THE SCOPE OF CANADIAN MEAT SCIENCE RESEARCH AND SOME INDUSTRY APPLICATIONS*

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Virtually all of Canada's agricultural history belongs to the present century. Although substantial livestock populations existed in the Eastern provinces of Quebec and Ontario prior to 1900, production was geared to domestic requirements for meat and to the provision of breeding stock for the expanding western frontier. Indeed, at the time Denmark established her pig progeny testing program, agricultural settlement has just begun in Saskatchewan and Alberta and the immense plains stretching west of the Great Lakes were largely virgin prairie. To illustrate this point we need only remember that the last great buffalo drive in Western Canada took place less than 100 years ago.

The first agricultural college in Canada was established in Guelph, Ontario in 1874 to train young farmers in the science and practice of agriculture. The Experimental Farms System, now the C.D.A. Research Branch, was initiated in 1886 for the purpose of identifying the crops, livestock and husbandry procedures appropriate to different regions of Canada.

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Early work with livestock was largely of a demonstrational nature. However, by the mid-1920's some institutions had developed programs of innovative research not directly connected with existing production practices or techniques. Examples were the crossbreeding experiments with beef cattle (Shaw and MacEwan, 1938) and pigs (Shaw and MacEwan, 1936) conducted by the University of Saskatchewan. However, such investigations were the exception rather than the rule and emphasis on husbandry procedures, housing, rations and management continued to dominate livestock research programs throughout Canada until approximately 1950.

As for carcass research per se, the first scientific publication from Canadian research was the pioneer work at the University of Saskatchewan on x-ray determination of skeletal characteristics of pigs (Shaw, 1930). This was followed by studies of interrelationships among carcass measurements of pigs (Sinclair and Murray, 1935), quantification of environmental vs genetic contributions to pig carcass traits (Stothart, 1938, 1947; Fredeen, 1953) and specific studies on the magnitude and importance of sex differences in carcass measurements (Bennett and Cole, 1946; Fredeen and Lambroughton, 1956). Carcass evaluation techniques also came under study during this period with emphasis on methods appropriate for research application and use in pig testing programs (Fredeen et al., 1955a, b; Martin and Fredeen, 1966).

These examples, though not an exhaustive compilation, serve to illustrate three significant aspects of the carcass research conducted in

Canada prior to 1960.

1. The research effort was confined almost entirely to pigs.

2. It was directed toward quantity evaluation with emphasis on development of techniques and procedures appropriate to breeding programs.

3. Relatively few research centers were involved.

That this situation prevailed at least until 1965 was documented by a survey of Canadian meats research conducted by the Food Products Branch, Department of Industry. From responses to this survey it was concluded that meat as a product had stimulated little research apart from that generated by related studies in genetics, nutrition and physiology.

Current Status of Canadian Meat Research

This picture has changed substantially since 1965. Responses to a survey just completed by Dr. N.W. Tape, C.D.A. Research Branch, indicate that meats research is now being conducted at 16 locations in Canada. Eight of these are universities with graduate courses offered in departments of Animal Science (2), Food Science (8), Household Economics (1) and Chemical Engineering (1). Topics covered range from microbiology and methods of food preservation to study of factors influencing consumer

preferences.

Although this development is encouraging, facilities presently devoted to meats research in Canada remain at a relatively low level. They involve approximately 20 professional man-years with an equal number of graduate students and technical assistants (Table 1) and only 7 of the 16 locations devote more than one professional man year to meats. Approximately 58% of the total research is directed toward beef with 22% on poultry, 17% on pork and 3% on lamb.

(Table 1 near here)

Selected examples of the scientific papers generated by this research are listed in Appendix 1. In addition to these papers there have been certain developments of particular pertinence to meat processors. Specific examples have been provided by work at Laval University in Quebec which has subtended several patented procedures relating to the packaging, tenderizing and drying of meat products. However, the research with the most direct effect on the livestock industry has been that concerned with carcass grading procedures and standards. As a preface to describing this research and its application it will be useful to review briefly the history of livestock grading in this country.

