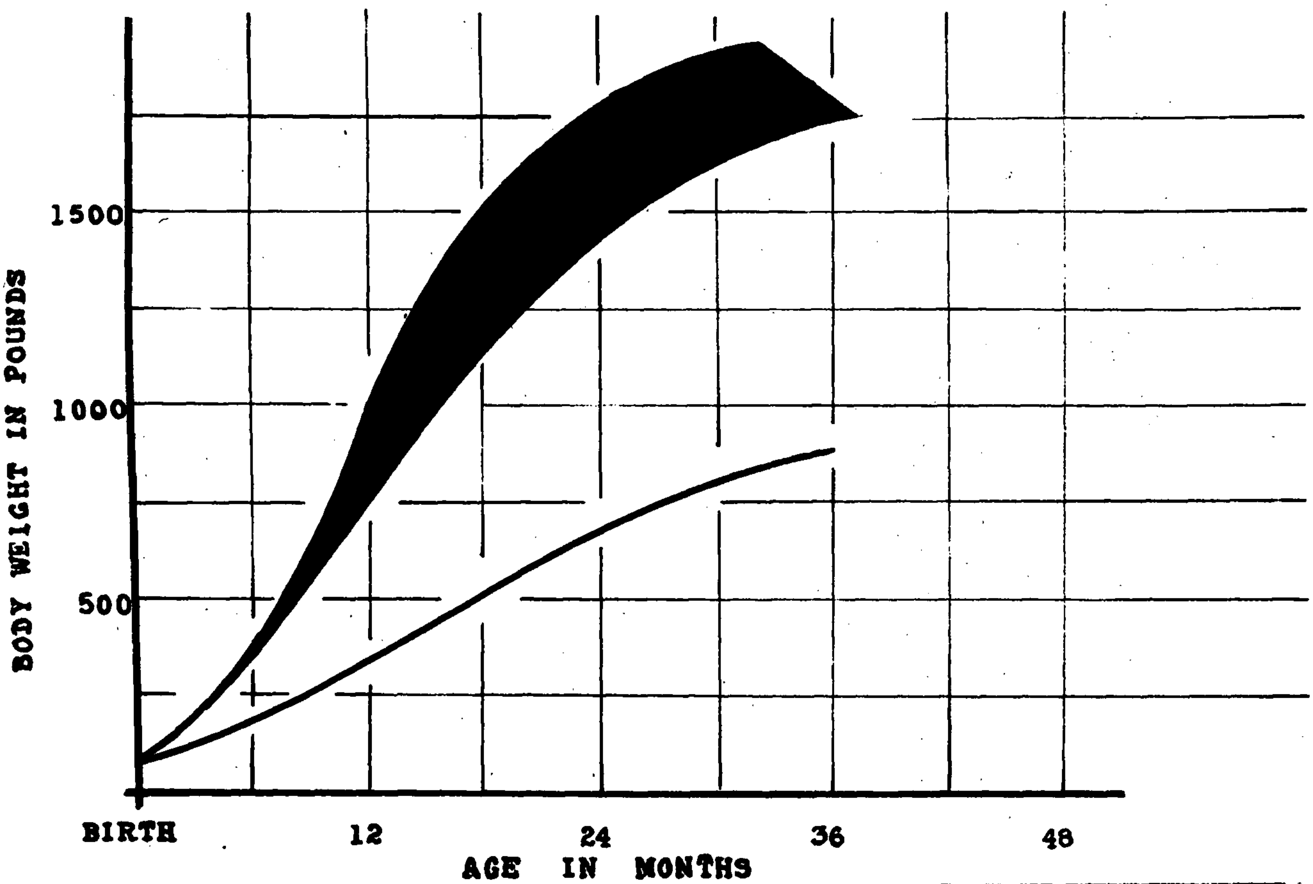


Figure 1 IMPROVEMENT OF GROWTH OF RANGE CATTLE BY ENVIRONMENT AND SELECTION PRESSURES

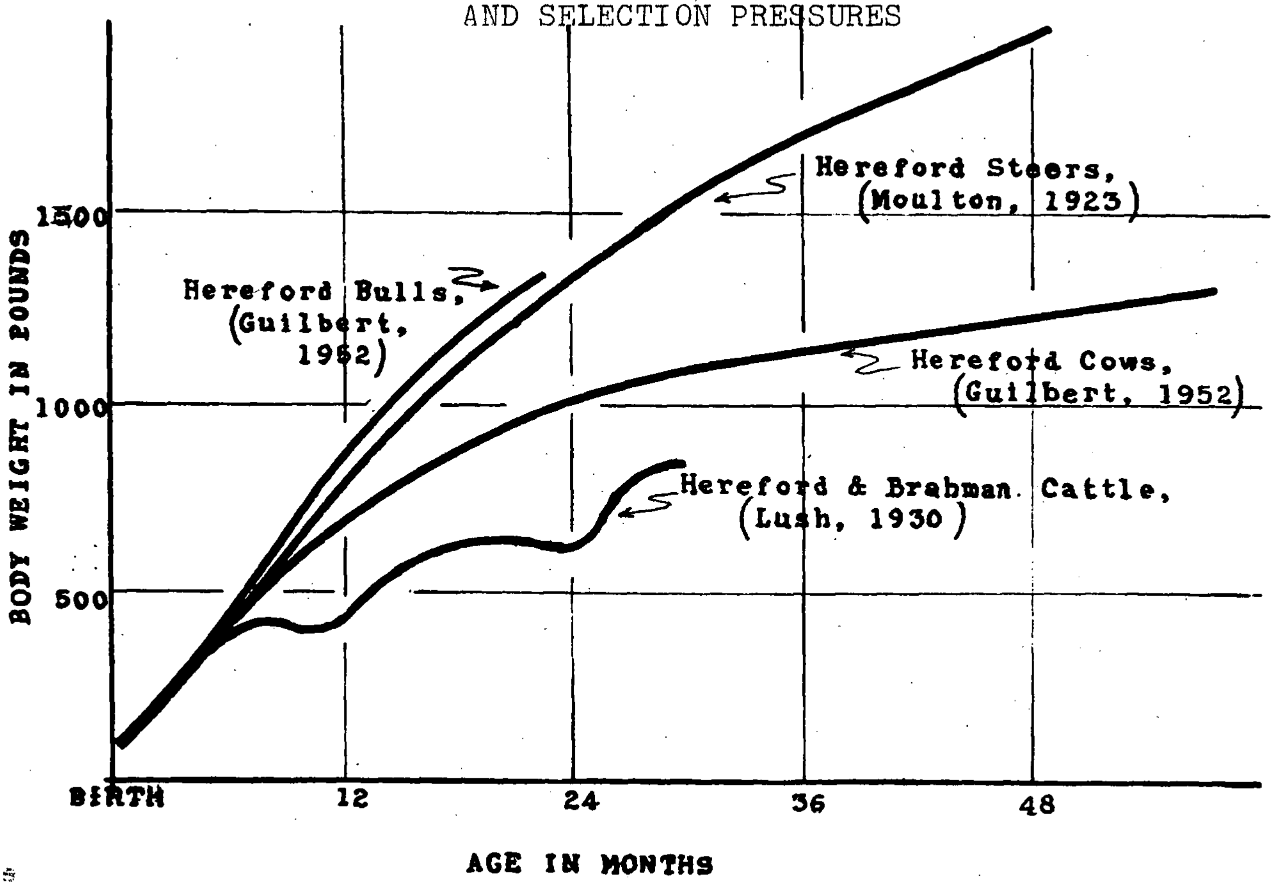


Figure 2

TYPICAL GROWTH OF BEEF CATTLE UNDER VARYING ENVIRONMENTS

II

Experimental

A. Beef Bull Research Project

The Hereford Bull Research Project was initiated at the University of British Columbia, in November, of 1951, in response to the wide interest in performance testing of beef cattle shown by the ranchers and technical agriculturists of British Columbia. The objects of the project as listed in the original prospectus are as follows:

(1) To ascertain if possible the controllable factors which might influence the rate and efficiency of gain of twelve purebred beef bulls.

(2) To establish a satisfactory procedure for such a program.

(3) To determine under British Columbia conditions, the feasibility of operating a Beef Bull Testing Program.

From the literature it appears that performance testing of beef cattle is not a new idea and has only been delayed in becoming a general policy by the technical difficulties of developing quantitative measures of beef production which could be used on large numbers of prospective breeding animals. Most of the research to date has followed the *a posteriori* type reasoning whereby the results of extensive feeding trials are treated statistically so that there is now amassed large amounts of data which will serve a purpose in directing the more fundamental studies.

It has been felt that this small scale preliminary experimental investigation, with a review of literature would be desirable as a foundation for further studies.

(1) Review of Literature

There is widespread dissatisfaction among livestock groups with the use of visual evaluation as the sole criteria of the breeding worth of meat producing animals. Large discrepancies have been noted from time to time between the standards required in the show-ring and those which best meet the market and feed lot requirements.

Stothart (1952) presents the ridiculous situation of the failure of a large percentage of the ribbon winners in the sow classes at the Royal Winter Fair, Toronto, to meet the requirements of the Advanced Registry of Swine.

An editorial appearing in the Farmer and Stockbreeder (May 6-7, 1952), indicates the situation at the Smithfield Show.

> ...the 117 cattle that were auctioned averaged 802 pounds per carcase. The 41 entered for carcase competition averaged 641 pounds per carcase. The 274 live sheep and lambs averaged 80 pounds and 97 sheep entered for carcase competition averaged 64 pounds per carcase.... This big difference in weight is made up mostly of superfluous fat. The fat stock show exhibits and entries for carcase competition should be much nearer each other in weight and conformation, because the ultimate end of all fat stock is distribution through the retail trade to the consuming public.

(2) Comparison of Direct Methods of Performance Testing

One early attempt was made to develop an aid to the evaluation of beef bulls by using the accumulated show-ring honors. (Holbert, 1930) This was improved upon by the suggestion that the progeny of a beef sire be entered in carcass classes and so provide an index of the worth of the sire. (Stephenson, 1932)

The first true Record of Performance (R.O.P.) test was devised by Sheets (1932), who required that the total body gains as well as feed consumption (including milk) from birth to 365 days be taken. This method has been used in experimental work conducted at the United States Department of Agriculture (U.S.D.A.), Experimental Station at Beltsville, Maryland.

Winters and McMahon (1932), felt that a simple method must be devised if breeders are to be able to performance test their animals. They suggested using body weight gain to 365 days of age as a measure of merit and pointed out that this would place a premium on the calves from heavy milking dams. A point considered desirable by these workers.

Black and Knapp (1936), proposed using an R.O.P. score based on the relationship .05 (E) (Q), where (E) is the gain per 100# total digestible nutrients (T.D.N.), and (Q) is the carcass grade in per cent. They carried out an analysis of variance on the same cattle evaluated by the methods of Sheets, Winters and McMahon, and Black and Knapp, to find the latter gave significant differences between sires which the other methods failed to do on the particular data treated. (Black and Knapp, 1938)

It has occured to many investigators that the correlation of rate and efficiency of gain with some readily measurable characteristic might be high enough to use the latter as a measure of the former. A method of eliminating the long, laborious procedures already suggested would be desirable.

Dawson (1947), found birth weight to be only 11 per cent hereditable after corrections for the dams age and weight were made. (Table 1). The heaviest calves at birth tended to be the ones that weaned out heaviest and reached slaughter weight earliest but significance was lacking. It would appear that birth weight could be of some interest to the animal breeder but not as an indicator of rate and efficiency of gain unless supported by additional growth data.

Knapp and Woodward (1951) indicated the heritability of live weight at weaning to be 28 per cent, which is about the same amount available to the dairy cattle breeder selecting for increased milk and butterfat production. This makes the σ^2_E (variance due to environment) a large factor, the major portion of which is due to preweaning nutrition.

Knapp and Black (1940) demonstrated statistically that 41 per cent of the variation in rate of gain observed between individuals during the suckling period was due to the nutrition of the animal and selection based on weaning weight merely selects the progeny of heavy milking dams who demonstrate the poorest beef conformation as measured visually.

One can readily realize why the heritability of weaning weights would be low since seldom is an animal allowed to realize its full genetic potential to grow during all the preweaning period because nutrition is limiting. This is evidenced in the work of Lush (1930) illustrated in Figure 2 where it may be observed that growth rate slows in July due to the

TABLE 1

Heritability Estimates

Characteristic	Heritability	Basis of Analysis	Species and/or Breed	Authority
Overall Weaning Score	50%	Within year regression of offspring on Dam	Aberdeen-Angus	Koger and Knox (1952)
Thickness Score	15%	"	"	"
Lowness Score	46%	"	"	"
Smoothness Score	15%	"	"	"
Overall Weaning score	30%	Half-Sib correlation	"	"
Thickness Score	10%	"	"	"
Lowness Score	13%	"	"	"
Smoothness Score	18%	"	"	"
Body Weight at 180 Days	33%	Paternal Half-Sib correlation	Poland China Danish Landrace PC x DL	Dickerson (1947)
Daily Gain after Weaning	33%	"	"	"
Feed/lb Gain	50%	"	"	"

Characteristic	Heritability	Basis of Analysis	Species and/or Breed	Authority
Yield of Lean Cuts	33%	Paternal Half-Sib correlation	Poland China, Danish Landrace PC x DL	Dickerson (1947)
Fatness	50%	"	"	"
Length of Carcass	75%	"	"	"
Live Weight at Weaning	28%	"	Progeny of Hereford Bulls	Knapp and Woodward (1951)
yearling	80 -/99%	"	"	"
Rate of Gain				
6 - 9 months	10%	Sire offspring correlation	"	"
9 -12 "	54%		"	"
12 -15 "	84%	"	"	"
Body Weight at 6 months	0%	"	"	Dawson, Vernon, Baker and Warwick (1951)
"	5%	Dam-offspring within sire group	"	
"	15%	Dam-offspring within sire group of Dam	"	"
Birth Weight	29%	Half-Sib correlation	Shorthorn	Dawson (1947)
"	11%	Dam-offspring correlation(corrected) for age and weight of Dam	"	"

Characteristic	Heritability	Basis of Analysis	Species and/or Breed	Authority
Feed lot Gain	70%	Sire-offspring correlation	Hereford	Knapp and Clark(1951)
Weaning Score	31%	"	"	"
Dairy Type	16%	intra sire daughter Dam regression	Jersey	Rennie (1951)
"	14%	"	"	Harvey (1949)
"	30%	"	Ayrshire	Tyler and Hyatt(1948)
Butter Fat Percentage	36%	"	Jersey	Rennie (1951)
Feed/100# Gain	26%	Regression of Progeny on mean of parents within strain and year	Durock Swine	Dickerson and Grimes (1947)
Length of Feed Period 72 Days-225 Bounds	47%	"	"	"
Weight at 72 Days	9%	"	"	"
Weight at Birth	-23%	"	"	"

inadequacies of the milk and feed supply which suppresses the growth potential since normal absolute growth rate continues to accelerate until puberty unless some set-back occurs. This situation is dealt with in detail using the Yorkshire pig. Energy intake becomes limiting by the tenth day following birth. (Waldern and Wood, 1952)

Dawson, Vernon, Baker and Warwick (1951), found that selection for increased body weight at six months would be a slow method of improving rate of gain.

Koger and Knox (1945) developed the equation for comparing all calves at a constant weaning age. Actually it

$$W = w + db$$

W = corrected weight
w = weight at weaning
d = standard age desired
b = the regression coefficient .60

was developed from the analysis of a large group of animals and introduces the inaccuracies associated with attempting to use the mean of a population to represent the individual. It undoubtedly is an improvement over attempting to compare animals at different ages and body weights.

It may be safely concluded that weaning weight may be of value to the animal breeder when culling females for milking ability but is not satisfactory in itself as a measure of the inherent ability to grow.

The heritability of rate and efficiency of gain of yearlings is 85 percent as estimated by Knapp and Woodward (1951). This leaves little doubt as to the time when most advantageous selections might be made and therefore the post-weaning period has been adopted by practically all investigators for the following reasons:

(1) Increased accuracy of selection due to the high heritability of animal differences for rate and efficiency of gain.

(2) The 6-18 month period coincides with the usual supplementary feeding schedule.

(3) If the testing of steers is practised, then it is merely a normal feed lot proposition with the addition of group penning and record keeping.

(4) If the individual bull is tested the period of feeding is coincident with the period between weaning and first service.

(5) The post weaning period is one of major physiological change in the life processes of the animal.

If it is accepted that the yearling period is the most desirable age for performance testing then the problem presents itself as to whether, steers, heifers or the individual bull will be treated.

The earliest and also the greatest amount of testing work has involved the progeny test with eight steers and a 168 day feeding period required for significant results. (Knapp, Phillips, Black and Clark, 1942). The progeny test using steers has one great advantage in that there are available eight carcasses for scoring and testing which is not so with the individual performance test. The advanced Registry Policy for Beef Cattle operating in Ontario has reduced the number of steers in the test to four. (Knox, 1951)

Some of the disadvantages of the progeny test limit its use and value:

(1) The results are not known until a bull is in his third year (providing he is mated in his first year).

(2) The bull to be tested must be carefully hand mated as a yearling to at least 16 cows to calve out 8 bull calves. To protect the young bull the matings must be spaced with a resulting spread in the ages of the calves to be tested.

(3) The high cost of individual penning and feeding of groups of steers.

Knapp, Baker, Quesenberry and Clark (1941) found the body weights of heifers at 18 and 30 months of age significantly different between sire groups, when they were handled as a group under approximately uniform ranch conditions.

This of course has the disadvantage of being slow in showing results but obviously is cheap, very practical, and worthy of consideration.

The use of performance testing of individual bulls has attracted the interest of the "late-comers" to the field of the R.O.P. testing of beef cattle. There is much to be said in its favour:

(1) Only one animal need be fed and housed.

(2) Results are known before the animal is old enough for service.

(3) More animals may be tested.

(4) Individual characteristics may be studied which would otherwise be masked by group means.

(5) More data may be obtained from a few individuals than from a similar number of groups with less effort.

There are two main disadvantages to the individual performance test:

(1) There is no carcass available for scoring, (providing it is considered necessary to have the carcass score).

(2) All results are lost or at least biased if disease or accident should affect the animal under test.

(3) Relative Importance of Conformation

The formula for R.O.P. score developed by Black and Knapp (1936), poses the question of the relative importance of conformation and rate and efficiency of growth. Is it desirable to consider beef type as 50 per cent of the total reasons for retaining or rejecting a breeding animal as many investigators have done? In this connection Knapp (1939) carried out extensive analysis of the scores made on animals by the traditional standards and later subjected to grading following slaughter. His general comment in effect was that the scoring technique is so inaccurate as to have no value except where differences are large.

It seems inevitable that the breeder will maintain a constant selection pressure directed towards the continuance of a reasonably desirable conformation and perhaps type should receive little or no direct consideration in any selection index devised. Koger and Knox (1952) estimated the heritability score as 50 per cent (Table 1), which indicates that type may be controlled quite readily. In any case it is doubtful whether it is advisable to alter quantitative figures on rate and efficiency of gain by a factor which is merely descriptive.

Knapp and Clark (1951) concluded after correlating weaning scores and subsequent gains in feed lot that, "...there is little value in selecting feeder cattle for rapid gain if sole dependence is placed on visual methods of selection." An indication of how this consideration carries through to carcass grading may be found in the data of Knapp, Baker, Quesenberry, and Clark (1941) in which they found the only significant difference between the progeny of several sires when measuring carcass characteristics such as percentage lean or percentage fat in rib-cuts, was yearly variations which are the logical consequence of changing feeds and management. Again it is necessary to conclude that there is a lack of accuracy when selecting for the small differences that exist in the conformation of beef animals, and the extreme cases will be selected against by normal culling procedures. There seems to be no necessity of either a score or carcass test in an index of merit designed for beef cattle. Future work may reveal the need for such carcass tests but at present it is likely that over emphasis of this aspect of the broader problem may becloud more urgent issues.

(4) Genetic Considerations

Since the ultimate goal of a performance test of beef cattle is as an aid to selection, it is desirable to consider the improvement that may be reasonably expected. The genetic variation in the body weights of the population from which ise made the selection of parents probably amounts to as much as 30 per cent at 18 months of age. (Figure 1). Since the heritability of live weight at this age is suggested to be 80 to 99 per cent (Knapp and Woodward, 1951) a breeder should realize some rather large and rapid increases in the progeny of selected parents over the mean of the population. Unfortunately such is not the case as expressed by Knapp, Church and Flower (1951). After continuous selection for improved rate of gain for fifteen years in the Station herd at Miles City, Montana; "Improvement in rate of gain and weight at 15 months of age were found to be 0.16 pounds in daily gain and 66 pounds in body weight at 15 months of age." This is somewhat less improvement than hoped for considering the materials available. One might suggest that even the gains made are in part due to improved feeding and management. A possible conclusion is that the characteristics under consideration are inherited mainly in some other than a purely additive manner.

In the classic discussions presented by Lush (1945)

if: $\sigma^2 T$ = total variance observed for the characteristic studied

$\sigma^2 T = \sigma^2 H + \sigma^2 E + \sigma^2 EH$

$\sigma^2 H$ = variance due to heredity

$\sigma^2 E$ = " " " environmental effects

$\sigma^2 EH$ = " " " interaction of environment and heredity.

with further partitioning:

$\sigma^2 H = \sigma^2 G + \sigma^2 D + \sigma^2 I$

$\sigma^2 G$ = that portion of the heredity of the characteristic controlled by the additive genes (the expected effect)

$\sigma^2 D$ = variation from the purely additive effect due to dominance

$\sigma^2 I$ = variation from the purely additive effect due to the epistatic effect. (non-additive interaction of non-allelic genes)

Heritability is theoretically the ratio between the variance due to heredity and the total variance, ie:

$$\sigma^2 H / \sigma^2 T \quad \text{or} \quad \frac{\sigma^2 G + \sigma^2 D + \sigma^2 I}{\sigma^2 T}$$

If most of the $\sigma^2 H$ were due to $\sigma^2 G$ there would be very marked effects due to the selection pressures exerted by the researchers at Miles City since the simple Mendelian ratios would hold.

Lush (1951) pointed this situation out with three possible explanations:

(1) The actual heritabilities are not as high as calculated.

(2) The inaccuracy of measuring the improvement that takes place.

(3) Actual selection pressures are lower than believed.

The first possibility does not apply in this case since even a very marked error in the present calculated heritabilities would still provide ample variance due to heredity to allow reasonable effectiveness of selection.

The second possibility is also not applicable since the characteristics considered are quantitatively measured with limited possibility of error.

The third suggestion probably holds the answer for the slowness of improvement following selection for rate of gain in beef cattle and it is believed that a plausible explanation will be developed in the discussion to this thesis.

To illustrate, the genetic problems which must be answered before positive selection procedures can be developed are presented in the following liberal quotations from Lush (1950) "...if the additive genetic portion of the heritability ($\sigma^2 G$) is high, most of our efforts should be concentrated on selection - with individual selection being the centre of the program, but supported by life time averages, sib testing, progeny testing, pedigree considerations." "If heritability values are as high as present reports indicate, we have only limited use for inbreeding and progeny testing, and the testing of individual bulls by feeding under controlled conditions would be very effective." Lush goes on to suggest that if nicking is demonstrated as being important in the selection for rate and efficiency of gain, then individual selection will become relatively less important and selection between lines will be necessary. "If the cause (nicking) is due to epistasis; then we will try to find lines good in their own performance but which will cross well with other lines. From the best of these crosses, new lines will be built through a second cycle of inbreeding; enough to make the lines distinct, comparing them, crossing them, and breeding again for better crosses." If nicking is the result of overdominance, make the inbred lines first and then select those that do well in crosses with other lines. We judge the lines very little on their own characteristics, as long as they are good enough to be commercially usable. Once a good line is found, it is never crossed with the lines with which it nicks well."

All these suggestions require much time and money to carry out experimentally and therefore in the meantime gains in animal production can be made by performance testing individual bulls paying attention to blood lines.

(5) Rate and Efficiency of Gain

It is quite obvious that both rate of gain or growth and the gross efficiency with which the process is carried out are of vital importance to the producer of livestock. Just which is relatively more important is a matter of circumstance; ie; where feed is cheap and overhead is high, rate of gain is most important, however as the relative cost of feed increases so does the importance of efficiency of gain.

