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The study involved three separate research efforts in which 10 Holstein calves and 85 purebred Hampshire and Suffolk ewe and ram lambs were employed. The objectives of the experiments were to characterize appetite, describe its inheritance and evaluate its associations with animal performance.

In the calf experiment, appetite was determined by recording the time required by each calf to completely suckle 3 pints of milk from a standardized feeding bottle. The average suckling speed was 112 seconds with a standard deviation of 38.4 seconds. The maximum and minimum suckling speeds were 298 and 60 seconds, respectively and the coefficient of variation was 34%. A repeatability value of 0.33 was obtained for suckling speed indicating that it might be a moderately heritable trait. There was no significant correlation between MPPA (Most Probable Producing Ability) for appetite and any of the performance

characteristics tested.

In the lamb experiment, 44 lambs averaging 134.7 lbs. in weight and $10\frac{1}{2}$ months of age and 41 lambs averaging 95 lbs. in weight and $5\frac{1}{2}$ months of age were used in winter of 1974 and summer of 1975, respectively to study the association between appetite and animal performance.

Appetite was determined by weighing the feed remaining at the end of 2 one-half hour intervals after the presentation of daily allocation of fresh feed. Appetite was expressed as pounds of feed consumed in 30 or 60 minutes (FC 30, FC 60), the proportion of the 24-hour feed consumption eaten in 30 and 60 minutes, (FC 30/FC 24, FC 60/FC 24), the amount of feed consumed in 30 and 60 minutes per unit of metabolic weight, also called eating rate index (ERI 30, ERI 60), and the average daily feed consumption for the entire experimental period per unit of metabolic weight.

The appetite measures were found to be significantly associated with one another ($P < .01$), suggesting the possibility they are estimates of the same biological characteristic. The repeatability values for appetite ranged from 0.18 to 0.51 in the winter trial and from 0.33 to 0.59 in the summer trial. These values indicated that appetite might be a moderately to highly heritable trait. The males had higher repeatability values in both lamb trials. In the winter trial the males ate significantly faster than the females and also gained more. The

difference was 13.6 lbs. and 0.41 lb. at 60 minutes. In the summer trial the males still gained more but there was no significant difference in eating rate. The difference was 9.8 lbs. and 0.10 lb. at 60 minutes. This probably suggests metabolic differences associated with age and sex in relation to appetite, at different stages of the growth cycle. There were significant correlations between total weight gain, average daily gain, and feed efficiency and most of the appetite estimates in the winter trial. None of the above performance characteristics was significantly associated with appetite estimates in the summer lambs.

The results suggest that under specific conditions appetite might be a useful and easily obtainable predictor for gain and could be used in a selection program.

THE INHERITANCE OF APPETITE IN RUMINANTS

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Miy nyah nwahle yen izin ne boughom, Bobeh NGAM
BISUM STANISLAUS.

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THE INHERITANCE OF APPETITE IN RUMINANTS

CHAPTER I

INTRODUCTION AND OBJECTIVES

Introduction

Recent speculation in genetic-nutrition research in livestock has centered around seeking useful genetic traits or a compound genetic trait that will identify superior animals early in their life. (Frisch and Vercoe 1969). Such a finding would aid producers in selection of herd and flock replacements, and its application would reduce feed costs involved in raising animals for replacement and having to cull them when they attain production age.

Two hypotheses have received popular support on this speculation. Nutrients absorbed by an animal can be partitioned into two major functions: maintenance and production (Warwick and Cobb, 1974). Consequently, an animal that consumes relatively more over maintenance requirement should have higher production than one that consumes less in relation to its maintenance requirement. This implies that selection on the basis of heavy feed intake should result in increased production efficiency. Another hypothesis (Blaxter, et al. 1961; Frisch and Vercoe, 1969) is that animals which eat rapidly can quickly satisfy

their maintenance requirements and thereby excel in rate of gain. This implies that selection on the basis of rapid feed intake should result in increased production efficiency.

Objectives

The objectives of the experiments were threefold:

1. To determine appetite or eating rate
2. To describe its inheritance
3. To determine its relationship with various measures of body size and growth.

CHAPTER II

LITERATURE REVIEW

Definitions and Measurement of Appetite

Appetite is defined by Webster's New International Dictionary (3rd edition) as an inherent or habitual desire or propensity for some personal gratification, either of body or mind. In the scientific literature, appetite has been expressed in terms including: the number of boli swallowed per unit of time (Schalk and Amadon, 1928; Gill et al., 1966); the number of jaw movements or chews per minute (Fuller, 1928; Balch, 1958; Gill, et al., 1966); the number of bites per minute (Hardison, et al., 1956; Duckworth and Shirlaw, 1958); the quantity of feed consumed per unit of time (Bailey, 1959; Putnam, et al., 1964; Forbes and Wright, 1968); time per unit of feed (Burt, 1957; Stoddard, 1969); the percentage of daily ration consumed in a specific time after food presentation (Purser and Moir, 1966; Randall, 1974); and actual grams of feed consumed at a specific time per unit of metabolic weight (Randall, 1974).

Physiological regulation of eating rate

Bulatao and Carlson (1924) produced gastric-hunger contractions in dogs by hypoglycemia and prevented them by hyperglycemia. Mayer (1953) increased blood-glucose levels in rats by injections of insulin, thereby causing the rats

to eat more. Kennedy (1953) postulated that the whole complex of metabolites in the blood stream, rather than blood-glucose alone, acted on the regulation of food intake. He noted that the plasma levels of growth hormone necessary for lipolysis during low-glucose level in the blood was directly correlated with the onset of hunger and feeding. Seoane, et al., (1971) through cross-circulation experiments in sheep, reported evidence of a humoral factor in the blood controlled feeding behavior.

The biochemical causes of the onset of eating are not precisely known but blood borne factors that affect some detector system are implicated (Hafez 1969). Davis, et al. (1959) showed central neural detection of hunger. Artificial stimulation of neural elements in the lateral hypothalamic area caused rumination in sheep and goats and voracious eating and mouthing of objects in cats (Akert 1959).

Physical regulation of eating rate

As pointed out by Church (1969), variables whose effects on appetite have not been elucidated definitely include palatability of the ration, amount and physico-chemical nature of the feed, social facilitation (stimulation by other animals), presence of deficiencies of some nutrients in the diet, and health of the animal.

Stoddard (1969) reported that dairy cows ate

faster when the quantity of feed was small than when it was large. Contrary to Stoddard's results in cattle, Chase and Wangsness (1973) showed that an increase in meal size above 50 grams but below 350 grams resulted in an increase in both eating rate and meal duration.

Freer et al., (1962) reported that with a restricted eating time, cows ate faster; and if the available eating time were long, they ate more slowly. Suzuki et al. (1969) reported changes in eating rate during the course of a meal. They fed cows twice daily and observed that the cows ate faster during the first 5 to 10 minutes. Thereafter eating rate declined. Frisch and Vercoe (1969), Forbes et al. (1972), and Randall (1974) reported similar results in cattle and sheep. Suzuki et al. (1969) noted that silage was eaten faster than hay and concluded that the quality of the feed, the individuality of the cow and the emotional state of the cow were probable factors that affected eating rate.