Development of Carcass Grading

In the years immediately prior to 1920, Canada's annual export of bacon and pork products approximated 100,000,000 kilo or approximately 75% of the annual production. This substantial export trade encouraged the government to consider a system of grade standards to identify for the hog industry the kind of product then in demand. Such a system was introduced in 1922. It was based on the live hog and defined the "select" or top grade as one that would meet the specifications of the United Kingdom market. Twelve years later carcass grading was introduced with both live and carcass grading available on an optional basis until 1940 when carcass grading became the only official grading procedure. This grading system provided 4 grades with the top two grades (A and B) defined in terms of carcass weight, length and maximum tolerances for back fat thickness.

Carcass grading for beef cattle was introduced in 1928. The standards adopted were designed specifically for the domestic trade but the objective was the same as for pigs, namely the provision of a classification system that would serve both buyer and seller in identifying the characteristics of the product being offered for sale. The beef grade classifications were increased from two to eight in 1947 with a further expansion to 11 in 1958. The top two carcass grades, named Choice and Good, applied only to youthful cattle and were defined in terms of general conformation and the uniformity and amount of external fat cover. Visual appraisal was used to determine grade.

In a relatively short space of time following the introduction of carcass grading, the meat trade established price differentials which gave a premium to the top grades. This price incentive encouraged producers to improve their product using techniques of breeding, feeding and management and substantial changes resulted in the proportion of hog and beef carcasses qualifying for the top two grades. Grading statistics for hogs indicated that 83% of all slaughterings in 1935 were classified in the two top grades with 35% Grade A and 48% Grade B. In the case of beef cattle, the proportion of carcasses graded Choice or Good increased from 17% in 1950 to 63% in 1969.

Changes in Hog Carcass Grading

Early in the past decade it became clear that hog carcass grade standards required updating. The export market for which they had been designed had ceased to have relevance and the markets that remained, principally the domestic market, were concerned with general muscling of the carcass rather than bacon quality per se. It was also noted that the proportion of Grade A hogs had increased by only 2% (from 35% to 37% of total annual kill) over the period 1935 to 1963. Reasons for this plateau in carcass improvement were explored by Fredeen et al. (1964). They concluded that the grading standards provided very limited scope for recognizing genuine differences in carcass merit. The two top grades, A and B, differed by 2.3% in yield of trimmed retail product but the range in % yield within each grade was so extreme (approximately six times the grade

difference) that grade per se offered no useful guidance for carcass improvement programs (Figure 1). Indeed the difference between barrows and gilts was greater than the average difference between grades with top (A) grade barrow carcasses approximately identical with second (B) grade gilt carcasses.

(Figure 1 near here)

Data from this comprehensive carcass evaluation study (Fredeen et al., 1964) identified an objective procedure based on backfat measurements for predicting the potential yield of retail product from a carcass. Confirmation of the conclusions of this research was provided by a series of studies conducted jointly by the Canadian Swine Council, Meat Packers Council and the Canada Department of Agriculture over the period 1965-1968 (Fredeen and Bowman, 1968a, b) and a formula based on carcass weight and backfat was developed for predicting potential carcass value. This formula, which incorporated calculations of both processing costs and retail value of the product, was used to develop a value-yield table defined by 14 backfat categories and 6 weight categories. Carcasses in the fat-weight sub-class defined by 8.1 - 8.3 cm of total fat (the sum of maximum fat at shoulder and loin) and 67.5 to 72.0 kg weight, were given an index value of 100, all other entries in the value-yield table were calculated as a percentage of this average value, and the resulting "Table of Differentials" was adopted as the new carcass grading procedure on December 30, 1968 (Figure 2).

(Figure 2 near here)

The "quantity" aspects of this new system were augmented by provision for demerits in respect of type, quality and carcass damage of form. Type demerits, identified specifically in relation to deficiencies of belly quality and general "roughness" of the carcass, resulted in a decrease of 3 points in the index. Soft oily fat or abnormal color and/or texture of the lean resulted in a 10 point decrease in index. Deformities, pigmentation of skin, injury, arthritic joints, excess mammary development and several other conditions were classified as trimmable demerits. They did not influence index value but the weight of product trimmed was subtracted from the carcass weight to obtain the weight on which settlement was based.

The Canadian hog industry has now completed its third year under these revised grade standards. Grading statistics indicate a steady improvement in average index during this period (Table 2). Thus in 1969, 42.4% of the 7.5 million hogs slaughtered graded 102 or above while in 1971 the corresponding figure was 45.6 on 10.1 million carcasses. The improvement may in fact have been greater than this 3.2% since "Heavy" hogs increased from 6.6% to 9.1% during the same period. This observation is in accord with a survey conducted by the Meat Packers Council which indicated that carcasses in 1971, though heavier than in 1969, actually carried less fat. Three years is insufficient time to provide opportunity for meaningful genetic change and it is probable that the trends observed derive primarily from changes in management and nutrition.