An illustration may be made by observing the figures from the Gilliam County Cattle Improvement Association (1951-52) (Table 2). The rate of gain ranged from 1.6 - 2.8 pounds per day and at a market price of 25 cents per pound returns on investment per day of 40 cents and 70 cents respectively, an increase of 75 per cent. From the same project the efficiency figures ranged from 473 pounds of hay and 330 pounds of concentrate to 309 pounds of hay and 210 pounds of concentrate

HEREFORD BULL RESEARCH PROJECT 1951-52

Table 2 RESULTS OF THE GILLIAM COUNTY BEEF CATTLE IMPROVEMENT ASSOCIATION 1951-52

	Bull No.	Age in Days 15/11/51	Weight in lbs. 15/11/51	Weight in lbs. 3/4/51	Gain in 140 Days	Average Daily Gain	Efficiency per 100 lb. Gain			Grade
							Hay	Conc.	TDN	
Top 10	36	250	480	850	370	2.6	314	217	327	B+
	31	260	475	870	395	2.8	339	231	351	B+
	25	231	435	805	370	2.6	317	220	325	B+
	23	272	455	820	365	2.6	322	220	333	B+
	17	249	450	805	355	2.5	318	217	329	B+
	29	251	475	840	365	2.6	339	240	357	B+
	35	244	495	865	370	2.6	339	232	351	B
	39	233	515	835	320	2.3	348	245	365	B+
	20	212	445	770	335	2.3	299	204	309	B
	13	228	440	725	385	2.0	309	210	319	B+
Bottom 10	10	229	410	675	265	1.9	393	270	408	B
	19	256	490	785	395	2.1	473	330	494	B
	33	251	505	760	255	1.8	417	286	432	B
	57	215	570	845	275	2.0	423	312	456	B-
	53	249	560	800	240	1.7	479	315	486	B
	9	205	390	635	245	1.8	350	260	378	B-
	12	285	395	645	250	1.8	354	254	376	C+
	26	272	440	675	235	1.7	466	307	474	B
	41	206	500	785	285	2.0	390	282	416	C
	6	217	390	615	225	1.6	382	274	405	C+

per 100 pounds gain. Using 40 dollars per ton for hay and 80 dollars per ton for concentrate the range is 37 to 24 dollars per 100 pounds gain or a decrease of 35 per cent. These differences will take on more importance if the correlation of rate and efficiency of gain is low.

As suggested by Knapp and Baker (1944) it has been assumed by many to be a biological necessity that rate and efficiency of gain be closely correlated, however as indicated by data of Winters and McMahon (1933); Knapp (1941); Blackwell (1951), in a time constant population the correlation of the two factors is not high. This situation becomes necessary if it is to agree with previous findings such as the variation in changing metabolic rate, (Brody, 1945, p468) with increasing body weight which means that the physiologically younger animals will be bearing a heavier basal metabolism cost per unit body weight which will be reflected in a lowered feed efficiency. A quick maturing animal will have passed into the period of fattening from the period of greater muscle development. This calls for a lowered gross efficiency since the energy content of fatty tissue is approximately six times that of protein tissue. An animal that grows moderately slowly and mainly in the protein sense with correspondingly low feed intake will show a high efficiency. These three hypothetical animals may all be growing at the same absolute rate with widely different efficiencies. As a matter of fact the use of a time constant population when dealing with the growth phenomenon is questionable since it immediately presents time as having a physiological meaning which is an error since growth rate is the balance between the growth stimulus and the retarding effects of the environment with no reference to time except by the man imposed measuring devices. Stated another way, animal growth occurs relative to physiological time rather than sidereal time.

If time is allowed to vary and rate and efficiency of growth are measured over a constant weight period the correlation between the characteristics increases. However as concluded by Hess (1948) while studying the inheritance of food efficiency in domestic fowl, "There is a definite inherent difference in feed efficiency between individuals that cannot be explained on the basis of body weight, rate of gain, or time."

One of the most obvious reasons for the difference is the error involved in the measure of physiological age. Although body weight very nearly measures physiological age it has one criticism; it presupposes the same mature weight of animals under observation which is not necessarily true even within inbred families. (Hammond, 1928)

An animal receives the stimulus to grow depending upon the amount of growing left to complete and it will fulfill this potential to the ability of the protoplasmic mass available for growth.

Lerner (1938) considered this relationship in the light of discussions by earlier authors and presented the following formula for growth rate, (Q) at any time (t).

I	$Q = k(At-t)$;	When rate of growth is considered proportional to the time remaining for the completion of growth.
II	$Q = k(Aw-w)$;	When rate of growth is proportional to the weight yet to be gained.
III	$Q = \frac{k}{t}$;	When the rate of growth is inversely proportional to the elapsed time.
IV	$Q = \frac{k}{w}$;	When the rate of growth is inversely proportional to the weight already attained.

Aw = final body weight
At = time at Aw
w = body weight

$$k = \frac{\log w_2 - \log w_1}{t_2 - t_1}$$

(6) Procedures

The details of management, buildings, facilities, and record keeping will not be related herein since they have been adequately dealt with by Williams and Wood (1952) and in the undergraduate essays of Doornenbal (1952) and Phillips (1952).

(a) Rationing of Test Animals

The correct method of feeding individual bulls in order that the most accurate data will be forthcoming is a matter for conjecture and no one as yet has laid down a firm procedure which will satisfy all the requirements that may be suggested.

Presumably an animal should be fed in such a manner as to allow full expression of its "genetic potential" to grow. ("Genetic potential" is used for want of a better term to indicate the total of all stimuli which direct tissue development). While ad libitum feeding would appear to permit full expression of these growth propensities it suffers from certain disadvantages particularily at the experimental level as indicated by the following:

(1) Feeding *ad libitum* tends to increase the possibility of digestive disorders and loss of appetite which would of course be detrimental to the rate and efficiency of gain with a bias of results. Digestive upsets in the ruminant type animal are much more difficult to correct than in the non-ruminant.

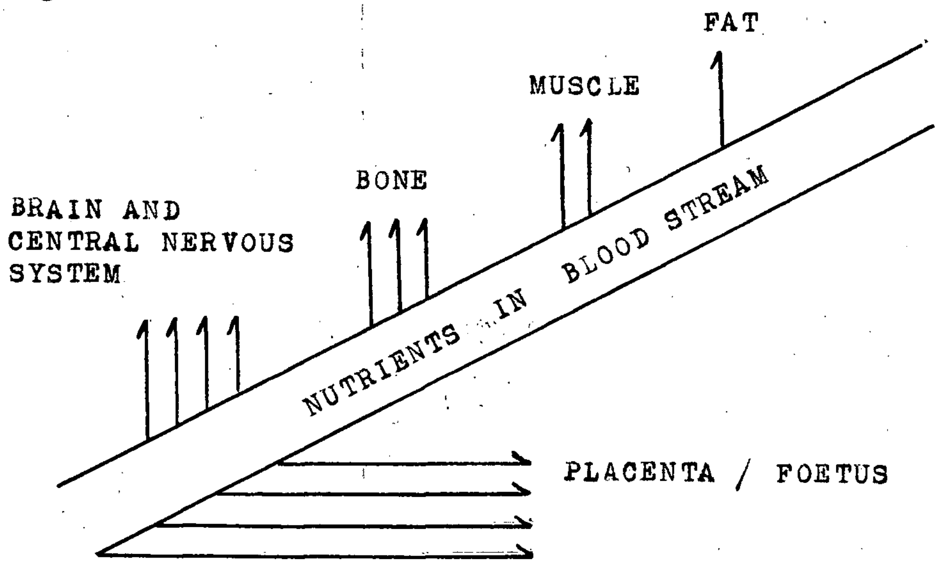
(2) The characteristic being measured is that of rate of growth and to obtain valid data, all other factors must be held constant. Allowing as large a factor as the nutrient intake of the animal to vary does not fit into the above well founded requirement for sound experimental design. Although appetite and rate of growth must have a degree of positive correlation, the variation in digestibility and the decrease in deposit energy per unit body weight due to a decreased protein to fat ratio with increased feed consumption may give inter animal variations which are false when intake of nutrients are not standard.

It is fairly obvious that there would be definite advantages feeding at a set level something less than *ad libitum*.

The interpretation of *ad libitum* feeding in this thesis is considered to be the free choice intake of an animal which has access to a ration so constituted as to satisfy all nutrient requirements without the capacity of the digestive tract or the palatability of the ration becoming a limiting factor.

Hammond's (1944) considerations of the effects of limiting the intake of the animal are pertinent to this discussion. His presentation implies that various body tissues

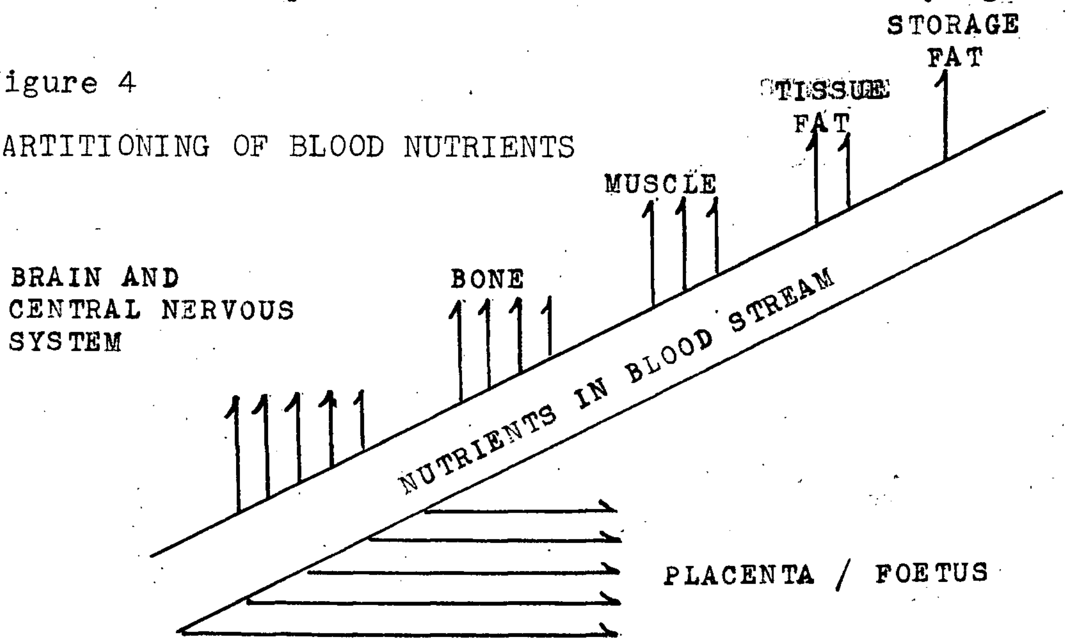
Figure 111 PARTITIONING OF BLOOD NUTRIENTS



have priorities on the nutrients in the blood stream as indicated by the number of arrows. As Hammond visualized the scheme, when the nutrient level drops the amount supplied to each tissue decreases. "When the supply of nutrients in the blood stream is limited we may suppose that one arrow is deducted from each tissue system and whereas the growth of fat is completely stopped, brain and bone growth continues." It must be remembered however that Hammond's hypothesis was based on the work of McMeekan (1940, 1941) and Pomeroy (1942) in which the animals ration was lowered from an adequately supplied, well balanced ration to one with the same proportion of nutrients but lower in amount so that protein as well as energy was limiting. If however only the total energy content of the ration is decreased with the levels of protein retained at the *ad libitum* level there is a completely different situation developed from the one Hammond was studying.

Figure 4

PARTITIONING OF BLOOD NUTRIENTS



Altering Hammond's diagram (Figure 4) with the fat portion divided into the "tissue fats" and "storage fat" (Dukes, 1947), it is suggested that the first reduction in the energy content of the ration will only result in an arrow being deducted from the "storage fats." Further reductions would result in removal of some "tissue fats" and also certain amounts of dietary protein which would be deaminized preparatory to use as an energy source with the subsequent reduction in the amino acids available for growth. When the energy level is lowered still further an actual removal of tissue protein does result.

This thesis assumes that storage fat is a reserve supply of materials which accrues when the energy intake is in excess of that which the body may utilize at that time. It is not under genetic control other than the site of deposition.

The bone fraction of the body gain however must be under complete genetic control since it is the supporting structure of the body and ultimately limits the mature size of the animal. This is in keeping with the high priority bone tissue has for nutrients in the blood stream. (Pomeroy, 1942).

Muscle tissue since it supports and provides locomotion for the genetically predetermined mass of the animal should also be under close genetic control. There is further indication by the fact that the percentage protein of the body mass on a fat free basis is a constant over all but the very early stages of growth and such a wide range of species as to include the rat and the cow. (Haecker,1922); (Moulton, 1922); (Spray and Widdowson, 1950); (Murray, 1922); (Callow, 1944, 1947, 1948).

McMeekan's (1951) observations indicate the constancy and close correlation between bone and muscle tissue which further suggests close genetic control, "In the many hundreds of animals of all species and breeds that we have dissected down to their basic tissues we have always found a heavy weight muscle associated with a heavy weight bone; big muscles and light bone do not go to-gether."

It may be concluded that bone, muscle and certain tissue fats represent the active protoplasmic mass of the body which is laid down in the orderly manner dictated by the gene material of the individual animal. The deposit fat is merely a representation of the energy intake in excess of body requirements and so it seems justifiable to suggest a feeding level slightly below ad libitum for measuring the inherent differences in rate of growth.

A few considerations of the energy requirements of growing beef cattle may assist in reaching a decision on the proper feeding procedures. Morrison (21st ed.) gives the following figures for, "growing beef cattle, fed liberally for rapid growth." At a body weight of 500 pounds or approximately weaning, the daily net energy requirement is 6.7 to 7.5 therms with a dry matter intake of 11.7 to 13.0 pounds. Working with two unknowns in simultaneous equations, assuming net energy values of .4 and .7 therms per pound of roughage and concentrate respectively the ratios 4.97 pounds to 5.33 pounds of roughage to 6.73 pounds to 7.67 pounds of concentrate or about one of roughage to one and one half of concentrate.

This is a departure from the usual supplemental system of feeding. Actually it is a case of providing enough roughage for proper digestion rather than making an addition of concentrate to raise the T.D.N. of a mainly roughage ration. By virtue of similar calculations the ratio of roughage to concentrate at a body weight of 1000 pounds is two to one. The level of concentrate is high in this rationing for the reason that a beef animal cannot express it's full "genetic potential" to grow during the most active growth phase on a diet excessively high in fibre.

The Gilliam County Beef Cattle Improvement Association (1950-52) have a method of feeding test animals in which the roughage is fed at a definite fraction of the roughage intake. This eliminates the variation in the roughage to concentrate ratio which exists when animals actually select their ration cafeteria style. Unfortunately the roughage to concentrate ratios they used are not those which provide for maximum growth for weaner and short yearling calves. (Table 3) This is due to the high percentage growth rate and high metabolic rate which is the result of both rapid growth and the larger surface area per unit mass.

Table 3 GILLIAM COUNTY FEEDING SCHEDULE

Calves	weighing	less than 600#	- 1#	grain	to	3#	hay
"	"	600# to 700#	- 1#	"	"	2#	"
"	"	over 700#	- 1#	"	"	1#	"

Washington State College, (1951-52), chop the roughage and concentrate to-gether in a definite ratio. This has the advantages of The Gilliam County System and in addition saves on the labour cost of feeding.

It is noted that the roughage to concentrate ratio in the Washington State College feeding trials supply the energy requirements of the animal.

With the foregoing considerations in mind the method of feeding for the U.B.C. Bull Testing Project was developed. To avoid digestive disorders and to improve the value of the feed efficiency figures, the plan of limited feeding was adopted.

The feeding level chosen was that of the minimum recommendation for feeding rapidly growing beef cattle. (Morrison, 21st ed.) This data was plotted on an arithmetic grid and the feeding schedule was drawn off the smooth curve at 50 pound intervals of body weight. (Table 4). All feed weights were rounded to the nearest half pound for convenience in weighing. (Table 5). The formulation of the actual ration as shown in Table 5a was done with reference to the recommendations of the National Research Council of the United States. (Recommended Nutrient Allowances for Beef Cattle). The roughage was chopped to ensure uniform consumption.

(b) Weighing Procedures

It is observed by investigators working with the ruminant type animal that large errors may be introduced into their data by the body weight fluctuations due to the variations in the amount of rumen contents.

There are several methods for reducing this error:

(1) Averaging weights taken on three consecutive days.

(2) Weighing at a set time relative to feeding and watering.

(3) The removal of feed and water for a period of 10 to 12 hours before weighing to obtain a uniform shrink.

T A B L E 4

Theoretical Bull Ration - Based on Morrison's "Growing Beef Cattle, Fed For Rapid Growth"

Body Weight	Dry Matter	Net Energy (therms)	Hay Pounds	Hay Therms	Net Energy Supplied(a)	Concentrate Pounds	Concentrate Therms	Crude Protein (b) Required	Crude Protein (b) Hay	Crude Protein (b) Conc	Protein in Ration
300	7.2	4.6	1.47	.58	4.58	5.73	4.0	.96	.17	1.02	1.19
400	9.1	5.6	2.57	1.01	5.58	6.53	4.57	1.08	.3	1.14	1.44
500	10.7	6.3	3.97x	1.59	6.29	6.73x	4.7	1.17	.46	1.18	1.64
600	12.4	7.2	4.93	1.97	7.17	7.47	5.2	1.2	.57	1.31	1.88
700	14.2	7.7	7.47	2.98	7.68	6.73	4.7	1.24	.87	1.19	2.06
800	15.9	8.2	9.77	3.92	8.22	6.13	4.3	1.28	1.13	1.07	2.20
900	17.3	8.7	11.37	4.54	8.69	5.93	4.15	1.32	1.32	1.04	2.36
1000	18.6	9.2	12.73	5.10	9.22	5.87	4.12	1.36	1.47	1.01	2.48

x Figures do not fit smooth curve.
(a) Assuming .4 therms per pound of Hay
.7 therms per pound of Concentrate
(b) Assuming Concentrate -17.5% C.P.
Hay -11.6% C.P.

HEREFORD BULL RESEARCH PROJECT 1951-52

Table No. 5 FEEDING SCHEDULE

ANIMAL WEIGHT	MORNING		AFTERNOON	
	HAY	CONC.	HAY	CONC.
350	1.0	3.0	1.0	3.0
400	1.5	3.0	1.0	3.5
450	1.5	3.5	1.5	3.5
500	2.0	3.5	1.5	3.5
550	2.0	3.5	2.0	4.0
600	2.5	3.5	2.5	4.0
650	3.0	3.5	3.0	3.5
700	4.0	3.5	3.5	3.5
750	4.5	3.0	4.0	3.5
800	5.0	3.0	5.0	3.0
850	5.5	3.0	5.0	3.0
900	6.0	3.0	5.5	3.0
950	6.0	3.0	6.0	3.0
1000	6.5	3.0	6.0	3.0

HEREFORD BULL RESEARCH PROJECT 1951-52

Table 5a U. B. C. RATION No. 50 - BEEF BULL CALVES

Ingredient	Pounds per Ton
Ground Oats	800
Ground Barley	500
Molasses	100
Alfalfa Meal	100
Bone Meal	20
Oilcake Meal	380
Bran	100
	2000

This ration was blended then pelleted into one-half inch cylindrical pellets.

Table 5b PROXIMATE COMPOSITION OF ROUGHAGE AND CONCENTRATE

Constituent	Hay	Concentrate
Moisture	16.61%	8.99%
Fiber	28.6	8.50
Protein (Nx6.25)	12.30	15.99
Fat	0.85	0.50
Ash	8.89	5.04
Nitrogen Free Extract	32.75	60.98
Calcium	1.57	0.85
Phosphorous	0.22	0.75

The procedure followed in this project was to weigh at a set hour every seven days rather than every 14 or 28 days as is common is experiments with beef cattle. It seems logical to increase the degrees of freedom for greater significance.

(7)

Results and Discussion

The results of weekly weighings as recorded are presented in Table 6. As indicated in the literature review there are certain difficulties associated with evaluating growth. The first problem in interpreting the data is to find a basis for comparing or identifying animals; whether it be made at a constant age or a constant body weight.

In Table 7 the data is given on an equal age basis and an extreme of 175# variation in body weight may be observed between bull numbers 7 and 10 at 35 weeks of age. According to the heritability data on Table 1 only 28% of the live weight differences at weaning are attributable to genetic control. These differences will have two effects on subsequent growth and development.

(1) The light weight calf has less "protoplasmic mass" with which to grow and therefore is being discriminated against when compared with animals of the same age but a greater body mass. However, as indicated earlier this difference is largely due to dam influences, presumably milk supply and is considered by many a valid point for discrimination. (Winters & McMahon 1933)

(2) It has been observed that an animals tends to grow at an accelerated rate for a period following suboptimum nutrition, which would coincide with the history of the light weaning calf and therefore selection for rate of gain at a constant age would encourage low weaning weights and more precisely poor milking cows. (McMeekon 1940), (Asmundsen and Lerner 1934)

HEREFORD BULL RESEARCH PROJECT 1951-52

Table 6 RECORD OF WEEKLY WEIGHINGS FOR ALL ANIMALS

	ARRIVAL					1951						1952																	
Bull No.	Nov 15	Nov 20	Nov 30	Dec 7	Dec 23	Nov 25	Dec 2	Dec 9	Dec 16	Dec 23	Dec 30	Jan 6	Jan 13	Jan 20	Jan 27	Feb 3	Feb 10	Feb 17	Feb 24	Mar 2	Mar 9	Mar 16	Mar 23	Mar 30	Apr 6	Apr 13	Apr 20	Apr 27	May 4
1	523					550	555x	565	569	582	588	608	620	630	655	660	675	675	692	702	728	745	762	767	782	800	810	830	835
2	545					560	582x	600	612	645	636	662	685	700	714	707	735	735	745	755	775	795	815	832	835	867	874	890	895
3	400					405	405x	410	430	448	440	471	475	491	504	510	540	545	560	572	590	628	625	635	662	680	685	705	730
4	445					460	463x	495	500	520	514	552	565	560	598	605	595	600	640	650	665	695	720	740	760	778	793	814	830
5	494					525	537x	555	570	593	610	642	645	663	663	673	690	695	698	708	728	745	750	770	782	795	798	825	838
6		370				415	437x	428	452	466	475	495	505	515	535	531	543	569	575	585	600	620	636	650	670	693	694	702	724
7		400				425	437x	450	472	488	490	512	525	540	538	558	558	584	585	593	615	640	640	665	675	694	700	730	743
8		430				440	452x	470	480	500	503	534	547	565	570	582	593	600	631	651	662	680	685	697	720	747	755	765	790
9			540				555x	555	562	565	588	614	630	630	650	658	672	660	700	720	730	746	740	780	787	803	818	832	845
10				555				540x	542	572	585	612	610	630	637	639	648	670	690	712	725	741	762	782	800	805	816	835	843
11					328					328	325	344x	350	370	380	390	407	430	438	455	470	490	492	500	522	530	537	542	570
12					263					263	269	286	293	307x	320	326	342	355	370	390	402	418	435	441	460	473	475	505	515

x - first weight on test

TABLE 7

Weights at Eqivalent Ages

Bull No.

Age Weeks	1	2	3	4	5	6	7	8	9	10
27			405							
28			410			437				
29			430	463		428				
30			448	495		452				
31			440	500		466				540
32			471	520		475				542
33			475	514	537	495			555	572
34			491	552	555	505			555	585
35	555		504	565	570	515	437	452	562	612
36	565		510	560	593	535	450	470	565	610
37	569		540	598	610	531	472	480	588	630
38	582		545	605	642	543	488	500	614	637
39	588		560	595	645	569	490	503	630	639
40	608		572	600	663	575	512	534	630	648
41	620		590	640	663	585	525	547	650	670
42	630		628	650	673	600	540	567	658	690
43	655		625	665	690	620	538	570	672	712
44	660	582	635	695	695	636	558	582	660	725
45	675	600	662	720	698	650	558	593	700	741
46	675	612	680	740	708	670	584	600	720	762
47	692	645	685	760	728	693	585	631	730	782
48	702	636	705	778	745	694	593	651	746	800
49	705	662	730	793	750	702	615	662	740	805
50	745	685		814	770	724	640	680	780	816
51	762	700		830	782		640	685	787	835
52	767	714			795		665	697	803	843
53	782	707			798		675	720	818	
54	800	735			825		694	747	832	
55	810	735			838		700	755	845	
56	830	745					730	765		
57	835	755					743	790		
58		775								
59		795								
60		815								
61		832								
62		835								
63		867								
64		874								
65		890								
66		895								
	3	0	0	-2	0	-2	-3	2	-1	-1

Age in weeks multiplied by seven plus the indice listed under each bulls weight column will be the bulls exact age in days.

The two foregoing statements suggest opposite effects but there is no reason to suppose they are equal and certainly they are not measurable so they must be considered as two separate criticisms of age as the basis for comparing individuals.

If all the animals had been allowed full expression for their genetic growth potential from birth to weaning, ie: eliminate the environment due to dam differences, there would be some merit in using age as the basis of comparison since then undoubtedly heritability would increase and a measure of the economically important factor of "age to market" would be developed. This is the basis for the R.O.P. program recommended by Sheets (1932) and previously described in the review of literature.

It would seem desirable that some basis other than age be used for comparing animals since it introduces bias due to previous environmental effects.

Since the difficulties of expressing the characteristic rate of gain seem so involved it may be well to digress and consider some basic principles in an effort to progress logically from simple, well established facts to a consideration of the problem under discussion.

The process of growth of animal tissue is a series of biochemical reactions obeying the mass law. It would be logical to expect the net result of all the reactions to also follow the basic rules of chemistry. Applying chemical kinetics to the growth process has merit since both are a study in reaction rates.

