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PROTEIN PRODUCTION FROM BEEF

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SUMMARY

The contribution of beef to animal protein supplies, and the efficiency of beef protein production, is reviewed.

It is established that beef production is a grossly inefficient method of producing protein for humans; that beef protein is very expensive; but that people eat beef because they like to do so provided they can afford it. The increasing world demand for beef offers attractive opportunities for New Zealand. If the demand is not satisfied, and if the cost of beef continues to rise, further development of simulated meat products can be expected.

Some factors affecting the efficiency of beef production are discussed. Major problems are distinguished as: the inefficiency of beef breeding cows; the antagonism between high output of beef per unit area of land, output per animal and economic returns in an intensive pastoral beef system; and the inadequate nature of the present carcass grading and payment system to producers.

In view of the relatively high efficiency of the dairy cow in protein production, and the low efficiency of the beef breeding cow, a policy of substantial enlargement of the national dairy herd is advocated. Animals surplus to dairying requirements could harvest protein as beef from hill country areas presently occupied by beef cows.

Experimental work is needed to indicate the most effective means of integrating crops, by-products and waste products with animal production. At the processing stage, pilot experimental plants to incorporate plant protein with beef into compound high protein foods is suggested.

THE contribution of beef and veal to the dietary protein intake of man varies — in developing regions less than 5 g/head/day and in developed regions about 21 g/head/day (FAO, 1970). Yet, in numerical terms, cattle comprise the largest number of domesticated animals in the world (Table 1) although their rate of increase (and those of sheep and buffalo) fails to keep pace with the rate of increase in humans.

Moreover, a high proportion of the world cattle population is located in developing regions supporting unproductive animals and with religious, cultural and social constraints on beef consumption. Cattle are also more frequently kept as milk producers, with meat as a by-product, and relatively few cattle are specifically bred and managed for beef consumption (Cuthbertson, 1969).

TABLE 1: ESTIMATED WORLD POPULATIONS (MILLIONS) OF HUMANS AND MAJOR DOMESTICATED ANIMALS

Species	*1950*	*1970*	*% Increase*	*Av. % Inc./yr*
Humans	2,497	3,647	46	2.3
Cattle	798	1,118	40	2.0
Sheep	774	1,073	39	2.0
Pigs	296	627	112	5.6
Buffalo	89	125	40	2.0
Goats	291	384	32	1.6

Source: Adapted from FAO (1970).

BIOLOGICAL EFFICIENCY OF PROTEIN PRODUCTION FROM BEEF

The biological efficiency of beef as a commodity supplying protein for human needs has been assessed recently (Duckham, 1968; Reid, 1969; Cuthbertson, 1969; Hodgson, 1970; Hutton, 1970; Lodge, 1970).

These several assessments differ in detail but not in the principle that beef is one of the poorest ways of converting feed nutrients into edible products or protein. Thus, as outlined by Hodgson (1970), the efficiency of beef protein conversion was estimated at 15% and only 10% of the feed intake was changed to gross edible product. To an appreciable extent this inefficiency of the beef animal reflects the high feed costs of rearing and maintaining the breeding unit to generate the meat producers.

The nutrient expense of the breeding unit for beef production has been revealed by Lodge (1970). Table 2, adapted from his data, indicates the substantially greater energy and protein intake required per unit of muscle protein derived from a "beef beef" system (based on a

TABLE 2: CONVERSION EFFICIENCY OF BEEF CATTLE

Character	*"Dairy Beef"*		*"Beef Beef"*	
Age (mth)	6	18	6	18
Slaughter LW (kg)	203	455	203	455
Daily LW gain (kg)	1.0	0.8	1.0	0.8
Carcass wt (kg)	110	260	110	260
Energy intake (ME)				
per kg muscle gain (Mcal)	25	47	86	79
per kg muscle protein gain (Mcal)	118	214	414	358
Protein intake (CP)				
per kg muscle gain (kg)	1.5	2.8	5.7	4.8
per kg muscle protein gain (kg)	7.4	12.8	27.2	21.9

Source: Adapted from Lodge (1970).