Randall (1974) studied the relationships between eating rate and rumen size (as estimated from weight of the full rumen minus rumen contents weight) and reported significant correlations at the 5% level of probability. Eating rate also was correlated positively and significantly with the weight of the abomasal tissue.

Bailey (1959) reported that hay, dried grass, silage, fresh grass and dairy cubes were consumed by dairy cows at

rates of 70, 83, 248, 283, and 357 grams per minute, respectively. He concluded that more fibrous foods were eaten more slowly than less fibrous foods. Hardison et al. (1956) and Gill et al. (1966) reported that more fibrous foods required a longer chewing time than less fibrous foods; consequently, they were consumed at a slower rate.

Forbes and Wright (1968) studied eating rate in sheep fed in individual pens by weighing feed remaining 30, 60, and 90 minutes after offering the daily allocation of fresh feed 15% in excess of voluntary intake. Sheep ate ground, pelleted, dried grass significantly faster than hay during the first 30 minutes. Chopped dried grass was eaten at an intermediate speed. The rate of eating of the unground diet was negatively related to mean retention time of feed in the rumen and positively related to voluntary intake. When hay was reduced and fed at 2/3 of ad libitum, the rate of eating was significantly faster than when it was fed ad libitum irrespective of whether penning was individual or in groups.

Forbes et al. (1972) observed that when groups of animals were fed restricted amounts of feed, the fastest eaters consumed more than their share. They subsequently fed non-lactating ewes individually on dried grass, ground and pelleted dry grass and hay diets. The rate of eating was significantly and positively associated with total intake and rate of passage in the case of dried grass and

hay. In the case of pelleted dry grass which had a rapid passage the relationship was not significant. In neither this nor a previous experiment (Forbes and Wright, 1968) was there a significant relationship between eating rate and liveweight. It was concluded that the speed at which an animal ate depended upon the speed with which space became available in the digestive tract, that rumen capacity did not limit intake, and that rate of eating was probably limited by oral factors.

Relationships of appetite to other characteristics

Frisch and Vercoe (1969) studied feed intake, liveweight gain and eating rate of three each of Brahman, Africander and Shorthorn x Hereford male cattle. Eating rate was a highly repeatable measurement both at different times within days and on different days. The eating rate of animals within breeds and years was significantly associated with both voluntary feed intake and gain. It was not correlated with liveweight however. Frisch and Vercoe suggested that eating rate could be a valuable index of intake and gain and could be used in a selection program. Burt (1957) studied the consumption of hay, kale, and concentrates by lactating cows of two different age groups (heifers and cows). There was a positive correlation between rates of eating of all three diets with liveweight.

Putnam and Davis (1963) reported that heavier

animals spent less time at the feeder than cows of lighter weight. Further studies by Putnam et al. (1964) reported that eating rate was directly related to the body weight of the cows, and that the type of ration also affected the eating rate (hay versus concentrate, ground versus pelleted). Eating rate was determined by dividing daily feed consumption by the time spent at the feeder. Randall (1974) studied the relationships between eating rate, or appetite, and total weight gain, average daily gain and feed efficiency in sheep. He reported positive significant correlations between eating rate at 30 and 60 minutes with total weight gain, average daily gain, and feed efficiency. There also was a significant correlation between eating rate index at 30 and 60 minutes (the amount of feed consumed in 30 or 60 minutes per unit of metabolic weight) and the above listed performance characteristics. Propensity to eat (proportion of the 24-hour feed consumption that is eaten in a specific time), another estimate of appetite, was not significantly related to any of the performance characteristics. Also, liveweight was positively and significantly related to eating rate at 30 and eating rate at 60 minutes but was not significantly related to eating rate index at 30 or 60 minutes.

CHAPTER III

MATERIALS AND METHODS

Dairy Calf Experiment

Population and Management

The calves utilized for this study were obtained from the dairy unit of the Department of Animal Science.

The breeding program is throughout the year by means of artificial insemination. Immediately after parturition, the bull calves are sold, but most heifer calves are retained for replacements. Within 24 hours post-calving, the heifer calves are confined to individual indoor stalls measuring 5 ft. x 15 ft. Depending on the season, the stalls are equipped with heat lamps to provide warmth during inclement weather. Between calving and weaning, the calves are individually fed twice a day, at 8 a.m. and 4 p.m. Their feed during this period is fresh milk at the rate of 3 pints per feeding. They also are allowed access to grass hay provided ad libitum. At 3 weeks of age, they are vaccinated for IBR (Infectious Bovine Rhinotracheitis), PI2 (Para-influenza) and BT (Blue tongue). The calves are weaned at 6-8 weeks of age, separated into size groups, and allowed to graze on improved pastures. Their daily ration is supplemented with 4 pounds of grain per calf per day.

Fourteen Holstein heifer calves from 6 sires were utilized for the appetite study. The study began January, 1976 and lasted until the end of April.

Experimental procedure

Whenever a heifer calf was born, its birth weight was recorded. A new nipple was fitted to a feeding bottle for each new calf on which appetite was to be measured. The nipples, of equal size and opening, were assigned to the calves such that each calf utilized the same nipple throughout the 10-day experimental period.

The calf was allowed 10 days to acclimate to the 'bottle' and to test conditions. Beginning at 10 days of age, appetite was measured as follows: At 8 a.m. each calf was offered its morning allocation of fresh milk in a feeding bottle. With the aid of a stop-watch, the time required by each calf to completely suckle 3 pints of milk was recorded. The same procedure was repeated 8 hours later. Ten successive morning and afternoon measurements were recorded for each calf during the test.

If a calf developed scours during the experiment, its daily feed allocation was reduced in proportion to the degree of scours. This resulted in some incomplete data.

After the 10th day of measurement, the calf was weighed and at 70 days of age the weight again was recorded.

Four of the calves were disqualified from the

experiment because they had scours on more than 5 of the 10 test days and were offered less than 3 pints of milk per feeding on those days. Thus 10 calves were available for analysis, with the number of observations per calf ranging from 12 to 20.

The following information was recorded and utilized in the analysis:

- Date of measurement
- Calf's suckling speed in the morning
- Calf's suckling speed in the afternoon
- Calf's final weight on the 10th day
- Calf's weight at 70 days of age
- Calf's gain or loss during 10-day period
- Calf's gain from 20 days of age to 70 days of age.

Statistical Methods

Descriptive statistics were computed on suckling speed measurements, and important measures of central tendency and dispersion were examined.

From examination of the experimental plan, it was considered appropriate to include calves, time of measurement (morning versus afternoon), days of measurement, and calf x time interaction as possible sources of variation in the model for the analysis of suckling speed. The model postulated was:

$$(1) \text{ Suckling speed} = \mu + C + T + (C \times T) + bD + \text{error}$$

where μ = overall mean,

C = individual calves, for which there were 9 degrees of freedom,

T = time of measurement with 1 degree of freedom,

D = day of measurement,

b = partial linear regression coefficient of suckling speed on day of measurement.

error = random error peculiar to each observation, including variation unaccounted for by effects included in the model.

A two-step analysis was performed. First the linear regression of suckling speed (dependent variable) on day of measurement was computed.

$$(2) \quad \text{Suckling speed} = a + bD + \text{error}$$

Residuals for each observation on each calf were obtained from the formula.

$$(3) \quad \text{Residual} = Y - \hat{Y}$$

where Y equalled observed suckling speed and \hat{Y} equalled $a + bD$ or estimated suckling speed for each observation on each calf. Examination of the plot of these residuals against day of observation did not suggest a departure from linearity, so quadratic or higher order models were not tested.