Growth may be classed as a "first order reaction" since it fills the requirement,","the rate is directly proportional to the concentration of the reacting substance", (Daniels 1948), or expressed in the terms of the physiologist, "growth rate is directly proportional to the active protoplasmic mass of the body." (Moulton 1922)

Since the rate is directly proportional to the concentration then it must be measured relative to the concentration at that particular instant since in the next instant the concentration will be altered by an increment.

Then rate $= \frac{W_2 - W_1}{t_2 - t_1}$ — where W_1 is the first and W_2 is the final weight of the period from time t_1 to t_2.

To make two actual measurements W_1 and W_2 over the instant $t_2 - t_1$ is impossible and therefore recourse is made to the following mathematical calculation:-

$\frac{dW}{dt} = kW$, or $k = \frac{\frac{dW}{dt}}{W}$ — Where $\frac{dW}{dt}$ represents the relationship of an infinitely small body weight (W) to an infinitely small time period (t); and k is the instantaneous relative growth, ie; relative to body weight (W)

The summation of all the infinitely small changes in body weight relative to changes in time between the limits W and A, (integration) results in the following:

IX

$$A \frac{dw}{w} = k \; dt$$ Where w is the initial weight and A is the final weight.

$$\ln w = \ln A \quad kt$$

$$w = Ae^{kt}$$

Or $$k = \frac{\ln w - \ln A}{t}$$

When computing instantaneous relative growth rate the equation may be more conveniently written

$$k = \frac{\ln w_2 - \ln w_1}{t_2 - t_1} = \frac{(\log w_2 - \log w_1) \times 2.303}{t_2 - t_1}$$

Note that due to the selection of napierian logarithms which are calculated to the base "e", the value for "k" when multiplied by 100 reads as per cent.

A first order reaction may be identified by the characteristic straight line plot which results when the concentration is regressed on time on an arith-log grid. Therefore any reaction which will give a straight line on an arith-log plot will have the reaction rate $k = \frac{\ln w_2 - \ln w_1}{t_2 - t_1}$

It is pertinent to this discussion to present certain growth data to investigate the results of regressing log body weight on time.

Figure 5 represents data collected on individual albino rats and plotted on a semi-log grid. The rats were fed a stock ration ad libitum. Attention is drawn to the

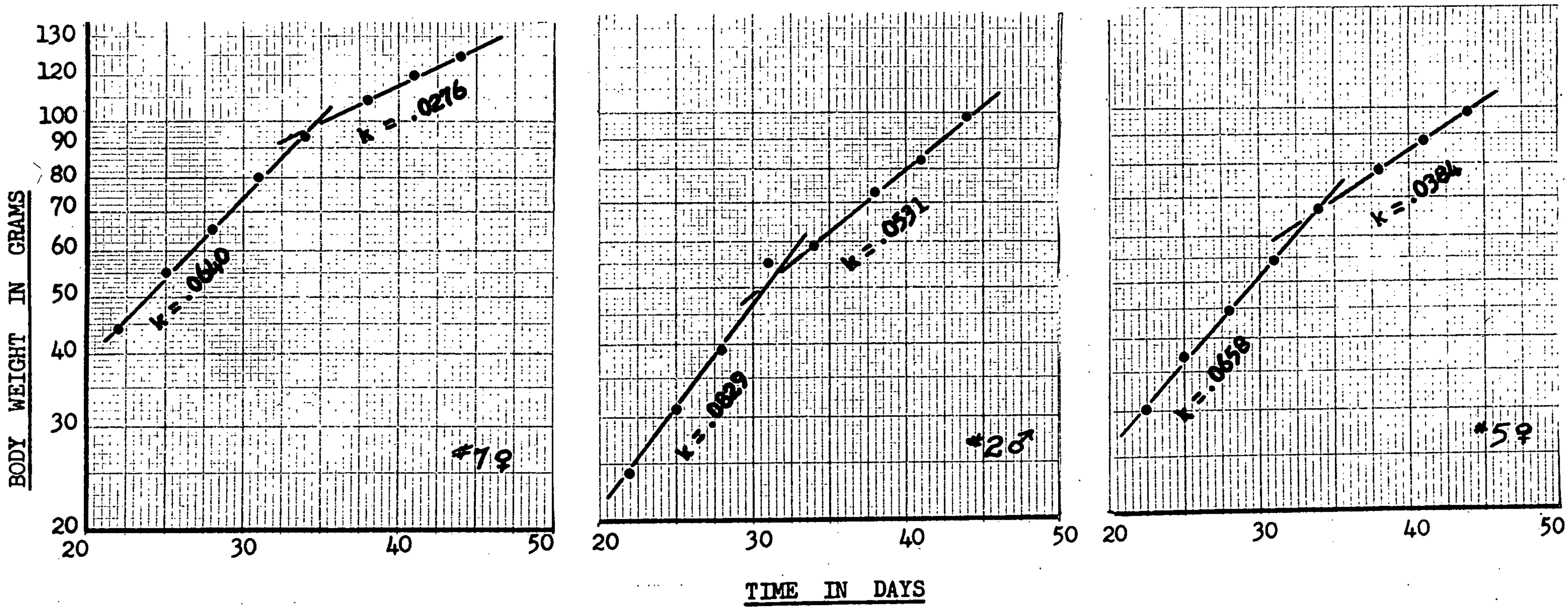


Figure 5 GROWTH PATTERN OF TYPICAL ALBINO RATS

remarkable fit of the data to a straight line over portions of the growth pattern. This is not the "scatter gram" type of plot usually associated with biological results but rather is of the exactness expected when extracting data from a complex chemical reaction. The statement should now be made that an animal tends to grow at a constant percentage rate relative to body weight, over certain portions of their growth curve.

This latter statement is better illustrated by reference to certain data presented in Figure 6.

This same data was accumulated by Waldern (1952) working with a large commercial swine herd to demonstrate the levels of production which may be attained by improvements in feeding and management. The "k" values for instantaneous relative growth rate are given on each segment of the growth diagram. From the "k" values the gain per day may be accurately calculated. For example number 323 at 40 days of age weighed 13.7 pounds and was gaining at 4.9 per cent per day or .67 pounds per day. The same pig at 50 days of age weighed 22 pounds, was still gaining at 4.9 per cent but in absolute terms was now gaining 1.1 pound per day.

This method of presentation is a more accurate appraisal of the growth of the animal than are the usual methods ofcalculating the mean gain per day. In this case the mean rate of

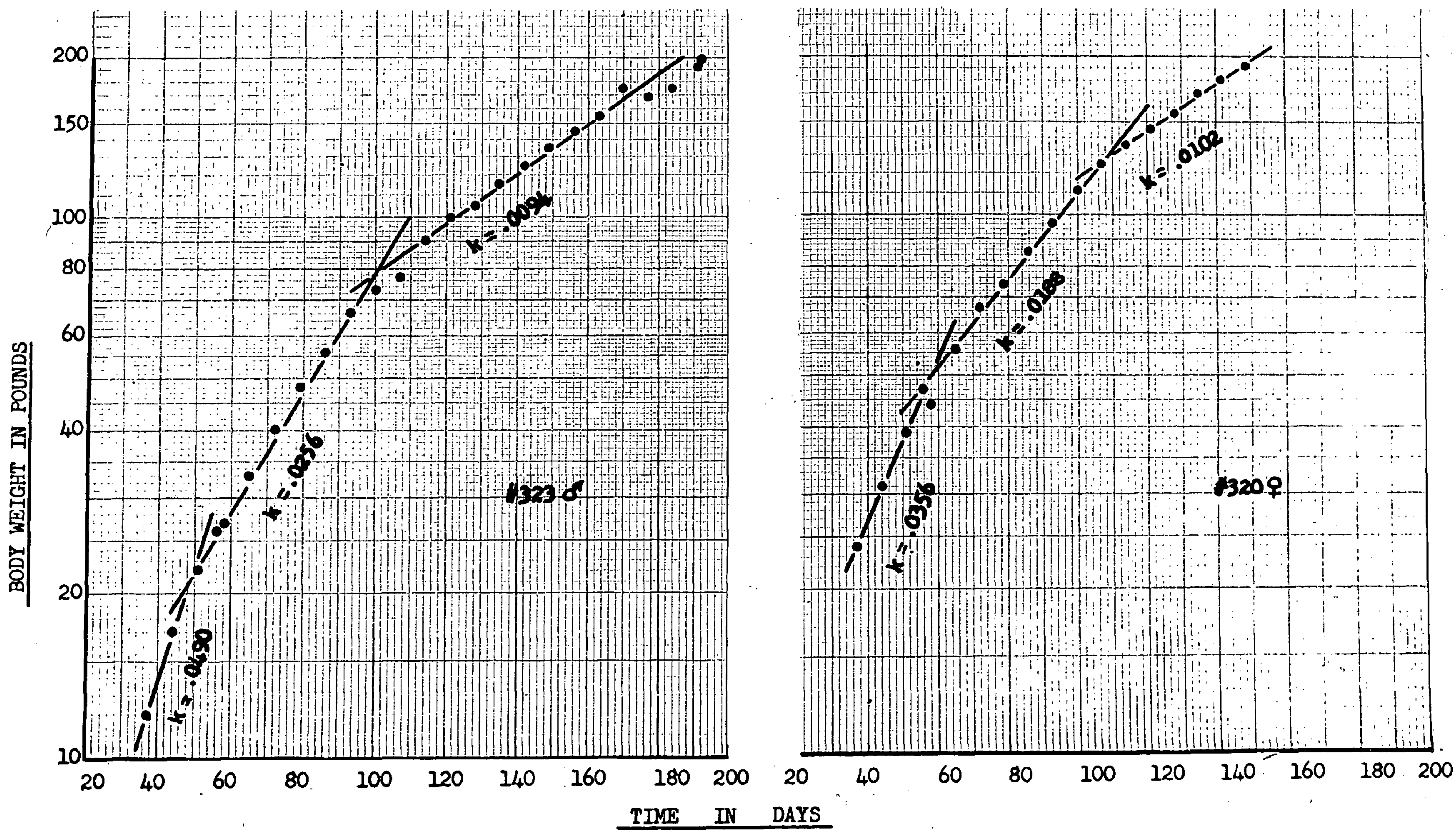


Figure 6 GROWTH PATTERN OF YORKSHIRE SWINE

gain per day over the 40 - 50 days of age period was .83 pounds per day. Actually this is not a true figure, since only for an instant during the period did the pig lay down body tissue at that rate.

It is interesting to compare the barrow number 323 with the gilt number 320. Note that the barrow has a greater relative growth rate during the second growth phase than the gilt but makes less absolute body gain because it breaks into a slower growth phase 10 days earlier. It is obvious that the longer an animal maintains itself on a rapid growth phase the shorter will be the time to market. Note that the foregoing observations would have been impossible had the data been that of groups of individuals or the measurements had been taken less frequently.

As a further illustration of the broadness of the application of instantaneous growth rate, observe figure 7 the arith-log plot of data collected from two "Black-tailed Deer". Again the data fits a straight line over certain growth phases and as noted in the same data "Blackie", although growing at a lesser instantaneous relative rate managed to maintain each phase longer than "Brownie" and so attain a greater body weight.

The foregoing applications of the arith-log method of plotting growth data, from which the conclusion has been drawn that animalstend to grow at a constant percentage rate relative

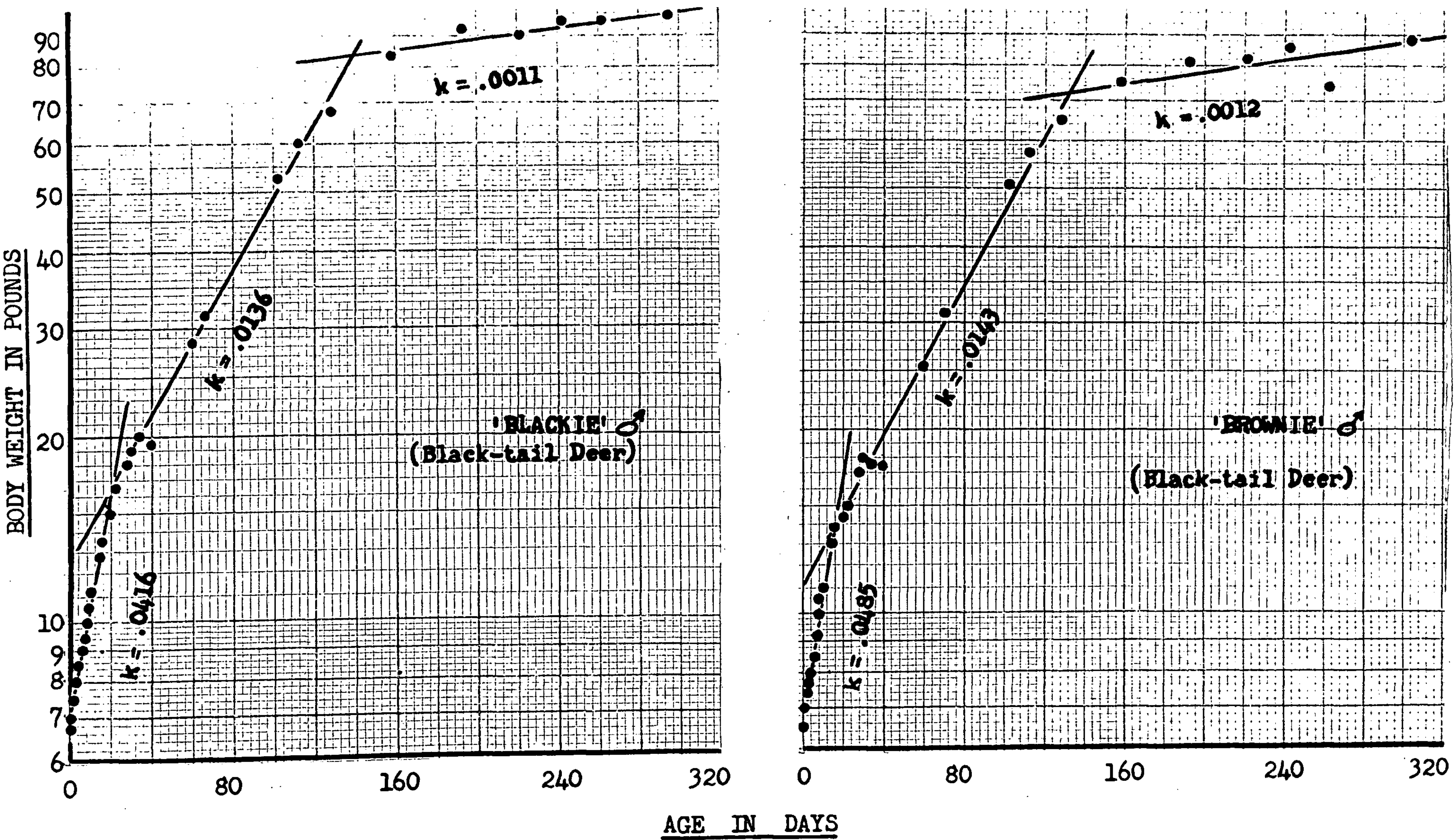


Figure 7

GROWTH PATTERN OF BLACK-TAIL DEER

to body weight over certain portions of their growth curve, suggests that some worthwhile information may be obtained by treating the individual bull data in a similar manner.

Figures 8 to 17 represent the bulls plotted on arith-log graph paper and fitted with a straight line by the method of least squares. Again we find a remarkable fit of data to the line.

There is an advantage not previously mentioned in using the instantaneous relative growth rate method of presenting data. Most other methods have attempted to carry on calculations for rate of gain with figures for body weight directly as they were measured despite the variations which unavoidably occur due to "fill" of the gastro-intestinal tract. The rest usually attempt to draw in a smooth curve with limited points. The instantaneous rate method provides a mean line which is actually the true measure and not merely an average, therefore calculations should be made with body weight figures taken off the straight line. Another factor of course is that the human eye is much more sensitive to variations from a straight line than from a curved line.

If the line of best fit for the growth data on bull number one is extended to zero days for an estimate of birth weight, the body weight arrived at is 269 pounds, obviously impossible. The only conclusion to be drawn is that the bull

Figure 8

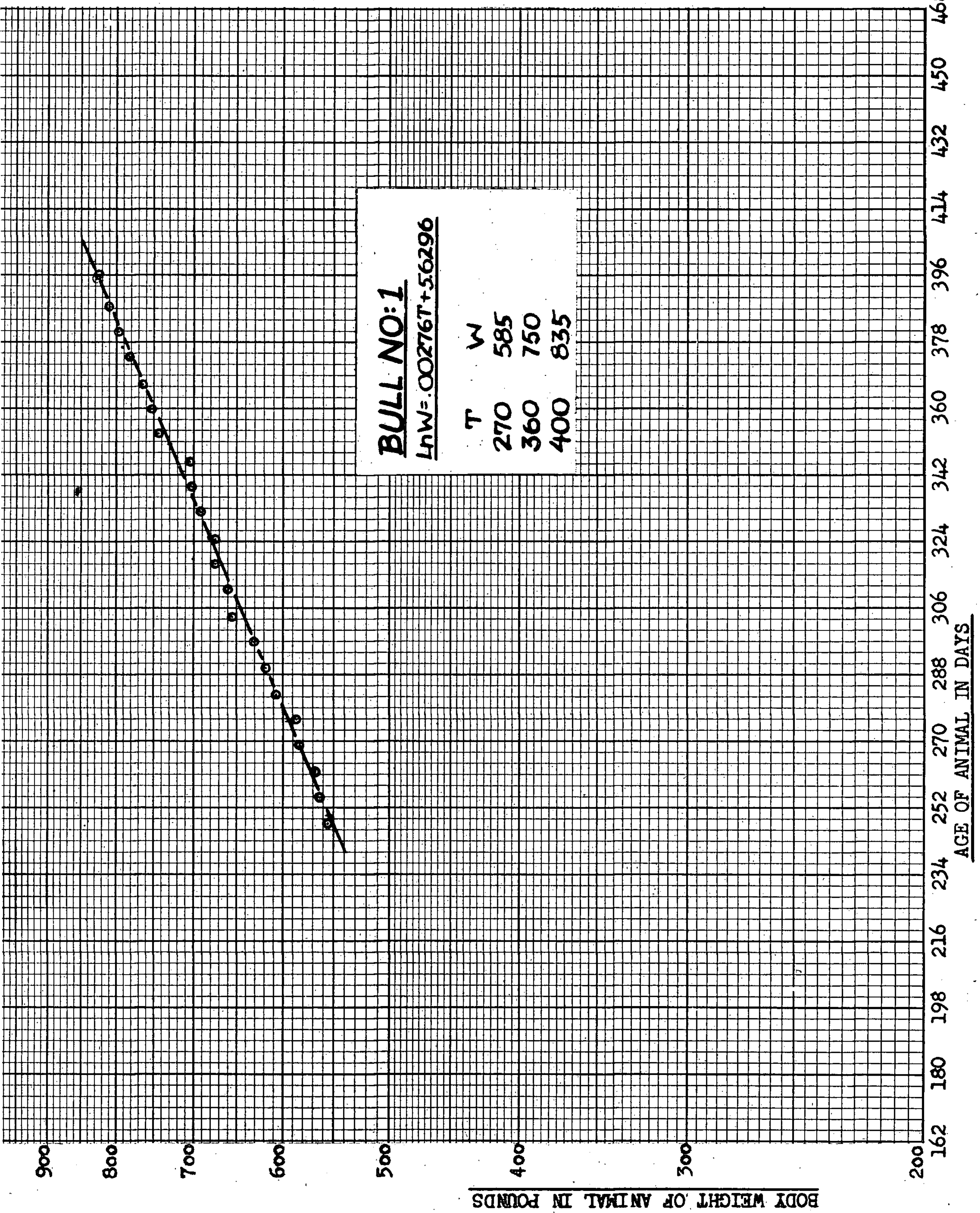
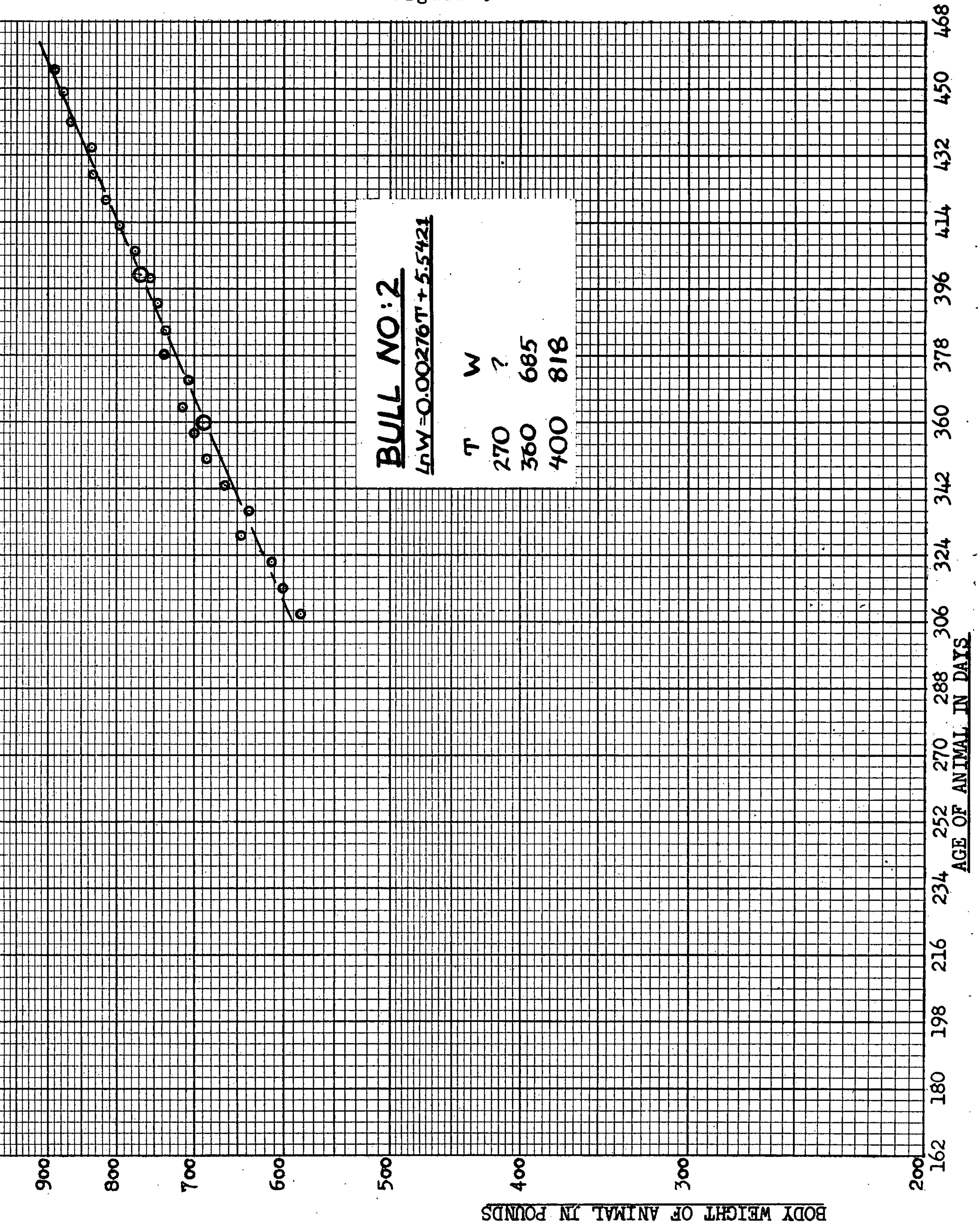

BULL NO: 1
LnW=.00276T+5.6296
T W
270 585
360 750
400 835
AGE OF ANIMAL IN DAYS
162 180 198 216 234 252 270 288 306 324 342 360 378 396 414 432 450 468
BODY WEIGHT OF ANIMAL IN POUNDS
200 300 400 500 600 700 800 900

Figure 9


BULL NO: 2
LnW = 0.00276T + 5.5421
T W
270 ?
360 685
400 818
AGE OF ANIMAL IN DAYS
162 180 198 216 234 252 270 288 306 324 342 360 378 396 414 432 450 468
BODY WEIGHT OF ANIMAL IN POUNDS
200 300 400 500 600 700 800 900