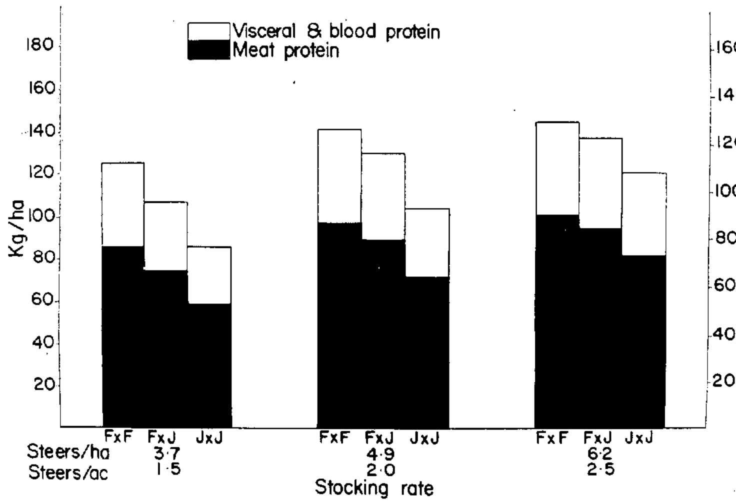

FIG. 1: *Net production of protein per unit area of land per annum from beef, viscera and blood by Friesian (F × F), Friesian × Jersey (F × J) and Jersey (J × J) steers grazed at three stocking rates.*

breeding cow suckling one calf for 8 months), as against the "dairy beef" system where the calf is separated from the cow at birth and milk, in a sense, becomes a by-product of the beef system. No account of the greater food costs of grazing as compared with stall feeding (Joyce, 1971) appears to have been taken in Lodge's (1970) calculations. This would further accentuate the relatively poor efficiency of the "beef beef" system. Table 2 also shows the advantage in terms of conversion efficiency of slaughtering at a young age and light weight, except for the "beef beef" system. In the latter, when feed requirements of the dam are included, the advantage in terms of feed conversion moves in favour of heavier slaughter weights, spreading the overhead costs of maintaining the breeding unit.

Another illustration of the biological efficiency of beef production as a source of protein for humans is to examine production per unit area of land. Some data are presented in Fig. 1 drawn from a replicated trial in progress at Ruakura where comparisons of production per unit land area are being made between straightbred Friesian (F × F), straightbred Jersey (J × J) and the Friesian × Jersey (F × J) crossbred. Steers of each breed are grazed at either 3.7, 4.9 or 6.2 animals/ha. Weaner cattle enter the area at approximately 4 months of age and are slaughtered off the area a year later. Pastures are producing approximately 10,000 kg dry matter/ha/year. No supplements are fed except for grass conserved on respective areas. The highest stocking rate with F × F animals, however, requires importation of feed, as hay, into the system.

Taking the F × F as an example, meat protein production increased from 86 kg/ha/annum at the lowest stocking rate to 102 kg/ha/annum at the highest. An average protein yield for soya beans grown in New Zealand of 1,000 kg/ha was indicated by Gerlach *et al.* (1971) and Hutton (1970) used an estimate of 1,350 kg/ha of protein from soya beans grown with more advanced crop technologies. Vartha and Allison (1971) have recorded yields of crude protein from lucerne in Canterbury of 2,340 kg/ha.

Thus the highest beef protein output from the described intensive grassland systems of production (Fig. 1), freed of overhead costs of breeding cow maintenance and production, produced only about 10% of the protein output reasonably expected from soya beans in New Zealand, about 8% compared with Hutton's (1970) higher estimate for the crop, and about 4% compared with irrigated lucerne.

Cuthbertson (1969), Shorland (1969) and Lawrie (1971) have drawn attention to the valuable sources of protein, and other nutrients, lost as human food during the processing of meat animals. Locker (1968, 1969) advocated development of a co-ordinated protein technology unit for New Zealand to produce large quantities of low-cost protein, including extraction of protein from viscera (Stafford and Cameron, 1965), blood (Tervit, 1969) and factory wastes (Grant, 1968).

Marginal improvement in protein output from the beef system described (Fig. 1) can be sought by including the protein content of viscera and blood derived from the cattle killed. Figure 1 indicates that the highest level of combined protein output of 145 kg/ha/annum was derived from 6.2 F × F steers/ha; this represents about 14% of the average yield expected from soya beans grown in New Zealand (Gerlach *et al.*, 1971).