A least-squares analysis of variance was performed on the residuals from the regression analysis using the model:

$$(4) \quad \text{Suckling Speed Residual} = \mu + C + T + (C \times T) + \text{error}$$

The calf x time interaction was not significant statistically and was unimportant biologically, so it was excluded from the final model:

$$(5) \quad Y = \mu + C + T + \text{error}$$

The repeatability for suckling speed; the ratio of the variance component among calves to the sum of among and within calf variance components, was estimated. The variance components for among calves and within calves were found by equating the mean squares to their theoretical expectations. The coefficient for the among calf variance component was computed according to the indirect method outlined by Henderson (1953).

To have a meaningful basis for relating appetite to the 70-day gain and future milk production, the MPPA (Most probable producing ability) of each calf for appetite was computed from the formula:

$$(6) \quad \text{MPPA} = \bar{H} + \frac{NR}{1 + (N-1)R} \times \bar{C}$$

where \bar{H} = the overall average appetite of the experimental group

N = number of observations or records per experimental animal

R = the repeatability of suckling speed residuals

\bar{C} = average suckling speed residual from an individual animal's records

Correlation coefficients between MPPA and 70 day-weight and other weight and gain variables were determined. Data on the 10 calves utilized in the statistical analyses are recorded in Appendix Table 1.

Lamb Experiment

Population and Management

The animals used for this study were obtained from the sheep research unit of the Department of Animal Science at Oregon State University. This unit provides the necessary animals for research in breeding, nutrition, management and behavior.

The breeding season for the university purebred flocks is from mid-August to late September. The ewes are mated in single sire groups. The lambing season lasts from early January through February. Lambing occurs in a shed where careful identification is guaranteed. Between birth and weaning, the ewes and their lambs are placed on improved hill pastures without access to supplemental feeding. Lambs are weaned in June at about 135 days of age. After weaning they are drenched for parasites and separated into sex groups.

From lambs available at weaning, lambs for replacement or for eventual sale are selected based upon weaning weight adjusted for age of dam, age of lambs and type of birth and rearing. Emphasis also is placed on the dam's record for lamb production. Lambs also are scrutinized for jaw defects, cryptorchidism, horns, scurs and face covering.

The appetite study involved 85 purebred Suffolk and

Hampshire ram and ewe lambs derived from the above source. The two lamb crops of January-February of 1974 and January-February of 1975 were utilized for the study. Appetite for the 1974 lambs was measured November-December 1974, and appetite for the 1975 lambs was studied July-August, 1975. Ram lambs from the 1974 lamb crop were raised after weaning in dry lot. They were provided a diet of 2:1 roughage to concentrate ratio to ensure rapid growth to market weight. The ewe lambs were returned to pastures and given access to alfalfa pellets at the rate of 1 lb. per ewe per day. Because the 1975 lambs were tested shortly after weaning, there was no differential treatment of sexes.

The experimental subjects differed in age, breed, sire within breed, and sex as shown in Table 1.

Facilities

The animal nutrition research facility is a rectangular building with both ends and the north side open. It measures approximately 175 ft. by 25 ft. The facility was bedded with straw and partitioned into individual pens measuring 12 ft. by 5 ft. Feeding buckets of known weight and equal depth and diameter were assigned to each pen. The experimental ration was 3/8 inches pellets consisting of 35% alfalfa, 35% grass-hay, 25% barley and 5% molasses. A stop-watch and a scale were available for timing and weighing the feed.

Table 1. Distribution of Experimental Lambs Within Breeds, Sires, Sexes and Years.

<u>Breed</u>	<u>Sire</u>	<u>Fall '74</u>		<u>Summer '75</u>		<u>Total</u> <u>With-</u> <u>in</u> <u>Sire</u>	<u>Total</u> <u>With-</u> <u>in</u> <u>Breed</u>	
		<u>Ages (10-11 mos.)</u> <u>Ram</u> <u>Lambs</u>	<u>Ewe</u> <u>Lambs</u>	<u>Ages (5-6 mos.)</u> <u>Ram</u> <u>Lambs</u>	<u>Ewe</u> <u>Lambs</u>			
Hamp-	Hamp-	74	7	7	-	-	14	32
	Hamp-	75	-	-	7	11	18	
Suf-		1	8	6	5	4	23	
folks		2	10	6	-	-	16	53
		3	-	-	2	1	3	
		4	-	-	5	6	11	
Totals			25	19	19	22	85	85

Experimental Procedure

- Acclimation:

During the 3-week test period for each trial, the subjects were confined to individual pens. Initial weight was recorded after an overnight stand without access to feed. Lambs were allowed 1 week to acclimate to test conditions and to the pelleted diet which was offered ad libitum. During this period, the daily feed consumption was recorded at 8 a.m. and the quantity of feed was increased depending on the amount eaten by the most glutinous lamb. After the acclimation period a fixed quantity of fresh feed was allocated ad libitum.

- Measurement:

Six appetite trials at 2-day intervals were recorded for each of the lambs. For each appetite trial, feed was removed from the pens at 4 p.m. and re-introduced at 8 a.m. the following day. Food consumption was measured after 30 minutes, after 60 minutes and after 24 hours. Appetite was computed as the proportion of the 24-hour feed intake eaten in 30 minutes (FC_{30}/FC_{24}), also called propensity to eat in 30 minutes. The proportion of the 24-hour feed intake eaten in 60 minutes (FC_{60}/FC_{24}) also was called propensity to eat in 60 minutes. Another appetite parameter called eating rate index (ERI) was computed as the amount of feed consumed at 30 minutes and at 60 minutes per unit of

metabolic weight (Brody, 1945). Appetite also was estimated as the average daily feed consumed during the entire test period per unit of metabolic weight.

The following information was recorded:

- The breed, sex, and sire
- The initial weight and final weight
- The weight gain during the test
- The feed consumed at 30 and 60 minutes
- The total feed consumed during the test
- The average daily feed

Statistical Methods

The winter 1974 and summer 1975 trials were analyzed separately. This was partly because the two trials were conducted on lambs that were managed differently prior to testing and partly because the experiments were conducted at different times of the year on lambs of different chronological age. The 1974 lambs averaged $10\frac{1}{2}$ months of age and the 1975 lambs averaged $5\frac{1}{2}$ months of age at the time that their appetite was evaluated.

In each trial descriptive statistics were computed for the repeatable dependent variables, and important measures of central tendency and dispersion were examined.

Non-repeatable dependent variables used in the study as measures of appetite (average feed consumed in 30 minutes per unit of metabolic weight and average feed consumed in 60 minutes per unit of metabolic weight, average daily food per unit of metabolic weight) were examined and compared with the repeatable variables.

The second phase of the statistical study involved analyses of variance. From examining the recorded data and the experimental design, the following initial mathematical model was postulated:

$$(7) \quad Y = \mu + \text{Sex} + \text{Breed} + (\text{Sex} \times \text{Breed}) \\ + \text{Sires/Breeds} + \text{Lambs/Sires/Breeds} \\ + \text{Observations/Lambs/Sires/Breeds} \\ (\text{error})$$

The simultaneous inclusion of all these variables would have overloaded available programs and computational facilities. Therefore, the model was subdivided into two component parts, and two analyses of variance were performed.

