TWO HUNDRED AND TWENTY-FIRST SCIENTIFIC MEETING
EIGHTY-EIGHTH SCOTTISH MEETING
GLASGOW AND WEST OF SCOTLAND COLLEGE OF DOMESTIC SCIENCE, GLASGOW

25 APRIL 1970

THE FUTURE OF ANIMALS AS SOURCES OF HUMAN FOOD

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Animals for food

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Food and population

In this paper an attempt is made to outline the background to the use of animals for food production. Everyone is familiar, at least at the superficial level, with the world food problem, the conflict between increasing population and the capacity of agriculture to produce the extra food needed. In broad terms, one-fifth of the world, the temperate regions, is, on average, well fed, while four-fifths, mainly in the tropics and subtropics, are, on average, poorly fed. It is quite likely that the apparent association between economic wealth and a high level of agricultural output is important. As Rostow (1960) in *The Process of Economic Growth* pointed out, the conditions for economic 'take-off' and sustained economic growth usually depend on a high level of agricultural productivity, and the transfer of labour to industry. The food problem therefore tends to arise in the low income countries where agricultural technology is at a low level (Bunting, 1970).

Recent trends in food production and population have been summarized by FAO (1969). In all the developing regions, food production has hardly kept pace with the rate of population growth and food per head of population has remained stable, at best, or even fallen slightly in the last decade. In the so-called 'developed' countries, agricultural technology is much further advanced but, because of other limitations, food production has grown at the same average rate of 2·7% per annum as in the developing countries. However, since population growth was much lower in the developed countries, food production per head has risen from an index figure of 102 in 1957 to 122 in 1967.

The rate of population growth is a vital component of the equation, and Bentley (1968) indicates that if the current rate of increase in agricultural production continued but the rate of population growth was halved, the world food problem would in global terms be solved. At the other extreme, Abercrombie (1969) points out that the present growth rate of 2·6% per year could result in a population of 47 000 million in 125 years. The difficulties of forecasting both population growth and rates of increase in food production are well known. Any long-range forecast is suspect. One can only hope that the current emphasis on the subject will be beneficial.

If difficulties arising from hunger and malnutrition are solved, of course, other (economic) problems may arise; the food surpluses in the USA and the European Economic Community, and the apparently ridiculous policies adopted to deal with them are examples.

The food situation in selected countries

Careful analyses of the food situation in the majority of the countries of the world are given by FAO (1969). The errors of such estimates, and the wide variations around the average values, are well recognized. Nevertheless, the average diets for Ceylon, Jamaica, Pakistan, Uganda and the United Kingdom are shown by way of illustration in Table 1.

Table 1. *Average national diets*

Country	Date of estimate	Energy per d (kcal)	Total protein per d (g)	Protein calories (% of total calories)	Animal protein per d (g)	Animal protein (%)
UK	1967–8	3150	87·5	11·4	53·8	61·5
Ceylon	1967	2170	48·0	9·1	8·3	17·3
Jamaica	1966	2260	52·6	9·5	18·7	35·6
Pakistan	1966	2230	51·5	9·5	11·2	21·8
Uganda	1961–3	2070	50·1	9·9	10·2	20·3

In the UK the average calorie and protein intake agrees with accepted norms (Ministry of Health, 1969), 11% of the energy is derived from protein and 62% of the protein is of animal origin. In all the other countries listed, which are typical of most of the developing countries, calorie intakes are low, protein provides about 9% of the calories and animal protein supplies from 17 to 36% of the total protein.

These average diets may be less deficient than is at first apparent, since adult energy requirements in tropical countries are of the order of 2500 kcal/d (Clark 1970) and, as Bender (1969) has pointed out, an adult diet requires no more than 6% of the calories in the form of protein, and mixed vegetable proteins can be of equal value to animal proteins. His views are supported by the recent report of the United Nations Economic and Social Council (1968) on *The Protein Problem*, but it stresses that diets of low protein percentage are adequate only when sufficient food is eaten to meet calorie requirements.