It is, however, also important to remember that consumer acceptance needs to be satisfied; and consumers, in developed countries at least, eat beef and not protein.

This recognized biological inefficiency of beef production has led some authorities (*e.g.*, Mehren, 1968) to suggest that, in future, man may not be able to afford to feed primary plant foods to cattle to obtain such a secondary product as beef. Other authorities (Duckham, 1968; Blaxter, 1968; Reid, 1969; Cuthbertson, 1969; Hutton, 1970; McMeekan, 1971) advance equally, or more convincing arguments, that much of the earth's surface can only be utilized for production of food for human consumption by grazing it with livestock. The validity of this latter view for New Zealand, with relatively little cultivable land in relation to the total land area, is patently obvious. It is only through the ruminant that crops, including grass, crop residues, various by-products and waste-products (Anthony, 1969) can be readily converted into human food. Cattle possess the unique qualities, as ruminants, for hydrolizing cellulose and hemicellulose; they can synthesize protein from ammonia and carbon chains, and undertake synthesis of vitamin K and the B-complex vitamins. All these attributes lend support to the thesis that, far from being gradually reduced in numbers, there is a good case for more ruminants in protein production. Reid (1969) also advances the view that the low feed conversion efficiency of beef-producing cattle would make them the last species of domesticated animals to receive feeds surplus to human requirements; a situation he envisages for the future. This may be sound reasoning, but in no way diminishes the usefulness of cattle as beef protein producers from grazing areas unsuitable for cropping or supporting milk-producing cattle, areas that would otherwise not produce even 1 g of protein for humans.

ECONOMIC EFFICIENCY OF PROTEIN PRODUCTION FROM BEEF

In economic terms, beef is one of the most expensive sources of protein available. The development of meat analogues (reviewed by Sault and Gale, 1970) as alternatives to animal protein including beef has assumed importance; and the simulated meats are at competitive prices (Meyer, 1971; Spicer, 1971).

Thus, it is becoming increasingly difficult to justify the economic value of beef as a protein food as compared with others at a substantially lower price.

BEEF AS A HUMAN FOOD

Leaving aside the value of cattle for harvesting protein from crop residues, by-products and land that would otherwise be wasted, it is quite clearly untenable to propose that beef protein production should be continued if only biological and economic criteria of efficiency are used.

Beef is valued by humans for reasons other than, or in addition to, its protein content. First, beef prices in developed areas have risen at a faster rate in the past 20 years than general cost-of-living indexes, and today beef stands at record price levels. Affluent people are apparently prepared to pay for beef as a luxury food. Secondly, world production of beef and veal (over 38 million tons in 1970) has increased at an average rate of nearly 5% per annum over the past 20 years (FAO, 1970) with substantial financial and technological inputs (McMeekan, 1971). Thirdly, projections for the world surplus and demand for beef, shown in Table 3, reveal a marked increase in projected demand over the next decade to create a dramatic short-fall by 1980 (FAO, 1971).

The largest foreseen deficits lie in the United States, United Kingdom, EEC, Russia and Japan, New Zealand's present major customers. Importantly, these are affluent countries.

Humans attach great significance to the consumption of animal products, especially beef. Organoleptic satisfaction is important for consumers and beef consumption serves as a status symbol or a gain in social prestige in many parts of the world (Abbott, 1966). Beef consumption is closely allied to affluence, a factor seen in beef demands projected for different countries (Table 3). Although theoretically an adult can live on cereals, supplemented by a mixture of vegetable proteins, the biological value of dietary proteins is enhanced by intake of meat (Lawrie, 1971). Apart from its amino acid composition, beef supplies other nutrients and improves food flavour

TABLE 3: PROJECTED BEEF SURPLUSES AND DEMANDS ('000 tons)

Region	*1970*	*1980*	*Increase*
		Surplus	
Argentine	650	1346	696
Australia	320	453	133
New Zealand	170	274	104
Ireland	290	369	79
World total	2575	3490	915
		Demand	
U.S.A. and Canada	710	1198	488
EEC and U.K.	1055	1490	435
U.S.S.R. and China	115	1218	1103
Japan	25	166	141
World total	2252	5128	2876

Source: Adapted from FAO (1971).

and taste — even in hamburgers. To the dismay of academic nutritionists people eat beef rather than diets. Acceptance of a food is vital if it is to be eaten. Religious, cultural and social dictates cannot be ignored while familiarity with the food and economic acceptability may determine the level of demand (Gordon, 1970; Pirie, 1970). Demand may also be modified in the future if the association between the concentration of saturated fatty acids in meat and cardiovascular diseases in man is proven (Lawrie, 1971).