The following components of the initial model were used to study repeatable differences among lambs:

$$(8) \quad Y = \mu + \text{Lambs} + \text{Observations/Lambs} (\text{error})$$

From this, the variance components among and within lambs were obtained by equating the respective mean squares to their theoretical expectations. The repeatability of each repeatable measure of appetite was computed from the formula:

$$(9) \quad r = \frac{\sigma_B^2}{\sigma_B^2 + \sigma_W^2}$$

where σ_B^2 is the among lamb variance component and σ_W^2 the within lamb variance component.

The remaining factors of the initial model:

$$(10) \quad Y = \mu + \text{Sex} + \text{Breed} + (\text{Sex} \times \text{Breed}) \\ + \text{Sires/Breed} + \text{Lambs/Sires/Breeds (error)}$$

were used to partition the variation into the various sources and to test their influence upon non-repeatable dependent variables and upon average values per lamb for repeatable dependent variables.

Using the least-squares analysis of variance technique, the effects of the various factors in the model on the dependent variables were assessed by the F test.

CHAPTER IV

RESULTS AND DISCUSSION

Dairy Calf Experiment

The objectives of the dairy-calf experiment were to examine appetite (as estimated by the time required to suckle a fixed quantity of milk) and to study its phenotypic relationship with other performance characteristics. The mean suckling speed was 112 seconds with a standard deviation of 38.4 seconds. The maximum and minimum values were 298 and 60 seconds, respectively, and the coefficient of variation was 34%.

The correlation coefficient between suckling speed and day of measurement was highly significant ($r = -.33$, $P < .01$). Therefore the linear regression of suckling speed on days was computed so that variation in suckling speed could be examined with variation attributable to days of measurement held constant. The regression equation obtained was:

$$(11) \quad \text{Suckling speed} = 137 - (4.6 \times \text{days})$$

The regression coefficient of -4.6 seconds implied that for each later day of measurement, the calves became faster in consuming the fixed quantity of milk. This increase in speed could be attributable to a possible increase in size of the outlet or opening of the nipple as

the calf exerted suckling pressure each additional day. If the opening of the nipple became larger, there would have been more outflow of milk per suck. Alternatively the negative regression could have been caused by greater experience and maturity allowing for faster sucking.

Residuals were computed from the day analysis and further plotted against day of measurement. There was no evidence for a departure from linearity. A least-squares analysis of variance was performed on the residuals and the repeatability estimate for suckling speed was estimated to be 0.33. This suggests a moderate heritability for suckling speed. The problem in this case of using repeatability as an upper limit to heritability is that the repeated observations were made on successive days and psychological short-lived effects could have been considered as permanent repeated actions caused by the same genes. This would limit the reliability of repeatability in this case.

None of the correlation coefficients between MPPA for suckling speed and initial weight, final weight, post-test gain and 70-day weight gain was significant (Table 2).

Table 2. Coefficients of Correlation Between MPPA (Most Probable Producing Ability) and Various Performance Characteristics of Calves

	Initial Weight	Final Weight	70-Day Weight	Post-Test Gain ^a	70-Day Gain
MPPA	0.18	0.23	0.26	0.04	0.58

^a Gain from 20 days to 70 days of age.

Lamb Experiment

There were four principal methods used in this study to estimate appetite. The methods which are considered 4 from a statistical viewpoint, could as well be subdivided into 7 methods. The four methods were:

1. Amount of feed consumed in 30 and in 60 minutes (FC 30 and FC 60, respectively).
2. The proportion of daily feed consumed in 30 and in 60 minutes, also called propensity to eat (FC 30/FC 24 and FC 60/FC 24, respectively).
3. The amount of feed per unit of metabolic weight consumed in 30 and in 60 minutes, also called eating rate index (Randall, 1974) (FC 30/W $3/4$ and FC 60/W $3/4$, respectively).
4. The average daily feed per unit of metabolic weight (Hohenboken et al. 1973) (ADF/W $3/4$).

Comparison of Descriptive Statistics

To investigate the different methods of estimating appetite, a comparative descriptive study of the measures of appetite and some performance characteristics of lambs in each trial (winter vs. summer) was first undertaken (Table 3).

The lambs ate significantly more during the first half hour than in the second. This was no surprise because the animals had involuntarily fasted for 16 hours prior to appetite measurements. This observation confirms similar reports in the literature (Forbes and Wright, 1968; Suzuki et al. 1969; and others) that eating rate was not

Table 3. Mean Performance of Lambs in the Winter and Summer Trials

<u>Trait</u>	<u>Mean</u>	<u>Standard Error</u>	<u>Standard Deviation</u>	<u>Coefficient of Variation</u>
<u>Winter</u>				
Initial wt.	134.8 lbs.	3.2	21.40	0.15
Gain	12.7 lbs.	1.2	8.01	0.63
ADF ^a	5.7 lbs.	0.13	0.80	0.15
FC - 30 ^b	1.4 lbs.	0.06	0.39	0.27
FC - 60 ^c	1.9 lbs.	0.06	0.40	0.21
FC 30/FC 24 ^d	0.2 lbs.	0.00	0.04	0.20
FC 60/FC 24	0.282	0.006	0.04	0.16
W 3/4 ^e	40.80 lbs.	0.80	0.53	0.13
ADF/W 3/4	0.14 lbs.	0.002	0.01	0.09
FC 30/W 3/4	0.03 lbs.	0.001	0.01	0.19
FC 60/W 3/4	0.04 lbs.	0.001	0.01	0.14
<u>Summer</u>				
Initial wt.	95.1 lbs.	2.1	13.40	0.14
Gain	12.3 lbs.	1.7	10.20	0.86
ADF ^a	4.3 lbs.	0.07	0.46	0.10
FC 30 ^b	1.4 lbs.	0.04	0.25	0.18
FC 60 ^c	1.8 lbs.	0.05	0.30	0.18
FC 30/FC 24 ^d	0.243	0.006	0.04	0.17
FC 60/FC 24	0.302	0.007	0.05	0.14
W 3/4 ^e	31.60 lbs.	0.49	3.16	0.09
ADF/W 3/4	0.14 lbs.	0.001	0.01	0.07
FC 30/W 3/4	0.04 lb.	0.009	0.06	0.18
FC 60/W 3/4	0.05 lb.	0.012	0.07	0.14

^aADF is average daily feed consumption based on entire test period.

^bFC 30 is pounds of feed consumed during the first 30 minutes after daily feed allocation following a 16 hour fast.

^cFC 60 is pounds of feed consumed during the first 60 minutes after daily feed allocation following a 16 hour fast.

^dFC 24 is pounds of feed consumed during the first 24 hours after a 16 hour fast.

^eW 3/4 is body weight to the 3/4 power, or metabolic weight.

constant over time.

The differences in mean weights of the animals in the two trials could be attributed largely to differences in ages of the lambs. Differences in average daily feed were accounted for by the difference in initial weights because average daily feed per unit of metabolic weight was about equal in both trials. Surprisingly, the gains in both trials were nearly equal, even though average daily feed consumption was higher for the winter trial (5.7 lbs. vs. 4.3 lbs.). The coefficients of variation of appetite measures ranged from a high of 27% for FC 30 to a low of 7% for ADF/W $3/4$.