Changes in Beef Carcass Grading

Developments in beef carcass grading have paralleled those in the hog industry. Criticism of over fat carcasses led the beef industry to initiate studies on grade standards in 1966. Data provided by the Canada Department of Agriculture provided clear evidence that the grade standards tended to encourage the production of excess fat (Figure 3; Fredeen and Weiss, 1970). Detailed cut-out studies identified rib eye area and average fat depth over the longissimus dorsi at the 10-11 rib as the two most useful predictors of potential yield of retail product (Martin et al., 1970). Conclusions from this research were confirmed and extended by additional studies which provided the initial basis for specific recommendations on new grading standards (Fredeen et al., 1970). Research on quantity-quality relationships in beef carcasses has continued since that date (Martin et al., 1971) and the resulting information has been utilized by industry in identifying quality criteria for carcass grading.

(Figure 3 near here)

The beef industry represented by the Canadian Cattlemen's Association and the Meat Packers Council of Canada has taken an active role in developing the quantity-quality criteria for the new beef grading system recently announced by the Canada Department of Agriculture. This system, to be implemented on September 5, 1972, represents a comprehensive updating of standards applicable to all slaughter cattle. However, the standards applied

to the youthful age group (i.e. as defined by visual examination of skeletal development) are of the greatest interest to beef producers. The quantity-quality schedule pertinent to this age class is given in Table 3.

(Table 3 near here)

A preview of the results that may be achieved by this new carcass classification procedure was provided by applying the standards against youthful beef carcasses utilized in detailed carcass cut-out studies at the Lacombe Research Station. The sample comprised 1184 carcasses which met the requirements for Canada A. The results are summarized in Table 4. These data indicate that the yield of externally defatted bone-in product from the five major carcass cuts will be approximately 6% greater for fat class 1 than for fat class 4 (i.e. 93 vs 87%).

(Table 4 near here)

Implications for Industry

The livestock industry, in defining new grade standards for hog and beef carcass, was concerned primarily with the problem of product description. The underlying philosophy was that a reasonably precise pattern of carcass classification would facilitate the expression of realistic price differentials reflecting consumer demand for specific quantity-quality

attributes. These differentials, translated back to the producer in terms of price for live animals and/or carcasses would thus provide the economic incentives for product improvement. Tentative evidence to support the philosophy has been demonstrated in the case of hogs and there is reason for optimism that the same will hold for beef cattle.

Long term implications for livestock producers relate primarily to adoption of management-nutrition-breeding practices appropriate to serve consumer demand. The direction of change will be toward the development of leaner products and this will subtend lower production costs, specifically feed (e.g. Fredeen, 1970; Mukhoty et al., 1970). Although net returns to the meat industry are unlikely to be altered there will be economic benefits for those producers who are most successful in adjusting their product to suit demand. Some economic benefits may also accrue to other segments of the meat industry. However, the principle benefactor of the revised grade standards will be the consumer. Reduced feed inputs, reduced labor inputs for trimming carcasses of excess fat, and a reduction in the total trim should all contribute to a gradual reduction in product costs at the retail level.

Synthesis

Basic meat science research, if viewed in terms of facilities and professional man years, has received relatively little emphasis in Canada. Current trends, particularly those associated with the development

of graduate training programs at several Canadian universities, indicate that this situation is changing.

However, considerable emphasis has been devoted to mission oriented research with specific emphasis on criteria and techniques for product evaluation. This has had direct relevance to research, but its primary application has been to practical livestock improvement through development of better techniques for carcass appraisal in national testing programs, and through the evolution of new carcass grade standards for pigs (1968) and beef cattle (1972). The upward trend in carcass merit of hogs delivered for slaughter over the past three years encourages optimism that these revised standards will serve a vital function in improvement of meat products from both species.

The emphasis given in Canada to mission oriented vs basic meats research is a direct reflection of the inputs from scientists working in the fields of animal breeding, nutrition, and management. Since product evaluation is an integral and essential part of such research it was inevitable that these scientists would become intimately involved in problems of carcass evaluation. This resulted in research on prediction procedures applicable to live animals and carcasses, to studies of interrelationships between quantity and quality of product, to investigations on factors influencing consumer preferences, and ultimately to the development of standards appropriate to commercial use in carcass grading.