The most efficiently produced foods, because of their relatively low cost, will not necessarily be preferred to less efficiently produced, more costly, perhaps unaccustomed, items. As the standard of living rises so also does the ability to pay for quality foods (Wilson, 1968). Expensive beef has to be considered as a human food as compared with the low cost protein produced from plants (Pirie, 1970) or single-celled organisms (Walker, 1971).

The cost of beef as a food represents the greatest problem for the future. Parpia (1968) drew attention to the fact that about 71% of the world human population lives in the economically less-developed regions. They produce some 42% of the world's food but earn only 21% of the world's income. Their problem, therefore, is not simply that they need more food; they also need more nutritious and less expensive food. For the developed countries, Marks (1971) recognized that the biggest question mark for the future of beef was also cost. He asks, "Given the likely very buoyant demand in the next decade or two, will people be able to afford to eat it?"

The rapidly rising costs of beef as a food spell danger ahead as far as competition from meat analogues is concerned (Hutton, 1970). Spicer (1971), discussing meat analogues, stated recently, "Where beef is available at a price people can afford, [analogues] will not supplant it but form an alternative in the increasing protein food market".

SOME FACTORS INFLUENCING THE EFFICIENCY OF BEEF PRODUCTION

Beef as a luxury food at the consumer stage represents the end product of a complex chain of production, processing and marketing events. Each stage is susceptible to efficiency characteristics and costs. These factors determine the product cost to the consumer. Thus, it is appropriate that some aspects of efficiency should be examined, with particular reference to selected factors operating at the production level in the New Zealand pastoral scene.

Cattle fail to achieve their biological potential because of numerous biological and economic constraints including, for example, reproductive efficiency; longevity; generation interval; growth rate and feed conversion efficiency; feed costs; and environmental adaptation (Wilson, 1968). Ultimately, all these factors determine the level of muscle and protein production from a particular management system.

Muscle Growth and Meat Production

Muscle (and protein) production in beef cattle tends to increase after birth reaching a maximum rate and then declining as age, weight and fatness continue to increase (Anon., 1966). The percentage of protein in beef falls as the percentage of fat increases (Callow, 1951). The most efficient production of muscle will be obtained by maintaining deposition at the maximum rate up to the point of natural decline when the animal is best slaughtered (Lodge, 1970). But the definition may need extending to cater for consumer requirements by addition of a defined proportion of fat to form a saleable, edible product. Thus, the animal should be slaughtered when the minimum degree of fatness necessary for consumer satisfaction has also been achieved. This minimal fatness level varies; Callow (1951) determined that the acceptability of 12th rib roasts from steer and heifer carcasses increased with boneless beef fat content up to 40%, and then declined.

Breed Effects on Meat Production

Breeds differ in muscle production when compared at a common age and, to a lesser extent, at a common carcass weight. These differences reflect rates of maturity and therefore age, too, has an important influence.

Much published information on breed differences in meat production is not very informative because the growth curve has not been studied. Comparisons have generally been made at a single slaughter point; sometimes a fixed weight; sometimes a fixed age; sometimes at a fixed, subjectively assessed state of fatness; and sometimes a combination of criteria.

Everitt *et al.* (1970) summarized most of the available New Zealand information on breed differences in growth rate and carcass composition. Breeds of large mature size and rapid liveweight gain tend to produce high meat

TABLE 4: BREED EFFECT ON PROTEIN PRODUCTION — CONSTANT AGE

Character	*Breed*	
	Friesian	*Angus*
Age (days)	520	520
Slaughter LW (kg)	411	352
Mean daily LW gain (kg/day)	0.79	0.67
Carcass wt (kg)	213	184
Meat wt (kg)	139	126
Meat gain/day of age (g/day)	267	242
Meat protein (kg)	31	28
Meat protein/day of age (g/day)	60	54

Note: Corrected for sex effects.
Adapted from Hight *et al.* (1971).

yields at commercial slaughter weights. Theoretically, high growth rate breeds should be efficient food converters into lean meat but this needs to be established under New Zealand conditions in such a manner as to allow the relevant section of the growth curve to be determined.