The averages based on six appetite observations per lamb were used to compute the correlation between the eating rate estimates. The correlation between eating rates in 30 and 60 minutes (\bar{FC} 30, \bar{FC} 60), propensity to eat in 30 and 60 minutes (\bar{FC} 30/ \bar{FC} 24, \bar{FC} 60/ \bar{FC} 24) and eating rate index in 30 and 60 minutes (\bar{FC} 30/W $3/4$, \bar{FC} 60/W $3/4$) were highly and significantly correlated with each other (Table 4). Part of this positive correlation was automatic or "spurious" (Pearson, 1897) because \bar{FC} 30 contributes to \bar{FC} 60 for each observation and either \bar{FC} 30 or \bar{FC} 60 is the numerator of each eating rate estimate. Average daily feed per unit of metabolic weight was not significantly correlated with any of the appetite terms, suggesting that it was not estimating the same biological

Table 4. Simple Coefficients of Correlation Between Eating Rate Measures in Winter and Summer Lamb Trials

<u>Winter</u>	<u>FC 60</u>	<u>Prop 30</u>	<u>Prop 60</u>	<u>ERI 30</u>	<u>ERI 60</u>	^a <u>ADF/W 3/4</u>
Feed consumed in 30 minutes (FC)	0.94	0.86	0.63	0.88	0.66	-0.08
Feed consumed in 60 minutes (FC)		0.77	0.67	0.84	0.77	-0.06
Propensity in 30 minutes (Prop)			0.77	0.83	0.61	0.14
Propensity in 60 minutes (Prop)				0.73	0.76	0.26
Eating Rate Index in 30 minutes (ERI)					0.87	0.26
Eating Rate Index in 60 minutes (ERI)						0.42
<u>Summer</u>						
Feed consumed in 30 minutes (FC)	0.93	0.52	0.58	0.85	0.77	0.06
Feed consumed in 60 minutes (FC)		0.42	0.58	0.77	0.86	0.21
Propensity in 30 minutes (Prop)			0.91	0.65	0.52	-0.22
Propensity in 60 minutes (Prop)				0.68	0.67	-0.08
Eating Rate Index in 30 minutes (ERI)					0.89	0.25
Eating Rate Index in 60 minutes (ERI)						0.45

^a Average daily feed per metabolic weight

* Correlations above 0.42 are significant at the 5% level of probability

** Correlations above 0.52 are significant at the 1% level of probability

characteristic (Table 4). Upon reflection, it is reasonable that eating rate and quantity (feed consumed in 30 or 60 minutes), although both could be related to appetite, should be somewhat distinct phenomena.

Inheritance of Appetite

There were three sources that could provide some information on the inheritance of appetite measures.

1. The repeatability of a trait measured more than once in the life of an individual is an upper limit to heritability.

2. Differences among groups of paternal half sibs are a reflection of genetic variation for a trait.

3. Breed differences also are suggestive of genetic variation for a trait.

Six one-way analyses of variance were performed using the six repeatable measures of appetite (FC 30, FC 60, FC 30/FC 24, FC 60/FC 24, FC 30/W 3/4, FC 60/W 3/4) as dependent variables (Table 5). Repeatability values derived from these analyses ranged from 0.18 to 0.51 in the winter trial and 0.33 to 0.59 in the summer. These results suggested that appetite might be moderately to highly heritable. It is very likely, though, that for these characteristics and the experimental conditions, repeatability greatly overestimated heritability. Because the repeated appetite trials were only 2 days apart

Table 5. Mean Squares and Repeatability Values
For Appetite From Various Methods in
the Lamb Experiments

Source	df	Feed Consumed in		Propensity in		Eating Rate Index in	
		30 Minutes	60 Minutes	30 Minutes	60 Minutes	30 Minutes	60 Minutes
<u>Winter Trial</u>							
Mean Square among Lambs	43	0.956	0.979	10726.8	11465	0.4543	0.3047
Mean Square within Lambs	220	0.132	0.210	2194.7	3584.4	0.1760	0.1152
Repeatability		0.51	0.38	0.39	0.26	0.21	0.18
<u>Summer</u>							
Mean Square among Lambs	40	0.397	0.620	9589.4	12003.9	2.3019	3.6448
Mean Square within Lambs	205	0.042	0.064	2339.7	2918.4	0.4754	0.9114
Repeatability		0.59	0.59	0.34	0.34	0.39	0.33

* Repeatability values above 0.33 are significant at the
1% level of probability

correlations among repeated records on the same individual may well have been caused more by short term, repeatable behavior, or habit, rather than by repeated expressions of the same effects of the same genes.

The lambs within each trial were further subdivided into sex groups within breeds to investigate if there were sex and breed differences in the expressions of repeatability. All possible product-moment correlations among repeated observations on the same trait were computed for lambs in each of the sex-breed-trial sub-populations. These were averaged to estimate repeatability. Most repeatability values (19 out of 24) were higher for males than for females in both the summer and winter trials (Table 6). Also the Hampshire breed tended to have higher repeatability values than the Suffolks, especially in ewe lambs. Such differences might be a reflection of sex and breed differences in the inheritance of appetite.

Least-squares analyses of variance were then performed with the non-repeatable traits and average values of repeatable traits as dependent variables (Tables 7 and 8). The objective was to assess the relative significance of sex, breed, sex x breed interaction and sires/breeds on eating rate terms and animal performance.

Differences resulting from sex were observed (Tables 9 and 10). These results are partly in agreement with reports by Randall (1974) who found significant sex

Table 6. Repeatability Values Within Breeds and Between Sexes for Appetite of Lambs (Winter and Summer)

Trait	Hampshire Ewes	Hampshire Rams	Suffolk Ewes	Suffolk Rams
<u>Winter</u>				
Feed Consumed in 30 minutes	0.61	0.60	0.06	0.35
Feed Consumed in 60 minutes	0.62	0.15	0.31	0.27
Propensity in 30 minutes	0.37	0.53	0.10	0.38
Propensity in 60 minutes	0.44	0.40	0.20	0.26
Eating Rate Index in 30 minutes	0.48	0.55	0.04	0.26
Eating Rate Index in 60 minutes	0.42	0.09	0.15	0.20
<u>Summer</u>				
Feed Consumed in 30 minutes	0.45	0.55	0.23	0.60
Feed Consumed in 60 minutes	0.09	0.58	0.19	0.68
Propensity in 30 minutes	0.48	0.66	0.42	0.54
Propensity in 60 minutes	0.40	0.59	0.32	0.57
Eating Rate Index in 30 minutes	0.40	0.58	0.19	0.68
Eating Rate Index in 60 minutes	0.19	0.50	0.27	0.47

Table 7. Mean Squares and Tests of Significance for Sex, Breed, Sex x Breed and Sires/Breed Effects on the Performance of Lambs in the Winter Trial

df	Weight Gain in lbs.	Pounds of Feed Consumption	Feed Consumed in		Propensity in		Eating Rate Index in		Daily Feed/Metabolic Weight	
			30 Minutes	60 Minutes	30 Minutes	60 Minutes	30 Minutes	60 Minutes		
<u>Winter</u>										
Sex	1	1743.5**	16.114**	15748**	16588	5618*	5458	0.264	0.051	0.00001
Breed	1	2.6	0.105	3733	2454	6689	9829	1.599	1.032	0.00015
Sex x Breed	1	73.9	0.056	2213	478	3929	253	0.709	0.036	0.00014
Sires/Breed	1	7.2	0.200	1640	3927*	1703	10728*	0.968	1.927*	0.00005
Error	39	24.3	0.429	934	1060	1318	1660	0.409	0.472	0.00018