Industry has also had a prominent role in this development of mission oriented research. Producers and processors, working in conjunction with the scientists engaged in production research, contributed substantially to identification of the issues pertinent to product development. This is as it should be. Meat science research, if it is to be of value to society, must develop in the context of industry needs and achievement of this objective requires close liasion between industry and the research organizations. This philosophy does not diminish the importance of basic meats science research but it does underscore the pertinence of assigning priority to mission oriented research.

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Appendix 1

Abridged bibliography of recent scientific publications generated by Canadian meat science research

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Table 1. Man years committed to meats research in Canada, 1972.

	No. Centres	Professional	Graduate Students	Technical Support	Professional			
					Beef	Pork	Lamb	Poultry
C.D.A.	7	5.9	1.0	9.3	3.8	1.0	0.7	0.4
N.R.C.	1	3.5	-	2.5	2.6	-	-	0.9
Universities	8	10.2	19.0	10.8	5.0	2.3	-	2.9
Total	16	19.6	20.0	22.6	11.4	3.3	0.7	4.2

Table 2. Trends in Canadian hog carcass grades since December, 1968.

		1969	1970	1971
Total carcasses graded		7,481,479	8,648,250	10,091,695
% indexing	112	0.1	0.1	0.1
	110 and 109	1.7	1.7	2.1
	107 and 105	10.9	11.4	13.0
	103 and 102	29.7	30.0	30.4
	100	16.9	16.0	15.3
	98 and 97	21.0	19.6	17.8
	95 and 92	6.6	5.8	4.9
	88	1.2	1.0	0.8
	Light and 80	1.8	1.8	2.6
	Heavy	6.6	8.7	9.1
	Ridgling	0.5	0.5	0.4
	Stags	0.1	0.1	0.1
	Sows	2.8	3.3	3.4
% demerits	Type	.06	.02	.02
	Quality	.007	.002	.002
	Trimmable	4.3	5.1	5.7

Table 3. Quantity-quality schedule applicable to youthful* beef carcasses under the new Canadian beef grading standards.

Warm carcass weight (pounds)	1	2	3	4
		Fat level Canada A		
300 - 499	.20 - .30	.31 - .50	.51 - .70	over .70
500 - 699	.20 - .40	.41 - .60	.61 - .80	over .80
700 and over	.30 - .50	.51 - .70	.71 - .90	over .90
		Fat level Canada B		
300 - 499	.10 - .30	.31 - .50	.51 - .70	over .70
500 - 699	.10 - .40	.41 - .60	.61 - .80	over .80
700 and over	.20 - .50	.51 - .70	.71 - .90	over .90

For Canada A, the longissimus dorsi, when exposed by ribbing, must be firm, fine grained, of a bright red color, and marbling at least slight. For Canada B, color may range to medium dark, texture of flesh may be somewhat coarse and there is no minimum marbling standard. Both grades must meet the same specifications in respect of type and completeness of external fat cover.

* Youthful carcasses, defined as Maturity Class 1, must meet the following age criteria: Bones are soft, red and porous when split, there are pearl-like capping cartilages on the lumbar vertebrae and marked indications of youth in the chine, sternum, ribs, sacrum and aitch bones except that the ends of the cartilaginous caps on the dorsal processes of the thoracic vertebrae may have slight granulation.

Table 4. Proportion of 1184 Canada A carcasses in each fat-weight sub-class and the average rib-eye area and % yield of closely trimmed bone-in product from the five major carcass cuts.

		Proportion of carcasses (% of sample)			
Fat Class		1	2	3	4
Weight (kg)	136-225	0.8	6.4	5.3	7.7
	226-315	12.7	21.1	16.0	18.2
	316+	4.8	3.0	1.0	3.0
	Total:	18.3	30.5	22.3	28.9
		Rib-eye area (longissimus dorsi at 11-12 rib) cm^2			
Weight (kg)	136-225	65.8	63.2	61.3	58.7
	226-315	80.0	76.1	72.2	69.0
	316+	94.2	89.0	83.2	77.4
		% Yield (externally defatted bone-in product from chuck, rib, sirloin, shortloin and round)			
Weight (kg)	136-225	92.7	91.0	88.7	86.5
	226-315	92.6	90.6	89.3	87.4
	316+	92.8	90.6	88.9	86.7