In general, dairy-bred animals, like the Friesian, record a lower meat:bone ratio but higher meat:fat ratio than traditional British beef breeds, such as the Angus, when killed at the same age. Table 4 compares the meat and protein productions of the Friesian and Angus breeds when reared together and killed at a constant age. Friesians grew appreciably faster than Angus and produced more meat and protein per day of age. Relative feed costs for the two breeds were not established.

Heritabilities of liveweight growth within cattle breeds have been calculated but the genetic variability and heritability of meat production itself need determining. Consumers eat beef, not liveweight gain. Harrington (1971), using the data of Cundiff *et al.* (1969, 1971) on 503 steer progeny of 75 sires of Angus, Hereford and Shorthorn breeds, examined some of these points. Selection for increased saleable meat per day of age in one generation showed an appreciable response in carcass weight but also a more marked response in the proportion of saleable meat. At the same age, carcasses would be marginally leaner than those in which selection was based on carcass weight, but if the animals were killed at younger ages and the benefits of selection taken in terms of quicker growth to similar carcass weights, the percentage yield of meat from the carcass would be substantially increased.

Harrington (1971) stresses that the benefits of selection for greater weight-for-age should be taken largely in the form of additional saleable meat per animal, rather than by slaughtering marginally leaner animals at the same weight and younger age, provided that the carcass weight remains within an acceptable range for the trade. A programme aimed at selecting for actual saleable meat yield per day of age or per unit of feed will cost more than those procedures using liveweight gain alone. Perhaps the answer lies in performance testing for liveweight gain, followed by a progeny test for saleable meat per day of age.

Sex Effects

Appreciable differences between sexes exist in the rate of muscle production (Lodge, 1970). The differences are comparable with those between breeds of different mature size; the male, like the late maturing breeds, grows faster and produces more muscle than the female (equivalent to earlier maturing breeds) at commercial slaughter weights. Much greater use of intact males in efficient beef production has been strongly advocated (Cooper, 1969).

Data to illustrate differences between bulls, steers and heifers are regrettably short in New Zealand. In one Ruakura trial (Everitt, unpubl.) cull Jersey cows each suckled two Charolais × Jersey (C × J) bull or steer calves from birth to weaning at 270 days of age. The crossbred animals were killed as they attained 364 kg (800 lb) liveweight. The stocking rate was one cow plus 2 calves per acre up to weaning, and 2 calves per acre from weaning to slaughter.

Table 5 records some results and shows that bulls reached slaughter weight 20 days, on average, earlier than

TABLE 5: MEAT PRODUCTION FROM BULLS AND STEERS

Character	*Mean* *Bulls*	*Steers*	*Diff.* ± *S.E.* *(Bulls — Steers)*
No. of animals	12	12	—
LW at slaughter (kg)	368	362	6 ± 11
Age at slaughter (days)	439	459	20 ± 4***
Carcass wt (kg)	184	182	2 ± 3
% meat	67.2	63.6	3.6 ± 1.1***
Carcass wt/ha/annum	756	703	53
Meat wt/ha/annum	524	463	61

Source: Everitt (unpubl. data).
S.E. = standard error; *** $P < 0.001$.

steers. Bulls produced more meat/ha/annum than steers due, in part, to a higher meat yield in the carcass for bulls (67.2%) compared with steers (63.6%).

CONFORMATION EFFECTS

It has almost become a scientific vogue to dismiss the effects of shape or conformation as a factor influencing efficiency of beef production. A degree of caution is advocated.

Carcass cutting tests show that the factors affecting the relative realization values of carcasses in decreasing order of importance are the amounts of excess fat removed, the bone content and the distribution of saleable meat (Harrington, 1971).