Averages, however, notoriously fail to reassure individuals. When ignorance and poverty lead to maldistribution of food between groups, or even within the family, severe malnutrition can occur. As the United Nations Economic and Social Council (1968) report says 'If the staple foods of a country are relatively poor sources of protein, such as maize or rice, or very poor sources such as cassava (manioc), sago or plantains, young children are unlikely to obtain the quantity and quality of protein they need' and it continues 'this lack of proteins of sufficient quality is particularly likely to arise during infancy at the time of weaning from breast milk . . . the protein problem is most frequent and severe among the children of poor families particularly where the staple foods are poor sources of protein'. The importance of adequacy of the protein supply for young children and the possibility that deprivation may have a permanent adverse effect on their mental development is now widely accepted.

The need for animal production

While the purist may argue that there is no protein problem, the difficulties arising from lack of education and distribution explain why many developing countries are attempting to implement programmes for increased protein production. FAO (1964) suggested that by the year AD 2000, a threefold increase in total protein supplies and a fivefold increase in animal protein supplies would be needed in the developing countries. The protein food programmes therefore often include encouragement for improved animal production and such activities are often supported by international organizations. Moreover, the value of animal products as sources of other nutrients especially minerals and (within limits) fats must also be recognized.

Apart from nutritional considerations, the consumption of animal products is often regarded as a measure of status and indeed some animal production programmes might be criticized as prestige projects. However, so long as Western civilisation is associated with a high level of consumption of animal products, any suggestions by Westerners that vegetable protein would be equally nutritious and more efficient in developing countries are bound to be treated with some suspicion.

There is, therefore, a need to equate population and food supplies so as to improve the protein intake especially for young children, and there is a demand in many countries that much of this protein be derived from animal sources.

Elasticities of demand

A measure of the demand for products is given by the economist's income and price elasticities which measure the amount by which demand for a product changes with change in income or price of the product. Income and price elasticities for foodstuffs are calculated for the UK by the National Food Survey Committee (e.g. Ministry of Agriculture, Fisheries and Food 1967, 1969). In general, they show that as income rises the demand for the higher-quality animal products also rises while that for cereal staples tends to fall. All foods are sensitive to price; but the demand for carcass meat falls more markedly with rising prices (price elasticity −0·89) than it does for potatoes (−0·08) which are regarded as a more staple food. Readers interested in this complex field should consult recent reports of the National Food Survey Committee. Whether elasticities calculated in the UK are applicable in developing countries is, of course, doubtful and consumer goods are often preferred when incomes rise (Clark, 1970).

The efficiency of farm animals as food converters

The following speakers will refer to the peculiar advantages and disadvantages of various species but some indication of their relative merits and a comparison of animal and vegetable food crop production might be of interest.

The efficiency with which farm animals convert feedstuffs into food for man has received much attention and many (sometimes conflicting) values have been quoted (e.g. Leitch & Godden, 1953; Holmes & Jones, 1964; Coop, 1967; Blaxter, 1969; Spedding, 1969). In any such estimates it is essential that the numerator and the denominator of the fraction, and the time-scale be clearly defined. Table 2 shows estimates recently prepared by Holmes (1970), which refer to self-sustaining populations producing at reasonable levels of farm performance on normal diets in the UK. Efficiencies are lower in tropical conditions, especially for ruminants (Holmes, 1962).

Table 2. *Feed efficiency in whole farm situations*

	ME* (%)	GE† (%)	Protein‡ (%)	Protein (g/ Mcal ME)§	Protein (g/ Mcal GE)¶
Dairy herd	21	12	23	10	5·4
Dairy+beef herd	20	11	20	9	4·7
Beef herd	7	4·5	6	2·6	1·5
Sheep flock	3	1·7	3	1·3	0·8
Pig herd	23	17	12	6	4·0
Broiler flock	13	10	20	11	7·7
Egg flock	15	11	18	11	8·0

Each enterprise allows for replacements.
*(Edible energy × 100) ÷ (total metabolizable energy consumed).
†(Edible energy × 100) ÷ (total gross energy consumed).
‡(Edible protein × 100) ÷ (total food protein consumed).
§(Edible protein (g)) ÷ (total metabolizable energy consumed (Mcal)).
¶(Edible protein (g)) ÷ (total gross energy consumed (Mcal)).