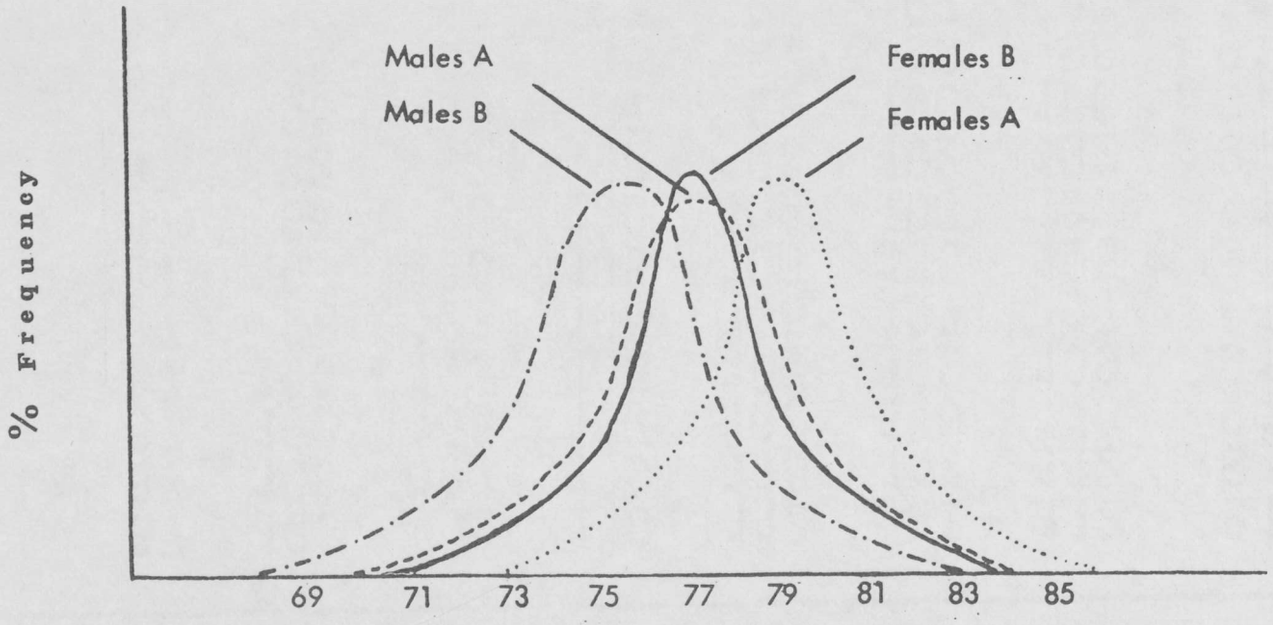

FIGURE 1: PERCENT YIELD OF PRIMAL CUTS IN RELATION TO SEX AND COMMERCIAL GRADE.

FIGURE 2. TABLE OF DIFFERENTIALS FOR HOG CARCASS EVALUATION.

BACKFAT IN.	PREDICTED YIELD (PERCENT)	90 - 124	125 - 129	130 - 139	140 - 149	150 - 159	160 - 169	170 - 180	181 - 195	196 AND OVER
1.9	69.7	87	105	109	110	112	112	112	91	85
2.0-2.1	69.0	87	103	107	109	110	112	112	91	85
2.2-2.3	68.2	87	102	105	107	109	110	110	91	85
2.4-2.5	67.5	87	100	103	105	107	109	109	91	85
2.6-2.7	66.7	87	98	102	103	105	107	107	91	85
2.8-2.9	66.0	87	97	100	102	103	105	105	91	85
3.0-3.1	65.2	87	95	98	100	102	103	103	91	85
3.2-3.3	64.5	87	92	97	98	100	102	102	91	85
3.4-3.5	63.8	87	88	95	97	98	100	100	91	85
3.6-3.7	63.0	87	88	92	95	97	98	98	91	85
3.8-3.9	62.3	87	88	88	92	95	97	97	91	85
4.0-4.1	61.5	87	88	88	88	92	95	95	87	82
4.2-4.3	60.8	87	88	88	88	88	92	92	87	82
4.4- +	69.1	87	88	88	88	88	88	88	87	82

PRICE FOR LIVE HOGS IS BASED ON THE INDEX VALUE OF 100. WHEN CARCASS GRADE HAS BEEN DETERMINED THE ACTUAL PRICE FOR EACH PIG IS CALCULATED BY MULTIPLYING THE BID PRICE BY THE APPROPRIATE INDEX VALUE.