In a biological sense, the distribution of musculature in cattle is remarkably constant even in radically different types of animals. This has been shown in laboratory dissections (Butterfield, 1965) and in commercial cutting procedures (Everitt *et al.*, 1969; Everitt and Evans, 1970). But variation does exist, even though small in relation to other sources of variability. However, these small variations in meat distribution can represent large sums of money to the meat trade. Everitt *et al.* (1969) emphasized that C × J cross cattle yielded not only about 4.5 kg more saleable meat (at a constant carcass weight) than any of the other 7 breeds and crosses compared, but (at a constant total weight of meat) an additional 0.91 kg in the high-priced cuts region. At current beef values the superior distribution of meat in C × J cattle represents approximately $2/head. Likewise, it was shown that heifers tended to yield proportionately more high-priced meat than steers. These are important economic effects which it may be wise to build into a progeny test selection programme as a bonus to high meat yield per day of age.

SLAUGHTER WEIGHT EFFECTS

Muscle, and thus protein, production tends to be weight dependent rather than age dependent. Table 4 showed that cattle of the same age, but differing in weight, differed in protein production. Table 6 indicates that breeds and sexes of cattle of the same weight, but different age, did not differ appreciably in protein production. Heavier animals produced more meat and protein than lighter animals. Guenther *et al.* (1965) recorded comparable effects for Hereford cattle.

TABLE 6: BREED, SEX AND SLAUGHTER WEIGHT EFFECTS ON PROTEIN PRODUCTION — VARIABLE AGE

Character (kg)	*Steers*				*Heifers*	
	Friesian		*Angus*		*Angus*	
Carcass wt	114	250	114	250	114	250
Meat wt	76	174	80	177	79	174
Protein wt	17	38	18	39	17	38

Source: Everitt (unpubl. data).
Based on regression analyses of 143 Friesian steers, 289 Angus steers and 109 Angus heifers.
Carcass wt = frozen carcass wt *minus* internal fats.

But, as Lodge (1970) points out, muscle production tends to decline as age and weight increase. In Hereford and Friesian cattle, for example, the proportion of muscle in the carcass increased from birth to about 5 months of age, remained relatively constant to 12 months of age and then declined to 17 months of age as fat deposition increased (Anon., 1966).

It is important that muscle growth curves for different breeds and sexes of cattle under different management systems should be established.

EFFECTS OF CARCASS FATNESS

The present efficiency level of beef production suffers markedly from ill-defined and some inappropriate requirements at the carcass and meat stages. This has a profound effect upon breeding strategies and effective employment of nutritional resources.

Existing beef carcass grading and producer payment systems in New Zealand (Everitt and Evans, 1970) tend to disregard the principles of maximizing muscle and meat production discussed earlier. Excessively fat animals receive the same financial reward as leaner ones of the same weight within the same carcass grade. The feed cost of the fat excess to consumer needs militates against high output of beef and protein per acre.

Table 7 offers a more rational approach to improving the present subjective criteria used for selecting animals for slaughter. Using equations developed by Everitt and Evans (1970), based on large numbers of steers and heifers of different breeds and crosses, the predicted meat yields at different carcass weights and fatness levels have been derived. Meat yield increases as carcass weight increases, and yield decreases as fatness increases.

Arbitrary minimal fatness levels for varying consumer requirements, specified by the carcass grades, can be defined by measurement of fat thickness over the loin. Producer payment for individual animals, based on the yield values shown, with the highest prices being offered for carcasses of least fatness within a grade, can be envisaged as a practical system.

Nutritional Effects

One aspect only of the complex effects of nutrition on meat and protein production by beef animals will be considered. In a pastoral system of beef production, stocking rate is a major determinant of physical output per unit area of land, output per animal, and also economic profitability. Unfortunately, attainment of these characteristics tends to be antagonistic.

Figure 2 records the net meat production per unit area of land and per animal for the beef system discussed earlier in which weaners enter the system at 4 months of age and are killed at approximately 16 months of age.

Increasing the stocking rate from 3.7 to 4.9 to 6.2 steers/ha increased net output/ha/annum, but at a declining rate of increase, and with differences between the breeds. On the one hand, the F × F output increased by 12% from 3.7 to 4.9 steers/ha, but only by 4% between the latter stocking rate and 6.2 steers/ha. The J × J, on the other hand, increased by 23% between 3.7 and 4.9 steers/ha and by 17% between 4.7 and 6.2 steers/ha. Output from the heavier F × F breed, with higher food costs for maintenance, was clearly being affected more than the smaller J × J over the stocking rates employed; with the F × J occupying an intermediate position.