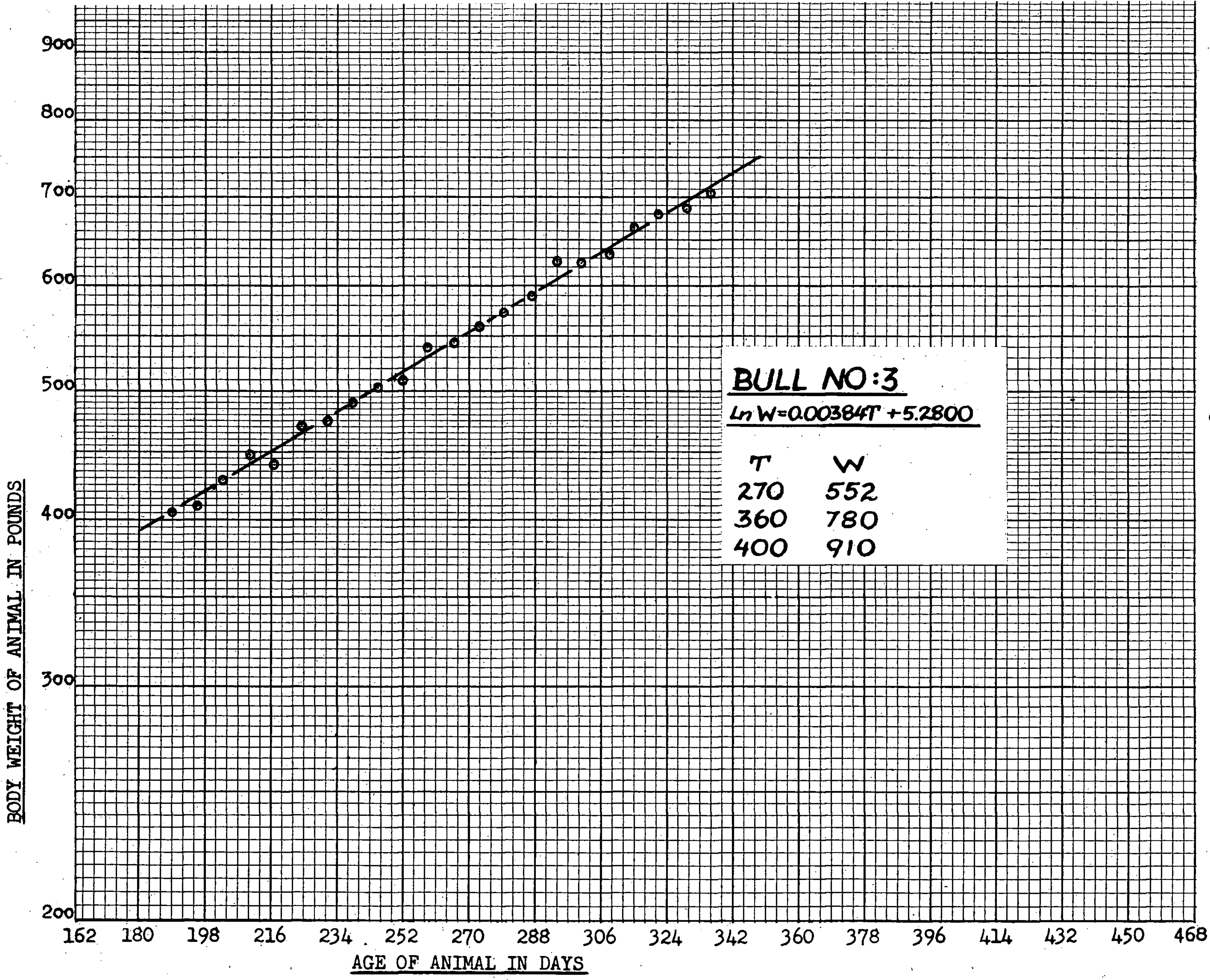

900
800
700
600
500
400
300
200
BODY WEIGHT OF ANIMAL IN POUNDS
162 180 198 216 234 252 270 288 306 324 342 360 378 396 414 432 450 468
AGE OF ANIMAL IN DAYS
BULL NO:3
Ln W=0.00384T +5.2800
T W
270 552
360 780
400 910

Figure 10

Figure 11

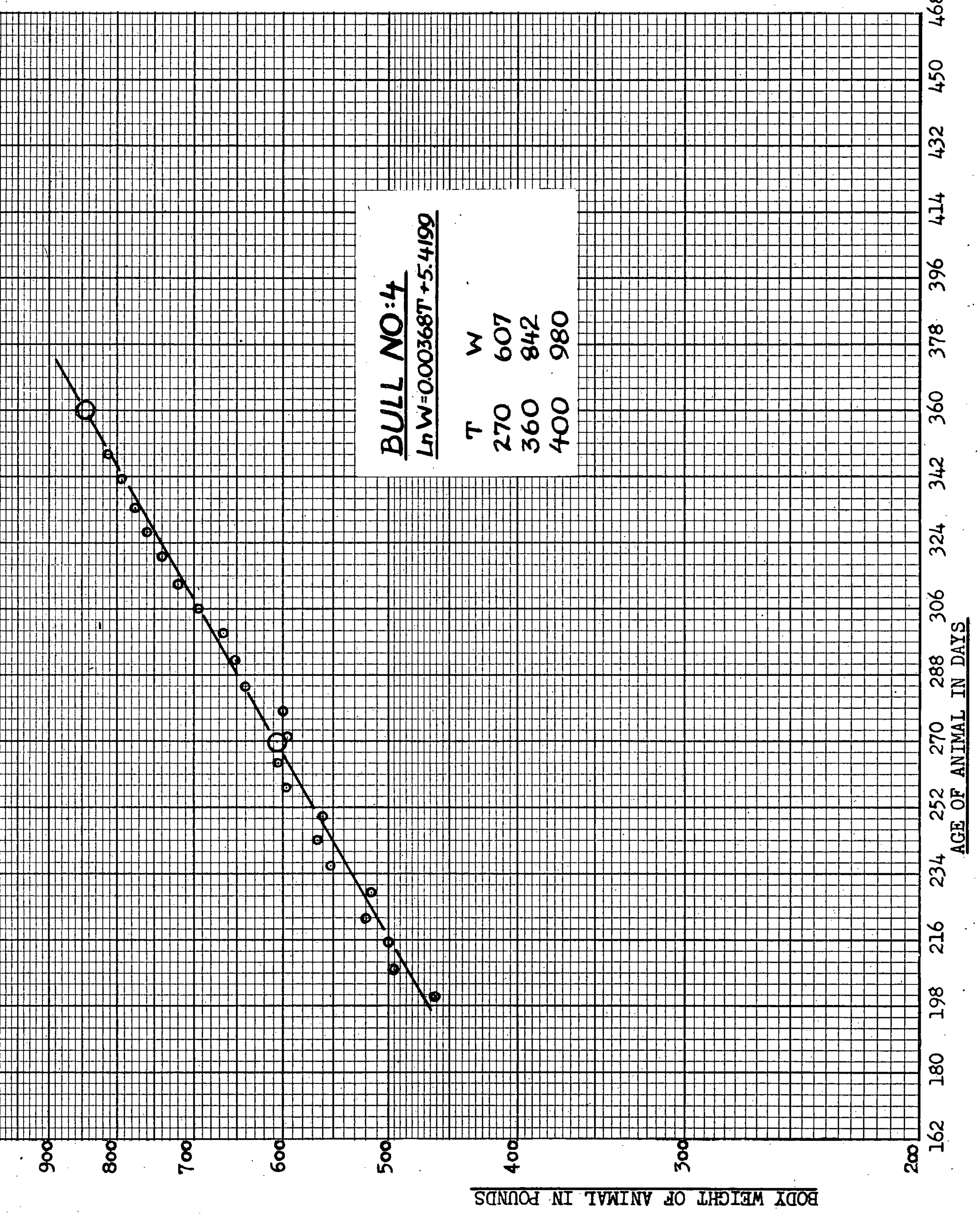

BULL NO:4
LnW=0.00368T+5.4190
T W
270 607
360 842
400 980
AGE OF ANIMAL IN DAYS
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468
BODY WEIGHT OF ANIMAL IN POUNDS
200
300
400
500
600
700
800
900

Figure 12

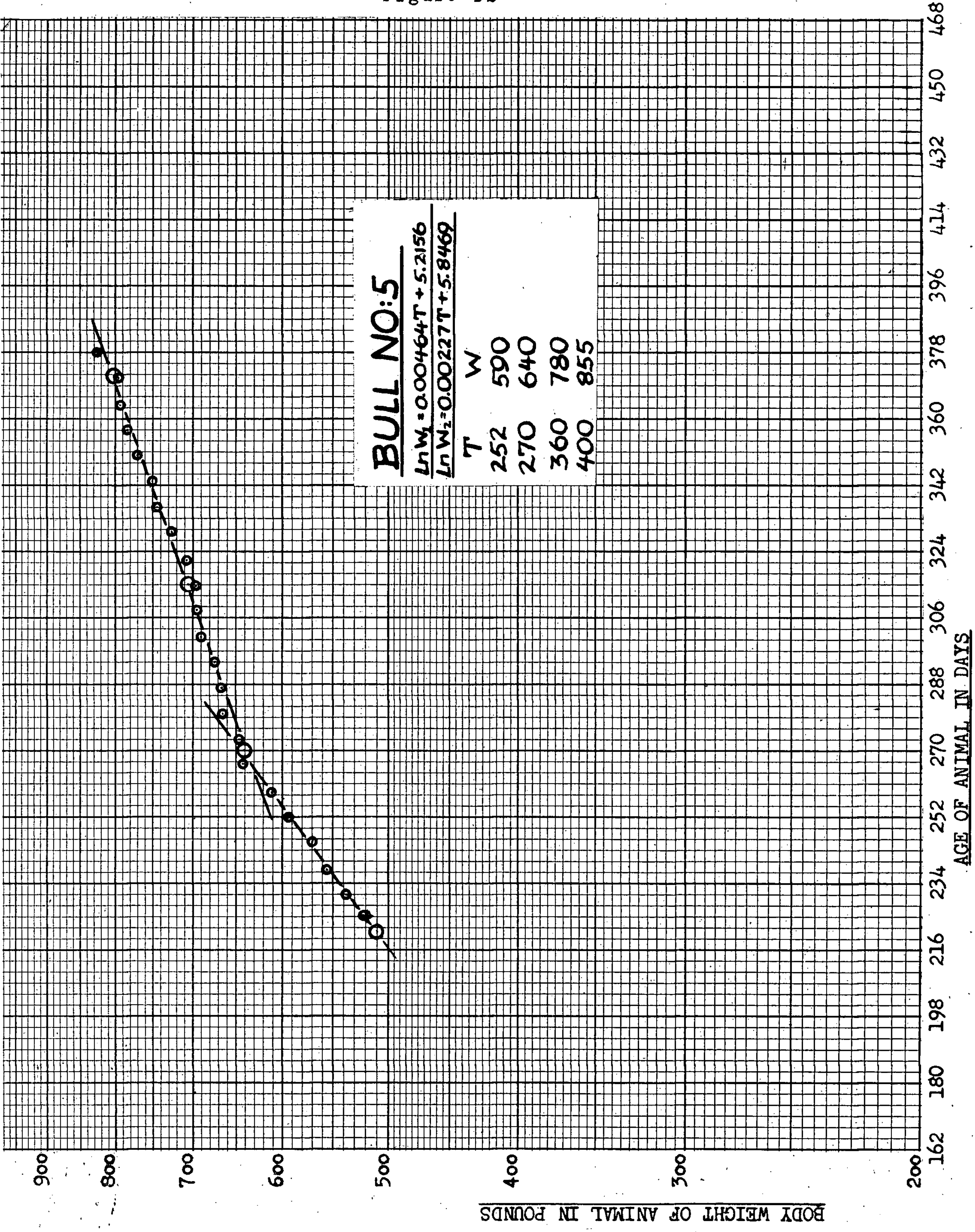

BULL NO:5
$Ln W_1 = 0.00464T + 5.2156$
$Ln W_2 = 0.00227T + 5.8469$
T W
252 590
270 640
360 780
400 855
AGE OF ANIMAL IN DAYS
162 180 198 216 234 252 270 288 306 324 342 360 378 396 414 432 450 468
BODY WEIGHT OF ANIMAL IN POUNDS
200 300 400 500 600 700 800 900

Figure 13

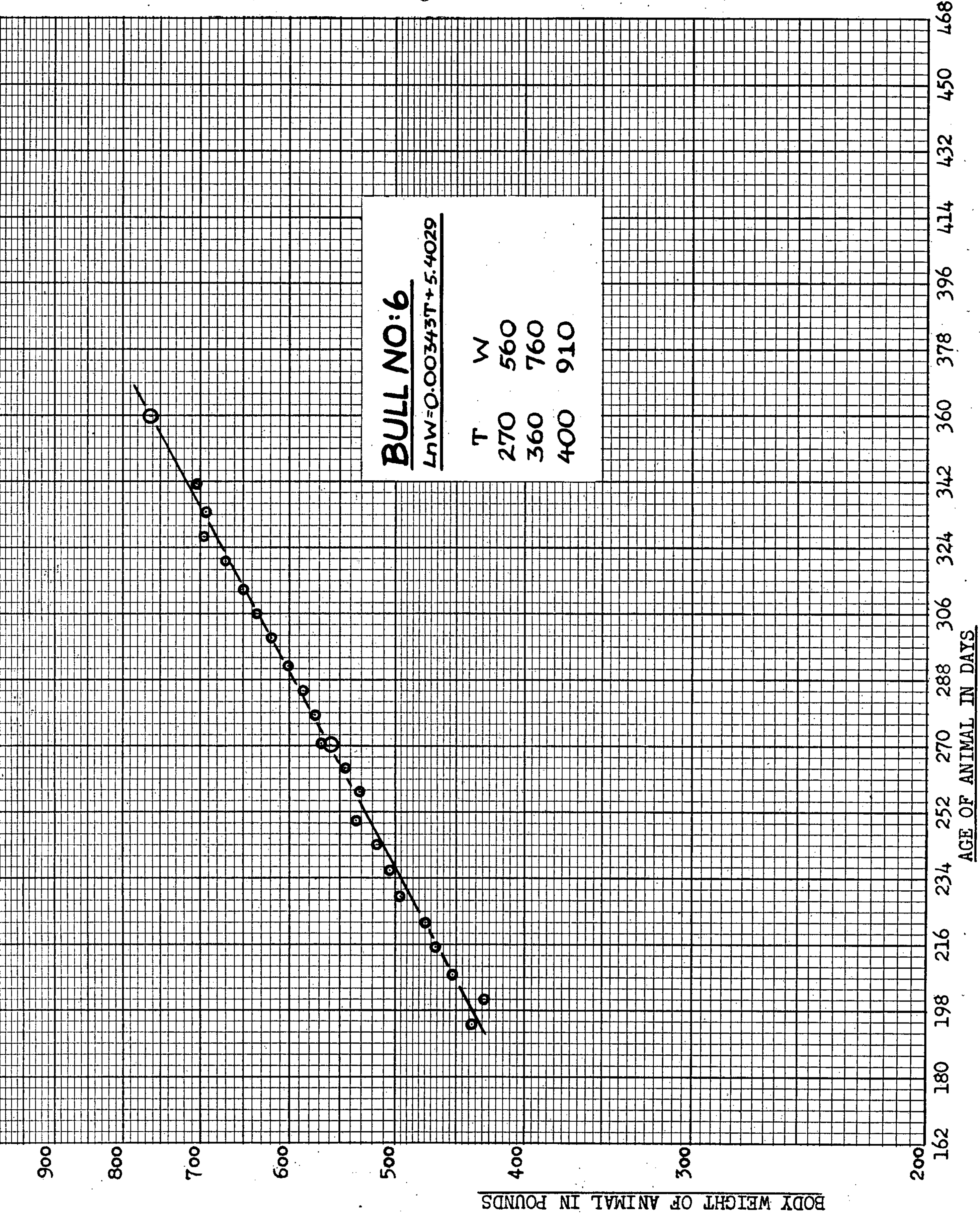
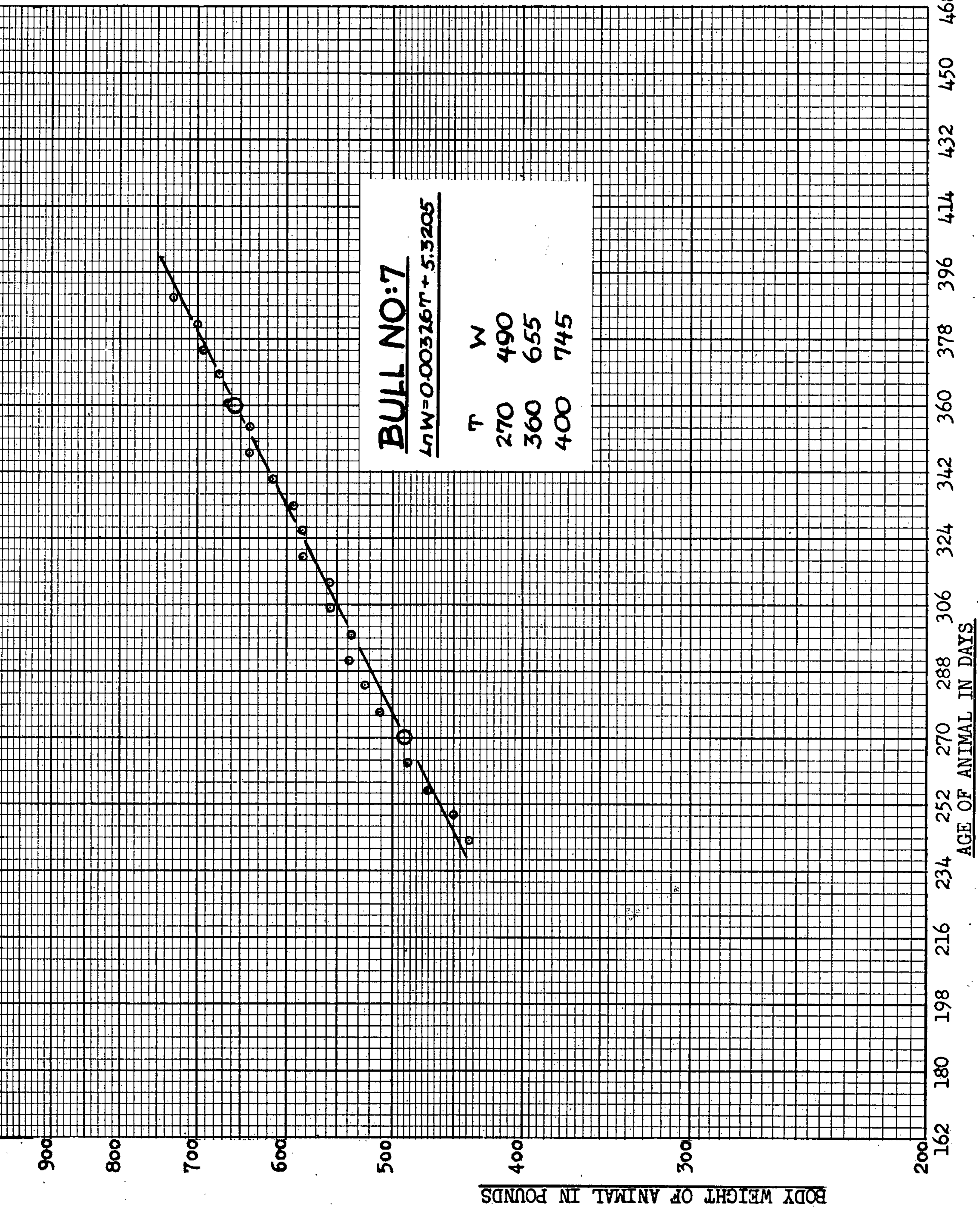

BULL NO:6
LnW=0.00343T+5.4029
T W
270 560
360 760
400 910
AGE OF ANIMAL IN DAYS
162 180 198 216 234 252 270 288 306 324 342 360 378 396 414 432 450 468
BODY WEIGHT OF ANIMAL IN POUNDS
200 300 400 500 600 700 800 900

Figure 14


BULL NO:7
LnW=0.00326T+5.3205
T W
270 490
360 655
400 745
AGE OF ANIMAL IN DAYS
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468
BODY WEIGHT OF ANIMAL IN POUNDS
200
300
400
500
600
700
800
900

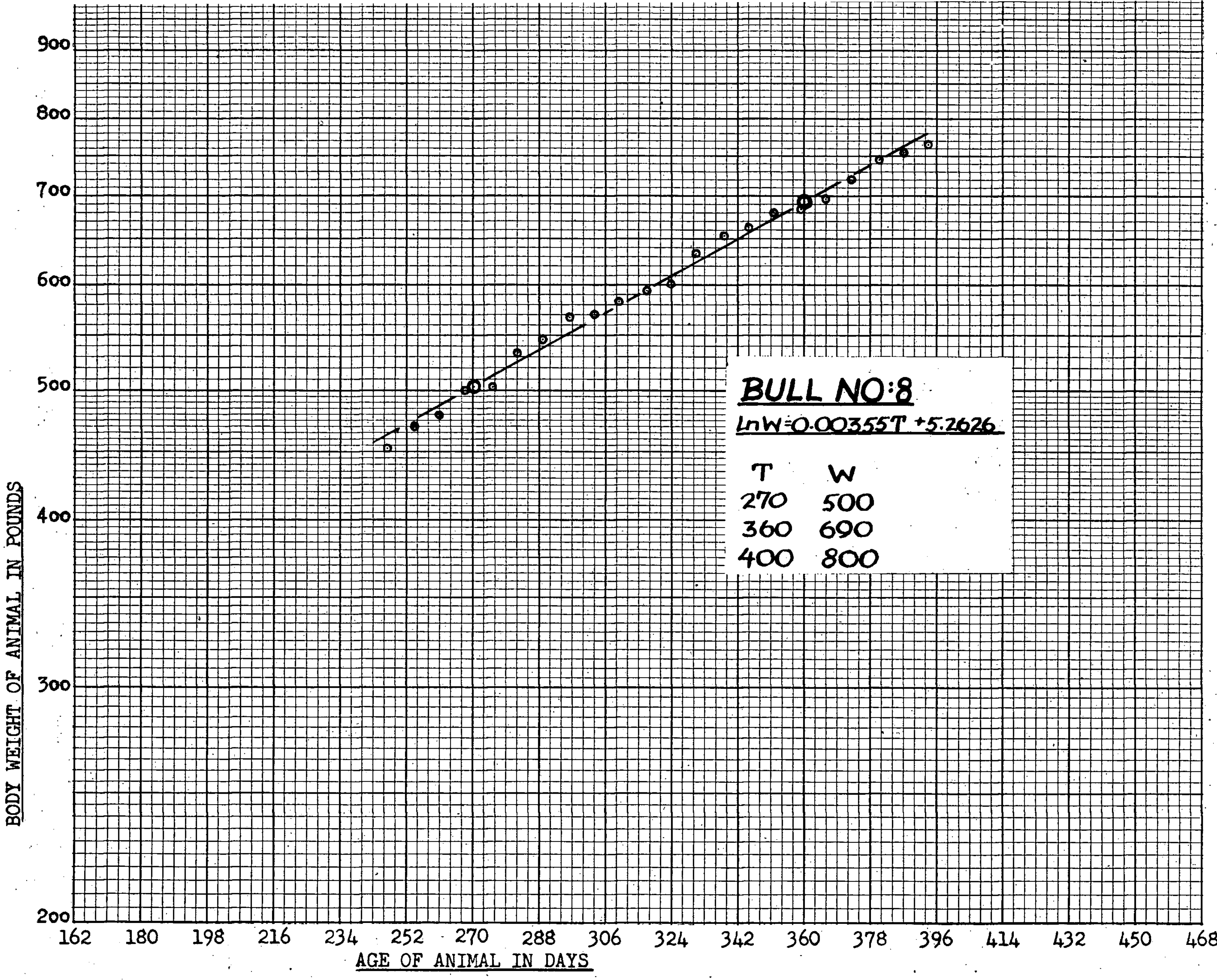

BODY WEIGHT OF ANIMAL IN POUNDS
900
800
700
600
500
400
300
200
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468
AGE OF ANIMAL IN DAYS
BULL NO: 8
LnW=0.00355T +5.2626
T W
270 500
360 690
400 800