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

Table 8. Mean Squares and Tests of Significance for Sex, Breed, (Sex x Breed) and Sires/Breed Effects on Performance of Lambs in the Summer Trial

	df	Weight Gain in Lbs.	Pounds of Feed Consumption	Feed Consumed in		Propensity in		Eating Rate Index in		Daily Feed/Metabolic Weight
				30 Minutes	60 Minutes	30 Minutes	60 Minutes	30 Minutes	60 Minutes	
<u>Summer</u>										
Sex	1	964.4**	0.220	20	214	4690	12982*	0.00	0.410	0.030
Breed	1	26.7	0.320	998	768	136	256	1.00	0.920	0.040
Sex x Breed	1	339.4	0.007	703	341	1548	993	0.120	0.000	0.040
Sires Within Breed	2	241.6	0.470	1726	3660*	3174	3076	0.390	1.000	0.004
Error	35	85.8	0.180	591	888	1769	1686	0.370	0.560	0.009

* Significant at the 5% level of probability

** Significant at the 1% level of probability

Table 9. Least-Squares Means For Performance Characteristics For Winter Lambs

Effect	Weight Gain in lbs.	Food Con- sump- tion in lbs.	Pounds of Food Consumed in		Propensity to eat in		Eating Rate Index in		Daily Food/ Metabolic Weight
			30 Minutes	60 Minutes	30 Minutes	60 Minutes	30 Minutes	60 Minutes	
<u>Winter</u>									
Overall	11.9	5.66	1.42	1.87	20.4%	27.5%	3.5%	4.68%	0.141
Male	18.7	6.31	1.62	2.08	21.6%	27.9%	3.7%	4.71%	0.140
Female	5.1	5.01	1.21	1.67	19.2%	27.2%	3.4%	4.61%	0.141
Suffolk	14.5	5.61	1.52	1.95	21.7%	29.2%	3.7%	4.84%	0.140
Hampshire	9.3	5.71	1.32	1.79	19.1%	25.9%	3.3%	4.52%	0.141

Table 10. Least-Squares Means For Some Performance Characteristics For Summer Lambs

Effect	Weight Gain in lbs.	Food Consumption in lbs.	Pounds of Food Consumed in		Propensity to eat in		Eating Rate Index in		Daily Food/ Metabolic Weight
			30 Minutes	60 Minutes	30 Minutes	60 Minutes	30 Minutes	60 Minutes	
<u>Summer</u>									
Overall	11.8	4.40	1.43	1.81	24.4%	30.3%	4.4%	5.6%	0.137
Male	16.7	4.33	1.44	1.78	23.3%	28.5%	4.3%	5.5%	0.135
Female	6.9	4.47	1.42	1.83	25.5%	32.1%	4.41%	5.7%	0.139
Suffolk	12.8	4.31	1.38	1.76	24.2%	30.0%	4.20%	5.4%	0.130
Hampshire	10.9	4.49	1.49	1.85	24.6%	30.6%	4.60%	5.8%	0.140

differences in eating rates in sheep. The contradiction lies in the fact that the effect of sex on eating rate was not consistent in the winter and summer trials in this experiment. Some eating rate estimates differed significantly between sexes in one trial but not in the other. This observation suggests that appetite at different stages of maturity may not be the same trait genetically and/or metabolically. There was no significant breed or breed x sex interaction effect either for gain or for any of the eating rate expressions (Tables 7 and 8).

There was a significant sire/breed effect for propensity to eat at 60 minutes and for eating rate index at 60 minutes for the winter trial. In the summer trial, the sires/breed effect was significant for feed consumed in 60 minutes and not significant for other measures of eating rate. This suggests that eating rate at 60 minutes is possibly moderately heritable. Other appetite measures for which the sires/breed effect was not significant involved eating rate during the first 30 minutes after 16 hours of fasting. The absence of a significant sire effect on these methods could be interpreted in terms of how hungry the animals were at the time. During the first 30 minutes of feed presentation, they must have been very hungry, so much so that each ate as fast as it could, so the sire effect apparently was overwhelmed.

During 60 minutes the effect of sires became evident,

not because the lambs were extremely hungry but because they probably had the genes for rapid eating. This also probably explains why the effect of sex on eating rate became important only during the second half-hour. In the first 30 minutes all were ready to eat rapidly regardless of the sex. In 60 minutes, the males, because of their greater capability for rapid eating, overtook the females and the effect of sex was rendered significant.

Correlations between appetite and some performance characteristics

Correlation coefficients among appetite measures and some performance characteristics: initial weight, total weight gain, average daily gain, feed efficiency and feed conversion, were computed for each trial (Tables 11 and 12). Feed efficiency was defined as gain per unit of feed and feed conversion was the reciprocal. There were significant correlation between gain during the winter trial and most of the appetite estimates. Coefficients of determination of gain and eating rate ranged from 0.50 ($r = 0.71$, $P < 0.01$) to 0.14 ($r = 0.38$, $P < 0.05$). The correlations between average daily feed and most appetite estimates were positive and highly significant for both winter and summer trials, with coefficients of determination ranging from a high of 0.53 ($r = 0.73$, $P < 0.01$) to a low of 0.10 ($r = 0.32$, $P < 0.05$). These results are in close agreement with those reported by Frisch and Vercoe (1969)

Table 11. Simple Coefficients of Correlation Between Performance Traits and Appetite for Lambs, Winter Trial

	Aver- age		Aver- age Daily Feed	Feed Effic- iency	Feed Con- sump- tion	Actual Eating Rate		Propensity to Eat At		Eating Rate Index		Average Daily Feed per Metabolic Weight
	Weight Gain	Daily Gain				30 Min.	60 Min.	30 Min.	60 Min.	30 Min.	60 Min.	
<u>Winter</u>												
Initial												
Weight	0.70	0.70	0.74	0.64	-0.10	0.68	0.64	0.47	0.17	0.28	0.02	-0.12
Wt.Gain			0.80	0.97	0.03	0.65	0.71	0.38	0.23	0.40	0.32	0.23
Average Daily Gain			0.80	0.97	0.03	0.65	0.71	0.39	0.23	0.40	0.31	0.23
Average Daily Feed				0.67	-0.07	0.68	0.73	0.34	0.12	0.42	0.32	0.55
Feed Effic. Feed Conversion					0.07	0.60	0.65	0.39	0.26	0.36	0.28	0.09
						0.08	0.02	0.09	0.14	0.19	0.12	0.00

42 df

* Correlations above 0.29 are significant at 5% level of probability

** Correlations above 0.39 are significant at 1% level of probability

Table 12. Simple Coefficients of Correlation Between Performance Traits and Appetite for Lambs, Summer Trial