Performance per animal (Fig. 2) declined sharply as the stocking rate increased, with noticeable differences between the breeds. At 3.7 steers/ha the average carcass weight of F × F steers was 47% heavier than J × J steers; but at 6.2 steers/ha F × F steers were only 23% heavier than J × J steers. Production per animal is important in beef production, contrasting with efficient milk production. Meat processors discriminate against light weight carcasses, because of the overhead costs of killing and processing and because of the small meat cuts derived.

This paradox of grassland beef production remains an important and unresolved problem. The work of Conway (1968) in Ireland and others (Joblin *et al.*, 1970) indicates ways to achieve higher output per animal and per area

TABLE 7: PREDICTED MEAT YIELD PERCENTAGES ACCORDING TO CARCASS WEIGHT AND FATNESS — SAMPLE VALUES FOR STEERS AND HEIFERS

Carcass Wt Range (kg)	*Depth of Fat over 12th Rib (mm)*																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
138-143	71.9	71.4	70.8	70.2	69.6	69.1	68.5	67.9	67.4	66.8	66.2	65.7	65.1	64.5	63.9	63.4	62.8
184-189	71.9	71.5	71.1	70.7	70.2	69.8	69.4	68.9	68.5	68.1	67.6	67.2	66.8	66.3	65.9	65.5	65.0
229-234	72.0	71.6	71.3	70.9	70.6	70.2	69.9	69.5	69.2	68.8	68.5	68.1	67.8	67.4	67.1	66.8	66.4
275-280	72.0	71.7	71.4	71.1	70.8	70.5	70.2	69.9	69.6	69.4	69.1	68.8	68.5	68.2	67.9	67.6	67.3
320-325	72.0	71.7	71.5	71.2	71.0	70.7	70.5	70.2	70.0	69.7	69.5	69.2	69.0	68.7	68.5	68.2	68.0
365-370	72.0	71.8	71.5	71.3	71.1	70.9	70.7	70.4	70.2	70.0	69.8	69.6	69.4	69.1	68.9	68.7	68.5
Carcass Grade	Boner			Y.A.Q.			F.A.Q.					G.A.Q.					

Note: Derived from data of Everitt and Evans (1970).
Carcass wt = frozen wt *minus* internal fats.
Meat yields based on standard specifications for cutting and fat trim.