APPROPRIATE INDEX VALUE.

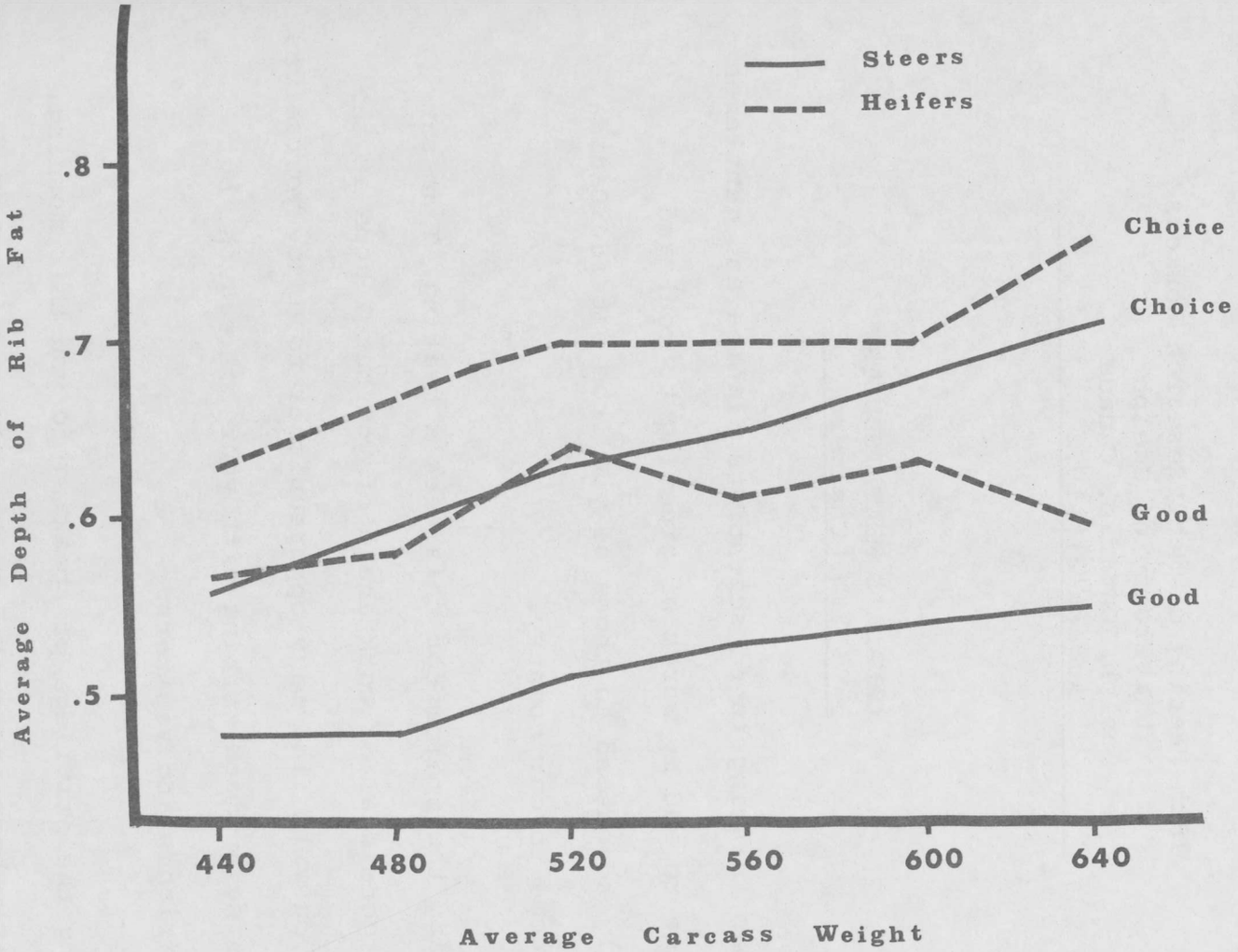

FIGURE 3: AVERAGE RIB FAT IN RELATION TO SEX, GRADE AND WEIGHT OF BEEF CARCASSES.