Figure 15

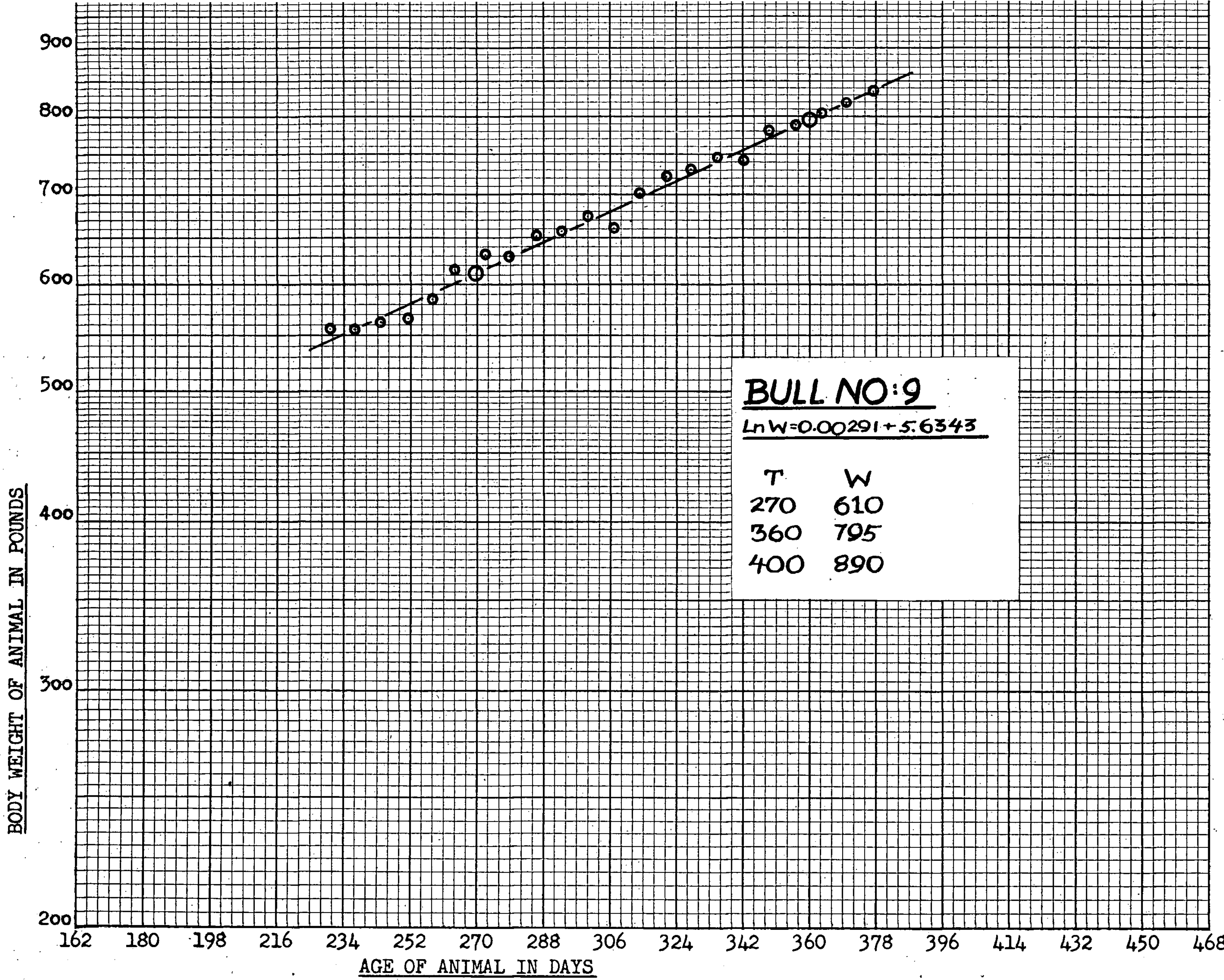
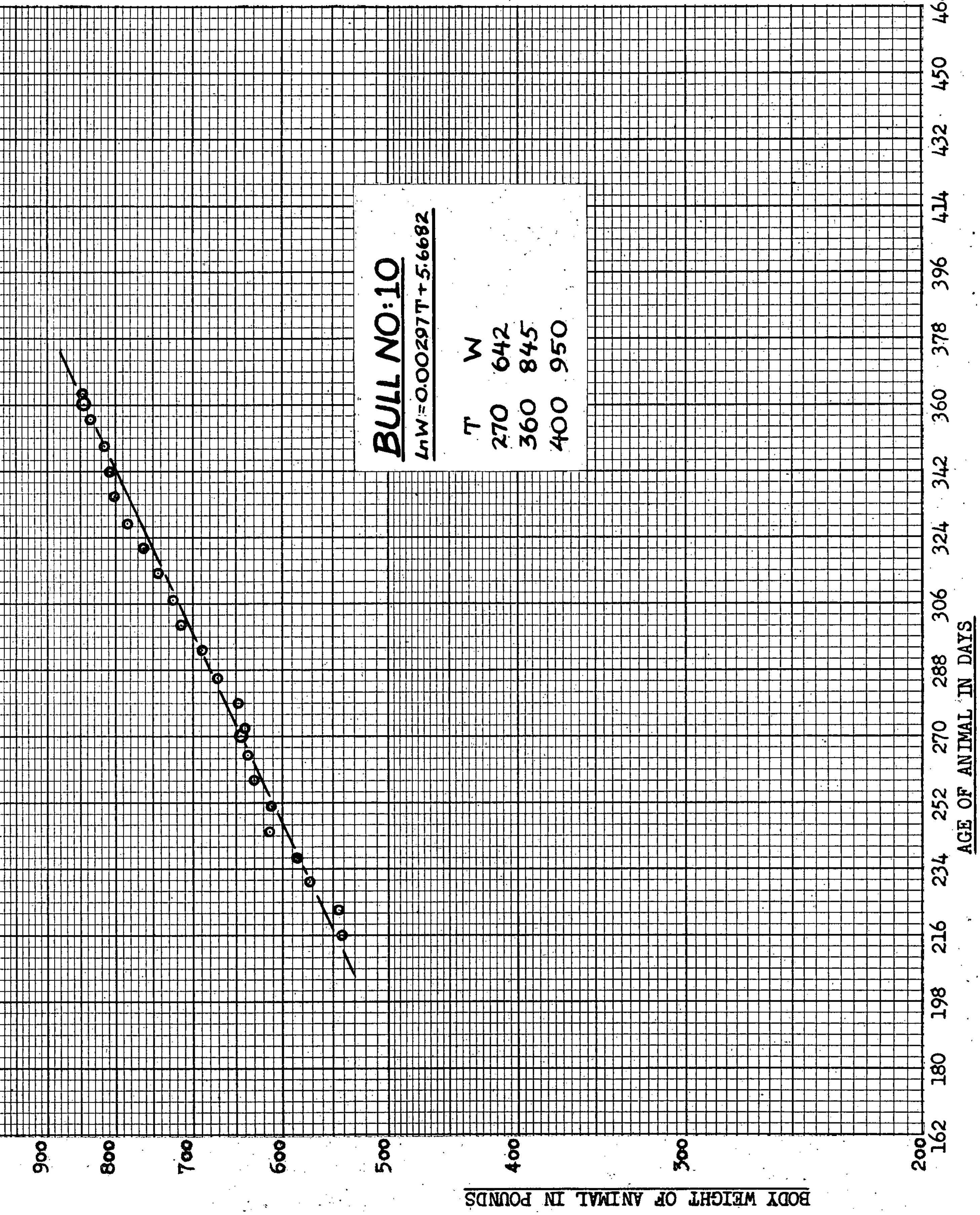

BULL NO:9
LnW=0.00291+5.6343
T W
270 610
360 795
400 890
900
800
700
600
500
400
300
200
BODY WEIGHT OF ANIMAL IN POUNDS
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468
AGE OF ANIMAL IN DAYS

Figure 16

Figure 17


BULL NO:10
LnW=0.00297T+5.6682
T W
270 642
360 845
400 950
AGE OF ANIMAL IN DAYS
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468
BODY WEIGHT OF ANIMAL IN POUNDS
200
300
400
500
600
700
800
900

has had at least one other more rapid growth phase preceding the one during which the data was collected. This is reasonable since the other species studied previously had at least one rapid growth phase during very early life. Extrapolating beyond the line of best fit to the age of three years leads to a body weight of 5012 pounds, again an obviously incorrect figure so there also must be at least one more growth phase following the one under inspection. A similar situation exists for all bulls in test except for one important item. There is no way of knowing whether or not all the bulls are on the same phase of growth. As a matter of fact bull number 5 made the change from one phase to another during the test period.

Table 8 presents the "k" values or instantaneous relative growth rates of the bulls arranged in order of magnitude. Note there appears to be a definite grouping, i.e. bulls 3,4,8, 6,7 are growing at very nearly the same relative growth rate while 10,9,1,2 are proceeding as a group at a slower rate. Bull number 5 grew the most rapidly for a time and then "broke" and grew the most slowly.

There are three plausible explanations for the above:

(1) Bulls 10,9,1,2, have had a major break in their growth curve while 3,4,8,6,7, have not done so and are growing at a more rapid relative growth rate;

(2) Bulls 10,9,1,2, have a very rapid "juvenile" period of growth relative to bulls 3,4,8,6,7, and so are more early maturing and have a compensatory slowing of growth during the period under inspection.

TABLE 8

Bull number	5	3	4	8	6	7	10	9	1	2	5
"k"	.00464	.00384	.00368	.00355	.00343	.00326	.00297	.00291	.00276	.00286	.00227

difference between subsequent "k" values										
	.00080	.00016	.00013	.00012	.00017	.00029	.00016	.00015	.0000	.00049

THE RELATIVE GROWTH RATES ARRANGED IN ORDER OF MAGNITUDE

(3) Bulls 3,4,8,6,7 were on a sub-optimum plane of nutrition during the pre-test period and are now showing the characteristic increase in growth following an increase in intake.

It would appear in any case that the growth pattern of bulls can be quite different and has implications concerning the production of commercial beef:

(1) Animals such as numbers 10, 9, 1, and 5 appear to have a very rapid instantaneous relative growth rate previous to the test period since their first test weights were considerably above the average of all the animals. Following a major shift in relative growth rate they became slow growing but it must be remembered that they now have a relatively large body to maintain so that they might be best suited for marketing at a low body weight such as those required for baby beef.

(2) A very different pattern is followed by animals 3, 4, 6, 7, 8. They have only a moderately high weaning weight which requires a slow relative growth rate during early life followed by a less severe shift in rate than noted for the previous group of bulls with a resulting rapid relative growth rate during the test period. This situation typifies the animal which will have a relatively low accumulated maintenance requirement and therefore being the most suitable type for carrying

through to a heavy market weight. This animal would be slow to reach baby beef weight but more rapid at attaining a 1000 pound market weight.

(3) Bull number 2 represents a group which have not the attributes of either of the preceeding situations. This animal grew slowly in the preweaning period as indicated by the low body weight at the commencement of the test. Following the characteristic break its growth rate was again very slow so there was no compensation during either growth phase. This bull appears to have little growth potential to recommend it for breeding.

Although a body weight of 1000 pounds more closely approaches the market weight of beef cattle it appears advisable to make comparisons in this work at body weights actually measured rather than trust an extrapolation since there is no guarantee that there is not a major shift in growth rate immediately beyond the period of data collection. It is probably quite valid to compare animals at one or two points during the test period without some factor to weight the data because of differences in weight for age since we already considered that weaning weight differences are mainly a result of environmental differences.

Reference to Table 9 presents the animals at the constant body weights of 575 and 675 pounds. It may be noted that since they are taken from the regression lines that they are always in the same order except for bull #5 which has two segments of regressions lines.

TABLE 9 RATE OF GAIN TAKEN AT THE SAME BODY WEIGHT

Bull No.	1	2	3	4	5	6	7	8	9	10
Rate of Gain at 575# B.W.	1.59	1.59	2.21	2.12	2.66	1.98	1.87	2.04	1.67	1.71
Rate of Gain at 675# B.W.	1.86	1.86	2.60	2.48	1.54	2.32	2.19	2.39	1.96	2.01

It is interesting to note the result of comparing bulls in weight groups rather than at an exact weight. Consider the rate of gain of bulls numbers 2 and 9 at a body weight of 600 and 650 pounds which would represent the extremes of comparing animals in weight groups of 50 pounds. Table 10.

TABLE 10 BULLS COMPARED IN 50 POUND BODY WEIGHT GROUPS

Bull No.	2	9
600# B.W.	1.66	1.75
650# B.W.	1.79	1.89

Note that bull number 2 can be considered as being more desirable than number 9 for the characteristic rate of gain if the mean body weights at which they were compared were allowed to vary within as narrow a limit as 25 pounds either way. Conversely bull number 9 could show an excessive superiority over bull number 2 if number 9 were at the greater body weight. This would be an unfortunate situation which is being repeated in many programs in operation at the present time. Bull number 9 of course was demonstrated as having a much superior rate of growth by a detailed observation of the growth pattern.

Another interesting error might arise if an animal has a change in instantaneous relative growth rate during the test period. For example, in the case of Bull No.5, if his growth rate is expressed by the usual average rate of gain method a series of "rates" is obtained dependent upon the position of the "breaks" in his growth curve relative to the initial and final weights selected for the determination of average rate of gain. Results are illustrated in Table 11. It is obvious that this animal might be considered as an ideal animal if his gain is measured from 500 to 650 pounds since he is gaining at the rate of 2.67 pounds per day. This rate is probably close to the maximum achievable by an animal at this body weight. On the other hand if the rate of gain is expressed over the weight range 650 to 800 the bull is gaining 1.52 pounds per day. A figure which must be close to the minimum rate of an animal of this weight under the management conditions of the experiment. Therefore bull no. 5 might be chosen as the best or poorest bull on test depending upon the test period.

TABLE 11

EFFECT OF VARIATIONS IN THE TEST PERIOD

Body weight Range	500-650	550-700	650-800
Average Rate of Gain per day	2.67 lbs.	2.05 lbs.	1.52 lbs.

Note that the differences are actually greater than those observed on the performance test. The suggestion may be made that extensions of the period would lessen this error but unfortunately this procedure would possibly introduce another "break" in the relative growth rate which would increase the error involved if interpretation is made by conventional methods.

It appears from the observations made that some of the procedures at present being followed for the performance testing of beef bulls are introducing errors which could result in an insignificant selection pressure which may in part account for the lack of improvement experienced in the fifteen years of testing at Miles City, Montana.

In the experiment conducted on beef bulls at this institution the unique situation is provided that 10 bulls, maintained under uniform conditions, fed exactly the same amount of feed per unit of body weight, gain in body weight at varying rates.

Included in any discussion on the methods of measuring these variations should be some observation on the reasons for the variations, physiological or otherwise.

The first step in a logical consideration of variations in rate of gain is the individuals ability to digest the feed. This point was discarded as a possibility following work at Cambridge. (Dunlop, 1933). Jordan and Staples (1951) gave the standard error of digestibility as being less than 1 per cent on a ration containing 45 per cent dry matter. Using round numbers the energy content of the total ration may be assumed to be .6 therms per pound dry matter and thence on a dry matter intake of 10 pounds, the extremes due to differences in digestibility would be 4 per cent (.24 therms) or 6.12 therms to 5.88 therms. This amount of energy would account for .26 pounds of body weight gain per day between the animals having the upper and lower extremes of digestibility (Assume 909 Calories per pound body gain, Brody, 1947). This of course is relatively small compared to the 1.0 to 2 pound per day difference in rate of gain noted for animals on performance tests.

Digestibility variation is most probably only a result of inaccuracies of measurement, variability in quality of feed or insufficient time allowed for the rumen microflora to reach a state of dynamic equilibrium.

If digestibility is not considered the factor which accounts for variations in rate of gain then the answer must lie in one of the energy partitions; basal metabolism, maintenance or growth.

Basal metabolisn has been the subject of very intensive study by a great many investigators who found it to be by actual measurement a rather firm figure based on surface area and summed in the equation, B.M. = 70.5 x $W^{.7}$ (Brody, 1947), where "B.M." is basal metabolism in Calories per day and "W" is the body weight in kilograms.

Deighton found that basal metabolism does not account for variations in rate of gain of pigs. (Dunlop, 1933).

Further confidence in the lack of variability expected in basal metabolism may be taken from the experimentally demonstrated fact that under basal conditions the excretion of nitrogen approximates 2 milligrams per Calorie of basal heat produced in the species ranging from the mouse to the mature swine. This would suggest that the active protoplasmic mass of the body is metabolizing at constant rate as would be expected of the sum of a series of chemical reactions proceeding with the same concentration of reactants under similar conditions.

Any consideration of maintenance relative to variations in growth is very nearly a repeat on the discussion of basal metabolism. The maintenance of two-animal bodies under the same environment (temperature), activity, energy intake and body weight would reasonably be the same since as stated in the preceeding paragraphs, the basal metabolic rate by actual measurement is a firm relationship with surface area subject to the errors involved in making such a complex measurement. Maintenance could be materially different between animals providing their body temperatures were markedly different, but such is not the case as indicated by the temperature for Jersey Cows of 101.1 - 0.5° F and of the beef cow of 101.0 (Dukes, 1947). Another factor which may be involved if the maintenance requirement of two animals is different is their body composition. If the one animal has a greater percentage fat it will have a lower maintenance requirement because the tissue itself has no anabolic requirements to keep it in repair since its metabolism is merely deposition and withdrawal. In addition the insulating effect of fat would tend to lower the costs of maintaining homeothermy.

Although the maintenance requirements of animals may not differ appreciably, the suggestion that body composition might differ leads to an attractive explanation of the differences which have been observed for the rate of gain of beef animals.

This consideration may best be illustrated by reference to the energetics of a hypothetical situation created by Williams and Wood (1952) based on composition figures of beef cattle published by Haecker (1922).

Case I -a 700 pound animal gaining in such a way that 10 per cent of the weight gain is in the form of fat and 16.5 per cent is in the form of protein; each pound of body weight gain will represent the storage of approximately 860 Cals.

Case II-a 700 pound animal gaining in such a way that 20 per cent of the weight gain is in the form of fat and 14 per cent is in the form of protein; each pound of body weight gain will represent the storage of approximately 1200 Calories.

This means that for each 1000 Calories of net energy consumed above maintenance, the animal in Case I will be able to gain 1.18 pounds per day, while the animal in Case II will gain 0.83 pounds per day.

Such an example is in keeping with the results obtained by investigators conducting performance tests as well as those who have made complete tissue separations of entire carcasses.

To apply the "variation in body composition" concept to the bulls on test at this institution, the use of theoretical calculations are necessary since the bulls were not given any slaughter or carcass evaluation.

Consider bulls #2 and #3 at a body weight of 600 pounds. Their calculated energy partitioning appears in Table 12.

The basal metabolism is estimated from the formula previously cited: $B.M. = 70.5 \times W^{.7}$

Maintenance requirement is assumed to be 130 per cent of basal metabolism. This assumption may be subject to criticism but since it is a relative figure applied to both animals it may be used without introducing any appreciable errors. Net energy intake is calculated from the actual feed intake. Energy for growth is the net energy intake minus the requirements for basal metabolism and maintenance. The actual rate of gain has been calculated from the regression equation for each bull.

The gain in protein and fat tissue is calculated using the actual rate of gain in two simultaneous equations, assuming protein and fat tissues to have the Caloric contents of 450 and 3900 Calories respectively. This calculation includes the increase in water but ignores ash since it is such a relatively small quantity. ie; $X + Y$ must $=$ rate of gain and $450X + 3900Y = 2600$ Calories

Table 12 ENERGY PARTITIONING FOR TISSUE GROWTH

	calculated Basal Metab.	Maintenance 130% of B.M.	Net Energy intake	Energy for Growth	Rate of Gain
	cals.	cals.	cals.	cals.	lbs.
Bull #2	3580	4650	7250	2600	1.66
Bull #3	3580	4650	7250	2600	2.30

	Gain in Protein Tissue	Gain in Fatty Tissue
Bull #2	1.12	.54
Bull #3	1.85	.45

Note that bull #2 is making approximately 36 per cent of his gain in the form of fatty tissue while bull #3 is only making 20 per cent of his gain as fatty tissue. It is of interest to consider this calculation in the light of the results of the visual evaluation made by seven competent livestock men with reference to the scorecard recommended by the Canadian Hereford Association..(Table 13). Bull #2 graded highest and bull #3 lowest in the estimation of the classifiers. By viewing the plates made during the test, any experienced eye can perceive that bull #2 is "rounder" and "smoother" than bull #3. This is possibly because some fat is laid down subcutaneously and would tend to produce a "smooth" appearance while muscle tissue is added unevenly in a anterior to posterior manner (McMeekan, 1942) to already existing muscle bunches so exaggerating the already uneven outline relative to the show-ring ideal.

This suggestion that body gains differ in composition between animals so explaining the differences in rate of gain and possibly explaining some of the visual evaluation differences makes an attractive theory.

It would be desirable that it were true since it would explain the lack of correlation which has been found between rate and efficiency of gain and type evaluation. On the bull test at this institution the situation arose that the instantaneous relative rate of gain and type evaluation were given a correlation coefficient of -.0046.

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Table 13 SCORES ASSIGNED TO ANIMALS BY GRADERS

JUDGE	BULL NUMBER									
	1	2	3	4	5	6	7	8	9	10
A	73	74	55	73	84	80	70	79	77	65
B	81	75.5	54	76	76	72.5	82	75	77	85
C	96	94	86	92	81	77	83	79	82	91
D	75	75	51.5	66	64.5	63.5	66.5	69.5	67.5	68.5
E	72	75	58.5	70.5	65.5	62	69.5	65.5	69	67.5
F	74	85	57	66	68	65	73	69	76	76
G	80	79	64	72	71	67	77	72	68	78
TOTAL	551	557.5	426	515.5	510	487	521	509	516.5	531
AVERAGE	78.7	79.7	60.8	73.6	72.8	69.6	74.4	72.7	73.8	75.8

This lack of significance has been interpreted as an assurance that a breeder may exert a selection pressure for a greater rate of gain without influencing type classification materially.

This thesis would take exception to this interpretation however on the grounds that despite the results of statistics it is not in harmony with biological observations.

The following line of thought may serve as an illustration. According to Gowen (1932), the best single body measure of the milk producing potentialities of a cow is her body weight, "...the larger the yield, the larger the size of the cow...." Body size has long been known to be associated with thyroid activity which could have no better reference than the work of Gregory (1950) on the dwarf characteristic in beef cattle. Thyroid activity indirectly is a measure of pituitary activity. Pituitary activity is necessary for a large output of the growth hormone. The work of Baird, Nalbandov and Norton (1952) indicates that the growth in a strain of rapid growing swine as compared with a slow growing strain can be accounted for by an increased content of growth hormone per unit of anterior pituitary tissue. From the foregoing it may be said the "larger mature body size and rapid growth must be associated in the same animal." This is contrary to the type selection being practised for the show-ring standards which call for a deep, compact, tidy (not too large), smooth (excess fat from early "breaking" growth curve), well-balanced (early maturity associated with a small mature weight), in general an animal approaching the "compress" type, genetically heterozygous for the characteristic dwarfism which is brought about by an inactive thyroid associated with slow growth.

A consideration of body size seems necessary providing it can be demonstrated conclusively, ie: quantitatively that it is closely associated with rapid growth.

It has long been known and the fact utilized that heart girth measurements were a very good measure of body weight, and so might give an indication of the inherent growth ability of an animal. This measure however could be an error because an animal carrying high condition and consequently having a large body weight and heart girth, would have an apparent "growthiness" which actually may be early maturity, slow growth and an early laying on of fatty tissue.

It would appear more reasonable that height at withers, a measure of the skeletal structure which in turn is a measure of size and is only affected by environment in extreme cases would serve as an indexo of rapid growth.

The first impression may be that it is unnecessary to introduce another factor to measure growth rate which can be obtained from absolute weights, however it has been pointed out earlier that rate of gain measured over any period in the growth phase is liable to considerable error due to changing relative growth rate and so it may be desirable to utilize a final weight as a standard by which an animal is selected for ability to grow. To eliminate certain animals achieving the final weight by excess fattening, the minimum height at withers could be introduced.

(B) Wistar Rat Research Project

(1) Introduction

As has been previously noted in the preceeding sections there is some evidence that animals tend to grow at an accelerated rate for a period following an increase in energy intake preceded by a period of sub-optimum nutrition. The literature contains vague references to the necessity of an initial feeding period of 14 - 30 days as a precautionary measure to avoid introducing a bias which might favor the animal with a history of sub-optimum nutrition. Just how adequately this preliminary period corrects for previous environmental affects is in some doubt and with this in mind the following objectives were laid out.

(1) To determine the resulting growth pattern of rats which have been on lowered planes of nutrition for varying periods.

(2) To provide some very accurate and detailed data on rate and efficiency of growth which is not readily available for study from other sources.

(3) To determine the value of the laboratory rat as material for studying rate and efficiency of growth of the relatively expensive and slow maturing beef breeds.

T A B L E 15(a)

COMPOSITION OF U.B.C. RATION No. 18	
Hulled Oats	1050 lbs.
Ground Wheat	525
Fish Meal	175
Meat Scraps	75
Skim Milk Powder	50
Alfalfa Leaf Powder ...	100
Steamed Bone Meal	20
Salt	5
	2000 lbs.

Crude Protein (Nx6.25) .. 19.44 %

(2) Materials and Methods:

Nine litters of the Wistar strain Albino rat were selected from the U.B.C. stock colony. They were weighed on the 3rd day and every other day following until the 21st day. No attempt was made to identify the animals, but it was soon obvious that the rats were different enough in their body weights to allow segregation into individual growth patterns as illustrated in Appen.(A) All the rats were weighed on the 22nd day and 15 pairs of males were selected to meet the requirements of being litter mates and having as nearly as possible the same bodyweight. Actually all pairs were within 2 grams of each other in body weight. The rats were individually penned and weighed daily from the 22nd day until they had attained a body weight of 200 grams.