Weight Gain	Aver- age	Aver- age	Feed Effic- iency	Feed Con- sump- tion	Actual Eating Rate		Propensity to Eat At		Eating Rate Index		Average Daily Feed per Metabolic Weight	
	Daily Gain	Daily Feed			30 Min.	60 Min.	30 Min.	60 Min.	30 Min.	60 Min.		
<u>Summer</u>												
Initial												
Weight	-0.22	-0.22	-0.27	0.33	0.60	0.60	0.08	0.18	0.12	0.13	-0.25	
Wt.Gain		-0.18	0.98	-0.17	0.00	-0.03	0.04	-0.07	0.10	0.15	-0.09	
Average Daily Gain		-0.18	0.98	-0.17	0.00	-0.03	0.04	-0.07	0.10	0.05	-0.09	
Average Daily Feed			-0.28	0.36	0.64	0.74	0.10	0.08	0.34	0.05	-0.50	
Feed Effic. Feed			-0.15	-0.06	-0.06	-0.11	-0.02	-0.06	0.05	0.00	-0.10	
Conversion					0.11	0.22	-0.35	-0.13	-0.04	0.10	0.10	

39 df

* Correlations above 0.3 are significant at 5% level of probability

** Correlations above 0.4 are significant at 1% level of probability

who found eating rate to be significantly correlated with both live weight gain ($r = 0.63$, $P < 0.01$) and voluntary feed intake ($r = 0.61$, $P < 0.01$) and Randall (1974) who reported significant correlations of appetite with average daily feed intake and average daily gain ($r = 0.48$ to 0.68).

The associations between initial weight of the lambs and eating rate also were examined (Tables 11 and 12). In both trials initial weight was significantly correlated only with eating rate at 30 and 60 minutes. There also was a significant correlation between initial weight and propensity to eat at 30 minutes for the winter trial. The other eating rate estimates were not significantly correlated with initial weight either in the summer or winter trial.

The correlation of eating rate and live weight is in agreement with the reports of Putnam et al., (1963, 1964) who reported that heavier animals spent less time at the feeder each day than animals of lighter weight, and showed that rate of feed consumption was directly related to body weight. Rate of eating in those studies was determined by dividing daily feed consumption by hours spent at the feeder.

In this study the winter lambs were both chronologically and physiologically more mature than the summer lambs. Young lambs would be expected to gain more rapidly during the 3-week test period. Contrary to expectations, the older and heavier lambs gained nearly as rapidly as the

younger lambs (Table 3). However, they required a greater average daily intake of feed to achieve this gain. This could be explained in terms of the differences in pre-test management of the experimental groups, differences in their appetite-weight relationship associated with maturity or chronological age, or differences in physical environment during the test. The winter lambs were more acclimated to the experimental feed than the summer lambs, and this could have enabled them to eat more than the summer lambs which were on pasture most of the time prior to the test. The winter trial was performed during the period of cold weather; a greater amount of feed would have to be metabolized to provide body heat and maintain a stable body temperature. Consequently, an increase in daily feed intake would have been a 'sine qua non.' Older, heavier animals use a higher percentage of their feed intake for maintenance and a lower percentage for gain.

Furthermore, there was a significant positive relationship ($r = 0.80$, $P < 0.01$) between average daily gain and average daily feed intake for the winter lambs only. The summer lambs had a negative correlation ($r = -0.18$) between the same parameters that was not significant. According to Blaxter and Wainman (1964), cited by Frisch and Vercoe (1969), the relationship between gain and feed intake above maintenance requirement can be considered positive and linear. It would be illogical to claim that

the winter lambs ate more over maintenance since average daily feed per unit of metabolic weight was approximately equal for the two trials. However, it would seem reasonable that the heavier winter lambs ate relatively more feed at a significantly faster rate (a difference of 0.05 lb. in 30 minutes and 0.13 lb. in 60 minutes). This enabled them to achieve a relatively greater supply of nutrients and consequently gained 0.4 lb. more (not significant) than the more efficient but less rapidly eating summer lambs.

CHAPTER V

SUMMARY AND CONCLUSIONS

Dairy Calf Experiment

Ten Holstein calves from 6 sires were used to determine suckling speed by recording the time required by each calf to completely suckle 3 pints of milk from a feeding bottle. The repeatability of suckling speed was computed, and the relationship between suckling speed and performance was examined.

The mean suckling speed was 112 seconds. The standard deviation was 38.4 seconds, the maximum value was 298 seconds and the minimum was 60 seconds. The coefficient of variation of suckling speed was 34%, and the repeatability was 0.33 ($P < 0.1$).

The most probable producing ability for suckling speed was then computed for each calf on test. The degree of correlation between MPPA and initial weight, final test weight, post-test gain and 70-day weight was then calculated. None of the correlations was significant.

The repeatability value of 0.33 indicated that suckling speed might be moderately heritable but under the experimental conditions the validity of the repeatability estimate as upper limit of heritability is questionable. The measurements were taken on successive days, and for a

period of only 10 days it is possible that short-term effects could have been assigned to permanent effects caused by the same genes. The failure to obtain any significant correlation between suckling speed (expressed in MPPA) could either mean that there was no relationship between the suckling speed and gain or other parameters, or because the number of calves was small. It is most probable that the 10 calves were not sufficient to produce a significant correlation.

Lamb Experiment

Eighty-five purebred Suffolk and Hampshire ewe and ram lambs from 6 sires were used to study the inheritance of appetite in sheep during the winter of 1974 and summer of 1975. The winter trial involved 44 Suffolk and Hampshire lambs. The lambs averaged 134.7 lbs. in initial weight on test and were $10\frac{1}{2}$ months old. The summer trial involved 41 lambs averaging 95 lbs. in initial weight and $5\frac{1}{2}$ months of age.

The study consisted of estimating appetite by various methods, computing repeatability values for appetite measures and finally correlating appetite with some performance characteristics, notably rate of gain.

The appetite measures were highly correlated among one another except with average daily feed per unit of metabolic weight was not correlated significantly with

other measures. These significant correlations among the appetite measures indicated that each was estimating similar biological phenomenon, and the lack of correlation of average daily feed per unit of metabolic size with any of the appetite terms was interpreted as either not measuring the same phenomenon or measuring it inaccurately.

Repeatability values ranged from 0.18 to 0.51 in the winter trial and from 0.33 to 0.59 in the summer trial. Although these values suggest that appetite might be moderately to highly heritable, the reliability of repeatability as an upper limit of heritability may not be taken as absolute, because the repeated measurements were made only 2 days apart.

The ram lambs ate faster and gained more than the ewe lambs. The difference in gain was 13.6 lbs. in the winter trial and 9.8 lbs. in the summer trial. The differences in eating rates were 0.41 lbs. of feed for winter lambs and 0.37 lb. of feed for summer lambs, for feed consumed in 60 minutes.

There were no significant breed effects on any of the eating rate measures or on rate of gain. There were significant sires/breed effects in both summer and winter trials on some of the eating rate measures, especially during the first 60 minutes of eating.

The relationships between eating rate and rate of gain were examined. There were significant positive

correlations between some of the eating rate measures and rate of gain. This suggests that eating rate under specific conditions could be a useful predictor of intake and gain as suggested by Frisch and Vercoe (1969).