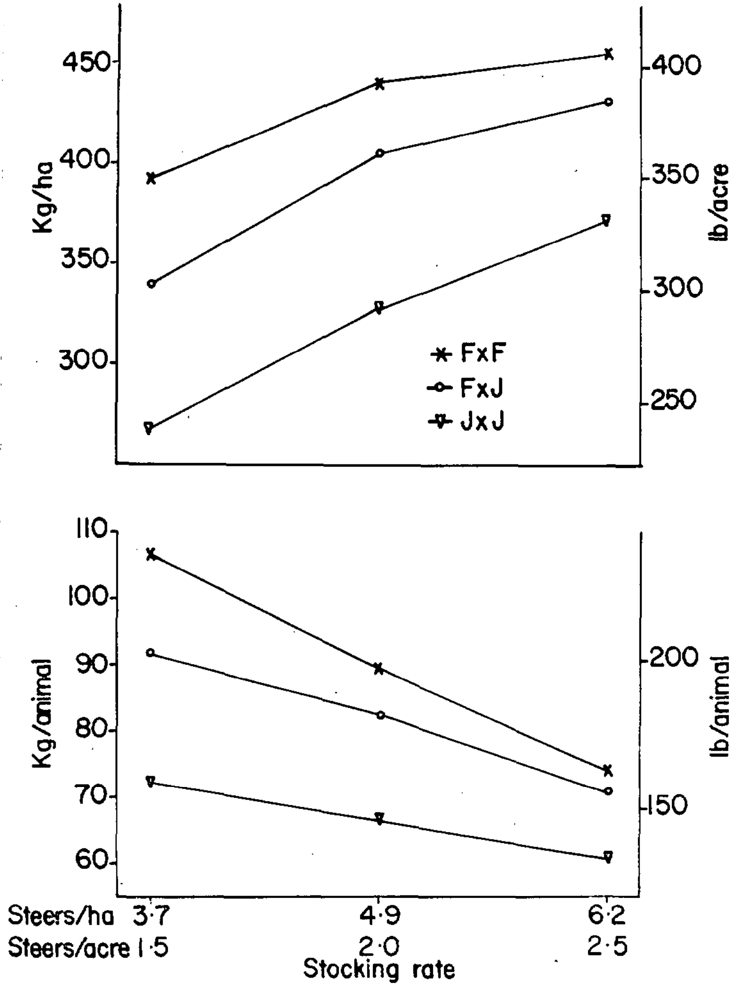

FIG. 2: *Net meat production per unit area of land per annum and per animal by three breeds at three stocking rates.*

by, for example, reducing the stocking rate as the season progresses, or feeding supplements at high stocking rates, and conserving high-quality digestible feed for periods of feed shortage. This problem diminishes if the sole criterion of beef production is protein and not meat per unit area of land.

Economic Effects

Joyce *et al.* (1969) showed that the financial gross margins per unit area of land decreased as stocking rate increased in a beef production system involving weaner F × F steers taken to approximately 200 kg carcass weight. The high stocking rate used (6.2 steers/ha) exceeded the level of self-sufficiency in relation to the amount of pasture grown.

At a given level of feed resources, breeds differing markedly in body size and maintenance requirements (Fig. 2) will exert a marked effect on profitability.

CONCLUSIONS

It has been established, first, that beef production is a grossly inefficient method of producing protein for humans; secondly, that beef protein is very expensive; but, thirdly, that beef is eaten because humans like to do so provided they can afford it.

The world demand for beef is great and increasing. New Zealand, particularly, as a relatively low-cost producer and exporter, is offered attractive opportunities in helping to satisfy this demand. Failure to supply the quantities needed at reasonable prices will undoubtedly encourage further development of alternative foods such as meat analogues, and in the longer term diminish the market size and financial attractiveness of beef production.

Many factors at the farming level of beef production are open to substantial improvement in efficiency. The most vital area of inefficiency lies, however, in the carcass grading and payment system because of the reflections back into the production sphere of operations. Recognition of these deficiencies and initiation of corrective action is needed.

Protein for humans can be efficiently derived from several crops suitable for New Zealand conditions. Developments in this area should be regarded as complementary, not antagonistic, to animal production generally, and beef production particularly. Much more research is needed to examine the use of crop by-products and "waste" products from factories as sources of fodder for beef animals. A more integrative approach to animal production is required.

A speculative but rational approach to the future may now be sketched. Attention was drawn, first, to the high efficiency of the dairy cow in deriving protein for humans as far as animal production is concerned. Secondly, beef production is appreciably more efficient from a "dairy beef" than a "beef beef" system, reflecting the gross inefficiency of beef breeding cows. Thirdly, a high proportion of land in New Zealand is suitable only for grazing dry stock intended for beef or dairy herd replacements.

Considered jointly, these three factors suggest that the 1.5 million beef breeding cows in New Zealand should be markedly reduced and replaced by a proportionate number of beef stock derived from a greatly enlarged dairy herd. The present level of 2.3 million dairy cows in-milk could be increased by 100%, either by doubling the present average stocking rate for dairy cows or by doubling the land devoted to dairying. In practice, a compromise might be sought.

The number of calves surplus to dairying requirements and suitable for beef would thus increase proportionately. These stock, of course, could be derived from a sophisticated, easily implemented artificial breeding service based on a small number of bulls, progeny tested and selected for high growth rate and meat yield propensities. These dairy beef stock, plus a high proportion of dairy herd replacements, would be grazed on land presently occupied by breeding beef cows. The dairy beef stock would be fattened, in the terminal stages, to a minimal level of fatness consistent with defined consumer requirements, through integrated and effective employment of crop byproducts and factory wastes in low-cost feed systems. The producer in this enlightened age would be paid for the meat produced.

Finally, it is suggested that a pilot experimental plant should be established which would attempt to integrate protein of plant origin with beef into high-protein, low-cost, compound foods. New Zealand can produce the raw protein materials but needs to acquire expertise and technology in their most effective employment.

A greatly enlarged output of protein for humans from the pastoral and cropping lands of New Zealand, principally in the form of milk-based products, beef and beef compounds, can be envisaged by such means.

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