Five possible criteria are used; edible energy as a proportion of gross or of metabolizable energy in the food eaten and edible protein as a proportion of the digestible protein in the food eaten are self-explanatory. The use of protein per unit of gross or of metabolizable energy is based on the suggestions of Blaxter (1967) and Kielanowski (1967) that energy supply generally limits animal production while animal protein and the nutrients associated with it are the main nutritional justification for the farmers of livestock. The results in Table 2 indicate that for energy conversion the pig excels, closely followed by ruminants with their production of milk, or milk and beef, then by poultry and finally by the breeding ruminant typically found on land of low agricultural potential. There is a similar ranking for efficiency of use of protein except that the pig falls behind poultry. However, in terms of protein production per unit of metabolizable energy, poultry slightly exceed milk production and the pig occupies an intermediate position. Poultry excel in terms of protein per unit of gross energy. None of the values in Table 2 is absolute, they depend on the levels of performance assumed. However, they agree closely with independent estimates by Reid (1970).

https://doi.org/10.1079/PNS19700052 Published online by Cambridge University Press

By all measures, Table 2 shows the relative inefficiency of sheep and cattle breeding enterprises where the cost of maintaining the dam for a year is a charge on the product (compare the sow with fifteen to twenty progeny per year).

In any comparison between species it should be remembered that the non-ruminant consumes a smaller proportion of the whole crop. This is reflected in Table 3.

The farmer is interested not only in nutritional efficiency but in making the best use of capital and labour. In general, the return on tenants' capital is positively correlated with feed efficiency but lower feed efficiencies may be acceptable where land is cheap. Where labour is dear it is sometimes justifiable to sacrifice feed to save labour.

Food production per unit area

On the basis of Table 2 and representative crop yields, it is possible to compare different methods of livestock production in terms of output per unit area and also to contrast them with crop production. This information is in Table 3. Tropical estimates were given by Holmes (1962).

Table 3. *Annual yields from animals and from crops*

	Energy (Mcal/ha)	Protein (kg/ha)
Dairy cows	2500	115
Dairy+beef cattle	2400	102
Beef cattle	750	27
Sheep	500	23
Pigs	1900	50
Broilers	1100	92
Eggs	1150	88
Wheat	14000	350
Peas	3000	280
Cabbage	8000	1100
Potatoes	24000	420

The results agree in general with those of Middleton (1923), Schuphan (1965), Holmes (1966) and Duckham & Lloyd (1967) in showing that crop production is superior to any form of animal production in food production per unit area. It is on such grounds that claims have been made for vegetable food production (Lucas, 1968; Pirie, 1969); doubts have been expressed for the future of animal production (Morley, 1969) and as yet far-fetched proposals for the industrialization of photosynthesis have appeared, not only in science fiction (e.g. Pohl & Kornbluth, 1965) but in serious works (Calder, 1967). Virtanen (1969) has also referred to possible applications of industrial materials such as urea to food production and there are frequent popular reports of new industrial sources of protein. The improvement of or replacement of photosynthesis by biochemical engineering is not yet on the horizon and indeed was dismissed (perhaps too abruptly) by the Agricultural Research Council Working Party on the Forward Programme (Agricultural Research Council, 1969), but some of the industrial processes will gradually develop. Competition from vegetable foods is, however, already present in the form of so-called 'analogue' foods, 'meats' and 'milks' made from vegetable products. The soya bean appears to be the most suitable raw material and, on the basis of a yield of 2000 kg beans/ha, a yield of 600–800 kg edible protein/ha can be obtained (these yields should be halved for tropical conditions). This material is competitive in price with the cheaper meats in the USA and it is estimated that 5% of the meat market may be claimed by such products in a few years. A similar product (based on imported material) is available to the catering trade in Britain at attractive prices and it appears to be of high nutritive value. The wider adoption of soya-based 'milk' products is also possible. The availability of soya products will depend on terms of trade and on the extent to which artificial barriers to trade are raised. At present, soya analogue foods are the product of a sophisticated industry and, although they might compete in terms of cost with indigenous protein foods, they might increase rather than lessen the dependence of developing countries. However, local processing of local protein crops may develop in the future. High-protein cereal varieties, e.g. Opaque 2 maize, may also become more popular.