One animal of each pair designated by the letter "A" was considered the control and was allowed _ad libitum_ U.B.C. ration 18, the stock ration of the colony, with the analysis shown in Table 15.(a)

The opposite animals in each pair, designated by the letter "B" were divided into three groups. Groups one, two and three received 70 per cent of the ration eaten by its

TABLE 15

AVERAGE FEED INTAKE PER DAY FOR PERIODS OF CONSTANT RELATIVE GROWTH AS INDICATED GRAPHICALLY

Rat No.	Weaning to 1st break		1st Break to Puberty		Puberty to Body Weight of 200gms		Total Weaning to 200gms		Weaning to Increase to *Ad Libitum*
15 A	22-38 days,	9.4gms.	38-55 days,	14.3gms.	55-61 days,	16.7gms.	22-61 days,	12.7gms.	
15 B	22-34 "	6.3 "	34-60 "	10.2 "	60-68 "	15.5 "	22-68 "	10.1 "	22-49 days 7.3gms.
4 A	22-39 "	9.8 "	39-53 "	14.1 "	53-59 "	13.8 "	22-58 "	12.1 "	
4 B	22-39 "	8.1 "	39-54 "	10.3 "	54-65 "	11.8 "	22-65 "	9.8 "	22-34 days 6.6gms.
8 A	22-36 "	10.0 "	36-51 "	14.4 "	51-56 "	16.6 "	22-56 "	12.9 "	
8 B	22-37 "	6.5 "	37-47 "	13.0 "	47-62 "	15.4 "	22-62 "	11.5 "	22-37 days 6.5gms.
1 A	22-36 "	10.1 "	36-51 "	13.9 "	51-55 "	15.3 "	22-55 "	12.4 "	
1 B	22-39 "	7.1 "	39-52 "	11.9 "	52-62 "	13.7 "	22-62 "	10.3 "	22-43 days 7.4gms.
12 A	22-37 "	10.3 "	37-50 "	14.1 "	50-60 "	16.2 "	22-60 "	13.1 "	
12 B	22-36 "	6.8 "	36-60 "	9.8 "	60-77 "	14.1 "	22-77 "	10.4 "	22-55 days 11.7gms.
3 A	22-34 "	8,8 "	34-47 "	13.7 "	47-56 "	15.3 "	22-56 "	12.4 "	
3 B			22-49 "	8.3 "	49-62 "	14.3 "	22-62 "	8.2 "	22-44 days 6.9gms.
14 A	22-39 "	9.9 "			39-61 "	14.5 "	22-61 "	12.5 "	
14 B	22-42 "	8.0 "			42-65 "	14.1 "	22-65 "	11.3 "	22-36 days 6.4gms.

Rat No.	Weaning to 1st break		1st Break to Puberty		Puberty to Body Weight of 200gms.		Total Weaning to 200 gms.		Weaning to Increase to Ad Libitum
6 A	22-35 days,	7.8gms.	35-46 days,	12.5gms.	46-64 days,	15.2gms.	22-64 days,	12.2gms.	
6 B	22-42 "	6.5 "	42-52 "	10.3 "	52-71 "	13.1 "	22-71 "	9.9 "	22-48 days, 7.0gms.
13 A	22-30 "	7.6 "	30-50 "	11.8 "	50-62 "	15.4 "	22-62 "	12.0 "	
13 B	22-32 "	6.5 "	32-71 "	7.0 "					32-71 days, 7.0gms.
11 A	22-38 "	10.2 "	38-49 "	13.4 "	49-61 "	8.5 "	22-61 "	10.3 "	
11 B	22-47 "	6.6 "	47-66 "	8.2 "					22-66days, 7.3gms.
10 A	22-30 "	8.1 "	30-54 "	10.2 "	54-66 "	15.1 "	22-66 "	11.1 "	
10 B	22-29 "	5.9 "	29-47 "	6.4 "	47-81 "	11.1 "	22-81 "	9.0 "	22-59 days, 6.8gms.
7 A	22-36 "	9.5 "	36-50 "	14.5 "	50-55 "	17.6 "	22-55 "	12.8 "	
7 B	22-40 "	6.8 "			40-68 "	11.8 "	22-68 "	9.8 "	22-54 days 7.8 gms.
9 A	22-37 "	10.8 "	37-50 "	15.0 "	50-62 "	15.6 "	22-62 "	13.6 "	
9 B	22-42 "	8.5 "	42-55 "	13.8 "	55-74 "	13.4 "	22-74 "	11.6 "	22-38 days, 7.8gms.
2 A	22-34 "	10.7 "	34-46 "	14.3 "	46-51 "	15.4 "	22-51 "	13.0 "	
2 B	22-40 "	7.9 "	40-53 "	12.4 "	53-66 "	12.5 "	22-66 "	10.6 "	22-41 days, 8.0gms.
5 A	22-39 "	9.7 "			39-57 "	14.1 "	22-57 "	12.0 "	
5 B	22-42 "	7.3 "			42-61 "	13.4 "	22-61 "	10.3 "	22-36 days, 5.3gms.

particular litter mate at the same body weight. Group one upon attaining a body weight of 70 grams was allowed the same ration as its pair at that body weight. Group two was increased to full feed at 110 grams body weight and group three at 130 grams body weight.

For further details of management reference is made to the undergraduate essay of Amde Wondefrash (1952).

Results and Discussion:

Following through the reasoning presented in the preceding sections the data on the Wistar rats was plotted on semi-log graph paper and as would be expected the rats grew at a constant rate relative to body weight over certain phases of the growth period. Although only three actual pairs are presented graphically Figure 18, 19, 20, the "k" value for each particular phase of the growth period with its duration in days is presented in Table 16.

Extensive tests of significance were carried out in the differences in slope of the repression line over the same growth phase for the rat pairs following the low intake individuals return to full feed. Results indicate that all differences are insignificant, which prompts the following statement:

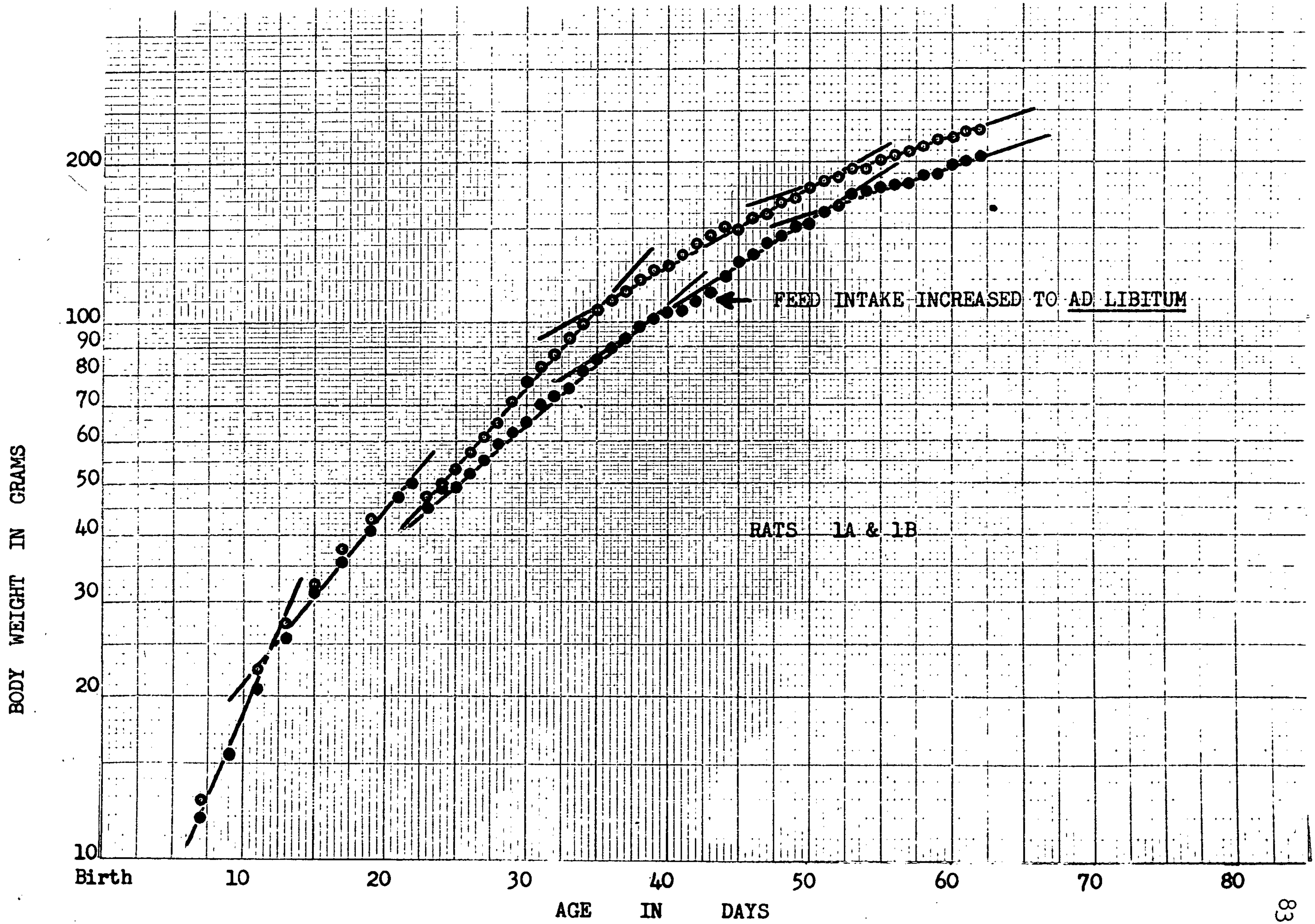
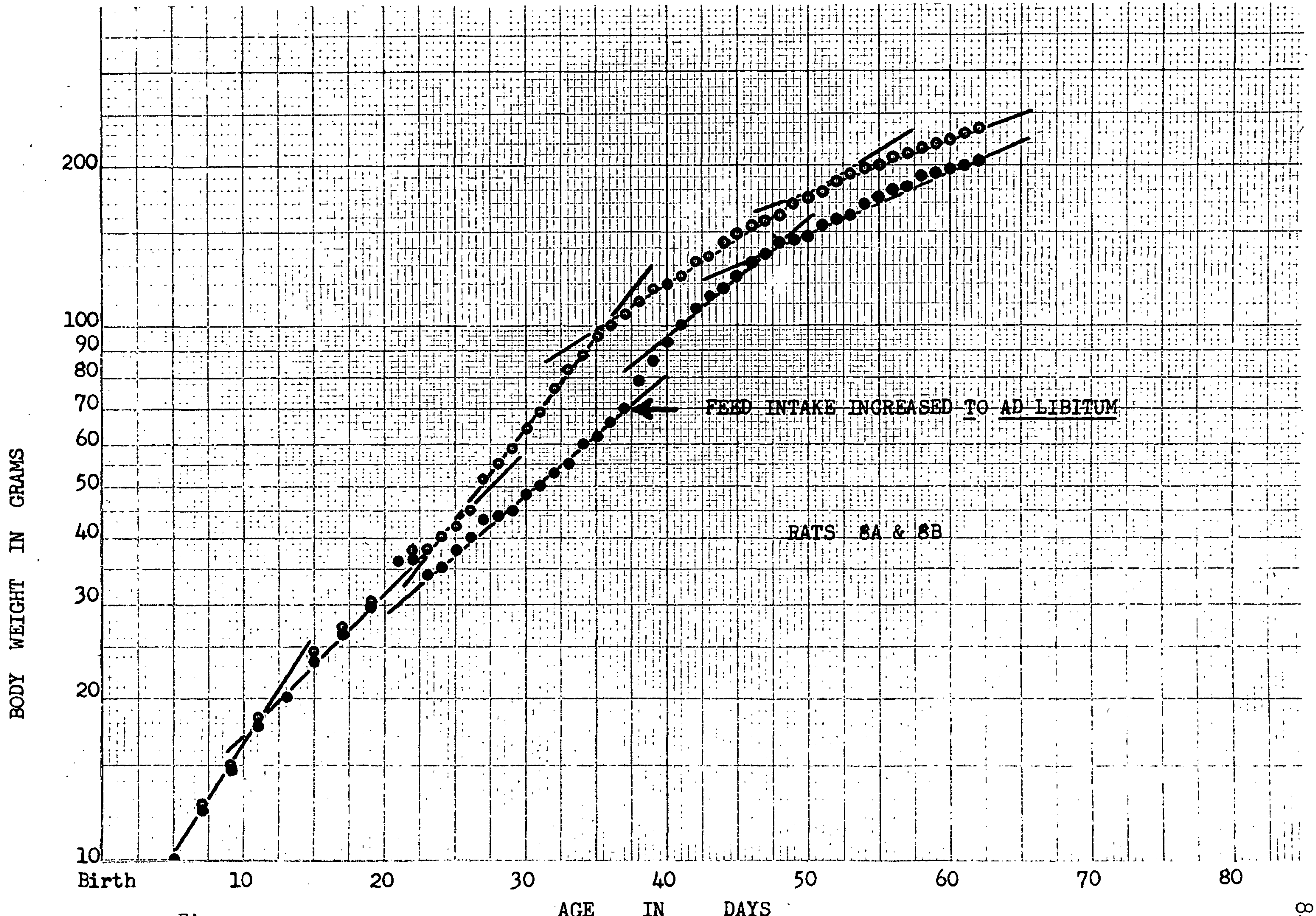
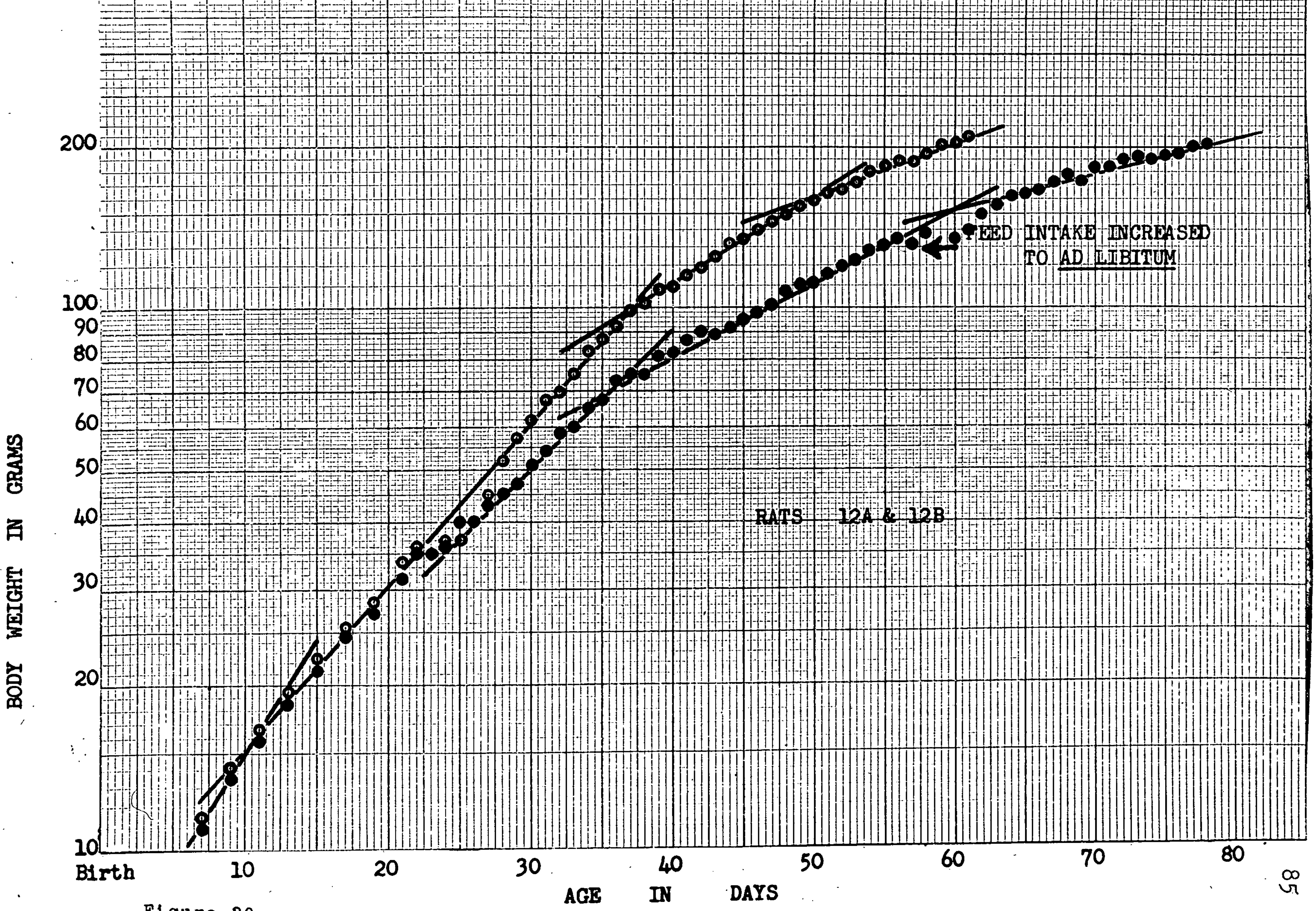

BODY WEIGHT IN GRAMS
10
20
30
40
50
60
70
80
90
100
200
Birth
10
20
30
40
50
60
70
80
AGE IN DAYS
FEED INTAKE INCREASED TO AD LIBITUM
RATS 1A & 1B

Figure 18



BODY WEIGHT IN GRAMS
10
20
30
40
50
60
70
80
90
100
200
Birth
10
20
30
40
50
60
70
80
AGE IN DAYS
FEED INTAKE INCREASED TO AD LIBITUM
RATS 8A & 8B

Figure 19



BODY WEIGHT IN GRAMS
10
20
30
40
50
60
70
80
90
100
200
Birth
10
20
30
40
50
60
70
80
AGE IN DAYS
RATS 12A & 12B
FEED INTAKE INCREASED
TO AD LIBITUM

Figure 20

T A B L E 16

"K" Values And The Period Maintained in Days For Male Wistar Rats

Rat No.					
8A	Birth-11days K = .0937	11-24 .0620	24-36 .0782	36-51 .0382	51- .0223
8B	"	11-22 .0620	22-37 .0338	37-47 .0495	47- .0226
4A	Birth-13days K = .1310	13-22 .0641	22-39 .0732	39-53 .0341	53- .0267
4B	"	"	"	39-54 .0271	54- .0128
14A	Birth-10days K = .1020	10-22 .0532	22-39 .0710	----- -----	39- .0308
14B	"	"	22-42 .0546	----- -----	42- .0276
3A	Birth-14days K = .1130	14-22 .0610	22-34 .0835	34-47 .0456	47- .0266
3B	"	"	22-49 .0359	49--- -----	49- .0269
12A	Birth-11days K = .0952	11-37 .0639	----- -----	37-50 .0381	50- .0225
12B	"	11-22 .0639	22-36 .0591	36-60 .0310	60- .0153
1A	Birth-12days K = .1390	12-22 .0741	22-36 .0679	36-52 .0339	52- .0183
1B	"	"	22-39 .0551	39-50 .0393	50- .0199
15A	Birth-11days K = .1060	11-22 .0621	22-38 .0764	38-55 .0318	55- .0236
15B	"	11-34 .0621	----- -----	34-60 .0374	60- .0128
6A	Birth-22days K = .0759	----- -----	22-35 .0845	35-46 .0605	46- .0223
6B	"	----- -----	22-42 .0539	42-52 .0404	52- .0258
5A	Birth-11days K = .1180	11-22 .0714	22-39 .0653	----- -----	39- .0270
5B	Birth-22days K = .0848	----- -----	22-42 .0693	----- -----	42- .0323
2A	Birth-14days K = .1230	14-22 .0629	22-34 .0785	34-46 .0433	46- .0298
2B	"	"	22-40 .0548	40-53 .0391	53- .0206

The male Wistar Rat has the ability to grow at the same instantaneous growth rate relative to body weight as its ad libitum fed litter mate, when it has been raised to full feed, following a 30 per cent reduction in food intake from weaning to 70, 110, and 130 grams body weight. Before attempting extrapolation from the Albino Rat to the beef animal, the relative severity of the reduction of food intake must be considered for the two species. The average age of all Group "A" rats at 200 grams body weight was 59 days and the body weight of Group "B" at this age was 159 grams. The average body weight at weaning was 39 so that Group "A" increased body weight 161 grams in 37 days and Group "B" increased body weight 120 grams in the same period or 75 per cent of maximum. Reference to the work of Brody (1942) indicates that the period of 22 days to 60 days in the rat corresponds physiologically to the period birth to 10 months in the cow. Maximum body weight expected of a group of steers has (cont. next page)

already been set down in the introduction to this thesis and appears to be approximately 625 pounds at 10 months. 75% of this maximum would be 470 pounds and represents a difference of .5 pounds per day which is as great as would be expected of calves being raised in a pure bred herd. It seems safe to state that the severity of the ration limitations imposed on the Wistar rats are of the magnitude which might be expected in the history of certain bulls coming on to a performance test

Previous to this point in the thesis there has been no reference to the reasons for the changes in relative growth rate occuring in the various species being studied.

By referring to figure 18 it may be noted that with the passage of time and the increase in body weight, there is a decreasing relative growth rate. The reason for this stated very simply is that as the body mass increases the surface area per unit mass becomes larger by the power .73 and so there is less opportunity for growth by either the cell division or cell accretion method because of population crowding much as is experienced with bacterial cultures. It has been observed that when a growth phase shows an increase relative growth rate over the preceeding section some factor has been limiting during the earliest period. This phenomenon may be noted in figure 19 in which the control rat grew at an increased rate following weaning since energy intake was limiting while nursing the dam. The first change in relative growth in the rat at 10-11 days following birth may be said to be the point when energy intake is limited by the milk production of the dam. A simple calculation on the possible energy requirement of a litter at this point will demonstrate that it is impossible for the female to consume enough energy to produce the necessary milk (Waldern & Wood 1952). This milk shortage is peculiar to the multiparous animals but it has a counterpart in the growth of beef calves when the capacity of the calf limits the energy intake in the form of milk. This situation however can only occur when the cow has the potential and available energy to exceed in production the appetite of her calf. The next main alteration in relative growth rate is at 21 days or weaning and as already observed there may be an increased rate due to the increase in available energy.

The change in growth rate which occurs at about 30-40 days in the rat is difficult to explain. The growth data on the Wistar rats were subjected to statistical analysis to find the correlation, if any, between the rats A and B of each pair when their age or their body weight were considered at the point of the characteristic alterations in relative growth rate that appear twice following weaning. Unfortunately all the correlation coefficients were insignificant although it would appear that there was a trend towards the changes in growth rate to occur more at a constant body weight than at a constant age.

The lack of significance may be attributed mainly to two factors.

(1) The numbers are not great enough to correct for the wide variations that exist between individuals even in such an inbred group of animals as considered.

(2) Physiological age although usually closely correlated with body weight is not necessarily controlled by it and the neuro-endocrine drive to mature will eventually force physiological ageing despite complete cessation of growth in the body weight sense.

A consideration of the second change in relative growth rate following weaning has been made by many investigators and it is usual to term it the "pubertal break" since it coincides with the onset of sexual maturity. There are other factors than simple sexual maturity however involved in this marked slowing in growth rate. McMeekan (1942) observed in his work with swine that the stomach and small intestine reached their greatest percentage of their weight at birth by 24 weeks of age which is puberty for this species. The significance of this factor is obvious since food intake will not increase and while basal metabolism and maintenance requirements will continue to increase there will be a decreasing amount of nutriants available for growth. Another factor which may be involved is that the percentage body fat becomes greater than the percentage body protein at this point with the consequent high energy requirement per unit gain as previously described.

As an additional point of interest the heritability of body weight of the rats at 60 days of age was calculated as a full sib correlation. The figure obtained was 6.8% which indicates that there would be little advantage in selecting animals from the same litter over those from different litters in the highly inbred stock colony at the University of British Columbia

III

Summary and Conclusions

Two approaches to the problem of assessing merit in beef cattle have been elaborated upon in the present work.

The first approach has been made following *a posteriori* reasoning. Investigators have attempted to provide themselves with large amounts of data which presumably would lend itself to extensive statistical manipulation. Unfortunately undue reliance is placed on statistical analysis of the findings without sufficient regard for principles of biology.

The second approach to the problem which has attracted the minority of researchers to date utilizes *a priori* reasoning. In this approach fundamental findings in related fields such as biochemistry and physiology have been used to establish working hypothesis in an attempt to explain the variations in the rate and efficiency of gain of test animals.

As has been shown earlier these two approaches appear to be irreconcilable. This seems so since the popular approach can lead to invalid conclusions from what appears to be statistically valid data.

From the work carried out here as well as that provided in the literature the following tentative conclusions have been drawn.

(1) Animals tend to grow at a constant rate relative to body weight over certain portions of their growth curve.

(2) Rate of gain must be considered on a weight constant basis.

(3) The differences in rate and efficiency of gain which have been observed between similar animals maintained under identical conditions is mainly due to the type of tissue growth being made.

(4) Rate of gain measured over time interval other than instantaneous may introduce an error which is as great as the differences observed between test animals.

(5) Animals considered at any but the same body weight may provide biased results which can be in error as much as the differences observed between test animals.

(6) Detailed studies of growth must include a consideration of the data treated as the regression of the

logarithm of body weight on time.

(7) The feeding of beef bulls on test should follow a schedule in which the animals receive something less than they would under *ad libitum* conditions.

(8) The ration fed to beef bulls on test must first be balanced as to roughage and concentrate so that bulk does not limit the energy intake or the intake of other nutrients required to permit optimum growth.

(9) On the basis of present results there is no justification for the inclusion of a live animal score in an index of merit for beef cattle.