BIBLIOGRAPHY

- Adolph, E. F. 1947. "Urges to eat and drink in Rats,"
Am. J. Physiol. 151:110.
- Akert, K. 1959. Physiology and pathophysiology of the
hypothalamus. Introduction to Stereotaxis. G.
Schatlenbrand and Bailey Editions. Stuttgart:
Thieme, pp. 152.
- Bailey, C. B. 1959. The role of secretion of saliva in
the cow, Proc. Nutr. Soc. 18:XIII.
- Balch, C. C. 1958. Observations on the act of eating in
cattle. Brit. J. Nutr. 12:1330.
- Blaxter, K. L., F. W. Wainman and R. S. Wilson. 1961.
The regulation of food intake by sheep. Anim.
Prod. 3:51.
- Blaxter, K. L. and F. W. Wainman. 1964. Utilization of
the energy of different rations by sheep and
cattle for maintenance and for fattening. J. Agric.
Sc. 63:113.
- Brody, S. 1945. Bioenergetics and growth. New York,
Reinhold.
- Bulatao, E. and A. J. Carlson. 1924. "Contribution
to the physiology of the stomach influence in
blood sugar level on gastric hunger contractions."
Am. J. of Physiol. Vol. 69:107.
- Burt, A. W. A. 1957. Factors affecting rate of eating
roughage and responses to an increase in the
amount of concentrate feed. J. Dairy Res. 24:678.
- Chase, L. E. and P. J. Wangsness. 1973. Feeding behavior
of sheep fed a complete ration. J. Anim. Sc.
37:340 (Abstr.).
- Church, D. C. 1969. Digestive physiology and nutrition
of ruminants. OSU Bookstores, Inc., Corvallis,
Oregon, Vol. 1, 316pp.
- Davis, R. C., Garafolol, L., and Kverm, R. 1959. Condi-
tions associated with gastro-intestinal activity.
J. Comp. Physiol. Psychol. 52:466.

- Duckworth, J. E. and S. W. Shirlaw. 1958. The value of animal behavior records in pasture evaluation studies. *Anim. Behav.* 6:139.
- Falconer, D. S. 1960. Introduction to quantitative genetics. The Ronald Press Company, New York, 365 p.
- Forbes, J. M. and J. A. Wright. 1968. Rate of eating in sheep. *Anim. Prod.* 10:240.
- Forbes, J. W., J. A. Wright and A. Bannister. 1972. A note on eating rate of sheep. *Anim. Prod.* 15:211.
- Freer, M., R. C. Campling and C. C. Balch. 1962. Factors affecting the voluntary intake of food by cows. *Brit. J. Nutr.* 16:279.
- Frisch, J. E. and J. E. Vercoe. 1969. Liveweight gain food intake and eating rate in Brahman, Africander and Shorthorn x Hereford cattle. *Austr. J. Agric. Res.* 20:1189.
- Fuller, J. M. 1928. Some physical and physiological activities of dairy cows. *N. Hamp. Agric. Exp. Sta. Tech. Bull.* 35.
- Gill, J., R. C. Campling and D. R. Westgarth. 1966. A study of chewing during eating in the cow. *Brit. J. Nutr.* 20:13.
- Hafez, E. S. E. 1969. The behavior of domestic animals. 2nd edition, The Williams and Wilkins Co.
- Hardison, W. A., H. L. Fischer, G. C. Graf and N. R. Thompson. 1956. Some observations on the behavior of grazing lactating cows. *J. Dairy Sc.* 39:1735.
- Harvey, W. R. 1960. Least-squares analysis of data with unequal subclass members. *U.S.D.A. ARS* 20-8.
- Henderson, C. R. 1953. Estimation of variance and covariance components. *Biometrics* 9:226.
- Hohenboken, W. D. 1968. Repeatability of weight in beef cattle. M.S. thesis. Colorado State University, Fort Collins.

- Hohenboken, W. D., E. R. Hauser, A. B. Chapman and L. W. Cundiff. 1972. Partitioning lactation feed consumption in Herefords between maintenance, gain, and milk production. *J. Anim. Sc.* 34:152.
- Hohenboken, W. D., E. R. Hauser, A. B. Chapman, and L. V. Cundiff. 1973. Phenotypic correlations between dam traits expressed during development and lactating and traits of progeny in cattle. *J. Anim. Sc.* Vol. 37 No. 1.
- Kennedy, G. C. 1953. The role of depot fat in the hypothalamic control of food intake in the rat. *Proc. Roy. Soc., London*, 140:578.
- Kleiber, M. 1961. *The fire of life. An introduction to animal energetics.* University of California, Davis. pp. 282.
- Mayer, J. 1953. Genetic traumatic and environmental factors in the etiology of obesity. *Physiol. Rev.* 33:472.
- National Research Council. 1968. *Nutrient Requirements of Domestic Animals No. 5, Nutrient Requirements of Sheep.* National Research Council, Washington, D.C.
- Pearson, K. 1897. Mathematical contribution to the theory of evolution--on a form of spurious correlations which may arise when indices are used in the measurement of organs. *Proc. of Royal Soc. (London)* 60:489.
- Purser, D. B. and R. J. Moir. 1966. Rumen volume as a factor involved in individual sheep differences. *J. Anim. Sc.* 25:402.
- Putnam, P. A. and R. E. Davis. 1963. Ration effects on drylot steer feeding patterns. *J. Anim. Sc.* 22:437.
- Putnam, P. A., R. Lehmann and R. E. Davis. 1964. Rate of feed consumption and body weight of beef cattle, *J. Anim. Sc.* 23:425.
- Randall, P. R. 1974. Some psychophysiological aspects of taste, and eating rate in cattle, sheep and horses. Ph.D. Thesis, Oregon State University, Corvallis, Oregon.

- Schalk, A. F. and R. S. Amadon. 1928. Physiology of the ruminant stomach. N. Dakota Agric. Expt. Sta. Bul. 216.
- Seoane, J. R., C. A. Baile and F. H. Martin. 1971. Humoral factors modifying feeding behavior of sheep. *Physiol. and Behav.* Vol. 8, pp. 993.
- Stoddard, G. E. 1969. Symposium on dairy cattle feeding group. Feeding of concentrates to dairy cows, *J. Dairy Sc.* 52:844.
- Suzuki, S., H. Fujita and Y. Schinde. 1969. Change in the rate of eating during a meal and the effect of the interval between meals on the rate at which cows eat roughages. *Anim. Prod.* 71:29.
- Warwick, E. J. and E. H. Cobb. 1974. Genetic variation in nutrition of cattle for meat production. The effect of genetic variance on nutritional requirements of animals. National Acad. of Sc., Washington, D.C. 1975.

APPENDIX

APPENDIX

Table 1. Individual Calf Weights, Gain and MPPA for Suckling Speed

<u>Calf ID</u>	<u>Birth Weight</u>	<u>Initial Test Wt.</u>	<u>70 Day Weight</u>	<u>MPPA</u>	<u>Post Test Gain^a</u>	<u>70 Day Gain</u>
1457	86	95	205	70	110	119
1459	91	95	209	137	114	118
1460	91	85	235	105	150	144
1461	83	100	245	121	145	162
1462	85	79	231	93	152	146
1463	81	82	204	84	122	123
1465	105	122	209	104	87	104
C1	97	106	232	96	126	135
C7	92	-	195	80	-	103
C8	97	-	204	92	-	107

^aGain from 20 days to 70 days of age