The possibility of vegetable protein extraction on a home- or village-scale has been outlined by Pirie (1969) and deserves further study, but problems of palatability and acceptability have not been overcome and the nutritive value of extracted leaf protein requires critical evaluation.

The role of the animal

Although vegetable food production has many attractions there is still considerable scope for the animal.

The ruminant animal harvests forage from unploughable land which accounts for a large proportion of many countries. Ruminants can also help to maintain fertility of ploughable land by utilizing sown pastures and they can utilize many by-products of arable farming, such as straws, haulms, sugar-beet tops, industrial residues such as brewers' grains, sugar-beet pulp, molasses, distillers' grains and organic acids as well as surplus grain. The ruminant also provides a means of employment and of converting cheap feedstuffs into products which are more expensive and more attractive to many people. Small-scale animal production may be of considerable benefit to many tropical populations.

The non-ruminants, the pig and various fowls generally require a more concentrated diet although they can make some use of roughages and of by-products. The diets which are commonly offered to the non-ruminants include many materials of immediate value for human food. Clark (1970) suggests that only when the production of grain equivalent is in the region of 750 kg per head of population is the feeding of grain to non-ruminants justifiable. The importation to poor tropical countries of such foods for intensive pig and poultry industries must therefore be questioned from the point of view of the national economy, although they may supply a luxury product for the upper 5% of the population and yield a satisfactory profit to the entrepreneurs. Reid (1970) has suggested an order of priorities for the allocation of surplus cereals and oilseed products to animal production, with pigs taking precedence followed by poultry, milk production and, finally, meat-producing ruminants.

Other aspects of land use

It is common for nutritionists to regard food production as the major reason for land use. However, in the developed countries, if food production technology continues to exceed the rate of population growth, there will be increasing pressure to devote land to other 'conservation' or recreational activities.

In tropical lands, large areas have in the past been devoted to plantation crops such as cotton, groundnuts, oil palm, cocoa, tobacco, rubber and sisal for export. These crops not only occupy land which could produce food but they also concentrate rural populations. While, in theory, export crops could pay for food imports, they tend to be used to pay for other industrial imports and to reduce the area for food production.

Conclusion

A comprehensive consideration of the world food problem is extremely complex. There are, however, undoubtedly groups in many parts of the world which are undernourished or malnourished.

An increase in crop production is undoubtedly the quickest way of improving this position but alternative methods of increasing food production and protein production through animals are not necessarily competitive. Unless population growth can be halted all will be required. The situation when man might be obliged to eradicate all animals is still far in the future if it ever does occur (Harsany, 1967). The gradual expansion of animal production in conditions where climate and economic environment are favourable will therefore almost certainly contribute to human well-being and be of benefit to the community at large.

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Domesticated ruminants as sources of human food

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Domesticated ruminants account for about half the world's production of meat and virtually the whole of its production of milk. The most recent statistics on world production of carcass meat, milk and eggs are summarized in Table 1 from

Table 1. *World production of livestock products in* 1948–52 *and in* 1967* (*FAO*, 1969*b*)

	Tg (millions of metric tonnes) per annum 1948–52	1967
Meat, dressed carcass weight excluding offal		
Beef, veal and buffalo	20·3	36·7
Mutton, goat and lamb	3·9	6·3
Total ruminant meat	24·2	43·0
Pork	16·3	33·6
Poultry (dressed carcass)	4·2	11·8
Total non-ruminant meat	20·5	45·4
Milk (from cattle, goats, buffalo and sheep)	261·3	389·1
Eggs	9·4	16·1

*Estimates had to be made of poultry meat production in mainland China from the stated number of birds, using ratios of number to volume of production in SE Asian countries. The non-ruminant meat is an underestimate since it ignores the considerable production of meat from horses.