(10) There is no significant difference between the instantaneous relative growth rates of Wistar Rats fed *ad libitum* on balanced ration and those fed *ad libitum* following a restriction to 70 per cent of *ad libitum* for 70, 110, and 130 days following weaning.

IV

- APPENDICES -

A. Wistar Rat Body Weight and Feed Consumption Data

(a) Birth to Weaning

(b) Weaning to 200 grams

Body Weight in Grams

Litter No. 1

Males

Age Days	1	2	3	4	5	6	7	8	9	Mean Weight
3										
5	10.9	10.6	10.5	10.0	10.0	10.0	9.9	9.8	9.2	10.1
7	13.0	13.0	13.0	12.9	12.8	12.5	12.0	12.0	11.5	12.5
9	16.4	16.0	15.1	14.7	14.7	14.7	14.6	14.2	14.0	14.9
11	18.4	18.4	18.0	18.0	17.3	17.0	17.0	16.9	16.3	17.5
13	20.5	20.0	20.0	19.5	19.5	19.5	19.5	18.9	18.1	19.5
15	23.4	22.7	22.7	22.4	22.2	22.0	21.8	21.4	20.9	22.1
17	25.5	25.3	24.7	24.4	24.3	24.2	24.0	23.3	23.1	24.3
19	27.6	26.8	26.8	26.5	26.2	26.1	26.0	25.5	24.1	26.2
21	32.9	32.4	31.3	31.2	30.4	30.9	30.0	28.7	26.4	30.5
22	34.0	34.0	33.0	33.0	32.0	32.0	31.0	31.0	28.0	32.0
Test Rats	13A	13B	14A	14B						

Females

Age Days	1	2	3	Mean Weight
3				
5	10.0	9.6	8.7	9.4
7	12.2	11.2	11.2	11.5
9	13.9	13.3	11.2	12.8
11	17.0	17.0	15.7	16.7
13	19.1	17.6	16.3	17.7
15	21.3	20.0	19.6	20.3
17	22.7	21.7	20.6	21.6
19	25.1	22.8	21.6	23.2
21	30.1	27.3	25.9	27.8
22	Weaned			

Litter No. 2

Body Weight in Grams

Age Days	Females 1	Females 2	Females 3	Females 4	Males 1	Males 2	Males 3
3	9.3	8.8	7.3	6.8	10.0	7.3	7.2
5	11.2	11.2	9.5	8.5	12.4	9.3	8.4
7	14.2	14.2	10.2	12.2	15.8	11.9	11.4
9	19.2	18.7	14.9	13.1	21.0	14.0	14.0
11	24.5	22.8	18.0	16.0	25.7	17.8	17.8
13	28.8	27.3	22.0	19.0	30.0	20.5	20.5
15	32.7	31.4	26.2	21.5	34.3	24.1	23.7
17	37.2	36.5	29.5	25.0	39.1	29.0	28.7
19	42.2	40.5	34.1	29.2	44.5	32.7	31.9
21	47.4	45.5	40.2	31.8	49.9	37.7	36.0
22	Weaned						
Test Rats						6B	6A

Litter No. 3

Body Weight in Grams

Age Days	Females 1	Females 2	Males 1	Males 2	Males 3	Males 4	Males 5	Males 6	Males 7	Males 8	Males 9
5	9.1	8.9	10.0	10.0	9.7	9.3	9.3	9.3	8.9	8.7	8.4
7	10.3	10.0	12.7	12.5	12.5	11.8	11.5	11.0	10.9	10.3	10.0
9	13.2	12.6	15.0	14.8	14.5	14.5	14.1	13.6	13.4	12.4	11.7
11	16.4	14.8	18.5	17.8	17.5	17.0	16.7	16.7	15.7	15.4	14.9
13	18.8	17.1	20.2	20.2	20.0	19.8	19.4	19.4	18.5	17.6	16.6
15	22.4	20.0	24.6	23.6	23.5	23.5	22.4	22.3	21.2	20.7	19.6
17	23.7	22.3	27.2	26.4	26.2	25.9	25.5	24.9	24.5	23.8	22.0
19	28.9	23.9	30.3	29.8	28.9	28.7	28.5	28.5	27.0	26.1	25.6
21	33.4	25.0	36.4	36.1	34.4	33.8	33.8	33.0	31.2	31.0	30.3
Test Rats				8A	8B	11B	12A	11A	12B	15B	15A

Litter No. 4

Body Weight in Grams

Age Days	Females 1	2	3	4	Males 1	2
3	9.4	8.8	8.2	8.0	8.8	4.5
5	12.2	11.9	11.0	10.0	11.8	Dead
7	16.1	15.4	14.8	12.8	15.4	
9	19.7	19.2	18.5	17.0	20.0	
11	24.1	23.5	23.2	21.7	24.5	
13	28.9	28.0	26.7	25.4	29.0	
15	32.3	31.6	31.7	30.0	33.6	
17	36.6	36.3	35.5	33.7	38.7	
19	41.2	41.0	40.2	38.1	42.4	
21	48.4	48.4	46.8	44.7	49.9	
22	Weaned					

Litter No. 5

Body Weight in Grams

Females

Age Days	1	2	3	4	5	6	7	8	9
3	8.3	8.0	7.8	7.8	7.7	7.7	7.3	7.3	7.2
5	10.0	10.0	10.0	10.0	9.7	9.2	9.1	9.0	8.7
7	12.1	12.0	11.9	11.4	11.2	11.2	11.0	10.8	10.2
9	15.5	14.5	14.2	13.6	13.5	13.3	12.7	12.6	11.9
11	17.8	17.7	17.6	17.3	16.4	16.2	16.2	15.4	14.5
13	19.4	19.1	19.0	18.7	18.1	18.0	17.5	17.5	16.7
15	21.8	21.7	21.6	21.6	20.9	20.7	20.7	19.9	14.6
17	25.5	24.5	23.9	23.3	23.1	22.8	22.3	21.9	20.4
19	28.0	27.2	25.7	25.5	25.3	25.3	24.9	23.4	22.1
21	31.8	31.0	30.2	30.0	29.7	29.2	29.0	28.5	25.0
22	Weaned								

Males

3	8.0	7.9	7.7	7.7
5	10.1	10.0	9.8	8.9
7	12.6	12.6	12.4	10.9
9	15.5	15.4	15.3	12.4
11	19.3	19.3	18.8	15.5
13	22.1	21.3	20.4	17.5
15	24.3	22.4	22.5	20.0
17	27.0	25.7	24.9	22.8
19	29.2	27.8	26.6	23.1
21	33.8	32.5	32.2	28.9
Test Rats	9A	9B		

Litter No. 6

Body Weight in Grams

Females

Age Days	1	2	3	4	5	6	7	8	9	
3	8.8	8.7	8.6	8.5	8.4	8.3	8.2	8.0	7.4	7.2
5	11.0	10.8	10.4	10.3	10.2	10.0	9.9	9.6	8.6	8.6
7	13.7	12.6	12.5	12.4	12.4	12.3	11.9	11.7	10.7	9.9
9	16.5	16.1	15.9	15.8	15.7	14.6	14.3	14.1	12.3	11.3
11	20.0	19.5	19.1	18.7	17.4	16.2	16.1	15.8	14.7	12.9
13	22.2	21.6	20.9	20.8	20.5	20.1	19.5	18.3	16.5	15.3
15	24.4	24.3	24.1	23.4	23.2	22.1	21.5	18.2	18.0	16.5
17	27.3	26.3	25.7	25.1	24.9	23.4	23.1	21.2	20.0	18.1
19	30.5	30.1	29.4	29.0	28.6	26.2	26.2	24.6	22.8	20.8
21	34.4	33.6	33.3	33.2	32.0	30.5	29.8	28.4	26.7	23.4
22	Weaned									

Males

Age Days	1	2	3	4	5
3	9.3	9.2	8.9	8.7	8.7
5	11.6	11.1	11.1	10.8	10.1
7	15.0	14.4	14.1	13.5	12.6
9	18.1	17.8	16.8	16.6	14.9
11	21.3	20.2	20.0	19.3	18.4
13	22.8	22.0	21.9	21.8	20.8
15	26.3	24.7	24.1	23.5	23.0
17	28.0	27.2	26.3	26.3	25.7
19	32.6	29.9	29.7	28.9	28.3
21	36.8	34.5	33.8	33.5	32.6
22	Weaned				
Test Rats	7A	7B	10A	10B	

Litter NO. 7

Body Weight in Grams

Age Days	Females 1	2	3	4	Males 1	2	3	4	5
3	7.6	7.4	7.4	7.0	7.9	7.6	7.2	7.2	7.2
5	9.7	9.7	9.6	8.7	9.9	9.8	9.6	9.5	9.2
7	12.6	12.1	12.0	11.9	12.6	12.4	12.2	11.1	11.0
9	15.7	15.7	15.7	15.5	15.9	15.6	15.6	13.4	13.4
11	20.3	20.2	1818	16.8	20.0	20.0	19.7	16.5	15.1
13	25.0	24.3	21.6	20.3	24.6	24.3	23.3	19.3	17.9
15	30.3	29.3	26.4	23.4	28.7	28.5	26.7	21.8	20.2
17	35.0	33.7	30.0	28.4	31.9	31.7	31.3	26.7	28.7
19	40.3	39.5	36.2	33.1	37.0	36.3	36.2	30.7	28.7
21	45.4	44.9	40.4	37.6	42.7	42.7	40.4	37.1	33.1
22	Weaned								
Test Rats					4A	4B	5B	5A	

Litter No.8

Body Weight in Grams

Age Days	Females 1	2	3	4	5	Males 1	2	3	4	5
4	10.4	9.6	9.4	9.2	9.0	11.0	10.2	9.7	8.5	8.5
6	13.8	11.8	11.7	11.6	11.0	13.1	13.1	12.5	10.5	10.3
8	14.5	14.0	13.8	12.8	12.1	16.9	16.6	15.9	15.5	12.4
10	20.4	17.8	16.7	16.2	14.5	19.4	19.1	18.4	14.8	13.4
12	24.1	20.1	19.7	18.8	17.4	23.0	22.7	22.5	15.4	15.4
14	28.5	23.7	22.8	22.1	20.4	29.0	25.6	25.2	16.4	-
16	33.4	27.2	25.9	25.4	23.0	31.2	30.0	28.4	17.7	
18	38.0	30.9	29.8	29.3	25.5	35.5	34.2	33.2	15.6	
20	44.7	37.4	34.7	34.1	30.0	42.5	40.2	39.7	14.5	
22	51.8	43.4	40.1	40.9	36.5	49.8	48,7	46.0	-	
23	Weaned					52.0	51.0	50.0		

Body Weight in Grams

Litter No. 9

Age Days						
3	7.1	7.0	6.5	6.5	6.1	5.7
5	8.6	8.9	7.9	7.5	7.4	7.3
7	13.1	10.0	9.8	9.8	9.5	8.5
9	12.3	11.5	11.2	11.0	9.2	8.9
11	19.4	16.2	10.0	⌿	-	-
13	21.2	20.1	14.0			
15	26.4	24.0	18.5			
17	31.3	29.2	24.0			
19	35.7	31.9	28.0			
21	39.8	37.8	36.0			
22	Weaned					

Age Days									
3	8.0	7.9	7.6	7.6	7.6	7.5	7.3	7.1	5.5
5	9.8	9.5	9.5	9.4	9.3	9.3	9.3	9.0	-
7	12.8	11.9	11.9	11.1	11.1	11.1	11.1	10.1	
9	15.6	15.5	15.4	14.8	14.6	14.4	12.6	-	
11	22.5	20.6	20.0	19.2	18.7	18.4	-		
13	27.3	25.8	25.0	24.7	23.4	22.4			
15	32.2	31.2	30.3	29.8	28.7	27.0			
17	37.7	35.5	35.5	32.9	32.9	32.2			
19	42.8	40.6	39.0	38.4	37.8	32.9			
21	47.6	47.3	44.6	43.0	41.8	35.9			
22	50.0	50.0	48.0	48.0	45.0	45.0	Weaned		
Test Rats	1A	1B	2A	2B	3A	3B			

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 22nd Day					DATE 23rd Day					DATE 24th Day				
				WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
	1A		male	50	5	1			45	10	1			50	10	9		
U.B.C.	2		"	48	5	1			45	10	4			47	10	9		
Ration	3		"	45	5	3			37	10	3			44	10	7		
#18	4		"	45	5	0			35	10	4			38	10	7		
	5		"	40	5	1			40	10	3			43	10	7		
	MEAN																	
	6		"	37	5	1			32	10	3			30	10	5		
	7		"	39	5	1			36	10	4			38	10	8		
	8		"	38	5	3			38	10	4			40	10	9		
	9		"	36	5	1			31	10	4			35	10	8		
	10		"	36	5	4			36	10	5			40	10	9		
	11		"	35	5	3			33	10	5			35	10	8		
	MEAN																	
	12		"	36	5	2			35	10	5			37	10	8		
	13		"	34	5	2			32	10	5			36	10	8		
	14		"	33	5	4			33	10	6			35	10	9		
	15		"	32	5	4			32	10	6			34	10	7		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 25th Day					DATE 26th Day					DATE 27th Day				
				WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18	1A		male	53	11	10			57	17	8			61	12	10		
	2		"	52	10	10			55	17	10			60	12	12		
	3		"	41	8	8			45	14	8			43	9	9		
	4		"	40	8	8			44	13	8			48	10	10		
	5		"	45	9	7			50	15	8			53	11	10		
	MEAN																	
	6		"	31	6	6			32	10	7			37	7	7		
	7		"	43	9	9			46	14	9			50	10	10		
	8		"	42	8	8			45	14	9			52	10	10		
	9		"	39	8	8			43	13	10			47	9	9		
	10		"	43	9	9			48	14	9			51	10	9		
	11		"	37	7	7			40	12	10			45	9	9		
	MEAN																	
	12		"	40	8	8			45	14	9			48	10	10		
	13		"	39	8	8			43	13	9			48	10	10		
	14		"	38	8	8			42	13	9			45	9	9		
	15		"	37	7	7			34	10	8			40	8	8		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DATE 28th Day

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL (gms)	FEED OFFERED (gms)	FEED EATEN (gms)	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18	1A		male	65	16	12		
	2		"	62	16	14		
	3		"	50	13	12		
	4		"	51	13	8		
	5		"	58	15	11		
	MEAN							
	6		"	40	10	8		
	7		"	55	14	12		
	8		"	55	14	11		
	9		"	50	13	13		
	10		"	55	14	11		
	11		"	50	13	11		
	MEAN							
	12		"	52	13	11		
	13		"	52	13	10		
	14		"	49	12	9		
	15		"	43	11	10		
	MEAN							
	MEAN							

DATE 29th Day

ANIMAL NUMBER	WEIGHT OF ANIMAL (gms)	FEED OFFERED (gms)	FEED EATEN (gms)	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
1A	71	18	12		
2	70	18	13		
3	56	14	10		
4	55	14	11		
5	63	16	10		
MEAN					
6	43	11	9		
7	60	15	10		
8	59	15	11		
9	55	14	12		
10	60	15	9		
11	54	14	10		
MEAN					
12	57	14	10		
13	57	14	9		
14	52	13	10		
15	48	12	10		
MEAN					
MEAN					

DATE 30th Day

ANIMAL NUMBER	WEIGHT OF ANIMAL (gms)	FEED OFFERED (gms)	FEED EATEN (gms)	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
1A	77	19	13		
2	78	20	14		
3	62	15	12		
4	61	15	10		
5	68	17	12		
MEAN					
6	47	12	9		
7	65	16	10		
8	64	16	11		
9	61	15	13		
10	65	16	10		
11	59	15	10		
MEAN					
12	62	16	11		
13	61	15	10		
14	57	14	10		
15	54	14	11		
MEAN					
MEAN					

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 31st Day					DATE 32nd Day					DATE 33rd Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18	1A		male	82	21	13			87	22	12			93	19	14		
	2		"	84	21	14			88	22	13			95	19	14		
	3		"	66	17	14			72	18	5			79	16	14		
	4		"	65	16	11			69	17	12			75	15	12		
	5		"	73	18	12			78	20	12			84	17	11		
	MEAN																	
	6		"	50	13	12			55	14	11			60	12	12		
	7		"	70	18	11			75	19	12			80	16	12		
	8		"	69	17	13			76	19	13			83	17	11		
	9		"	66	17	13			70	18	15			75	15	14		
	10		"	68	17	10			70	18	7			72	14	8		
	11		"	65	16	12			69	17	13			76	15	12		
	MEAN																	
	12		"	67	18	13			70	18	13			75	15	12		
	13		"	65	16	7			70	18	9			73	15	9		
	14		"	60	15	11			65	16	11			70	14	12		
	15		"	58	15	12			63	16	12			68	14	11		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 34th Day					DATE 35th Day					DATE 36th Day				
				WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
	1A		male	99	20	14			106	21	12			110	22	14		
U.B.C.	2		"	103	21	16			109	22	13			114	23	12		
Ration	3		"	85	17	15			91	18	12			93	19	13		
	4		"	80	16	11			86	17	10			90	18	13		
# 18	5		"	90	18	13			96	19	12			100	20	12		
	MEAN																	
	6		"	65	13	12			70	14	10			73	15	13		
	7		"	87	17	13			93	19	12			98	20	13		
	8		"	88	18	14			95	19	13			100	20	14		
	9		"	81	16	14			87	17	13			90	18	15		
	10		"	74	15	10			79	16	19			80	16	10		
	11		"	82	16	12			88	18	13			92	18	14		
	MEAN																	
	12		"	83	17	13			87	17	13			92	18	12		
	13		"	76	15	10			80	16	7			84	17	8		
	14		"	75	15	10			82	16	11			85	17	12		
	15		"	74	15	9			80	16	11			84	17	13		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 37th Day					DATE 37th Day					DATE 37th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration # 18	1A		male	115	23	14			120	24	14			125	25	14		
	2		"	121	24	13			124	25	13			128	26	16		
	3		"	100	20	12			104	21	12			108	22	14		
	4		"	96	19	13			100	20	12			106	21	14		
	5		"	107	21	13			113	23	11			117	23	16		
	MEAN																	
	6		"	79	16	12			84	17	12			90	18	15		
	7		"	104	21	14			110	22	11			114	23	16		
	8		"	105	21	11			111	22	13			118	24	14		
	9		"	98	20	15			101	20	16			108	22	16		
	10		"	86	17	10			90	18	9			93	19	7		
	11		"	99	20	14			140	21	11			110	22	13		
	MEAN																	
	12		"	98	20	13			102	20	14			108	22	17		
	13		"	90	18	10			93	19	11			99	20	12		
	14		"	91	18	13			96	19	14			102	20	14		
	15		"	90	18	12			94	19	13			100	20	14		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 40th Day					DATE 41st Day					DATE 42nd Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
	1A		male	127	25	13			133	27	14			140	28	12		
U.B.C	2		"	136	27	16			141	28	15			149	30	13		
Ration	3		"	115	23	14			119	24	14			126	25	16		
# 18	4		#	111	22	11			116	23	13			125	25	10		
	5		"	124	25	13			126	25	8			119	24	4		
	MEAN																	
	6		"	94	19	11			100	20	13			108	22	12		
	7		"	120	24	13			125	25	14			139	27	13		
	8		"	119	24	14			125	25	15			132	26	15		
	9		"	110	22	13			115	23	14			120	24	14		
	10		"	90	18	8			95	19	9			100	20	9		
	11		"	111	22	13			116	23	12			120	24	14		
	MEAN																	
	12		"	109	22	13			115	23	13			119	24	14		
	13		"	100	20	11			105	21	9			110	22	15		
	14		"	104	21	11			110	22	12			111	22	12		
	15		"	103	21	10			107	21	13			111	22	14		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 43rd. Day					DATE 44th Day					DATE 45th Day				
				WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration No 18	1A		male	146	30	14			151	30	12			148	30	16		
	2		"	155	31	15			162	32	16			169	34	14		
	3		"	138	28	15			141	28	13			144	29	14		
	4		"	130	26	14			135	27	14			140	28	12		
	5		"	112	22	14			135	27	15			140	28	14		
	MEAN																	
	6		"	113	23	14			119	24	12			125	25	14		
	7		"	138	28	15			144	29	15			148	30	14		
	8		"	136	27	16			145	29	14			149	30	14		
	9		"	126	25	15			132	26	10			122	24	15		
	10		"	101	20	9			107	21	11			111	22	10		
	11		"	126	25	14			132	26	14			135	27	13		
	MEAN																	
	12		"	125	25	15			132	26	15			135	27	11		
	13		"	114	23	14			121	24	15			125	25	15		
	14		"	117	23	14			124	25	14			125	25	11		
	15		"	118	24	13			122	24	7			120	24	14		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES .WISTAR RAT — ASSAYER C. M. W.

				DATE 46th Day					DATE 47th Day					DATE 48th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration # 18.	1A		male	157	31	14			160	24	15			168	25	16		
	2		"	175	35	13			179	27	14			185	29	17		
	3		"	150	30	14			153	23	15			163	24	13		
	4		"	145	29	17			151	23	11			155	23	15		
	5		"	146	29	16			150	23	16			160	24	17		
	MEAN																	
	6		"	130	26	17			135	20	12			140	21	17		
	7		"	152	30	18			160	24	15			165	25	16		
	8		"	154	31	16			157	24	14			161	24	16		
	9		"	139	28	17			144	22	14			147	22	18		
	10		"	115	23	12			120	18	12			125	19	13		
	11		"	138	28	16			145	22	15			150	23	12		
	MEAN																	
	12		"	140	28	17			145	22	12			149	22	13		
	13		"	129	26	16			136	20	12			140	21	15		
	14		"	129	26	14			134	20	11			142	21	17		
	15		"	129	26	14			134	20	10			133	20	16		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT

ASSAYER C. M. W.

				DATE 49th Day					DATE 50th Day					DATE 51st Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
	1A		male	171	26	15			179	26	12			184	27	18		
	2		"	190	29	18			197	29	15			203	30	18		
U.B.C.	3		"	161	24	16			170	24	14			177	26	17		
Ration	4		"	160	24	14			165	23	12			172	26	16		
# 18	5		"	163	25	16			170	24	14			173	26	13		
	MEAN																	
	6		"	145	22	15			148	22	14			152	23	15		
	7		"	174	26	16			170	26	19			180	27	17		
	8		"	170	26	16			174	26	14			177	26	16		
	9		"	155	23	18			159	23	14			161	24	16		
	10		"	129	19	14			134	20	11			137	20	14		
	11		"	155	23	12			154	23	16			161	24	13		
	MEAN																	
	12		"	155	23	16			159	23	13			164	24	15		
	13		"	145	22	15			150	23	12			151	23	16		
	14		"	144	22	9			135	20	15			154	23	17		
	15		"	145	22	18			152	23				154	23	23		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 52nd Day					DATE 53rd Day					DATE 54th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
	1A		male	188	28	15			194	29	13			195	30	15		
U.B.C	2		"	209	31	17			218	32	15			216	32	15		
Ration	3		"	180	27	17			187	27	15			190	29	18		
# 18	4		"	175	26	23			180	27	12			177	26	10		
	5		"	176	26	16			179	26	13			185	28	16		
	MEAN																	
	6		"	157	24	15			162	24	15			165	25	14		
	7		"	188	28	18			193	29	16			198	30	18		
	8		"	180	27	17			189	27	18			190	29	17		
	9		"	169	25	12			171	25	13			174	26	15		
	10		"	143	22	10			149	22	12			151	23	13		
	11		"	165	25	14			166	25	15			169	25	19		
	MEAN																	
	12		"	167	25	15			172	26	16			180	27	17		
	13		"	160	24	13			162	24	15			168	25	15		
	14		"	158	24	15			161	24	15			168	25	18		
	15		"	157	24	19			166	24	15			170	25	16		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 55th Day					DATE 56th Day					DATE 57th Day				
				WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
	1A		male	201	30	16			205	31	18			209	31	13		
U.B.C.	2		"	221	33	14			225	34	17			229	34	14		
Ration	3		"	193	29	13			200	30	-			187	28	19		
# 18	4		"	184	28	14			189	28	16			192	29	15		
	5		"	192	29	15			199	30	18			203	30	14		
	MEAN																	
	6		"	169	25	14			185	26	16			124	26	15		
	7		"	206	31	16			210	33	19			212	22	18		
	8		"	200	30	15			209	33	16			210	32	16		
	9		"	176	26	14			187	28	-			192	29	9		
	10		"	158	24	13			160	24	15			165	25	15		
	11		"	179	27	11			179	27	20			189	28	13		
	MEAN																	
	12		"	184	28	18			189	28	17			189	28	17		
	13		"	171	26	15			178	27	16			179	27	15		
	14		"	174	26	15			180	27	18			182	27	15		
	15		"	177	26	16			185	28	16			187	28	17		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTER RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 58th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 59th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 60th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration # 18	1A		male	213	32	14			220	33	17			222	33	18		
	2		"	234	35	16			242	36	18			244	36	15		
	3		"	204	30	14			207	31	17			210	31	16		
	4		"	199	30	16			204	31	18			209	31	17		
	5		"	206	30	17			214	32	17			217	32	18		
	MEAN																	
	6		"	180	27	14			185	28	17			189	28	17		
	7		"	219	33	18			225	34	20			230	35	20		
	8		"	216	33	15			220	33	21			224	33	19		
	9		"	190	28	11			191	29	13			192	29	19		
	10		"	170	26	15			175	26	18			177	26	17		
	11		"	191	28	18			196	29	17			198	29	18		
	MEAN																	
	12		"	196	29	17			201	30	17			203	30	16		
	13		"	184	27	17			189	28	16			192	29	19		
	14		"	185	28	17			195	29	17			197	29	18		
	15		"	193	28	16			197	29	18			199	29	18		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTER RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 61st Day					DATE 62nd Day					DATE 63rd Day				
				WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration # 18	1A		male	228	34	16												
	2		"	248	37	15												
	3		"	220	33	17												
	4		"	215	33	15												
	5		"	220	33	16												
	MEAN																	
	6		"	190	29	14			195	29	15			197	30	17		
	7		"	235	35	17												
	8		"	229	34	16												
	9		"	192	29	23												
	10		"	185	28	16			187	28	16			190	29	13		
	11		"	200	30	24												
	MEAN																	
	12		"	209	31	12												
	13		"	193	29	16												
	14		"	201	30	18												
	15		"	205	31	16												
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 22nd Day					DATE 23rd Day					DATE 24th Day				
				WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18	1B		male	50	5	0			47	10	3			49	10	6		
	2		"	48	5	0			43	10	4			46	10	8		
	3		"	45	5	2			42	10	5			44	10	8		
	4		"	45	5	2			41	10	4			43	10	8		
	5		"	40	5	0			42	10	0			38	10	5		
	MEAN																	
	6		"	34	5	1			35	10	5			40	10	10		
	7		"	37	5	1			30	10	4			36	10	7		
	8		"	36	5	2			34	10	5			35	10	8		
	9		"	36	5	0			34	10	3			35	10	9		
	10		"	36	5	4			34	10	5			46	10	8		
	11		"	36	5	0			33	10	6			41	10	9		
	MEAN																	
	12		"	35	5	3			35	10	4			36	10	8		
	13		"	34	5	5			35	10	6			34	10	9		
	14		"	33	5	3			34	10	6			35	10	8		
	15		"	33	5	5			34	10	5			35	10	6		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 25th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 26th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 27th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18	1B		male	49	6	6			52	7	7			55	6	6		
	2		"	50	6	6			50	7	7			55	7	7		
	3		"	49	5	5			48	6	6			50	6	6		
	4		"	48	5	5			48	6	6			50	6	6		
	5		"	41	5	5			43	5	5			44	6	6		
	MEAN																	
	6		"	45	4	4			40	4	4			39	5	5		
	7		"	40	6	6			44	6	6			45	6	6		
	8		"	38	6	6			40	6	6			43	6	6		
	9		"	40	6	6			41	6	6			44	7	7		
	10		"	50	6	6			52	6	6			53	6	6		
	11		"	45	6	6			44	4	4			41	7	7		
	MEAN																	
	12		"	40	6	6			40	6	6			43	6	6		
	13		"	42	6	6			42	6	6			44	6	6		
	14		"	40	6	6			40	6	6			42	6	6		
	15		"	39	5	5			40	5	5			42	6	6		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

				DATE 28th Day					DATE 29th Day					DATE 30th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
	1B		male	59	7	7			62	7	7			65	8	8		
U.B.C.	2		"	57	7	7			60	8	8			65	9	9		
Ration	3		"	53	6	6			56	8	8			61	7	7		
#18	4		"	51	7	7			56	6	6			59	8	8		
	5		"	45	5	5			48	6	6			50	6	6		
	MEAN																	
	6		"	41	5	5			43	6	6			46	6	6		
	7		"	47	6	6			50	7	7			54	8	8		
	8		"	44	6	6			45	6	6			48	6	6		
	9		"	46	7	7			49	9	9			54	8	7		
	10		"	55	6	6			58	8	8			62	6	6		
	11		"	45	6	6			46	6	6			48	9	9		
	MEAN																	
	12		"	45	6	6			47	7	7			51	8	8		
	13		"	46	7	7			50	7	7			54	7	7		
	14		"	45	6	6			48	6	6			50	6	6		
	15		"	45	6	6			48	7	7			51	7	7		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

				DATE 31st Day					DATE 32nd Day					DATE 33rd Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18	1B		male	70	8	8			73	8	8			75	9	9		
	2		"	70	9	9			73	9	9			75	10	10		
	3		"	64	8	8			68	10	10			74	4	4		
	4		"	64	7	7			67	8	8			70	12	12		
	5		"	52	7	7			55	7	7			60	8	8		
	MEAN																	
	6		"	50	6	6			52	8	8			55	8	8		
	7		"	57	8	8			60	7	7			64	7	7		
	8		"	50	7	7			53	8	8			55	8	8		
	9		"	49	9	5			46	6	6			57	13	13		
	10		"	64	7	7			66	7	7			69	5	5		
	11		"	54	7	7			56	7	7			59	7	7		
	MEAN																	
	12		"	54	8	8			58	7	7			60	8	8		
	13		"	56	6	6			57	6	6			58	6	6		
	14		"	51	7	7			55	7	7			58	7	7		
	15		"	54	8	8			56	8	8			60	8	8		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 34th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 35th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 36th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18	1B		male	81	9	9			85	9	8			89	8	8		
	2		"	81	10	10			85	10	10			90	9	9		
	3		"	73	4	4			73	4	4			75	7	7		
	4		"	81	12	12			86	11	11			93	10	10		
	5		"	64	7	7			65	7	7			70	12	12		
	MEAN																	
	6		"	60	8	8			63	7	7			66	8	8		
	7		"	66	8	8			69	8	8			74	8	8		
	8		"	60	8	8			62	8	8			66	8	8		
	9		"	67	9	9			68	10	10			74	14	14		
	10		"	70	5	5			69	5	6			73	6	6		
	11		"	60	7	7			63	8	4			65	8	1		
	MEAN																	
	12		"	65	9	9			67	9	9			73	8	8		
	13		"	60	7	7			63	6	6			66	5	5		
	14		"	62	8	8			65	8	8			70	12	12		
	15		"	65	8	8			67	10	10			74	6	6		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 37th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 38th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 39th Day: WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms	gms	gms	gms	gms	gms		
U.B.C	1B		male	93	10				98	10				101	10	10		
Ration	2		"	94	10				95	10				104	11	11		
	3		"	81	10				88	8				92	9	9		
# 18	4		"	95	13				104	18				111	12	10		
	5		"	80	12				85	11				91	13	13		
	MEAN																	
	6		"	70	7				70	7				76	9	9		
	7		"	78	8				80	8				84	9	9		
	8		"	70	13				79	13				86	14	14		
	9		"	83	14				88	13	12			96	15	14		
	10		"	78	6				77	6				81	7	7		
	11		"	66	8				69	9	0			75	8	8		
	MEAN																	
	12		"	75	8				75	8				81	9	9		
	13		"	67	6				69	6				71	6	6		
	14		"	74	10				85	12				89	13	13		
	15		"	75	6				75	6				77	7	7		
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION | DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT | ASSAYER C. M. W.

				DATE 40th Day					DATE 41st Day					DATE 42nd Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C.	1B		male	104	8				104	8				109	10			
	2		"	109	9				110	9				115	8			
Ration	3		"	96	9				100	8				105	8			
" 18	4		"	112	14	11			119	11	9			128	13	7		
	5		"	95	12				101	12				110	12	-		
	MEAN																	
	6		"	78	8				85	8				90	11			
	7		"	88	9				91	8				95	8			
	8		"	93	13	11			100	14	12			108	12	10		
	9		"	98	15	8			102	16	11			109	13	7		
	10		"	83	7				89	6				91	6			
	11		"	72	9	5			75	8	4			82	8	4		
	MEAN																	
	12		"	82	9				87	9				90	8			
	13		"	70	6				75	7				76	7			
	14		"	95	14	12			102	14	11			109	12	10		
	15		"	78	8				86	9				90	8			
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 43rdDay: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 44th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 45th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C Ration # 18	1B		male	113	14				122	14				129	12			
	2		"	117	12				123	13	12			129	16	11		
	3		"	106	9				111	14				119	14			
	4		"	132	13	8			132	13	8			131	14	8		
	5		"	114	11				117	16				126	8			
	MEAN																	
	6		"	94	8				95	8				99	9			
	7		"	97	9				102	10				105	10			
	8		"	114	13				118	14				125	15			
	9		"	113	14				118	14				124	15	12		
	10		"	94	5				96	6				97	9			
	11		"	85	8				87	9				90	10	9		
	MEAN																	
	12		"	89	9				92	8				95	9			
	13		"	76	7				78	6				80	5			
	14		"	113	12				117	14				125	14			
	15		"	90	8				92	8				95	9			
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 46th Day					DATE 47th Day					DATE 48th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C Ration # 18	1B		male	133	14				140	12				145	14			
	2		"	134	16				140	15				145	14			
	3		"	126	16				133	15				140	13			
	4		"	140	12	10			142	12	12			148	14	11		
	5		"	125	11				130	15				138	14			
	MEAN																	
	6		"	104	8				105	8				110	12			
	7		"	110	8				111	8				114	11			
	8		"	132	15				137	16				143	14			
	9		"	128	15				133	10				134	10			
	10		"	104	17				104	7				107	8			
	11		"	95	10				100	10				100	10			
	MEAN																	
	12		"	98	9				101	10				107	12			
	13		"	80	5				80	5				81	5			
	14		"	127	11				128	14				135	11			
	15		"	99	10				101	10				107	9			
	MEAN																	
	MEAN																	

UNIVERSITY OF BRITISH COLUMBIA

LABORATORY OF ANIMAL NUTRITION — DEPARTMENT OF ANIMAL HUSBANDRY

ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 49TH Day.					DATE 50th Day .					DATE 51st Day ..				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
	1B		male	150	12				153	12				160	15			
U.B.C.	2		"	147	13				149	13				155	15			
Ration	3		"	145	14				148	14				154	15			
# 18	4		"	149	11	9			153	13	12			159	14			
	5		"	142	14				143	15				153	16			
	MEAN																	
	6		"	115	14				120	12				129	17	13		
	7		"	117	10				118	9				122	9			
	8		"	145	14				148	14				156	14			
	9		"	134	17				140	17				148	18			
	10		"	108	8				110	7				114	8			
	11		"	106	8	2			97	10	3			95	10	8		
	MEAN																	
	12		"	111	9				111	9				115	9			
	13		"	82	6				84	6				87	7			
	14		"	135	11				136	11				143	17			
	15			110	14				116	13				124	7			
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 52nd Day					DATE 53rd Day					DATE 54th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C Ration # 18	1B		male	165	16				174	15	14			176	12			
	2		"	160	16	12			165	16	11			168	14	6		
	3		"	159	16				165	16	15			166	13			
	4		"	164	12				167	12				172	16	14		
	5		"	160	17				165	16				172	13	2		
	MEAN																	
	6		"	135	12	9			138	17	9			140	17			
	7		"	125	10				127	10				130	9			
	8		"	158	14				161	16				170	16			
	9		"	153	18				160	14				160	14			
	10		"	115	8				117	8				121	8			
	11		"	98	10	8			107	8				105	8			
	MEAN																	
	12		"	119	10				123	11				128	11			
	13		"	90	7				89	7				95	7			
	14		"	147	9				148	9				149	15			
	15		"	120	14				127	14				133	16			
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W.

				DATE 55TH Day					DATE 56th Day					DATE 57th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration # 18	1B		male	180	12	10			180	12	11			182	18	15		
	2		"	170	14	10			173	13				174	13			
	3		#	173	14	13			176	17	15			182	17	13		
	4		"	178	12	11			179	12	9			179	10	7		
	5		"	175	16				180	13				180	13			
	MEAN																	
	6		"	144	15	10			147	14	13			148	14	13		
	7		"	135	9				136	10				135	13			
	8		"	175	14				180	17				182	17			
	9		"	165	16				170	13				169	12			
	10		"	120	8				122	8				120	8			
	11		"	109	9				111	9				107	8			
	MEAN																	
	12		"	131	11				136	8				132	14			
	13		"	96	8				100	8				98	8			
	14		"	155	17				161	15				163	15			
	15		"	141	18				151	20	17			156	19	15		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES WISTAR RAT — ASSAYER C. M. W

				DATE 58TH Day					DATE 59th Day					DATE 60th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C Ration # 18	1B		male	189	15				190	15				191	13			
	2		"	180	14				183	17	13			188	18			
	3		"	186	15				191	18	17			197	13			
	4		"	179	10				182	14	13			185	14	12		
	5		"	184	16				192	15				195	15			
	MEAN																	
	6		"	156	15				164	14				165	14			
	7		"	143	15				150	16				156	15			
	8		"	190	17				195	18				197	15			
	9		"	174	15				177	14				177	14			
	10		"	125	9				130	14				135	11			
	11		"	112	9				115	8				112	9			
	MEAN																	
	12		"	139	17									136	11			
	13		"	101	8				105	6				105	6			
	14		"	168	18				176	15				178	18			
	15		"		- 4				172	16				170	16			
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

				DATE 61st Day					DATE 62nd Day					DATE 63rd Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18	1B		male	200	16													
	2		"	180	14				193	18	13			195	15	11		
	3		"	198	13													
	4		"	189	16	15			194	15	12			195	15	13		
	5		"	200	18													
	MEAN																	
	6		"	167	14				172	15	14			174	16	12		
	7		"	160	15				165	16				171	16			
	8		"	200	15				203									
	9		"	180					182	14				185	15	13		
	10		"	136	14				146	11				146	11			
	11		"	113	9				117	18				119	9			
	MEAN																	
	12		"	140	16				150	13				155	16	14		
	13		"	104	6				105	6				106	6			
	14		"	183	17				186	17				191	17			
	15		"	175	16				179	16	15			181	16	15		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 64th Day					DATE 65th Day					DATE 66th Day				
				WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
	B		male															
U.B.C.	2		"	197	15				197	15								
Ration	3		"															
	4		"	198	16	14			202									
#18	5		"															
	MEAN																	
	5		"	179	14				182	14				186	14	13		
	6		"	175	18				183	17				186	18	17		
	7		"															
	8		"	189	12	11			186	12				189	12			
	9		"	149	12				152	13				156	13			
	10		"	123	10				127	10				130	14			
	MEAN																	
	11		"	161	13				163	15				166	15			
	12		"	107	7				109	11				115	10			
	13		"	198	18				204									
	14		"	187	17	15			189	17	16			194	16			
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat | ASSAYER C.M.W.

				DATE 67th Day					DATE 68th Day					DATE 69th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18																		
	MEAN																	
	6B		male	189	17	14			193	15				187	14			
	7		"	195	16	16			200									
	9		"	188	12				192	19				186	12			
	10		"	161	15				169	15				165	15			
	11		"	138	16	13			145	15				140	16			
	MEAN																	
	12		"	171	16	15			179	17				174	17			
	13		"	120	11				126	10				120	11			
	15		"	198	18	15			204									
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 70th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 71st Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 72nd Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18																		
	MEAN																	
	6B		male	188	14				195	15	9			200				
	9		"	190	11				190	11				191	11			
	10		"	170	15	13			175	15				181	20	15		
	11		"	152	12	10			160	13	11			160	13			
	MEAN																	
	12		"	183	18	12			185	16	14			190	17			
	13		"	127	10				131	15	14			143	15			
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 73rd Day					DATE 74th Day					DATE 75th Day				
				WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18																		
	MEAN																	
	B		male															
	9		"	194	19	18			203									
	10		"	183	16	11			182	16	11			187	16	11		
	11		"	159	13				163	14	11			166	15	12		
	MEAN																	
	12		"	193	17	13			190	17	16			194	17	7		
	13		"	147	15	12			150	12	9			154	16	12		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

				DATE 76th Day					DATE 77th Day					DATE 78th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
				gms	gms	gms			gms	gms	gms			gms	gms	gms		
U.B.C. Ration #18																		
	MEAN																	
	B		male															
	10		"	189	13	12			192	14	13			195	15	8		
	11		"	173	19	12			174	19	13			175	19	8		
	MEAN																	
	12		"	195	17	14			199	17	15			203				
	13		"	157	13				160	13				165	15	12		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 79th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 80th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 81st Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18																		
	MEAN																	
	B		male															
	10		"	196	16	13			198	16	15			204				
	11		"	176	19	11			179	20	11			180	20	12		
	MEAN																	
	13		"	169	15				173	15	12			175	16	12		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 82nd Cay: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 83rd Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 84th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C.																		
Ration																		
#18																		
	MEAN																	
	B		male															
	11		"	182	20	9			179	20	11			182	20	10		
	MEAN																	
	13		"	178	16	14			184	17	13			185	17	13		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 85th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 86th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	DATE 87th Day: WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18																		
	MEAN																	
		B	male															
	11		"	186	13	10			185	13	11			183	20	11		
	MEAN																	
	13		"	188	16	13			189	16	15			193	16	12		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

				DATE 88th Day					DATE 89th Day					DATE 90th Day				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL gms	FEED OFFERED gms	FEED EATEN gms	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C. Ration #18																		
	MEAN																	
	11			189	20	7			190	20	10			192	20	10		
	MEAN																	
	13			194	20	8			196	20	10			198	20	14		
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat — ASSAYER C.M.W.

DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	DATE 91st Day					DATE 92nd Day					DATE 93rd Day				
				WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B.C																		
Ration																		
#18																		
	MEAN																	
	11			192	20	10			195	20	10			192	20	10		
	MEAN																	
	13			200	20													
	MEAN																	
	MEAN																	

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ASSAY DATA SHEET

SPECIES Wistar Rat
ASSAYER C.M.W.

				DATE 94th Day					DATE					DATE				
DIET	ANIMAL NUMBER	IDENTIFICATION	SEX	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED	WEIGHT OF ANIMAL	FEED OFFERED	FEED EATEN	TOTAL FEED CONSUMED	TOTAL WEIGHT GAINED
U.B. C. Ration #18																		
	MEAN																	
	11			200	20													
	MEAN																	
	MEAN																	
	MEAN																	

V

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A. List of References

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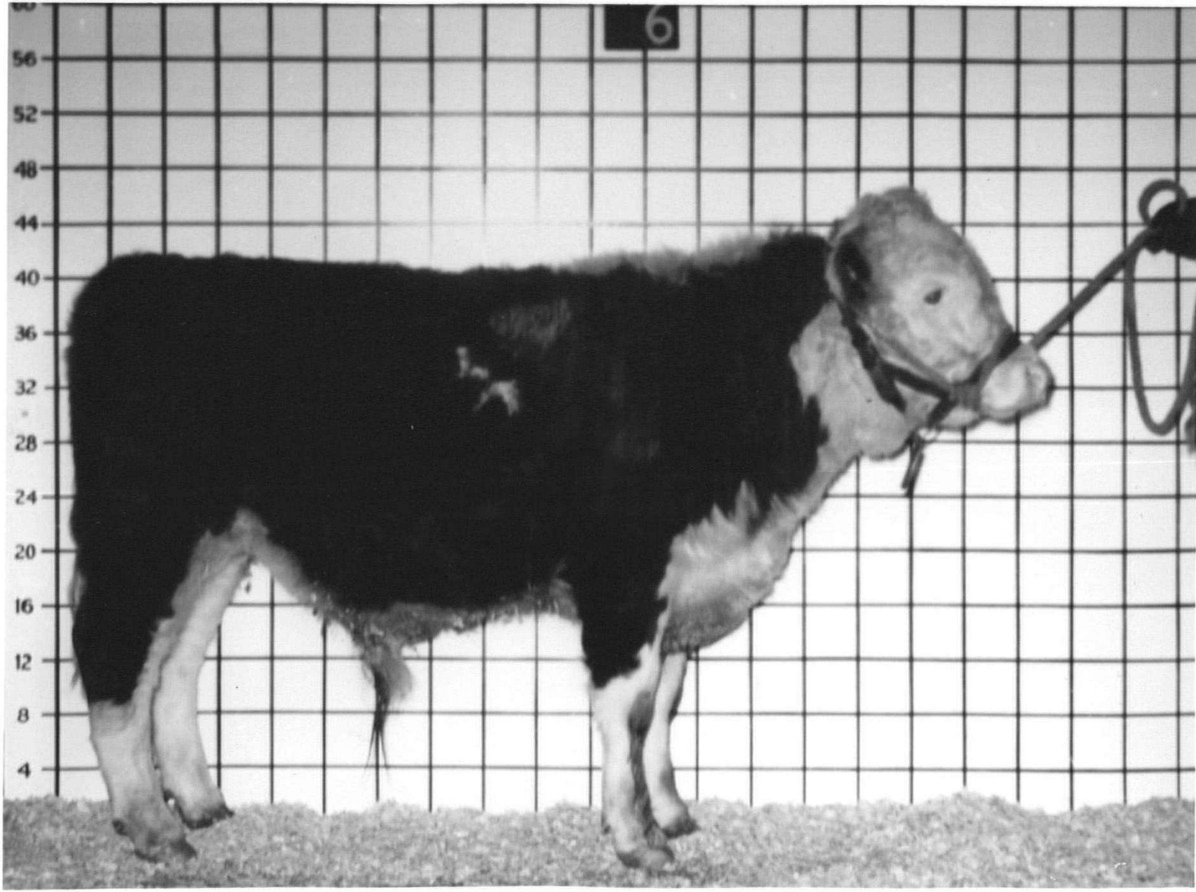
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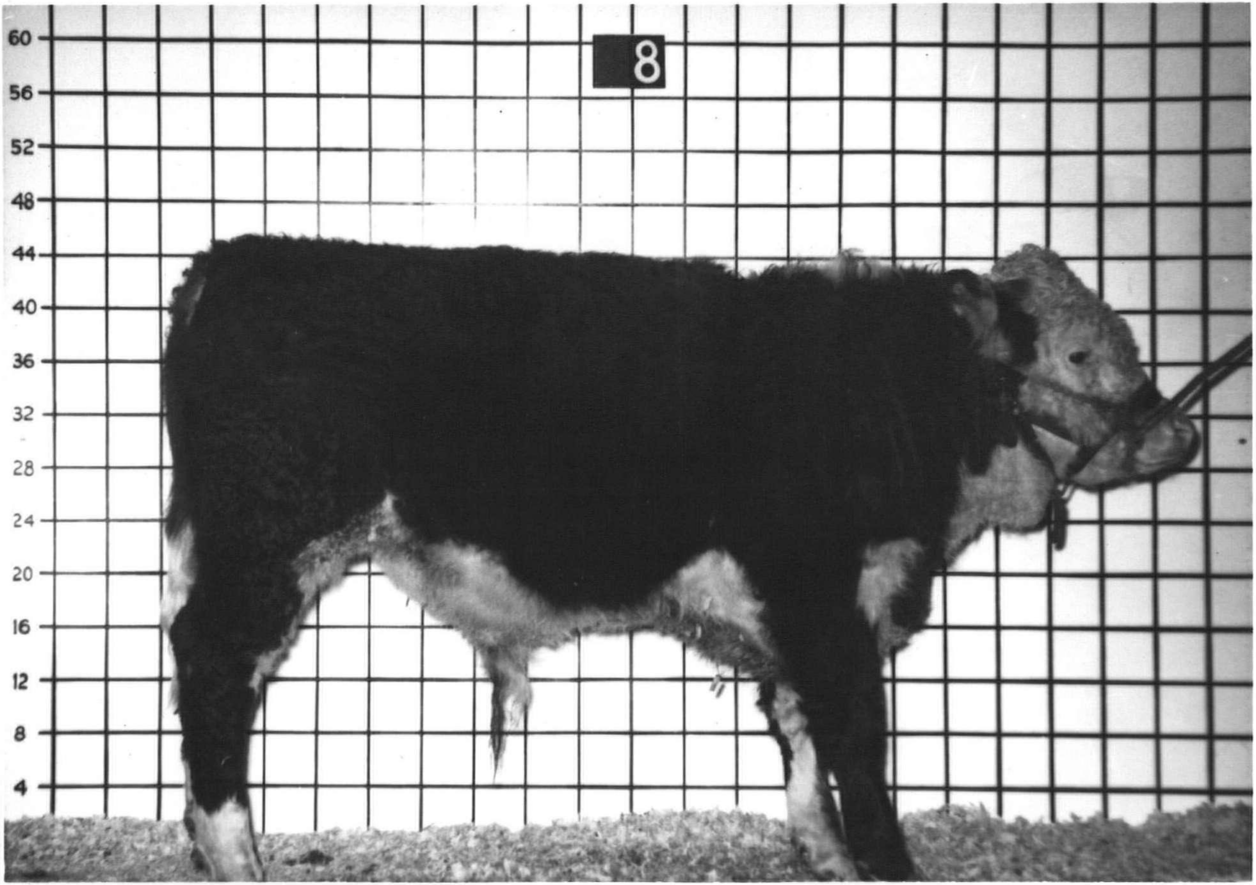
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